Non-Union of the Scaphoid

REvascularization of the Proximal Pole with Implantation of a Vascular Bundle and Bone-Grafting*

BY DIEGO L. FERNANDEZ, M.D., AND STEPHAN EGGLI, M.D., BERN, SWITZERLAND

Investigation performed at the Department of Orthopaedic Surgery, Lindenhof Hospital, Bern

ABSTRACT: Eleven patients who had an ununited fracture of the scaphoid associated with loss of the blood supply to the proximal fragment were managed operatively with a combination of an inlay corticocancellous bone graft from the iliac crest and implantation of the second dorsal intermetacarpal artery, its accompanying vena comitantes, and a thin cuff of perivascular tissue. The absence of the blood supply to the proximal pole was evidenced both by radiographic changes — which included increased bone density, absence of normal trabeculae, and cystic changes — and by failure to observe bleeding bone during the operation.

There were ten men and one woman. The average duration of non-union was fourteen months (range, six to thirty-three months). Six patients had had previous unsuccessful operative attempts to obtain union. Eight non-unions were in the proximal one-third and three, at the waist of the scaphoid. Union was achieved in ten patients at an average of ten weeks postoperatively.

According to the wrist-scoring system of the Mayo Clinic, at an average of five years (range, 2.5 to eleven years), three patients had a grade of excellent; three, good; three, fair; and two, poor. Four patients had subsequent reconstructive procedures: radial styloidectomy, styloidectomy and resection of osteophytes, radioscapoholunate arthrodesis, and total wrist arthrodesis were performed in one patient each.

The treatment of non-unions of the scaphoid that are complicated by avascular necrosis of the proximal fragment remains a challenge. The unfavorable results reported by a number of investigators who have used conventional autogenous non-vascularized bone-grafting procedures10,12,13,15 have led some authors to recommend other operations. These have included excision of the proximal fragment and replacement with a prosthesis12,13 or an allograft as well as salvage procedures such as resection arthroplasty or partial or total arthrodesis of the wrist12,15.

Alternatively, several investigators have tried to obtain union in the presence of an avascular proximal segment by providing additional vascularity to the site of the non-union. This has been attempted through the implantation of a vascular pedicle10,12,13 or vascularized bone graft10,12,13,14,15. The former technique was first described by Hori et al.10, who demonstrated, in experimental animal models, active proliferation of blood vessels and new-bone formation when a vascular pedicle or bundle consisting of peripheral vessels (an artery, venae comitantes, and perivascular tissue) was implanted into an isolated or necrotic bone. Success with implantation of a vascular pedicle has been reported in the treatment of Kienböck disease10,12,13,14,15. To our knowledge, however, other than the original paper by Hori et al.10, which described the procedure in one patient, the English-language literature contains no reports of the use of this method for the treatment of a non-union of the scaphoid with avascular necrosis of the proximal fragment.

In the current study, we report our experience with the operative treatment of eleven ununited fractures of the scaphoid in which the proximal segment was demonstrated to be avascular. A combination of implantation of a vascular pedicle from the second dorsal intermetacarpal artery into the proximal segment of the scaphoid and use of an inlay corticocancellous strut of autogenous graft from the iliac crest was employed in each patient.

Materials and Methods

From 1981 to 1992, ninety-six ununited fractures of the scaphoid were treated operatively by the senior one of us (D. L. F.) to obtain union. Eleven of these non-unions were thought to be associated with avascular necrosis of the proximal segment, and they formed the basis of the current study.

The presence of avascular necrosis was established with use of specific radiographic and clinical criteria. The radiographic criteria included an increase in the bone density, a loss of the normal trabecular appearance, collapse of the subchondral bone, cystic changes, and deformity of the osseous segment. Clinically, a find-
ing of sclerotic bone without visible punctate bleeding points after débridement of the proximal segment was required to confirm the diagnosis of avascular necrosis. Neither magnetic resonance imaging nor technetium-99m bone-scanning was used in this study.

