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Simplified scaphoid reconstruction technique with Zaidemberg’s vascularized radial graft

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Scaphoid non-union; Graft

Summary  For more than 10 years, we have been using a simplified reconstruction technique for scaphoid non-unions that involves the use of a graft first described by Zaidemberg et al. [1]. This approach requires that an island bone graft harvested from the radial styloid and pedicled on the 1,2-intercompartmental supraretinacular artery be embedded into the site of the non-union. The objective of our technical modifications was to simplify the harvesting and handling of the graft and the internal fixation. This technique is only used for cases of scaphoid non-union with avascular changes in the proximal fragment, repeated non-union after bone grafting and internal fixation, chronic non-union with osteophyte formation in the dorso-radial aspect and fracture secondary to Preiser disease.

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Anatomical basis

Thirty wrists (18 right, 12 left) were dissected after the intra-arterial injection of coloured latex. Evaluation of the 30 injected wrists showed that the 1,2-intercompartmental supraretinacular artery (1,2-ICSRA) was consistently present. However variations in the origin, trajectory and length of this anatomical structure [1,2] led to four artery types being defined:

- Type 1 (seven cases): the 1,2-ICSRA originates from the radial artery, volar to the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons, and makes a long curve from front to back to reach the distal part of the radius between the first and second dorsal extensor compartments (Fig. 1);
- Type 2 (12 cases): the 1,2-ICSRA originates from the radial artery deep to the APL and EPB tendons. The trajectory is much shorter than in type 1 arteries (Fig. 2). In Types 1 and 2, the 1,2-ICSRA can pass close to the styloid or actually come in contact with it;
- Type 3 (six cases): the 1,2-ICSRA originates from the radial artery dorsal to the APL and EPB tendons, and has a direct, ascending trajectory (Fig. 3);

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• Type 4 (five cases): the 1,2-ICSRA originates from a dorsal collateral articular branch of the radial artery and ascends towards the distal part of the radius between the first and second extensor compartments (Fig. 4).

The 1,2-ICSRA is between 14 and 23 mm long. It has a sinuous trajectory when the wrist is in neutral position or in extension. This extra length is taken up when the wrist is flexed. Its diameter is 0.3 to 0.8 mm at its origin and 0.2 to 0.4 mm near the distal end of the radius.

In the section over the periosteum, the artery has an upward trajectory along a line bisecting the first two extensor compartments. The branches of the 1,2-ICSRA are spread out in a regular pattern similar to an espaliered tree onto the periosteum and the extensor retinaculum, with superficial collateral branches also going to nerves in the skin. Thin arterioles are stretched out between the 1,2-ICSRA and the periosteum in the deeper aspects, and the terminal branches of the radial nerve in the superficial aspect.

To round out the anatomical evaluation, two spalteholz-diaphanizations revealed that the first collateral branches penetrating the bone originated 5 to 8 mm proximal to the distal margin of the radius. Thus the pedicle can be made longer and the graft harvested further away from the joint itself.

Figure 1 Type 1 artery.

Figure 2 Type 2 artery.

Figure 3 Type 3 artery.

Figure 4 Type 4 artery.

Figure 5 Dissection of the superficial branch of the radial nerve; the end of the scissors point to the 1,2-intercompartmental supraretinacular artery (1,2-ICSRA).
Figure 6  First and second extensor compartments are incised and the tendons retracted.

Figure 7  Longitudinal radio-carpal arthrotomy angled under the second extensor compartment.

Figure 8  Oscillating saw used to perform an osteotomy of the radial styloid; note that the vascular pedicle is protected.

Figure 9  Resection of the radial styloid.

Figure 10  Freshening of the non-union site on the scaphoid.

Figure 11  Graft harvesting: postage-stamp osteotomy.
Scaphoid reconstruction with Zaidemberg’s vascularized radial graft

Surgical technique

The procedure is performed under regional anaesthesia (ultrasound-guided axillary block) with a brachial tourniquet in place after partially draining the blood from the limb.

The surgical technique has five main steps:

- Approach and identification of the artery on the graft. A straight, longitudinal, 6 to 7 cm long incision is made on the dorso-radial aspect and centred over the radio-carpal joint line. The radial nerve and its branches must be carefully dissected because the 1,2-ICSRA has thin collateral branches stretched out between the periosteum and the superficial aspects. These small perforating vessels going to the nerves on the skin must be coagulated with bipolar forceps. This approach allows the 1,2-ICSRA to be quickly exposed between the first and second extensor compartments (Fig. 5);
• Arthroty and pedicle harvesting. A longitudinal incision is made over the first and second extensor compartments; a narrow strip from the extensor retinaculum is left intact on either side of the artery’s trajectory (Fig. 6). A longitudinal arthroty is performed over the length of the second compartment to harvest a capsular-periosteal flap that is continuous on the radial side, and used to protect the graft pedicle (Fig. 7);

