OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

ULNAR FOREARM FREE FLAP (UFFF): SURGICAL TECHNIQUE

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The ulnar forearm free flap (UFFF) is a fasciocutaneous free flap based on the ulnar artery. It was first described by Lovie et al. in 1984. It provides relatively thin tissue from the distal medial forearm. It shares many similarities with the radial forearm free flap (RFFF) but is used much less commonly for head and neck reconstruction.

Common reconstructive applications

The UFFF shares a lot of similar attributes to the RFFF, and thus shares a lot of the reconstructive applications

- Oral cavity (lateral tongue, soft palate, buccal mucosa, floor of mouth, pharyngeal defects)
- Orbital defects
- Small skin defects
- Lips

Advantages

- Thin, pliable skin paddle
- Reasonably long vascular pedicle
- Very little soft tissue bulk
- Favourable for 2-team simultaneous harvest and ablation
- Multiple skin islands are possible
- Easy flap harvest
- Reliable vascularity

Advantages over RFFF

- Improved donor site morbidity
- Better donor site cosmetic result (avoids a cosmetic defect over the dorsal aspect of the wrist) *(Figure 1)*
- Less hair-bearing skin than RFFF

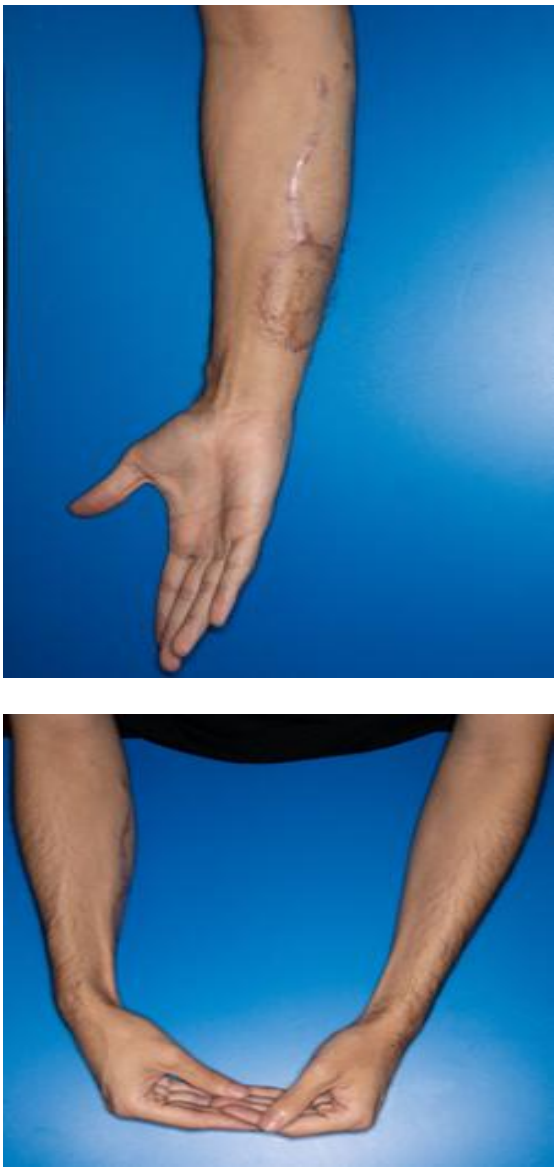

Figure 1. Donor site scar, demonstrating superior cosmetic result over the radial forearm free flap, as no cosmetic defect can be appreciated over the dorsal wrist

Disadvantages

- Skin of the forearm can be very thin, and can lack bulk for reconstruction
- Shorter pedicle compared to RFFF
- Donor site morbidity from loss of skin graft or tendon exposure
- Visible donor site

- Potential for vascular compromise of the hand

Surgical Anatomy of UFFF

Arterial Anatomy

- Ulnar artery with flap perforators

Venous Anatomy

- Venous drainage is via deep and superficial systems. Either system can carry the venous drainage of the flap
- The deep system consists of two venae comitantes of the ulnar artery. The venae can be small (≤2mm) and may not join to form a single larger vein at the proximal extent of the dissection
- The superficial system consists of the larger calibre basilic vein

Muscular Anatomy

- In the distal half of the forearm the ulnar vascular pedicle lies upon the flexor digitorum profundus
- The vascular pedicle is bordered by the flexor carpi ulnaris on its ulnar side and the flexor digitorum superficialis on its radial side

Surgical anatomy of volar forearm

The skin of the volar (anterior) surface of the forearm is usually thin and pliable, especially in the distal half. It is however unfortunately hair-bearing skin, especially on the proximal and radial sides of the forearm; consequently, one might have hair growth *e.g.* in the oral cavity. The subcutaneous fat is thin, especially over the distal third of the forearm. However, overweight patients and even some normal-weight individuals may have a disproportionate amount of fat in this distal area.