Ten patients were men and one was a woman; the average age was twenty-six years (range, nineteen to thirty-five years) (Table I). The dominant hand was affected in seven patients. The average duration of the non-union of the scaphoid was fourteen months (range, six to thirty-three months). Six patients had had a previous unsuccessful operative procedure. Of these patients, one (Case 1) had had open reduction and internal fixation of an acute fracture associated with a perilunate dislocation. In the remaining five patients, an established non-union had been treated with a bone-grafting procedure (a Matti-Russe inlay bone graft in two [Cases 3 and 4] and interpositional bone-grafting and screw fixation in three [Cases 6, 9, and 11]). In three patients, the non-union had developed after non-union of the initial fracture. Of these three patients, two (Cases 2 and 5) had been managed with immobilization in a below-the-elbow thumb-spica cast for three months each, and the third (Case 7) had had closed reduction of a transscaphoid perilunate dislocation and immobilization in a below-the-elbow cast for sixteen weeks. Two
The proximal polled avascular/scaphoid.

Additional cancellous bone chips are obtained.

Evidence of associated carpal instability.

A small spreader clamp may be used to distract the site of the non-union.

The proximal pole in association with dense sclerotic bone has been confirmed.

The central portion of the proximal fragment is excavated.

The most decisive criterion for inclusion in the study was the clinical finding of a proximal fragment that was dense, sclerotic, and avascular in association with a total absence of bleeding points after débridement. Vascularity was assessed intraoperatively according to the guidelines established by Green. Vascularity was considered good if there were numerous bleeding points, and it was considered fair or poor if sparse bleeding points were observed. The proximal pole was considered avascular if no punctate bleeding points were seen.

Operative Procedure

With the patient under general anesthesia and the iliac crest draped free, the scaphoid is approached through an extensile dorsoradial exposure (Fig. 1). The proximal part of the incision begins at the Lister tubercle and extends distally for four centimeters, running parallel to the extensor pollicis longus tendon and ending at the dorso-ulnar aspect of the base of the thumb. After identification and protection of the sensory branches of the radial nerve, an interval is developed between the extensor carpi radialis longus and brevis and the extensor pollicis longus. The wrist capsule is incised along the long axis of the scaphoid. The articular nutrient branches arising from the radial artery are identified as they enter the dorsal ridge of the distal fragment, and they are protected throughout the procedure. Next, the site of the non-union is visualized, and the interposed fibrous tissue is debrided with a scalpel, with care being taken not to damage the articular cartilage. A small spreader clamp may be used to distract the site of the non-union in order to visualize the ununited surface of the proximal fragment.

A sharp curet is employed to debride the sclerotic surfaces at the site of the non-union. If the surface of the non-union is very irregular, a small oscillating saw can be used to smooth the osseous prominences. The surface of the proximal fragment is carefully inspected for bleeding points with use of loupe magnification. The punctate bleeding points are seen even with the tourniquet inflated; however, if the surgeon is in doubt as to whether or not a small red spot is in fact a vessel, the tourniquet may be released and the surface may be observed during continuous irrigation with saline solution while the bleeding from the surrounding soft tissues is blocked with a sponge.

After the absence of vascularity of the fragment of the proximal pole in association with dense sclerotic bone has been confirmed, the central portion of the proximal fragment is excavated with power drills and burrs for subsequent insertion of an autogenous peg graft from the iliac crest. The diameter of this cavity should not exceed five millimeters. A rectangular trough is prepared on the dorsoradial aspect of the distal fragment with use of a small oscillating saw and small chisels. The most distal transverse cut of the trough is made slightly obliquely into the depth of the scaphoid in order to provide a trapezoidal surface to lock the graft into place. After the trough in the distal fragment and a cylindrical central cavity in the proximal fragment have been prepared, the scaphoid is reduced and the length, width, and depth of the defect are measured in millimeters. A corticocancellous peg graft is cut off the iliac crest, with use of power tools and small chisels, in accordance with the measurements of the defect of the scaphoid. Additional cancellous bone chips are obtained with a curet, and the wound over the iliac crest is closed.

