Ulnar artery free flap and the need for concern in its use: Anatomical studies and clinical experience

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MTM Rebot, MF Stranc, BM Abdulrauf. Ulnar artery free flap and the need for concern in its use: Anatomical studies and clinical experience. Can J Plast Surg 1997;5(2):88-91. The ulnar artery free flap is one of the choices available when selecting potential donor flaps from the forearm. This flap is reliable and versatile, but its use can potentially devascularize the forearm segment of the ulnar nerve. Clinical experience with this flap has demonstrated that in two of seven patients ulnar nerve dysfunction occurred in the hand. Anatomical studies may reveal a possible cause for this previously unreported finding.

Key Words: *Complications, Radial forearm flap, Ulnar artery free flap*

Réflexion sur l'emploi du lambeau libre de l'artère cubitale : études anatomiques et expérience clinique

RÉSUMÉ : Le lambeau libre de l'artère cubitale est l'un des choix offerts lorsque l'on opte pour un lambeau donneur potentiel à partir de l'avant-bras. Ce lambeau est fiable et polyvalent, mais son emploi peut contribuer à la dévascularisation du segment de l'avant-bras du nerf cubital. Selon l'expérience clinique acquise avec ce type de lambeau, deux patients sur sept présentent une dysfonction du nerf cubital au niveau de la main. Les études anatomiques effectuées peuvent révéler une cause possible de cette observation jamais signalée auparavant.

The vasculature of the forearm allows for the design of various free flaps (1-4). The ulnar artery can be incorporated as the dominant feeding vessel in a forearm free flap. Lovie et al (3) first reported its use and apparently had great success. This report outlines anatomical studies, clinical experience and, more importantly, the complication of ulnar nerve dysfunction following the use of the ulnar artery free flap.

ANATOMICAL STUDIES

A series of 30 fresh cadaveric dissections were performed to delineate the potential of this free flap. The studies included detailed anatomical dissections, injection studies with ink and Microfil silicone rubber (Canton Bio-Medical Products Inc, Colorado), and x-ray studies with barium sulphate solutions.

Anatomically, this fasciocutaneous flap is based on the ulnar artery distal to the common interosseous take-off from the brachial artery. The ulnar artery then courses under the

muscle belly of the flexor digitorum superficialis and runs distally along with the ulnar nerve between the musculo-tendinous units of flexor carpi ulnaris and flexor digitorum superficialis. The ulnar artery gives off multiple small branches to the overlying fascia along its course, with the largest branch (Figure 1) measuring 1 mm to 1.5 mm in di-

Figure 1) Proximal forearm segment of ulnar artery (UA) demonstrating its branches to adjacent musculature and ulnar nerve (UN)

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Figure 2) Top Staining of entire volar and dorso-ulnar forearm when entire ulnar artery from common interosseous take-off to wrist infused with ink. **Bottom** Only the distal half of forearm stains when dominant vessels 4 cm distal to common interosseous take-off of ulnar artery are excluded from infusion

ameter, arising approximately 4 cm distal to the common interosseous take-off point from the brachial artery. Where this branch arises, other similar calibre branches originate and commonly supply the flexor muscle mass and the proximal portion of the ulnar nerve. As well, the ulnar artery has smaller calibre branches (0.5 mm to 1 mm) supplying the overlying fascia, flexor muscles and ulnar nerve, which are in close association along its entire length in the forearm. The arterial calibre of the main ulnar artery is in the range of 3 mm to 3.5 mm proximally and 2 mm to 3 mm distally. The architectural arrangement of the ulnar artery allows nutrient blood-flow to occur in both antegrade and retrograde directions.

Venous drainage is obtained from two systems. The first is the superficial system of veins based on the basilic vein. The second system is the venae comitantes along the length of the ulnar artery measuring 1 mm to 1.5 mm in diameter on either side of the artery and approximately 2 mm to 2.5 mm in diameter at its confluence with the main venous system in the antecubital region.

Sensory input of the flap may be based on the branches of the medial antebrachial cutaneous nerve. The main branches of this nerve can usually be found in close proximity to the basilic vein in the antecubital region. Nerve diameters are in the range of 1 mm to 2 mm.