Venous system

In the subcutaneous tissues lie the small venous tributaries of the ***main superficial venous drainage system*** of the forearm, *i.e.* the ***cephalic*** and ***basilic veins***, which lie deep to the fatty layer *(Figure 2)*.

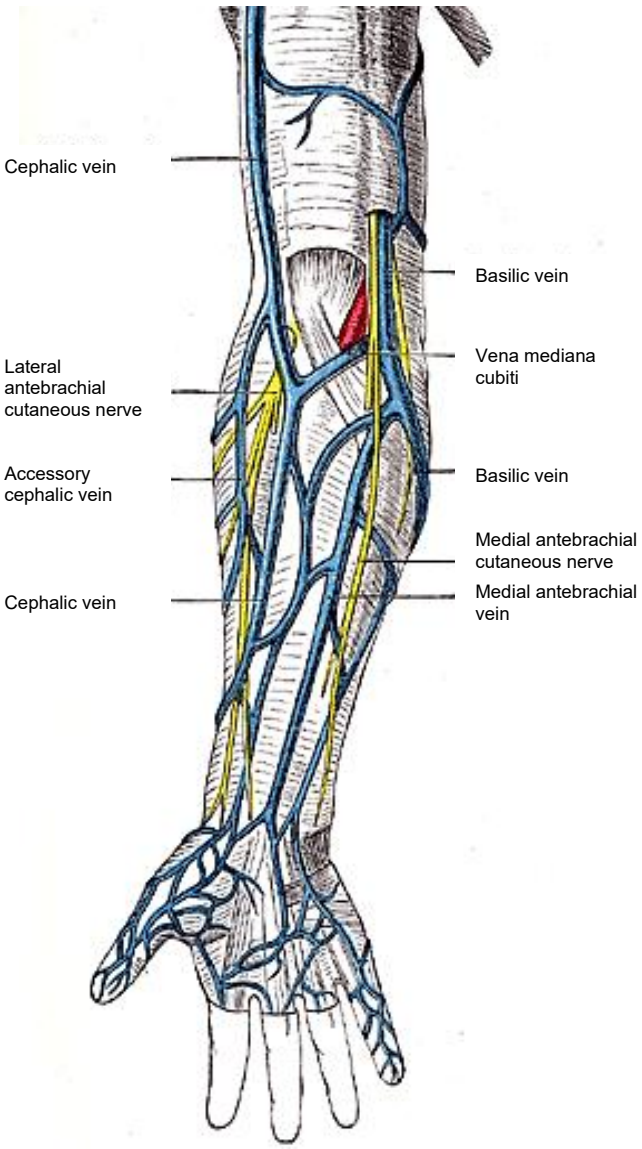

Figure 2: Volar surface of ***right*** *forearm demonstrating cephalic and basilic venous systems, the median antebrachial vein of the forearm and the associated nerves*

The ***venae comitantes of the ulnar artery*** and the ***basilic vein*** are ***used*** for venous drainage of UFFFs *(Figure 2)*.

The ***basilic vein*** runs towards the lateral cubital fossa along the medial side of the forearm and is located deep beneath the subcutaneous fat. It is a large, thick-walled vein and is found in a relatively constant location deep beneath the subcutaneous fat. ***Unfortunately, due to its size and superficial position, it is also very often used for intravenous lines, which may cause fibrosis and/or thrombosis of the vessel***. It drains the anterolateral forearm and is formed mainly by the confluence of superficial veins on the dorsal aspect of the hand *(Figure 2)*. From there the vein, or its tributaries, traverses the lateral "snuffbox" area to lie over the lateral side of the distal forearm. It gradually courses more medially towards the mid-lateral cubital fossa. It is accompanied by the lateral antebrachial nerve *(Figure 2)*. The superficial branch of the radial nerve lies near the vein in the distal third of the lateral forearm and over the "snuffbox" area up to the lateral aspect of the dorsum of the hand.

