Reverse Radial Forearm Fascial Flap With Radial Artery Preservation

Adam J. Hansen · Scott F. M. Duncan ·
Anthony A. Smith · Alexander Y. Shin ·
Steven L. Moran · Allen T. Bishop

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Abstract The reverse radial forearm fascial (RRFF) flap is widely used in soft-tissue reconstruction of the hand. The traditional RRFF flap incorporates the radial artery from the forearm and is perfused by retrograde flow through the palmar arch. In patients with an abnormal Allen test because of an incomplete palmar arch, the traditional RRFF flap is contraindicated unless a vein graft is used to reconstruct the radial artery. A simpler alternative approach for hand reconstruction in such patients is a distally based RRFF flap based on radial artery perforators, which preserves the radial artery. We used RRFF flaps based on radial artery perforators in five patients who had palmar or dorsal soft-tissue loss. All five recovered full hand function, and only one had any complications (full-thickness skin graft loss at recipient site). The RRFF flap based on distal radial artery perforators is suitable for thin coverage of soft-tissue defects in hands with either a complete or an incomplete palmar arch.

Keywords Artery · Radial · Flap · Forearm fascial · Reconstruction · Soft-tissue

Abbreviations

RRFF reverse radial forearm fascial

Introduction

The reverse radial forearm fascial (RRFF) flap, as either a fascial flap or a fasciocutaneous flap, has been used extensively for provision of hand coverage in distal soft-tissue reconstruction [1–7]. The traditional RRFF flap is a single-stage procedure that provides well-perfused tissue to the palm, dorsum, or thumb-index web space. The traditional RRFF flap incorporates the radial artery from the forearm and is perfused by retrograde flow through the palmar arch. Arterial inflow through the superficial and deep palmar arches can be assessed preoperatively with an Allen test by palpation or Doppler ultrasonography. An abnormal Allen test (absent palmar blood flow with radial artery occlusion) or an abnormal Doppler Allen test (no Doppler flow to thumb with radial artery occlusion) indicates an incomplete palmar arch that necessitates radial artery reconstruction if an RRFF flap is raised [6–12].

However, Weinzwieg et al. [9] and Jeng and Wei [13] demonstrated the use of the RRFF flap without radial artery reconstruction. This approach has beneficial implications for patients with incomplete palmar arches. The technique preserves the radial artery and bases the flap on radial artery perforators. We present a series of patients in whom the RRFF flap based on radial artery perforators was used for palmar or dorsal coverage.

A. J. Hansen
Division of General Surgery, Mayo Clinic,
Scottsdale, AZ, USA

S. F. M. Duncan (✉)
Department of Orthopedics, Mayo Clinic,
13400 East Shea Boulevard, Scottsdale, AZ 85259, USA
e-mail: duncan.scott@mayo.edu

A. A. Smith
Division of Plastic and Reconstructive Surgery, Mayo Clinic,
Scottsdale, AZ, USA

A. Y. Shin · A. T. Bishop
Department of Orthopedic Research, Mayo Clinic,
Rochester, MN, USA

S. L. Moran
Division of Plastic and Reconstructive Surgery, Mayo Clinic,
Rochester, MN, USA

Fig. 1 Recipient site of soft-tissue loss prepared appropriately in patient 1.

Methods and Results

Surgical Technique

The RRFF flap is performed with the patient supine and a tourniquet in place on the upper arm. The area of soft-tissue loss is prepared appropriately (Fig. 1). The radial artery perforators are identified and demarcated on the skin with a handheld Doppler device for sonographic guidance (Fig. 2). The fascial island is centered along the axis of the radial artery, extending proximally to the antecubital fossa with a distal pivot point 4 cm proximal to the radial styloid (Fig. 3). The arm is then exsanguinated by gravity, and the tourniquet is inflated. The incision starts at the proximal radial aspect of the flap over the radial artery and continues down to the deep fascia. Skin flaps are then raised to completely expose the fascia. Care should be taken to avoid injuring

Fig. 2 Mapping of radial artery perforators.

Fig. 3 Mapping of forearm fascia for RRFF flap.

the radial artery. The cephalic vein is ligated and divided at the proximal aspect of the flap.

The 4-cm wide flap is then marked (Fig. 4) and raised by incising the fascia proximally and continuing the dissection distally beneath the fascia (Fig. 5), while preserving the perforators at the distal end of the fascial flap. Once raised, the flap is rotated 180° to reach the defect in the hand (Fig. 6). The donor site can be closed primarily or covered with a skin graft if the recipient site is too large to close primarily (Fig. 7). Figure 8 shows the final appearance of the hand 9 months after surgery.

Case Reports

Patient 1

A 53-year-old, right-handed female computer technician presented with a 2-cm, painful right mid-palmar mass of

Fig. 4 Extent of RRFF flap marked out in situ.

Fig. 5 RRFF flap raised before transposition.

3 months' duration. Both Allen and Doppler Allen tests showed abnormal findings, indicating an incomplete palmar arch. Workup revealed a cellular cutaneous fibrous histiocytoma proximal to the index and long finger metacarpal heads volarly. Complete excision of the tumor was performed, creating a 30-cm² soft-tissue defect in the palm. Because of the patient's abnormal preoperative Allen test, an RRFF flap with radial artery preservation was used for palmar reconstruction. An immediate full-thickness skin graft was placed over the flap. The skin graft did not take, but the flap remained fully viable, and a second full-thickness skin graft closed the wound.