Ink injection studies demonstrated some interesting findings. With the ulnar artery injected at its origin just distal to the common interosseous take-off and the distal portion of the artery tied at the level of the wrist, most of the volar and ulnar aspects of the forearm measuring approximately 12x25 cm

Figure 3) Entire forearm degloved as a fasciocutaneous flap. Note mesentery and vessels extending from ulnar artery (UA) to ulnar nerve (UN), fascia and palmaris longus (PL)

became stained. Staining decreased once the radial aspect of the forearm was reached. If the ulnar artery was injected just distal to the first main fascial branch, only the distal two-thirds of the volar aspect of the forearm became stained, an area measuring approximately 16x12 cm (Figure 2).

Injection of the venous system demonstrated that the venae comitantes and the interconnecting cross branches are a valved system, allowing only one-way drainage in the proximal direction. However, retrograde injection could be accomplished to some extent but required much greater force to be exerted on the syringe plunger.

The entire skin of the forearm was freed to include the ulnar artery, ulnar nerve, the radial artery and the palmaris longus tendon (Figure 3). The proximal portion of the ulnar artery was then subjected to Microfil injections. This study again confirmed the ulnar artery's mesentery of vessels supplying the fascia, the adjacent ulnar nerve and the palmaris longus tendon. There was cross-fill into the radial artery through the fascial plexus of the ulnar artery.

Similar specimens were also subjected to barium sulphate solution injections, and x-rays were performed. Radio-opaque wires were placed along the course of the radial artery, ulnar nerve and the palmaris longus tendon (Figure 4). X-ray studies confirmed that the fascial network of vessels supplied by the ulnar artery extended the length of the forearm and transversely from approximately 6 cm to 8 cm on the ulnar side of the ulnar artery and to the radial artery on the opposite side. The ulnar nerve and the palmaris longus tendon also demonstrated vascular inflow from the ulnar artery.

TABLE 1: Summary of patients

Patient	Sex	Age (years)	Site	Size of flap	Complications
1	Male	32	Neck contracture	12x18 cm	Ulnar nerve palsy
2	Male	53	Gunshot of face	10x12 cm	—
3	Female	70	Floor of mouth	6x8 cm	Delay healing donor site
4	Male	38	Floor of mouth	10x8 cm	Ulnar nerve palsy
5	Female	40	Floor of mouth	6x8 cm	—
6	Male	78	Floor of mouth	8x8 cm	Loss of flap
7	Male	75	Hypopharynx	12x8 cm	Delay in healing donor site

Figure 4) Entire forearm fasciocutaneous flap injected with barium sulphate solution into ulnar artery. Note extent of vessel network supplied extending from dorso-ulnar aspect of the forearm to the radial artery volarly. Also, note the proximal feeding vessels of the ulnar artery with a branch to the ulnar nerve (UN). Course of UN, radial artery (RA) and palmaris longus tendon (PL) marked with radio-opaque wires. UA Injected ulnar artery

Figure 5) Claw deformity postoperatively that took 16 months to resolve completely

CLINICAL EXPERIENCE

The surgical approach to harvesting a flap based on the ulnar arterial system must first include an Allen's test. The requirements of the recipient defect are then determined. This flap has the potential to include skin, tendon, muscle, bone and a sensory input (3). A variable pedicle length can be obtained depending upon the size of the flap and its location on the forearm.

The size of the cutaneous portion of the flap can extend from the elbow to wrist, approximately 6 cm to 8 cm on either side of the ulnar artery. Meticulous subfascial dissection is required. Branches running to and from muscles and the ulnar nerve are ligated as necessary. Care is taken to preserve the branches in the mesentery coursing to the overlying fascia from the ulnar artery. Venous drainage can be obtained

either through the subcutaneous basilic system or at the confluence of the venae comitantes. If sensation is required, dissection of the medial antebrachial cutaneous nerve is carried out. When harvesting bone (3), the proximal 10 cm to 15 cm of the ulna sectioned in half along its length can be taken. This dissection should include the overlying portion of flexor carpi ulnaris muscle along with the overlying skin because of its fascial branches entering the periosteum of the ulna. Although the radial artery can usually maintain adequate arterial input to the hand, reconstituting the ulnar artery with a reverse vein graft should be undertaken. This prevents cold intolerance mainly (5), especially important in the Canadian climate where the temperature approaches -40°C in winter.