The ***median (antebrachial) vein of the forearm*** lies between the cephalic and basilic veins. Occasionally it may be large and be a better drainage system to use for a flap *(Figure 2)*. It is usually thin-walled and is situated more superficially in the subcutaneous fat than the cephalic and basilic veins.

A great variety of venous interconnections may be encountered in the ***cubital fossa***. The ***median cubital vein (vena mediana cubiti)*** runs obliquely from lateral to medial to connect the cephalic and basilic systems *(Figures 2, 3)*. There is often an important connection between the superficial veins and the deep brachial venous system in the cubital fossa; this is usually between the brachial *venae comitantes* and the median cubital vein or the cephalic vein.

The forearm and cubital fossa are invested by the ***deep fascia;*** in the cubital fossa it is strengthened by the ***bicipital aponeurosis*** *(Figure 2)*. The perforating vein connecting the superficial and deep venous systems lies lateral to the bicipital aponeurosis and the brachial vessels immediately deep to it *(Figure 2)*.

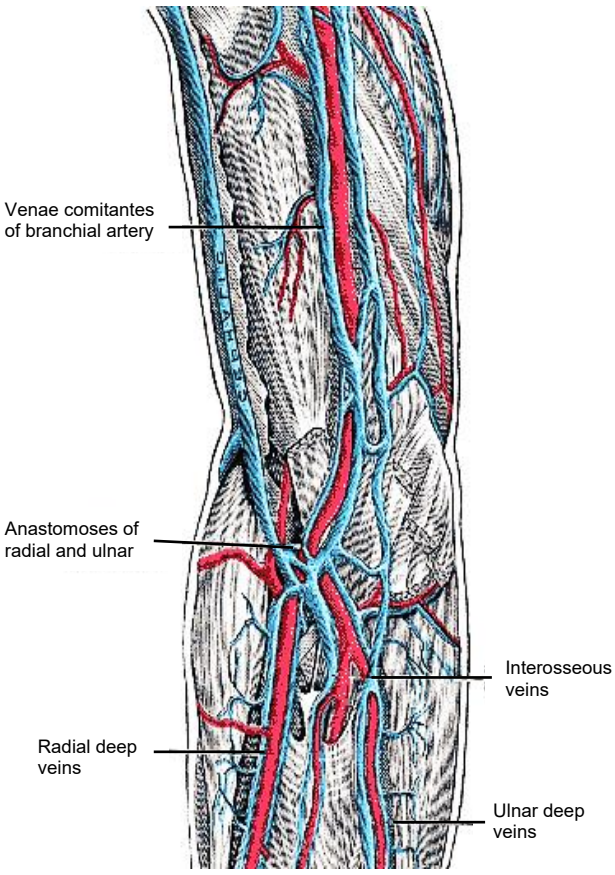

*Figure 3: Venous anatomy at **right** cubital fossa*

Nerves

The superficial nerves accompany the superficial veins *(Figure 2)*. The ***lateral antebrachial nerve*** *(Figure 1)* is the termination of the musculocutaneous nerve which, after supplying the flexors of the upper arm, pierces the deep fascia just proximal to the cubital fossa. The ***anterior branch of the antebrachial nerve then accompanies the cephalic vein*** distally *(Figure 2)* and supplies sensation to the anterolateral forearm, (which is also the main area of a distal RFFF). The posterior branch supplies sensation to the posterolateral forearm.

The ***medial antebrachial nerve runs with the basilic vein***; they pierce the deep fascia in the medial part of the mid-upper arm. It too, has an ***anterior branch*** supplying sensation to the anteromedial forearm and a ***posterior branch*** to the posteromedial forearm.

Deeper nerves include the ***median, ulnar nerves***. These are usually not at risk when elevating the flap. The ***median nerve*** lies between the *flexor carpi radialis* and *palmaris longus* tendons. The ***palmar cutaneous branch of the median nerve*** arises just above the *flexor retinaculum* at the wrist and becomes cutaneous between the tendons of *palmaris longus* and *flexor carpi radialis*. Elevation of a very distal skin flap may injure the latter branch and cause sensory loss of the proximal mid-palm.