The fragments of the scaphoid are separated slightly with a spreader clamp, and the graft is inserted in the central cavity in the proximal fragment. The graft is then reduced into the trough of the distal fragment, with care being taken to ensure that the cortical surface of the graft lies dorsoradially and that the surface of the non-union is not distracted by an oversized graft. Additional cystic cavities and the site of the non-union may be packed with free cancellous bone chips before the peg graft is reduced into the distal fragment. Depending on the size of the proximal fragment, one or two smooth Kirschner wires are used to stabilize the non-union. If the proximal fragment is very small (less than one-third of the size of the scaphoid), a single 1.0 to 1.2-millimeter Kirschner wire is inserted parallel to the peg graft in the most radial aspect of the scaphoid. The Kirschner wire is inserted with a power drill under image intensification without entry into the scaphotrapezial joint; it is then directed to the proximal pole of the scaphoid. Placement of the wire should not jeopardize the point of entry of the vascular bundle, which will be slightly ulnar to the center of the proximal pole, close to the scapholunate junction. If the proximal fragment is large enough, a second Kirschner wire may be inserted in the most ulnar aspect of the scaphoid.

With the exception of one patient (Case 11), for whom the preoperative radiographs exhibited a dorsally rotated lunate with an increased scapholunate angle of 70 degrees and signs of early periscaphoid osteoarthrosis, patients had normal carpal angles, with scapholunate angles ranging from 30 to 60 degrees and no radiographic evidence of associated carpal instability.

Eight non-unions were located in the proximal one-third of the scaphoid and three, at the level of the scaphoid waist.

Preoperatively, plain radiographs and tomograms showed increased bone density and an absence of normal osseous trabeculae in all patients. Additional cystic changes and collapse of the subchondral bone of the proximal segment were observed in the seven patients (Cases 2, 3, 5, 7, 8, 9, and 11) who had a longer duration of the non-union.

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Figs. 1, 2, and 3: Schematic drawings showing the operative technique.

Fig. 1: The extensile dorsoradial incision for grafting and revascularization of the scaphoid with use of the second dorsal intermetacarpal artery and vein.

The skin incision is then extended distally to the second dorsal web space, and the extensor tendons to the index finger are retracted toward the ulna. The second dorsal intermetacarpal artery and its venae comitantes are identified between the first and second metacarpals. The vessels lie underneath a thin layer of aponeurosis that covers the interosseous muscles (Fig. 3, a). This fascial layer is split longitudinally to the level of the second web space, and the vascular bundle is carefully dissected from proximal to distal, with care being taken to elevate the artery and its venae comitantes together with a thin layer of perivascular areolar tissue. Small collateral branches found during dissection are identified and coagulated. The vascular bundle is dissected up to the level of the web space, and the vessels are ligated with a 5-0 monofilament suture and are transected. Freeing of the second intermetacarpal artery and its venae comitantes from the base of the second metacarpal to the level of the web space produces a pedicle, five to six centimeters long, that will readily reach the proximal pole of the non-union.

After the vascular bundle has been elevated, a 2.7-millimeter drill-bit is used to create a hole across the proximal pole of the scaphoid (Fig. 3, b). The drill-hole must be placed carefully just ulnar to the iliac-crest peg graft. It is usually begun close to the scapholunate junction and is oriented slightly obliquely in a radio-volar direction. The vascular bundle is passed through the drill-hole in a dorsal-to-palmar direction (Fig. 3, c). The passage is facilitated by the attachment of a fine reabsorbable suture to the end of the pedicle and the use of a straight needle to guide the suture and the vascular pedicle through the bone. Care must be taken to avoid a focal constriction of the pedicle as it is ro-

a: The non-union of the scaphoid is exposed through a limited dorsoradial capsulotomy. Note the vascular bundle of the second intermetacarpal artery, lying between the first and second metacarpals. b: An inlay graft has been inserted and a 2.7-millimeter hole has been drilled in the proximal fragment; the vascular bundle has been raised and is held with a suture. c: The vascular bundle is passed through the proximal pole.
Nontunion of the Scaphoid

A persistent non-union of the scaphoid with avascular necrosis of the proximal fragment. The non-union had failed to heal after interpositional bone-grafting and fixation with a Herbert screw.

Fig. 4-A: Immediately after the index operation.
Fig. 4-B: Eight months after the index operation, the non-union has healed.

