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The Dorso-Radial Flap. A Useful Skin Flap for Hand Reconstruction

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Abstract

Background: Soft tissue defects on the dorsum of the hand are challenging to reconstruct and regional options with similar characteristics are limited. We thus report an original alternative, the dorso-radial flap, harvested from the distal quarter of the forearm dorsum and used to cover defects of the dorsum of the hand, first web space and thumb.

Methods: Anatomic studies showed a direct cutaneous branch of the radial artery arising constantly at the level of the first intermetacarpal space's apex, emerging directly or through a common trunk with the first dorsal metacarpal artery. These variations do not influence the operative technique or flap survival. A series of 12 clinical cases is reported. Four flaps were used to cover the MCP joint of the thumb, three were applied to resurface the first web space and the remaining five used to cover the hand dorsum and the MCP joints. The sizes of the dorso-radial flaps ranged from 4 to 7 cm in length and from 2 to 5 in width.

Results: Follow-up ranged from three to six months with a mean of 4.8 months. All flaps survived and allowed enough skin coverage for the hand dorsum, underlying bones, joints and reconstructed tendons. Donor sites were closed primarily in two cases and grafted in the remaining ten. Functional outcomes were related to the associated bony and tendinous injuries.

Conclusion: The dorso-radial flap is a direct anterograde flap. It is simple, reliable and useful in reconstructing soft tissue defects of the hand dorsum.

Keywords: Hand defect; Hand; Thumb; Forearm; Reconstruction; Skin flap

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Introduction

The management of soft tissue defects of the hand still remains a challenge in hand surgery. Various types of distally based island flaps have been reported, most notably the reverse flow radial forearm flap, the distally based ulnar forearm flap and the posterior interosseous flap [1-4]. However, for coverage of relatively small defects of the hand and thumb, these flaps appear to be too bulky and sometimes may be related to significant donor site morbidity. We thus report a cutaneous direct island flap, which is harvested from the dorsal aspect of the distal quarter of the forearm, and is useful in covering skin defects of the hand, the thumb and the first web space.

Material and Methods

Anatomical studies

Anatomical work was carried out on 36 fresh upper limb cadavers, focusing on the cutaneous vascularity of the dorsal aspect of the distal quarter of the forearm and wrist. This was done and published previously by the main author [5]. It aimed to demonstrate the consistency of the dorso-radial artery which is a branch of the radial artery, to delineate its cutaneous supply, and to define the operative technique used to dissect it and elevate the corresponding flap [5].

We focused on two branches in particular: the first dorsal metacarpal artery, which supplies the "kite" flap described by Foucher and Braun [6], and the dorso-radial branch corresponding to the feeding artery of the dorso-radial flap, subject of the present work.

Our anatomic dissections showed that the dorso-radial artery is a constant cutaneous branch of the radial artery, which arises at the apex of the first intermetacarpal space and enters the subcutaneous tissues, passing between the tendons of the extensor pollicis longus (EPL) and extensor carpi radialis longus (ECRL). More specifically, this artery runs proximally, parallel and

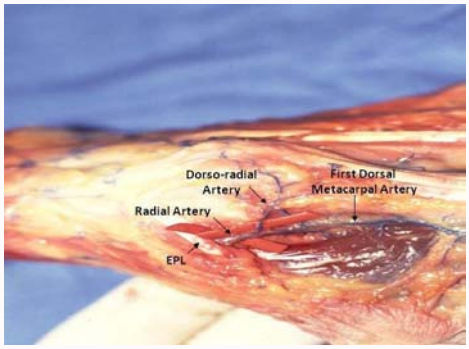

Figure 1A: Type I. The dorso-radial artery and the first dorsal metacarpal artery arise independently from the radial artery, in 84% of the cases.

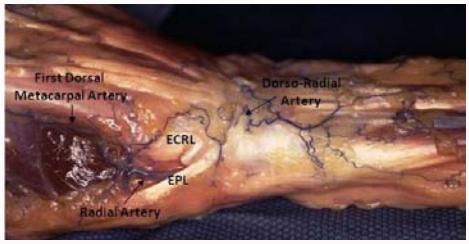

Figure 1B: Type II. The dorso-radial artery and the first dorsal metacarpal artery arise from a common arterial trunk, in 16% of the cases.

medial to the tendon of the extensor pollicis longus towards the distal radio-ulnar joint. It passes above the medial branch of the superficial radial nerve, crosses the fascia and enters the subcutaneous tissue of the dorsum of the wrist at the medial border of the ECRL tendon. It eventually divides into multiple fine cutaneous branches supplying the subcutaneous arterial network of the wrist dorsum and distal quarter of the forearm, an area which corresponds to the skin paddle of the dorso-radial flap.