Muscles

The muscles of the forearm will be described according to their relationships to the ulnar artery.

Where the ulnar artery enters the upper half of the forearm, it lies deep to the ***pronator teres***, ***flexor carpi radialis (FCR)***, ***palmaris longus*** and ***flexor digitorum superficialis (FDS)***. It lies on the ***brachialis*** and the ***flexor digitorum profundus (FDP*** In the distal half of the forearm the ulnar artery lies superficial to the ***FDP***, and between the ***FCR*** and ***FDS***. *(Figure 5).*

The ***ulnar artery*** runs in the ***medial intermuscular septum*** which it perforates. Medially lies the ***flexor carpi ulnaris (FCU)***, superficially the ***FDS*** *and deeply the* ***FDP*** *(Figures 6, 7).*

The ***key muscles when elevating a UFFF*** are the ***FCU, the FDS and FDP.*** *(Figures 5, 6, 7)*. The proximal ***FCU*** muscle has two heads; a humeral head and an ulnar head. ***Between those two heads passes the ulnar nerve and ulnar artery***. The ***FCU*** overlies the anteromedial side of the artery *(Figures 6, 7)*. It is supplied by the ulnar nerve.

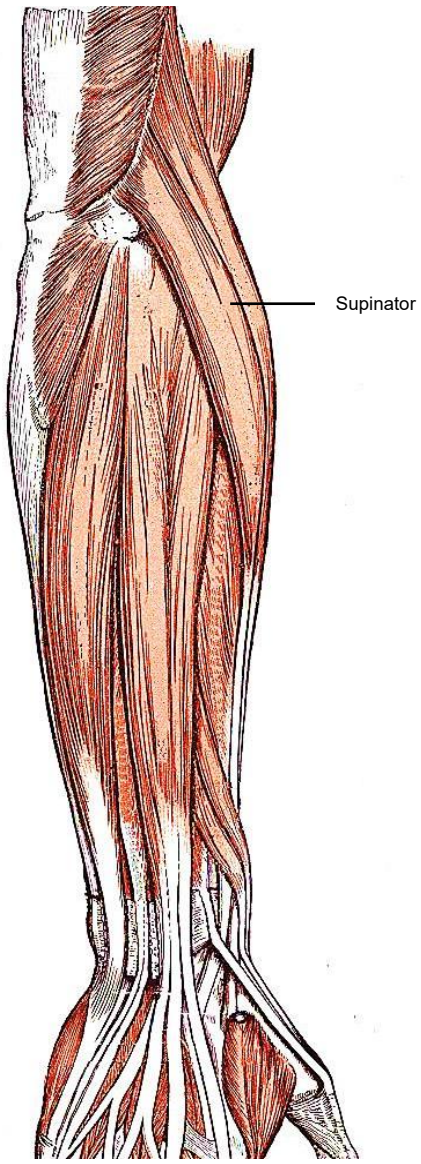

Figure 4: Dorsal view of ***right*** *forearm demonstrating the supinator muscle*

In the distal forearm, just before the wrist, the ***FCU*** becomes a flat tendon (either two or three). It lies as the most medial tendon in the wrist. In the distal forearm the ***FCU*** tendon overlies the anteromedial aspect of the ulnar artery and nerve. The ***FDS*** has two proximal heads, the radial, and the humeroulnar head. The ulnar artery passes between these heads and the median nerve. In the mid-forearm the ***FDS*** lies on the anterior

aspect of the ulnar artery, but as the muscle descends distally, lies more laterally to the artery. ***At the wrist the ulnar artery lies between the FCU and FDP*** *(Figure 6)*.