Postoperative Management and Assessment

Postoperatively, an above-the-elbow thumb-spica cast was worn for four weeks, followed by a below-the-elbow thumb-spica cast for another four weeks. At eight weeks, the cast was removed, and the Kirschner wires were removed through stab incisions with use of local anesthesia. Bone-healing was then evaluated with both standard radiographs and anteroposterior tomograms of the scaphoid. The non-union was considered to be healed if there was tomographic evidence of bridging bone trabeculae at the site of the non-union. Thereafter, the patient was encouraged to use the hand for activities of daily living; however, a removable wrist brace was recommended for strenuous activities for another four weeks. If tomographic evidence of union was uncertain, the below-the-elbow thumb-spica cast was worn for another two weeks, and anteroposterior tomograms of the scaphoid were again made.

The final evaluation was based on both subjective and objective criteria, including the patient’s satisfaction, residual pain, active range of motion of the wrist, grip strength, results of a sensory examination, and ability to work. The patient’s satisfaction was assessed by asking the patient if the condition of the wrist was better than before the operation and by asking if he or she would agree to have the operation again if the contralateral wrist were to have a similar condition. All patients were asked whether they had pain in the wrist during normal activities of daily living or during work. Pain was considered mild if it occurred at the extremes of the active range of motion of the wrist but the patient was neither physically nor psychologically disturbed; moderate if the patient was physically or psychologically disturbed, or both, during strenuous manual labor; and severe if it occurred during activities of daily living and at rest.

The active range of motion of the wrist was measured with a goniometer and was compared with that of the contralateral wrist. Sensory evaluation included...
Figs. 5-A through 5-G: Case 2. A twenty-year-old man.

Fig. 5-A: Radiographic appearance of the non-union of the scaphoid with avascularity of the proximal fragment, before the index operation.

Fig. 5-B: Radiograph made immediately postoperatively.

Fig. 5-C: Tomogram made at nine and one-half weeks, showing union.

Radiographs made one and four years postoperatively:

light-touch and pin-prick sensibility tests and a two-point discrimination test of the median, radial, and ulnar dermatomes. Particular attention was given to alterations of sensibility and to the presence of a neuroma of the superficial radial nerve at the level of the operative scar. Grip strength was measured with a Jamar dynamometer (Therapeutic Equipment, Clifton, New Jersey), was expressed as an absolute value of kilograms-force, and was compared with that of the uninjured wrist. The ability to work was evaluated on the basis of whether or not the patient had returned to his or her original occupation and was able to work full-time (100 per cent) or was restricted (to 25 to 50 per cent of the normal working time).

For the final combined assessment of the late results, the wrist-scoring system of the Mayo Clinic was used, with residual pain, functional status, range of motion, and grip strength being granted a maximum of 25 points each. A score of 90 to 100 points indicates an excellent result; 80 to 89 points, a good result; 65 to 79 points, a fair result; and less than 65 points, a poor result.

For the radiographic assessment of the early results, the criterion for union was the disappearance of a gap at the site of the non-union, with evidence of bridging bone trabeculae on both plain radiographs and trispiral tomograms. Restoration of normal bone density equal to that of the neighboring carpal bones as well as reappearance of normal cancellous trabecular structure on plain radiographs were considered signs of revascularization. Irregular areas of patchy sclerosis in the proximal pole were interpreted as a sign of partial revascularization. For the radiographic assessment of

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The late results, the carpal height, scapholunate angle, residual incongruity at the level of the non-union, and presence of degenerative changes were evaluated. Degenerative changes were graded from 0 to 3, with grade 0 indicating a normal appearance; grade 1, slight narrowing of the joint space; grade 2, marked narrowing of the joint space and formation of osteophytes; and grade 3, complete loss of the joint space, formation of osteophytes, and subchondral bone cysts.

Early Results

Ten of the eleven non-unions healed at an average of ten weeks (range, eight to twelve weeks) after use of the treatment protocol. Four patients (Cases 1, 2, 10, and 11) had evidence of union when the Kirschner wires were removed and the initial tomograms were made; the remaining seven patients needed additional immobilization in the below-the-elbow thumb-spica cast because of inconclusive tomograms. The cast was removed at two-week intervals, and repeat anteroposterior tomograms were made. Of these seven patients, three had healing at ten or eleven weeks, three had healing at twelve weeks, and one (Case 8) had no evidence of healing and had a persistent gap at the site of the non-union, fragmentation, and collapse of the proximal pole. Because of disabling pain, this patient had a total wrist arthrodesis five months after the index operation. An additional patient (Case 4) also had a result that was considered a failure because of persistent pain in the wrist despite radiographic union. At the time of the reoperation, eight months after the reconstruction of the scaphoid, synovitis and erosion of the cartilage of the radio-scaphoid joint were found, and an arthrodesis of the radio-scapholunate joints was performed. Two additional patients had residual pain in the wrist, which was mild in one (Case 1) and moderate in the other (Case 11); both had radiographic evidence of impingement of the scaphoid on the radial styloid process with early degenerative changes, evidenced by a slight narrowing of the joint space. The pain in these two patients was relieved by a radial styloidectomy in one (Case 1) and the removal of osteophytes in the other (Case 11), at seven and ten months, respectively, after the index operation.