In regards to the origin of this artery, two anatomical variants were recorded. Type I (84%) with the vessel arising directly from the radial artery, 3 to 4 mm proximal to the origin of the first dorsal metacarpal artery (Figure 1A), and Type II (16%) with both the dorso-radial artery and the first dorsal metacarpal artery arising from a common arterial trunk about 5 mm long and running vertically before it divides into its two terminal cutaneous branches (Figure 1B) [5]. These variations have no effect on the elevation and use of the flap. The pivot point of the pedicle is always located over the apex of the first intermetacarpal space, allowing a rotational arc that covers the dorsal aspect of the hand, the thumb and the first web space, even allowing the flap to reach the palmar aspect of the wrist if needed. In all specimens, two accompanying venae comitantes, draining into the radial venae comitantes were present.

Operative procedure

The skin island is designed over the distal quarter of the dorsal aspect of the forearm according to the size and location of the skin defect (Figure 2), although it can be extended to the entire width of the distal forearm dorsum. We recommend orienting the longitudinal axis of the skin paddle parallel to the EPL with its axis at the medial border of this tendon, in order to respect the main orientation of the dorso-radial artery.

The surgical procedure is carried out using a tourniquet. We prefer to empty the veins by simple elevation of the arm, as this

Figure 2: The EPL tendon is marked, the dorso-radial pedicle is drawn parallel to it and at 4 mm from its medial border. The cutaneous paddle is designed over the dorsal aspect of the distal quarter of the forearm and the pivot point is placed at the apex of the first webspace.

Figure 3: The EPL and ECRB tendons are identified and retracted. The dorso-radial pedicle with the whole surrounding fatty tissue is harvested and dissection is conducted volarly towards the apex of the first web space.

Figure 4: The dorso-radial flap is placed back on its donor site and the tourniquet is released in order to allow the revascularization of the skin flap before transferring and spreading the flap on the recipient site.

method avoids complete exsanguination of the upper limb and aids in the visualization of the vascular structures. The pedicle is exposed using a skin incision in a lazy S-shaped fashion over the apex the first web space, allowing skin elevation with preservation of the superficial venous network. The flap is then raised from proximal to distal including the forearm fascia and passing close to the extensor retinaculum. The medial branch of the superficial radial nerve should be identified and respected. At the distal border of the dorsal retinaculum, the EPL and ECRL tendons are identified and retracted. The pedicle is dissected with its surrounding subcutaneous tissue in order not to harm the vessels (Figure 3). At the apex of the first intermetacarpal space, the dissection continues palmarly to the origin of the dorso-radial vessels, obtaining a pedicle length of 5 cm. After completing the dissection, we prefer to place the flap back on its donor site and release the tourniquet to allow revascularization of the cutaneous paddle before transferring it to the recipient area (Figure 4). When the skin paddle does not exceed 3 cm in width, the donor area can be directly closed. If larger flaps are used, a skin graft is applied, either primarily or secondarily, to cover the donor site defect.

Figure 5A: Penatrating gunshot injury to the left hand involving bones, extensor tendons, MCP joints and skin over the base of the middle and ring fingers.

Figure 5C: The flap is harvested and replaced over its donor site for revascularization.

Figure 5B: After extensor tendon repair and temporary bone stabilization with K-wires, a dorso-radial flap of 6 x 4 cm is designed.

Figure 5D: The flap covers the whole defect and the donor site was nearly closed primarily.

Table 1: Summary of Patients Reconstructed With a Dorso-Radial Skin Flap.

Pt	*Age (yrs)*	*Sex*	*Type of injury*	*Follow-up (months)*	*Nature of soft tissue defect*	*Side*	*Flap size (L * W)*
1	31	M	RTA – Crush injury	6	Rupture of the extensor tendons with exposure of the finger's MCP joints	Right	7 x 2
2	45	M	Crush injury	4	Rupture of the extensor tendons – comminuted fracture of the thumb MCP joint	Left	4 x 3
3	23	M	RTA – Crush injury	5	Amputation of the index and middle fingers, exposure of the MCP joints of the ring & small fingers	Left	7 x 4
4	22	M	Crush injury	6	Subtotal amputation of the thumb with first metacarpal bone defect & skin defect over the first web space	Right	4 x 2,5
5	48	M	Crush injury	6	Exposure of the extensor tendons of the MCP joints of the index & middle fingers	Left	6 x 4
6	35	F	Electric burn	4	Contracture of the first web space	Right	6,5 x 3.5
7	41	M	Avulsion injury	3	Exposure of the extensor tendons on the hand dorsum	Left	7 x 5
8	42	F	Avulsion injury	5	Bone defect involving the first metacarpal, the MCP joint & the first phalanx of the thumb	Right	5 x 3
9	32	M	Electric burn	4	Contracture of the first web space	Right	6 x 3
10	53	M	Avulsion injury	5	Rupture of the thumb extensor tendons, comminuted fracture of the MCP joint & muscle defect of the thenar eminence	Left	5 x 5
11 12	41 16	F M	Crush injury Gunshot injury	6 4	Contracture of the first web space Rupture of the ring & middle fingers extensor tendons, comminuted fractures of the MCP joint of the middle & ring fingers	Left Left	5 x 3 6 x 4