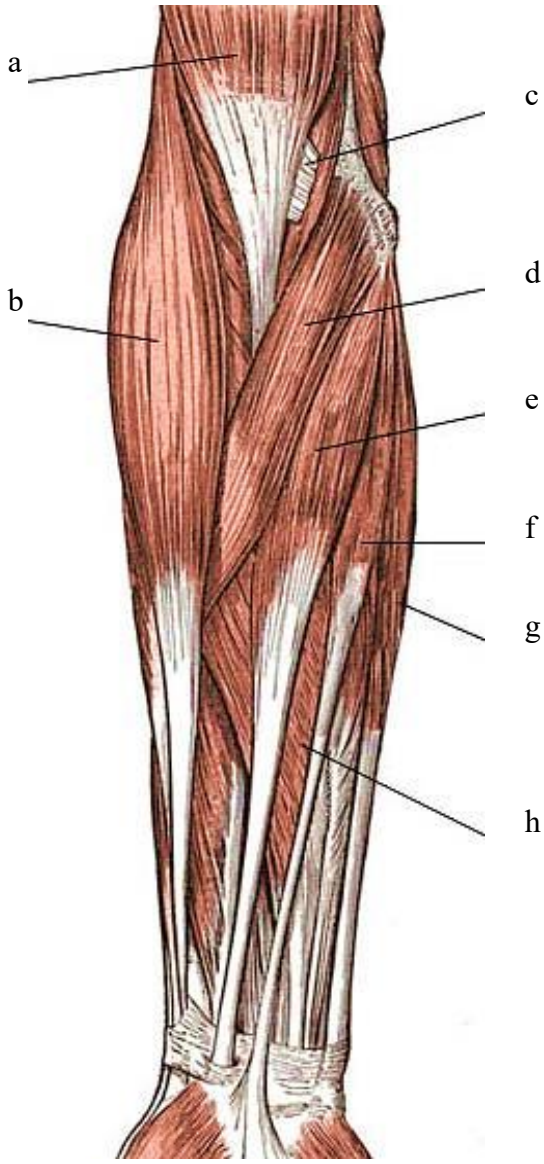

Figure 5: Volar view of ***right*** *forearm: a: biceps brachii; b: brachioradialis; c: biceps brachii tendon d: pronator teres; e: flexor carpi radialis; f: palmaris longus; g: flexor carpi ulnaris; flexor digitorum longus*

The ***palmaris longus tendon*** *(Figures 5, 6)* can be sacrificed without causing a functional deficit. It is absent in *ca.* 13% of individuals. Its tendon and muscle can be incorporated in a forearm flap for various reconstructive possibilities and it may therefore be an extremely valuable adjunct in complex reconstructions.

Ulnar artery and its branches

The brachial artery bifurcates into ulnar and radial arteries *(Figures 6, 7)*. The ***ulnar artery*** starts in the cubital fossa, 1cm distal to the elbow crease, just medial to the biceps tendon *(Figures 6, 7)*. It then courses down the forearm ***in the medial intermuscular septum*** to the (palpable) ulnar pulse, just lateral to the hook of hamate and the pisiform. tip of the styloid process of the radius. Branches in the forearm include the ***anterior and posterior ulnar recurrent artery*** close to its origin *(Figures 5, 6);* the ***common interosseous artery*** and distally the ***palmar branch*** and the continuation of the artery, the ***dorsal carpal branch***. Along its course in the forearm, it gives off ***muscular branches*** *(Figures 5, 6)*.

A variable number (average 7) of ***cutaneous perforators*** exit the artery to supply the overlying fascia and skin. Most of these are musculocutaneous, travelling through the FCU or FDS to reach the skin. The perforators are larger and more consistent in the proximal forearm and become smaller and less reliable in the distal forearm, closer to the wrist.

