Scaphoid reconstruction with vascularized bone grafts from the distal radius

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Abstract The aim of the present technical report is to describe the alternative solutions for the reconstruction of scaphoid nonunions with pedicled vascularized bone grafts from the distal radius. The surgical technique for the reconstruction A. of proximal scaphoid nonunions with pedicled bone grafts (based on the 1,2 or on the 2,3 intercompartmental arteries) or with capsular bone grafts from the dorsal distal radius and B. of waist nonunions of the scaphoid with grafts from the palmar distal radius, pedicled on the palmar carpal arch, is presented. Vascularized bone grafts from the adjacent radius are used for the treatment of scaphoid nonunions to enhance union and to revascularize a nonviable proximal pole. The most suitable graft is selected according to the location of the nonunion (at the waist or the proximal pole of the scaphoid) and to the previous procedures/scars at the wrist level.

Keywords Scaphoid nonunions · Vascularized bone grafts · Pedicled · Distal radius

Introduction

In scaphoid nonunions the union rate varies according to the stage of the nonunion and the vascularity of the proximal pole. Among the techniques that have been proposed for the management of scaphoid nonunions, the vascularized pedicled grafts from the distal radius were introduced as an alternative treatment method aiming to enhance the local biology and to improve outcome. Studies on patients with scaphoid nonunion who underwent vascularized bone grafting based either on the 1,2 intercompartmental artery or the palmar carpal artery [1] have reported union rates up to 100% [2–4].

Methods

Preoperative evaluation

Scaphoid imaging includes radiographic examination of both wrists with postero-anterior views in neutral rotation, lateral views and special scaphoid views. On the radiographs of the affected side, scaphoid shortening may be evaluated and compared to the length of the scaphoid calculated on the radiographs of the normal side. The presence of an avascular proximal pole, dorsal intercalated segmental instability, radioscaphoid arthritis or dorsal osteophytes is evaluated. Additional imaging evaluation includes CT on the longitudinal axis of the scaphoid for the assessment of the hump-back deformity and bone loss, and MR imaging for the assessment of the vascularity of the proximal pole.

Operative technique

The patients are informed about the anesthesia and the surgical procedure, the postoperative immobilization and the subsequent hand therapy, whereas the smokers are

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requested to quit smoking for 4–6 weeks before operation and for 6 months postoperatively.

The procedure is most commonly carried out under axillary block and exceptionally under general anesthesia utilizing loupe magnification and tourniquet controlled ischemia. The forearm must be elevated only and not exsanguinated with an Esmarch bandage, so that the small vessels of the distal radius will remain identifiable.

Dorsal bone grafts

The dorsal approach is selected in cases of proximal scaphoid nonunions.

The dorsal grafts are elevated from the dorsal-radial aspect of the distal radius and are based on the 1,2 or the 2,3 inter-compartmental supra-retinacular (ICSRA) artery [1]. Alternatively, capsular bone grafts may be elevated from the dorsal radius at the level of the 4th extensor compartment.

A lazy S skin incision at the dorso-radial aspect of the distal radius and wrist, between the first and the second dorsal compartments, is centered on Lister's tubercle and extends 4 cm proximally, and to the base of the second metacarpal distally. The sensory branches of the radial nerve at the wrist are identified and protected. The 1,2 ICSRA is identified under the subcutaneous fascia (Fig. 1). The vessel is running between the 1st and 2nd dorsal extensor compartment and is based on the radial artery both proximally and distally [1].

Through dorsal capsulotomy the proximal scaphoid nonunion is approached and two 1.2 mm K-wires are inserted to each fragment as joysticks. Distraction of the non-union site allows for curettage. The pathologic tissue from the nonunion is excised until rough bony surfaces are obtained in both sides. The fresh cut surfaces of both segments of the scaphoid are inspected for the punctuate bleeding, visible even with the tourniquet applied and confirmed immediately after tourniquet release. Absence of any bleeding foci from the proximal segment means that it is avascular and needs further excision of the sclerotic part, preserving the cartilage and a crust of the subchondral bone.