M: Male; F: Female; RTA: Road Traffic Accident; MCP: Metacarpophalangeal joint; L: Length; W: Width

Clinical Series

Twelve patients presented to us with deep lacerations to their hands combining soft tissue defects of the hand dorsum and the MCP joints, extensor tendon rupture and/or exposure and bone defect with comminuted joint fractures. After debridement, fixation of bone fractures and repair of extensor tendon lacerations, all patients were reconstructed using a dorso-radial skin flap.

Nine patients were male and three patients were female with their ages raging from 16 to 53 years old (mean, 36 year old). In four patients, the right hand was injured while in the remaining eight patients the left hand was involved. Six cases resulted from crush injuries with two from road traffic accidents (RTA). Three cases resulted from avulsion injuries, two cases of contracture of the first web space after electrical burn and one case of gunshot injury to the hand dorsum.

In four cases the injury was compound, involving the different structures around the MCP joint of the thumb with comminuted fractures, exposed joints and extensor tendon ruptures. These underwent an MCP fusion for thumb stabilization. Three patients presented with a contracture of the first web space; two resulting from electrical burns and one from a crush injury. One patient presented

with an isolated skin defect of the dorsum of the hand exposing the underlying tendons. The remaining four cases consisted of a defect located on the dorsal aspect of the finger MCP joints with extensor tendon exposure and/or rupture. The sizes of the dorso-radial flaps ranged from 4 to 7 cm in length and from 2 to 5 cm in width (Table 1).

Results

The follow-up period ranged from three to six months (mean, 4.8 months). All dorso-radial flaps achieved complete wound coverage. No flap failure was noted. Wounds healed uneventfully and no donor site complications were noted. The donor site was closed primarily in one case (the width of the flap did not exceed 2 cm), left to heal secondarily in another, grafted primarily in three cases, and was grafted secondarily after few days of wound stabilization and bed granulation in the remaining seven cases.

The functional result in terms of range of motion of the injured hand and fingers was determined by the extent of the injury and the structures involved. Among the four patients (2, 4, 8 and 10) who benefited from thumb stabilization with fusion of the MCP joint, two of them recovered with an opposition scale 7 over 10 according to Kapandji classification while the two others scored 8 over 10 on the opposition scale [7]. The three patients (6, 9 and 11) who benefited from a release of the first web space contracture showed a near normal thumb abduction with a limited thumb opposition of 6 over 10 due to the weakness of the adductor and thenar muscles. Of the three patients (1, 3 and 5) who presented with rupture of the extensor tendons and exposure of the MCP joints of the fingers, one scored an excellent result whereas the other two had a good result according to Strickland classification [8]. These patients benefited from a teno-arthrolysis of the extensor tendons and the involved MCP joints. Patient 7 who had an exposure of the extensor tendons on the dorsal aspect of his hand scored an excellent result on the Strickland classification [8]. Finally, patient 12 presented with a total loss of the ring finger and a near total destruction of the middle finger MCP joints as a result of a gunshot injury. The dorso-radial flap outcome was successful but this patient could not be assessed functionally as he still needed bone and joint reconstructions.

Discussion

The cutaneous vascularity of the dorsal aspect of the upper extremity has been the subject of multiple anatomic studies [9,10]. At the level of the hand, it is supplied by the dorsal intermetacarpal arteries originating from the dorsal arterial arcades of the wrist; whereas at the forearm, the cutaneous blood supply depends mainly on two arterial axes: the anterior and posterior interosseous arteries.