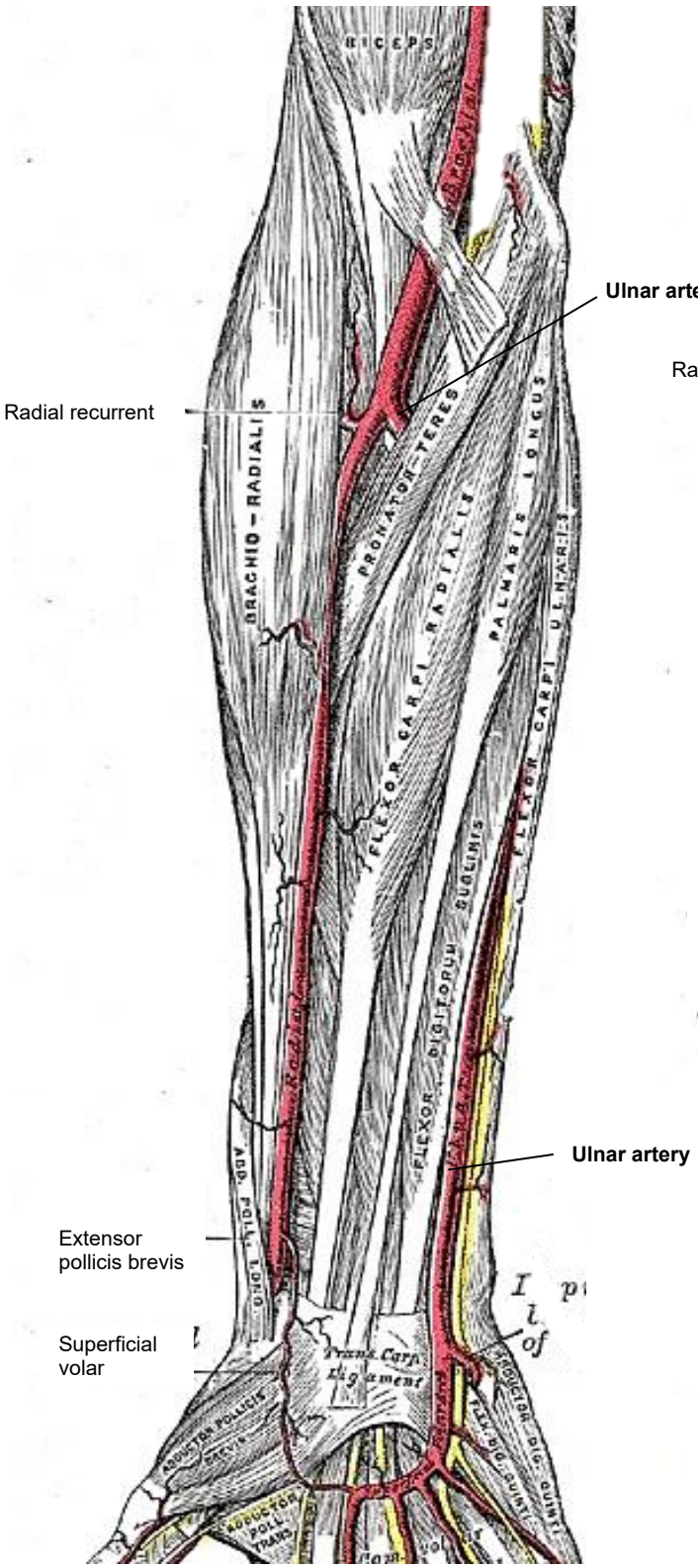

*Figure 6: Volar view of **right** forearm demonstrating course of ulnar and radial arteries relative to brachioradialis, pronator teres and flexor carpi radialis and ulnaris muscles*