Patient 2

A 37-year-old, right-handed female linen worker with right extensor carpi ulnaris tendonitis presented with painful fat atrophy caused by cortisone injections in the area of the ulnar snuff box. She underwent extensor carpi ulnaris

Fig. 6 RRFF flap transposed before release of tourniquet.

Fig. 7 RRFF flap after skin grafting and primary closure of donor site.

tenolysis, followed by creation of a RRFF flap based on radial artery perforators for soft-tissue coverage of the dorsal ulnar sensory nerve and carpal bones. The fascial flap was tunneled across the dorsal wrist and into position over the extensor carpi ulnaris muscle. The skin at the recipient and donor sites was closed primarily. The flap took completely, and the patient recovered full function.

Patient 3

A 33-year-old, right-handed female nursing assistant presented with multiple bony and soft-tissue injuries of the left upper extremity after a motor vehicle collision. After orthopedic repair and soft-tissue debridement, there was a 4×8 cm defect over the distal volar ulnar forearm with exposed flexor digitorum profundus and superficialis tendons, ulnar nerve, and ulnar artery. A 4×8 cm RRFF

Fig. 8 Appearance of RRFF flap 9 months after index procedure.

flap based on radial artery perforators was elevated, tunneled under the skin bridge, and inset over the defect. A vacuum-assisted closure device was placed, and full-thickness skin grafting was performed 19 days later. The flap and skin graft took completely.

Patient 4

A 74-year-old man presented with a defect measuring 5 × 2.5 cm that resulted from subcutaneous infiltration of doxorubicin hydrochloride. The patient underwent full-thickness resection of the defect, resulting in exposure of the first compartment tendons and the radial sensory nerve. An RRFF flap was elevated and used to cover the defect. This was then covered with an unmeshed split-thickness graft from the thigh. The wound healed without complications, and the patient had a full return of function in the hand.

Patient 5

A 58-year-old woman was involved in a motor vehicle collision that resulted in exposed extensor tendons over the first and second compartments at the level of the dorsal proximal wrist crease. An RRFF flap was used to cover the defect, which was then covered with a split-thickness meshed skin graft from the thigh. The patient healed without complications and had a full return of function in the hand.

Discussion

The traditional RRFF flap has been used extensively in reconstructive hand surgery [1–7]. However, to produce this flap, a major artery to the hand must be sacrificed, which compromises the viability of the hand [6–12] and may lead to ischemia. Some authors have recommended reconstructing the radial artery with a vein graft in a RRFF flap [10–12]. The vascular inflow to this flap occurs through the cutaneous perforators and the septocutaneous perforators from the radial and ulnar arteries to the forearm fascia. These vessels anastomose around the deep fascia in transverse and longitudinal directions to form a vascular network [9]. The success of the RRFF flap depends on these perforators. The distal radial artery is superficial and contains many small perforators where it runs between the brachioradialis tendon and the flexor carpi radialis tendon. Weinzwieg et al. [9] and Chang [14] have shown that six to ten small perforators begin roughly 2 cm proximal to the radial styloid process. These perforators are arranged longitudinally along the artery on the fibers of the deep fascia and along superficial veins. The perforators form a deep

fascial plexus. The venous system of the deep fascia in the forearm drains from the profunda venae comitantes through directly perforating veins to the superficial and deep venous systems. This interlinked vascular plexus provides ample perfusion to the distally based fascial flap.

The RRFF flap based on radial artery perforators provides soft-tissue coverage without sacrificing the radial artery. The perforators of the radial artery at the level of the radial styloid allow for creation of a pivot point for this pedicle-based flap. The median nerve and superficial branch of the radial nerve are not disturbed when the flap is raised. The RRFF flap can provide a large enough area of fascia to cover the hand to the fingertips.

Several different flaps may be used as alternatives to the RRFF flap with preservation of the radial artery. However, each one has major drawbacks. The flap described by Bertelli and Catarina [15] is similar to the distally based RRFF flap we discuss, but it uses the dorsal superficial branch of the radial artery and is lifted from the lateral dorsal forearm. This flap is technically more difficult, and we believe that it is ultimately less pleasing cosmetically. The dorsal ulnar flap [16–19] may be used, but it has a short pedicle and a limited arc of rotation. The posterior interosseous artery flap [20–23] is possible but requires a time-consuming and technically challenging surgical procedure.

Disadvantages of the RRFF flap include a large scar over the forearm and often the need for skin grafting to close the recipient site, unless the flap is quite small. In one of our five patients, the initial full-thickness skin graft was unsuccessful. For improved integration of the skin graft, the fascial flap may be kept moist, or the vacuum-assisted closure device may be applied directly to the flap, with skin grafting delayed until the flap has early granulation tissue (at least 72 h). By conducting the grafting several days later, we have not lost any further skin grafts in this low metabolic flap.

Conclusion

The RRFF flap based on distal radial artery perforators has distinct advantages over some of the other flaps we have used. It contains a constant and reliable blood supply that does not sacrifice arterial supply to the hand. Elevating the flap is technically simplified, which minimizes operative time. A distinct advantage is that the RRFF flap does not require microsurgical techniques. The RRFF flap based on distal radial artery perforators is a suitable option for thin coverage of palmar, dorsal, or thumb-index web space defects in patients who have either a complete or an incomplete palmar arch.

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