Fasciocutaneous flaps vascularized in a retrograde fashion were first described by Song et al. [1] in 1982 and their use has radically changed the reconstructive options of the upper extremity, particularly the hand. These flaps, raised on the radial, ulnar, posterior interosseous or anterior interosseous vascular pedicle, receive a reverse flow blood supply. Enforced by the rich anastomotic arterial network of the hand, these flaps have been widely used to cover distally located soft tissue defects [2-4,11]. However, drawbacks resulting from the use of these flaps should be seriously considered; i.e., they may require the sacrifice of one of the main vascular axes of the hand as in the distally based radial forearm flap or the reserve flow ulnar forearm flap [1,2]. They may also consist of a bulky skin paddle which does not always correspond to the contour of hand defects. In addition, their dissection, especially for the posterior and anterior interosseous flap, is a technically demanding procedure requiring previous experience [3,4,11]. Even, if the radial forearm flap can be transferred to the hand based only on the distal perforators without scarifying the radial artery, it cannot compete with the dorso-radial flap particularly by its bulkiness when used to the hand dorsum.

Figure 6A: Subtotal amputation of the right thumb with bone and MCP defect associated with skin loss.

Figure 6B: A vascularized bone flap is harvested from the second metacarpal bone.

Figure 6C: The skeleton of the first ray is restored.

Figure 6D: A dorso-radial flap of 5 x 3 cm is harvested.

Figure 6E: It allowed us to cover the skin defect and reconstructed bone.

Figure 6F: Near normal extension of right thumb.

Figure 6G: An opposition of 8/10 is achieved, 18 months postoperatively.

The dorso-radial flap, described herein, is an original alternative flap, simple to perform, and useful for covering various skin defects of the hand. The vascularity of the flap is reliable and the anatomy of its pedicle is constant. The dorso-radial artery has a mean diameter of 1 mm, arising in most cases (84%) directly from the radial artery (Type I). However, the artery emerged from a common arterial trunk with the first dorsal metacarpal artery in 16% of the cases (Type II), but its course remained the same. Hence, the operative steps of the procedure were maintained regardless of anatomic variance, making it an easy flap to learn and master, with a relatively easy learning curve. In cases where Type II anatomic variation is present, a further lengthening of the vascular pedicle might be obtained, according to the Y-V technique described by Martin et al. [12] which allowed the pivot point of this extended pedicle to be located more distally over the head of the second metacarpal. This provides for a wider rotation arc that covers the dorsal aspect of the long fingers, but its presence in only 16% of the situations do not make it a reproducible and constant procedure.

As has been already mentioned, the skin island of the flap should overlie the course of the dorso-radial artery. This runs proximally and medially, from the apex of the first intermetacarpal space to the inferior radio-ulnar joint, parallel and at 4 mm medial to the EPL tendon, supplying the skin of the dorso-radial aspect of the wrist and distal forearm. Paired venae comitantes accompany the artery and ensure an adequate venous outflow from the skin island. Although, flap dissection also includes the forearm fascia, its elevation is not mandatory for the vascularity of the skin paddle; we perform the dissection under the fascia, only to facilitate the raising of the flap and protect the overlying vascular structures. Therefore, the dorso-radial flap belongs to the group of direct axial cutaneous flaps.

The flap can be mobilized to reach the dorsal aspect of the hand including the MCP joints of the long fingers, the first web space, the thumb and the palmar aspect of the wrist (Figure 5A-5D). As the rotation point of the pedicle is located distal to the carpus, postoperative immobilization of the wrist is not required and rehabilitation may start immediately after surgery.

The fact that the dorso-radial artery shares its origin with the first dorsal metacarpal artery enables us to raise a “chimeric” flap, including a piece of cortical bone from the second metacarpal bone, as it has already been performed in patient number 8, allowing for composite tissue reconstruction (Figure 6A-6G).

The donor site management is easy and simple. It is closed primarily if the width of the flap does not exceed 3 cm, or left for secondary healing. A skin graft can also be applied primarily or secondarily after obtaining a granulation of the donor site. This late option is chosen when a thick layer of subcutaneous tissue is present in order to avoid a depression of the donor site. In the situations when a direct closure cannot be achieved, approximation stitches are applied in order to decrease as much as possible the donor site defect while waiting the wound to granulate before being grafted. In all cases, the mobility of the wrist particularly in flexion was not disturbed as the flap was designed and harvested from the distal quarter of the forearm dorsum far from the dorsal crease of the wrist. The main problem in the donor site is still the scar left by the skin grafts in a social exposed part of the body.

Conclusion

In conclusion, we believe that the dorso-radial flap certainly deserves to be added to the armamentarium of the reconstructive surgeon. It is a reliable and simple method for covering soft tissue defects of the hand, offering a fine reconstruction of the hand contour with similar tissues and acceptable donor site morbidity.

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