The ulnar artery free flap has been used for a total of seven reconstructions including four floor of the mouth reconstructions.

tions, one hypopharyngeal-esophageal reconstruction, one resurfacing of neck burn scar contracture and one postgun-shot wound facial reconstruction (Table 1). Flaps were all fasciocutaneous free flaps, sizes ranging from 6×8 cm to 12×18 cm. All donor site ulnar arteries were reconstituted with reversed vein grafts, and these remained patent when tested postoperatively using Allen's test. The cutaneous donor defects were corrected with skin grafts.

Complications included one total free flap loss in a floor of the mouth reconstruction. This was secondary to hematoma in the neck region impinging on the venous system of the flap which occurred 24 h after surgery. There were two minor wound healing delays of the skin grafted donor sites which resolved spontaneously. Most importantly, two incomplete ulnar nerve palsies occurred requiring nine and 16 months to resolve. The patient requiring the longest time to resolve still had some intrinsic muscle weakness and a minor degree of clawing, although sensation returned at 16 months (Figure 5).

DISCUSSION

The advantages of this flap as initially described by Lovie et al (3) include its ability to include vascularized tendon, muscle, bone and a sensory input. Another advantage is that the ulnar aspect of the forearm has relatively hairless, thin pliable skin, therefore making it more suitable for intraoral reconstruction. This flap has the desirable features of being relatively simple to harvest with large vessel diameters. Also, the donor site defect is somewhat more esthetically pleasing and easier to conceal than the radial forearm flap because of its ulnar position on the forearm.

The disadvantages of this flap can be considerable according to our experience. Other than the need to reconstruct the ulnar artery with a vein graft and the problematic donor site defect, devascularizing the forearm segment of the ulnar nerve is possible. An in-depth analysis of the anatomical studies regarding the vascular supply of the ulnar nerve may have found the cause of the problem. The forearm portion of the ulnar nerve usually has two types of vascular input. The first is a vessel from the ulnar artery that usually arises 4 cm distal to the origin of the common interosseous trunk (Figure 4). The second source is a series of small vessels arising from the ulnar artery as it runs parallel to the ulnar nerve in the distal two-thirds of the forearm. The two patients who developed ulnar nerve palsies postoperatively both had the entire ulnar artery harvested from its origin at the common interosseous take-off to wrist level. This was undertaken to obtain adequate pedicle length in one case and because a large flap (12×18 cm) was needed in the second case. Although both free flaps survived without any difficulties, within two weeks after surgery the two patients developed varying degrees of ulnar nerve deficiencies in the sensory and motor distributions of the hand. These were not complete palsies but rather

varying degrees of motor weakness and sensory loss in the hand only. The forearm musculature innervated by the ulnar nerve was not affected. The time for recovery ranged from nine months to 16 months. The proximal forearm segment of the ulnar nerve that gives rise to the branches supplying the forearm musculature likely had its vascular supply maintained by the more proximal supplies in the region of the elbow by the recurrent branches of the brachial artery (1). The remaining segment of the forearm ulnar nerve could no longer be nourished because of its distance from both the elbow and hand's extrinsic blood vessel supplies to the ulnar nerve. Thus, the resulting intervening segment of the ulnar nerve likely became devascularized. Due to the meticulous nature of the dissection, direct injury to the ulnar nerve was ruled out. Neither patient had a history of ulnar nerve neuropathy before surgery.

Christie et al (6) reported transient ulnar nerve paresthesias in 18 patients as a complication of this operation. This further supports our theory.

Two other cases treated by the authors involved harvesting of the entire forearm segment of the ulnar artery, and no resultant ulnar nerve deficiency was noted. The explanation for this may be that the surrounding tissues or proximal or distal segments of the ulnar nerve's vascular input maintained adequate nutrient flow to the vulnerable forearm segment.

CONCLUSIONS

Although the ulnar artery free flap is versatile, easy to harvest and has the potential to include tendon, sensory supply and bone, caution should be taken when harvesting this flap with respect to the length of the vascular pedicle taken, especially if it includes both vascular supplies of the forearm segment of the ulnar nerve. Because of our experience we have lessened the frequency of use of this free flap, using it only if the flap sizes and pedicle lengths allow us to avoid sacrificing both sources of blood supply to the forearm segment of the ulnar nerve.

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