Due to the commonly present humpback deformity and dorsal angulation of the nonunited scaphoid, the defect after the curettage at the nonunion site and the reduction of the two scaphoid fragments is wedge shaped with a wider dorsal base. The sum of the length of the proximal and distal bone segments is calculated on preoperative radiographs and subtracted from the length of the normal contralateral scaphoid leading to the approximate dimensions of the graft. Thus, a rectangle with average dimensions 12 × 10 mm is marked on the dorsal-radial aspect of the distal radius, placed longitudinally. The bone graft based on the dorsal 1,2 ICSRA pedicle is then precisely cut 10 mm proximal to the articular surface. A cortico-

cancellous graft (with minimum depth of 10 mm) is then separated from the radial metaphysis and carefully elevated with a very thin chisel. The cuboidal shaped graft is inserted with the opposite surface to the vascular attachment, facing palmarly. The vascular pedicle is elevated from the distal radius a 4–5 mm wide strip of fascia and periosteum throughout its length that preserves and protects it. The pedicle is dissected to its distal origin at the radial artery, approximately 1 cm distal to the radial styloid (Fig. 1), and with rotation of the pedicle the graft is transferred to the proximal scaphoid [2, 3].

Alternatively, the graft based on the 2,3 ICSRA may be used. The vessel is running between the 2nd and 3rd dorsal extensor compartment and is based on the anterior interosseous artery proximally and the dorsal carpal arch distally [1]. The graft is elevated from the dorsal-radial side of the metaphysis, as described previously and the pedicle is dissected distally to the dorsal carpal arch, so that it may be rotated and reach the proximal scaphoid.

Finally, capsular bone grafts may be elevated from the dorsal radius at the level of the 4th extensor compartment, as described by Sotereanos et al. [5]. After rotation of a capsular pedicle with length between 1 and 3 cm, that attached bone graft reaches the proximal scaphoid. The capsular pedicle includes the artery of the 4th extensor compartment and is based distally on the dorsal carpal arch or the 5th compartment artery.

Palmar bone grafts

The palmar approach is preferred in most cases of scaphoid nonunions located at the waist of the bone. The palmar grafts are elevated from the palmar-ulnar aspect of the distal radius and are based on the palmar carpal epiphyseal artery.

Fig. 1 Vascularized bone graft from the dorsal-radial aspect of the distal radius, pedicled on the 1,2 inter-compartmental supra-retinacular artery (arrow). The pedicle is running between the 1st and 2nd dorsal extensor compartment. ECRL: extensor carpi radialis longus.

A reversed L-shaped skin incision is used; a 5 cm longitudinal incision is made along the radial border of the flexor carpi radialis tendon and extends towards the thenar eminence at the level of the radial styloid. The radial artery is identified and protected, and the volar aspect of the scaphoid waist is exposed and visualized through volar capsulotomy. Two 1.2 mm K-wire are inserted in the scaphoid fragments to facilitate manipulation of the two fragments and curettage to normal viable bone.

At the ulnar side of the volar aspect of the distal radius a rectangle (12 × 10 mm) is marked, pedicled on the palmar carpal epiphyseal artery that runs on the distal edge of the pronator quadratus, between the radial and the palmar interosseous artery [1]. The artery is transverse to

the radial axis and is situated at the distal part of the pronator quadratus. The graft is separated and elevated while the vascular pedicle is dissected back to the radial artery, which permits free rotation and interposition of the graft at the nonunion site (Fig. 2a). The graft is of trapezoid shape with the vascular attachment on the wider palmar surface [3].

A technical tip common in both approaches, dorsal and volar, is that we harvest a larger graft based on the pre-operative measurements and then we trim it down to match the size of the defect. Moreover, the following technical steps are similar in either approach.