No other early complications, such as pin-track infection or sensory disturbances in the area of the radial nerve, were observed.

Late Results

The results were assessed at a mean of five years (range, 2.5 to eleven years) postoperatively. With the exception of the two patients (Cases 4 and 8) who had had a secondary arthrodesis, all patients were satisfied with the late result. The two patients (Cases 1 and 11) who had subsequently had a radial styloidectomy were pain-free at the latest follow-up evaluation.

With the exclusion of the two patients who had had a partial and a total arthrodesis of the wrist, the residual motion of the affected wrist averaged 50 degrees of flexion, 58 degrees of extension, 15 degrees of radial deviation, and 25 degrees of ulnar deviation compared with an average of 12 degrees of flexion, 1 degrees of extension, 70 degrees of radial deviation, and 30 degrees of ulnar deviation of the contralateral wrist.

Analysis of grip strength demonstrated an average of thirty-six kilograms-force on the affected side compared with an average of forty-one kilograms-force on
the contralateral side. This represented an average decrease of five kilograms-force for the entire series at the latest follow-up evaluation. Of the seven patients who had had the operation on the wrist of the dominant hand, two (Cases 7 and 9) had more strength in the dominant hand than in the non-dominant hand at the latest follow-up evaluation, one (Case 3) had equal strength in both hands, and four had less strength (fifteen kilograms-force less in two [Cases 4 and 11], five kilograms-force less in one [Case 8], and three kilograms-force less in one [Case 5]) in the dominant hand.

Ten of the eleven patients returned to their original work at an average of 4.8 months after the operation. The remaining patient (Case 8), who had had a total wrist arthrodesis and had been a road worker, had to change his occupation as he was no longer able to use a pick and shovel without difficulty.

Radiographic evidence of degenerative changes was noted in three patients at the latest follow-up evaluation. In two of these patients (Cases 1 and 7), the original injury had been a transscaphoid perilunate dislocation, which may account for the development of secondary osteoarthrotic changes at the level of the mid-carpal joint. In both patients, the changes were mild, with slight narrowing of the joint space and formation of osteophytes on the dorsal surface. The third patient (Case 11) had evidence of initial osteoarthrotic changes of the radioscaphoid joint, with formation of osteophytes at the level of the radial styloid process. Comparison of the radiographs made soon after healing of the scaphoid with those made at the latest follow-up evaluation failed to show any deterioration of the scapholunate angle or of the carpal height in any patient.

The over-all functional result, according to the wrist-scoring system of the Mayo Clinic, was excellent in three patients, good in three, fair in three, and poor in two. Analysis of the three unsatisfactory results showed that the treatment had failed to provide revascularization in one patient (Case 8), while two patients (Cases 4 and 11) had residual, disabling pain in the wrist despite union. Retrospectively, the initial periscaphoid degenerative changes were underestimated, and perhaps a salvage procedure should have been performed instead of revascularization. Relief of pain after anarthrosis of the radioscapholunate joints (Case 4), a total arthrodesis of the wrist (Case 8), and a styloideectomy (Case 11) was satisfactory in all three patients.

Illustrative Case Report

CASE 2. A twenty-year-old man sustained a fracture of the proximal third of the scaphoid on the left, non-dominant side and was managed with a below-the-elbow thumb-spica cast for three months. The fracture failed to unite; however, the patient had no symptoms referable to the non-union.