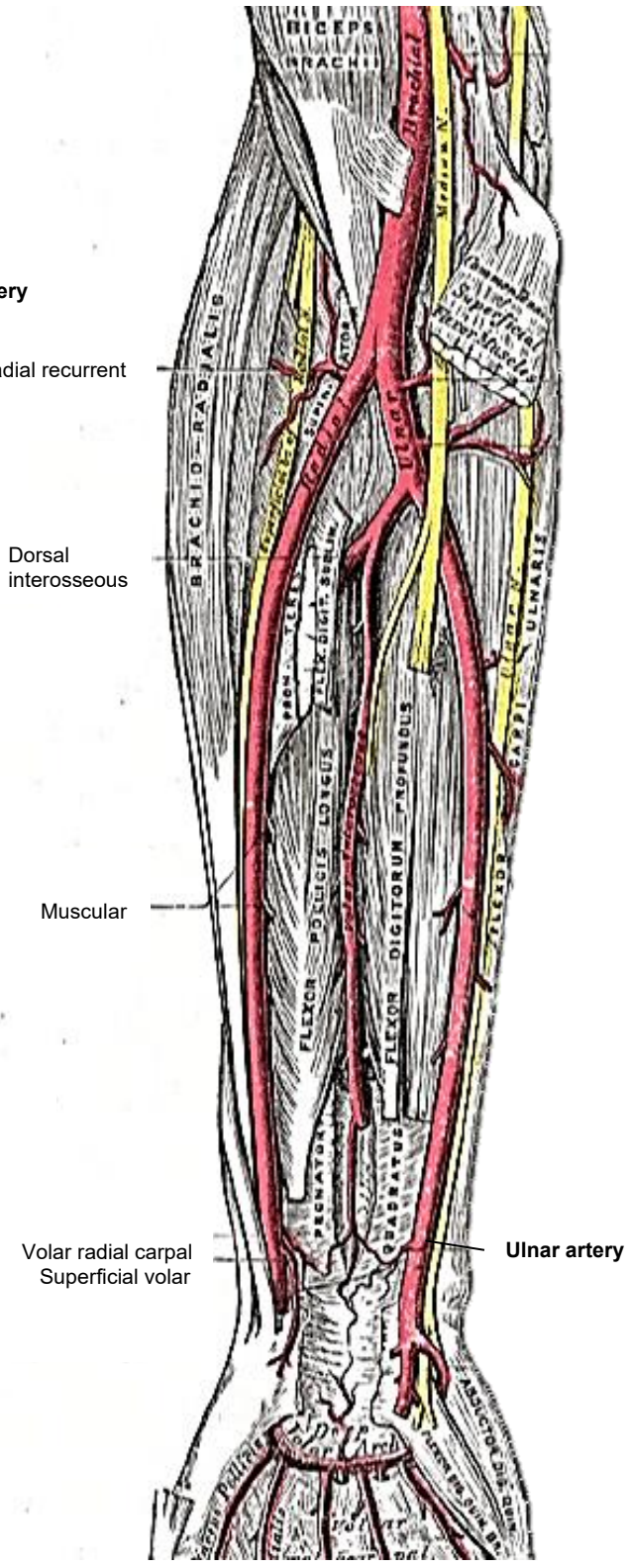

*Figure 7: Volar view of **right** forearm demonstrating course of ulnar artery with brachioradialis muscle reflected*

Preoperative considerations

Vascular status

The radial and ulnar arteries provide the dominant blood supply to the hand via the superficial and deep palmar arches. The blood supply to the hand is complex with numerous collateral variations. Thus, even when there are incomplete arches the hand is often adequately perfused after the radial or ulnar artery is harvested. However, particularly in patients with coronary artery disease, vascular disease may affect the upper extremities reducing the reliability of collateral flow. Harvesting the ulnar artery has a very small risk of compromising the blood supply to the hand, leading to claudication, or in extreme cases, to irreversible ischaemia of the hand. The surgeon must therefore confirm the presence of both an ulnar and radial pulse.

Allen Test

The Allen test is used to assess the adequacy of the palmar vascular arches and status of the radial and ulnar artery in providing collateral blood supply.

- Ask the patient to elevate the arm and make a tight fist
- Occlude the radial and ulnar arteries for several seconds by digital pressure
- Ask the patient to release the hand into a relaxed position
- Ensure the palm and fingers have blanched; if not, the test must be repeated
- Release pressure from the radial artery
- A positive Allen test occurs when the hand flushes and the colour changes from pallor to rubor within 5-15 seconds; it can be concluded that there is good collateral flow from the radial artery
- A negative Allen test indicates poor collateral flow from the radial artery and is considered a relative contraindication to the UFFF
- The Allen test is considered somewhat unreliable, and there exists controversy over its use; in the opinion of the authors, it still has utility and is always performed. In cases of an equivocal test, where there is some delay in the return of collateral circulation, the authors will still consider proceeding with the UFFF. A modified Allen test can be performed after induction of anaesthesia using a pulse oximeter. Additionally, the ulnar artery can be temporarily occluded using a vascular clamp prior to ligation if there is any question about collateral circulation.

Choice of arm

The choice of arm is not as critical as with other flaps, such as the fibular free flap, however some considerations should be taken into account:

- Previous intravenous or arterial lines within the last month may be a relative contraindication to using that arm
- Surgeries, injuries, skin abnormalities, fractures, or vascular compromise may preclude the use of one specific arm
- Patients' occupation, hand dominance, and preference should be taken into account
- The reconstructive surgeon should ideally be placed on the contralateral side to the ablative surgeon to create enough space for a simultaneous harvest, however this is not absolutely necessary

Preoperative counselling

- Patients should be counselled on the general complications of free flap reconstruction: bleeding, infection, seroma, loss of arm motor or sensory function and loss of limb

- Cosmetic issues arising from poor wounding healing or graft complications
- Postoperative immobilization and dressings
- Pain, cosmetic, or healing issues from skin graft donor site
- Patients with an equivocal Allen's test and a history of coronary artery disease may benefit from a preoperative evaluation of hand perfusion with a Doppler ultrasonography or less commonly angiography