Through temporary over-distraction facilitated by the joystick K-wires, the graft is interposed at the nonunion site (Fig. 2b), with particular care to correct the length and the rotational malalignment of the nonunited scaphoid. The bone graft is secured with two 0.8 mm K-wires, one of which extends into the lunate. Under fluoroscopic control in two planes the optimal alignment of the scaphoid is ensured. The area of the donor site is then packed with allograft and the wound is closed over a small drain. The average duration of the procedure is 110 min.

Postoperative care

A long arm cast with thumb spica is applied postoperatively. The K-wires are removed 5 weeks after the procedure and the hand is immobilized in a short arm cast for an additional period of 2–5 weeks.

Discussion

The meticulous surgical technique and the attention to detail are the prerequisites for the success of the procedure and the avoidance of potential pitfalls.

Several technical points are underlined in the present report.

- The cessation of smoking (pre- and postoperatively) to avoid its undesirable effect on the bone healing process and the vascularity.
- The tourniquet application simply with forearm elevation, avoiding Esmarch's bandage exsanguination so that the small vessels of the distal radius will remain visible.
- The surgeon needs to be familiar with the microvascular anatomy of the distal radius and may select alternative pedicles/vascularized grafts in case of previous lacerations/procedures at the dorsal or the volar aspect of the wrist [1]. For proximal nonunions dorsal pedicled grafts (based on the 1,2 or the 2,3 ICSRA) or capsular grafts are preferable whereas for nonunions at the middle segment of the scaphoid, volar grafts are preferred [2–5].

Fig. 2 *a*, Vascularized bone graft from the palmar-ulnar aspect of the distal radius, pedicled on the palmar carpal epiphyseal artery (arrow). The pedicle is running on the distal edge of pronator quadratus (PQ). *b*, With rotation of pedicle (arrow) the vascularized bone graft is advanced to the nonunion site and is intercalated between the two segments of the scaphoid. PQ: pronator quadratus.

- The dissection under loupes magnification needs to be meticulous and protect the pedicle with a sleeve of periosteum and or fascia.
- The preoperative planning of the graft dimensions comparing radiographs of both wrists, and the intraoperative shaping and size matching of the graft to increase the length of the scaphoid and correct the ‘humpback’ deformity and the height of the carpus [2, 3].
- The interposition of the graft in full width as an intercalary bone between the two segments of the scaphoid, and not as an inlay graft bridging the nonunion. The difficulty of the correction of the ‘humpback’ deformity and of the application of the graft can be addressed by using K-wires as joysticks in each scaphoid segment [2–4].

The management of scaphoid nonunions with pedicled vascularized bone grafts from the distal radius, although technically demanding, results in a high union rate as a viable graft with its intrinsic vascularity preserved is interposed between the scaphoid segments, in revascularization of an avascular proximal pole, and in correction of

the ‘humpback’ deformity leading also to the carpal alignment.

References

1. Dailiana ZH, Malizos KN, Urbaniak JR (2005) Vascularized periosteal flaps of distal forearm and hand. *J Trauma* 58:76–82
2. Malizos KN, Dailiana ZH, Kirou M, Vragalas V, Xenakis TA, Soucacos PN (2001) Longstanding nonunions of scaphoid fractures with bone loss: successful reconstruction with vascularized bone grafts. *J Hand Surg [Br]* 26:330–334
3. Malizos KN, Zachos V, Dailiana ZH, Zalavras C, Varitimidis S, Hantes M, Karantanas A (2007) Scaphoid nonunions management with vascularized bone grafts from the distal radius: a clinical and functional outcome study. *Plast Reconstr Surg* 119:1513–1525
4. Zaidenberg C, Siebert JW, Angrigiani C (1991) A new vascularized bone graft for scaphoid nonunion. *J Hand Surg [Am]* 16:474–478
5. Sotereanos DG, Darlis NA, Dailiana ZH, Sarris IK, Malizos KN (2006) A capsular-based vascularized distal radius graft for proximal pole scaphoid pseudarthrosis. *J Hand Surg [Am]* 31:580–587