Twenty months after the initial injury, a second injury occurred, and the patient began to have pain with strenuous activity. Anteroposterior, lateral, and scaphoid radiographs revealed an ununited fracture of the proximal pole with increased bone density (Fig. 5-A). Intraoperatively, the proximal pole showed no bleeding points and was white and sclerotic. A minus ulnare with corticocancellous graft from the iliac crest was inserted dorsally; a single 1.2-millimeter Kirschner wire was used to stabilize the non-union. The proximal pole was revascularized with the second dorsal intermetacarpal artery and its venae comitantes (Fig. 5-B).

Nine and one-half weeks postoperatively, anteroposterior tomograms showed osseous union and incorporation of the inlay graft (Fig. 5-C). Radiographs made one year later revealed that the scaphoid had regained a normal-appearing osseous contour, and there was evidence of bone trabeculae bridging the site of the non-union (Fig. 5-D). The vascular channel was still visible.

Four years postoperatively, the radiographs revealed normal cancellous bone trabeculae in the tip of the proximal pole without evidence of increased sclerosis (Fig. 5-E). At the time of the latest follow-up examination, seven years postoperatively, the patient was free of pain and the range of motion of the wrist was 65 degrees of palmar flexion, 50 degrees of extension, 10 degrees of radial deviation, and 35 degrees of ulnar deviation (Figs. 5-F and 5-G).

Discussion

The healing potential of an ununited scaphoid depends on two factors: vascularity and stability. Because of its vulnerable blood supply and the loss of retaining ligamentous support, unstable and proximal non-unions of the scaphoid have been associated with decreased rates of union after conventional bone-grafting procedures. With the advent of improved techniques for internal fixation in combination with autogenous bone-grafting, a substantial improvement in the rate of union of unstable non-unions of the scaphoid has been reported by several authors. However, the inlay-grafting procedure of Russe has resulted in a high rate of union of stable non-unions and has also been recommended for scaphoids that have failed to unite after an initial bone-grafting procedure.

The rate of success with conventional grafting is lower when the proximal pole of the scaphoid is completely avascular. Green analyzed the effect of impaired vascularity on the results of the Russe procedure and reported union in ten of fourteen patients in whom the vascularity was spotty or diminished and failure of the fracture to unite in five patients in whom the proximal pole was totally avascular. Green suggested that the best indication of true avascularity of the proximal pole is the absence of punctate bleeding points on the cancellous surface.

More recently, it was suggested that magnetic resonance imaging of the scaphoid allows a more accurate determination of the state of the bone circulation. Urban et al. performed both a qualitative and a quantitative histomorphometric analysis of six scaphoid specimens. Four of these specimens had a non-union, with presumed avascular necrosis of the proximal pole and increased radiographic density; one was obtained from a patient who had Preiser disease; and one was an intact scaphoid, removed as part of a proximal-row carpectomy, which served as a control. Two-millimeter-thick longitudinal and coronal sections from each speci-
non-union of the scaphoid

...vascularity of the proximal segment of a scaphoid fracture can be separated into three categories: transient ischemia; partial or reversible necrosis; and complete, irreversible necrosis. In transient ischemia, the proximal pole is temporarily deprived of its intraosseous circulation because of the fracture; the circulation is restored when the fracture unites. Transient ischemia is associated with increased radiographic density without subchondral collapse, deformity, or abnormal bone trabeculae. Partial or reversible avascular necrosis, as seen in some instances of non-union, reflects an increased bone density associated with a disappearance of normal cancellous bone trabeculation, deformity, and cystic changes. Complete, irreversible necrosis is characterized by the changes of partial necrosis as well as by subchondral collapse and fragmentation similar to those seen in the late stages of Preiser or Kienböck disease. At this stage, revascularization may not be possible since fragmentation is associated with permanent structural changes of the bone matrix. Not only is the vascular supply absent, but there is also incongruity of the joint surfaces because of post-ischemic collapse and fragmentation as well as degenerative changes of the cartilage envelope. For this reason, an operation that is done to promote union will compromise the chances for pain relief and for prevention of further collapse and of subsequent osteoarthritic changes of the wrist. However, if the proximal fragment is ischemic but not deformed and there is no evidence of advanced periscaphoid osteoarthrosis or of established carpal collapse, it seems that a logical way to preserve the anatomical integrity of the scaphoid is to accelerate union with a revascularization procedure.