• Styloidecomy and freshening of the non-union site. A styloidecomy is typically performed to make it easier to prepare the scaphoid. The periosteum is removed from the radius styloid down to the bone to protect the 1,2-ICSRA, which can be flush to the bone in cases of Type 1 or 2 arteries. An oscillating saw is used to perform the osteotomy, while making sure to protect the graft pedicle (Figs. 8 and 9). The non-union site is freshened (Fig. 10) with an osteotome and rongeurs to prepare the site to receive the graft cross-wise. Any osteophytes are resected;

• Harvesting of the cortical-cancellous bone graft. The bone graft is harvested by postage-stamp osteotomy centred over the 1,2-ICSRA (Fig. 11). The osteotomy is extended to the required depth with a scalpel and osteotome. In the ideal case, the graft will be cut all at once to the size needed for a cross-wise inlay over the non-union site. The graft is then harvested on the pedicle, which is protected by the capsular-periosteal flap (Figs. 12 and 13);

• Graft inlay and fixation. The vascularized graft is placed across the freshened area, then inlayed into the scaphoid by spreading the two scaphoid fragments with small hooks (Fig. 14). Internal fixation is performed with two 10/10 K-wires that are inserted at the waist of the scaphoid (Figs. 15 and 16). The K-wires are oriented through the graft into the proximal pole under visual control. Visual control of the internal fixation procedure while the K-wire is inserted and advanced through the graft up to the proximal pole is essential for good quality fixation and a fast procedure. The insertion of the K-wires is direct and intuitive. A straightforward radiology assessment after the internal fixation is usually sufficient.

A two-layer closure is performed without a drain (interrupted subdermal stitch and continuous intradermal stitch). Post-surgical bandaging is reinforced by a segmental splint to immobilise the wrist for the first 3 weeks; a removal brace is then used for the next 3 months.

Series and clinical cases

Our clinical experience is based on a homogeneous, continuous series of 37 patients (34 men and 3 women) from 1994 to 2003. We performed this scaphoid reconstruction procedure 19 times on the right wrist and 19 times on the left wrist. One bilateral procedure was performed under general anaesthesia. In 22 cases, the dominant hand was involved. The average patient age was 29 years; the age range was 17 to 54 years. The range of indications was the following:

• 23 non-union cases associated with avascular changes in the proximal pole of the scaphoid. Cases No. 1 (Fig. 17)
and 2 (Fig. 18) are examples of these avascular changes and the resulting reconstruction;
• nine cases of recurring non-union after failure with non-vascularized grafts and internal fixation;
• three cases of chronic non-union with dorso-radial osteophytes, as shown in Case No. 3 (Fig. 19);
• three fractures secondary to Preiser disease.

Scaphoid union was evaluated with at least 5 years of follow-up and found to be lasting and definitive in 33 of 38 cases. In 47% of cases, the lunate was normally aligned on true lateral radiographs of the wrist.
The only immediate complications observed were two cases of radial paresthesia that were reversible.

Discussion

The Zaidemberg vascularized graft and simplified harvesting technique is suitable only for use in the dorso-radial face of the scaphoid, including the proximal pole. The lunate however is more difficult to access. Our anatomical study confirms that the graft can only be implanted on the palmar face of the scaphoid if a Type 1 IRCSA exists, or with limited wrist extension when a Type 2 IRCSA is present.

The graft pedicle was reliably protected by a capsulo-periosteal flap. This flap made it easier to manipulate the graft. The cortical-cancellous bone in the graft is dense and has good mechanical properties. The harvesting technique described here takes into account potential anatomical variations and does not require the vascularisation pattern to be verified before hand. Independent of the anatomical variation present, the procedure was feasible without compromising the graft vascularisation.

The dorsal approach is an advantage in revision surgery, as previous scaphoid non-union procedures are typically approached from the volar side. This approach provides access to the graft harvesting site and is immediately adjacent to the reconstruction site. In chronic non-unions, the dorsal approach allows any dorso-radial osteophytes that developed at the non-union site and the stylo-scaphoid joint line to be resected.

Our clinical experience confirms the published data on the effectiveness of the Zaidemberg radial graft with high bone union rates for challenging indications. The Mayo Clinic group [3] attenuated the initial enthusiasm for this procedure [1,4—7] by reporting that only 33 of 50 cases showed bone union. In most published series, the importance of using a very precise surgical technique becomes obvious to avoid injuring the radial nerve and avoid having mechanical complications with the graft and internal fixation.

In cases of recurrent non-union or chronic non-union with dorso-radial osteophytes, avascular proximal pole fragment or fracture secondary to Preiser disease, the failure rate of non-vascularized grafts is quite high [8]. In such cases, the Zaidemberg vascularized graft is an appropriate solution, as it is technically feasible and has good reproducibility.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References