Although there is a chance that ischemic proximal poles will be revascularized with Russe inlay-grafting, the results with this method have been unpredictable, especially when the recipient bone has been completely avascular. If there is clinical and radiographic evidence of avascular necrosis or of recurrent pseudarthrosis due to instability, revascularization may be accelerated by the use of vascularized bone grafts or by the implantation of a vascular bundle as well as a conventional autogenous graft from the iliac crest. Vascularized bone grafts obtained from the distal part of the radius and pedicled on the pronator quadratus have been described by Braun, Leung and Hung, and Kawai and Yamamoto. Kuhlmann et al. reported the successful use of a radial graft that was pedicled on the radial branch of the volar carpal arch in the treatment of three chronic non-unions after a Matti-Russe operation had failed. Brunelli et al. used, for the same indication, a vascularized bone graft from the radial distal aspect of the second metacarpal; the graft was pedicled on the superficial dorsal interosseous artery.

Zaidemberg et al. reported success with the use of a vascularized bone graft from the radial styloid process in eleven patients who had had a long-standing non-union and a failed Matti-Russe procedure. The graft was pedicled on a constant ascending retrograde branch of the radial artery that runs deep to the first dorsal extensor compartment at the level of the radial styloid process. The average duration to union in their series was 6.2 weeks (range, five to eight weeks). Guimberteau and Panconi used a vascularized bone graft, obtained from the ulna and based on the ulnar artery, to treat recurrent non-unions of the scaphoid in eight patients. all of whom had had at least two previous failed procedures. Healing occurred at an average of 4.6 months in all eight patients. The major disadvantage of this approach is the need to transect the ulnar artery to move the graft distalward. This necessitates restoration of arterial continuity with a free venous graft. Pechlaner et al. reported the successful treatment of twenty-five non-unions of the scaphoid with a free vascularized iliac-crest graft based on a vascular pedicle from the deep iliac circumflex artery. This procedure was indicated for small, avascular proximal poles and for long-standing non-unions, for which the rate of union at their institution had been as low as 55 per cent with use of conventional Russe procedures.

Implantation of a vascular bundle is an alternative method that provides direct capillary ingrowth to avascular bone. Its clinical use, with or without curettage of the central necrotic areas of the lunate, has gained popularity in the treatment of the early stages of Kienböck disease. The advantages of the procedure are its simplicity and the shorter operative time; there is no need for complex vascular dissection of arterial pedicles or for microvascular reconstruction. Furthermore, manipulation of a free pedicled graft from the iliac crest is easier than that of a graft that is attached either to muscle or to a vascular pedicle. Insertion of a smaller free graft from the iliac crest requires a smaller trough, and more of the cartilage surface of the scaphoid can be preserved, thereby diminishing the possibility of late osteoarthritic changes.

The vascular pedicle that was used in our study proved to be of sufficient dimensions and was present in each patient. An alternative to use of the second dorsal intermetacarpal vessels is use of the dorsal branch of
the anterior interosseous artery and the vein of the distal part of the forearm. This artery emerges dorsally through the anterior interosseous membrane in the posterior aspect of the distal part of the forearm and crosses the wrist at the level of the radio-ulnar joint. It provides nutrient branches to the lunate and capitate and anastomoses distally with the dorsal carpal arch. We believe that the acceptable results in our small series were due to the fact that both factors that govern the healing of a non-union — stability and vascularity — were addressed simultaneously. Although we are aware of the lack of experimental models, biopsy material, and comparisons with similar series, we postulate that ultimate revascularization and healing of the non-union is probably obtained through two sources of capillary ingrowth: a direct source, through the vascular pedicle, and an indirect source, through incorporation and revascularization of the inlay graft from the viable cancellous bone of the distal fragment. Internal fixation provides a mechanically neutral environment, which also plays a role in undisturbed bone-healing. In summary, in a clinical situation in which the proximal fragment of a scaphoid non-union shows radiographic evidence of vascularity, appears sclerotic, and is deprived of bleeding points intraoperatively and in which there is no evidence of periscaphoid degenerative changes, the patient should be considered a candidate for an attempt to gain union with this approach. Given the small number of patients treated with revascularization procedures reported to date and the lack of randomized series, the choice of a particular method still remains based on the personal experience of the surgeon. The combined technique of inlay bone-grafting, internal fixation, and implantation of a vascular bundle is an attractive alternative to vascularized bone-grafting procedures.

References


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