Operating room setup

- The patient is positioned supine on the operating room table
- A two-team approach is usually employed to minimise length of surgery
- A single arm board, occasionally two, is used to support the arm while leaving room for the ablative team
- The arm is circumferentially prepped and draped
- A protective skin padding is applied to the upper arm and a tourniquet applied
- The flap is usually harvested in a seated position with one surgeon and one assistant

Flap Design and surface markings

- Palpate the ulnar artery at the wrist and mark its course; a pencil doppler can be used to aid this if needed
- Draw the superficial venous vessels in the medial forearm, including the median antebrachial vein
- The skin paddle is designed centred over the ulnar artery *(Figure 8)*
- Maintain some distance from the volar wrist crease to avoid an unfavourable scar
- The skin flap can be rectangular, circular, oval, or otherwise customized
- Draw a curvilinear line up towards the antecubital crease

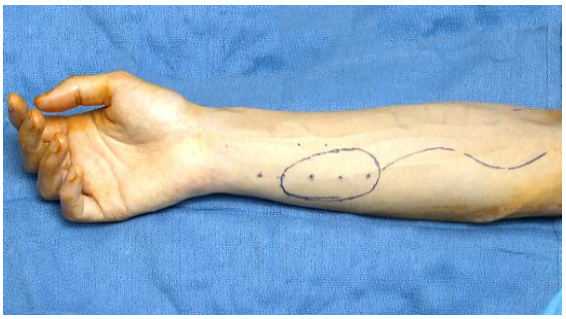

Figure 8: Skin markings and flap design. The ulnar artery can be traced out with a doppler probe. The median antecubital vein or the basilic vein can be included in the flap harvest

Harvest comparison with radial forearm flap

- The flap harvest is highly analogous to that of a radial forearm free flap. The main differences include
  - Close proximity of a large (ulnar) motor nerve
  - Despite having to separate out a large motor nerve, this is contrasted to having to dissect out smaller sensory nerves for the RFFF, arguably more difficult
  - Shorter pedicle length since cessation of proximal dissection is at the take-off of the interosseous artery
- As with the RFFF, the palmaris longus tendon can be incorporated into the flap if desired
- In contrast to the RFFF, the tendons of the flexor carpi ulnaris and flexor digitorum superficialis in the ulnar forearm are less pronounced. This lends to a better skin grafting bed and less risk of skin graft failure and tendon exposure at the UFFF donor site

Surgical Steps

- A tourniquet is applied to the upper arm (typically at 250 mm Hg) and inflated after exsanguination of the arm with an Esmark bandage
- Make the skin incisions and divide subcutaneous fat
- Divide the deep fascia unless a suprafascial dissection is to be performed
- Elevate proximal skin flaps with preservation of the superficial venous system if desired
- The skin paddle elevation can be started from either the radial or ulnar side
- On the radial side, the flap is elevated medially off the flexor digitorum superficialis *(Figure 9)*

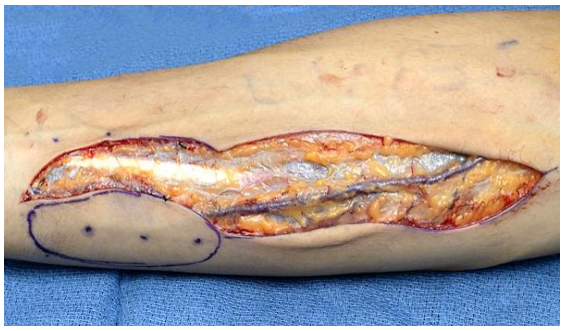

Figure 9: The radial cut is made first. The dissection is carried out onto the flexor digitorum superficialis

- Depending on the size and design of the flap, other flexor musculature may be encountered before reaching flexor digitorum superficialis, including flexor carpi radialis and palmaris longus
- Incise the fascia over the flexor digitorum superficialis *(Figure 10)*
- On the ulnar side, elevate the flap off the flexor carpi ulnaris *(Figure 11)*
- The skin can be raised in a subfascial or suprafascial plane
- Septocutaneous perforators from the ulnar artery are seen and preserved *(Figure 12)*

Figure 10: The fascia over the flexor digitorum superficialis is incised medial to the palmaris longus tendon

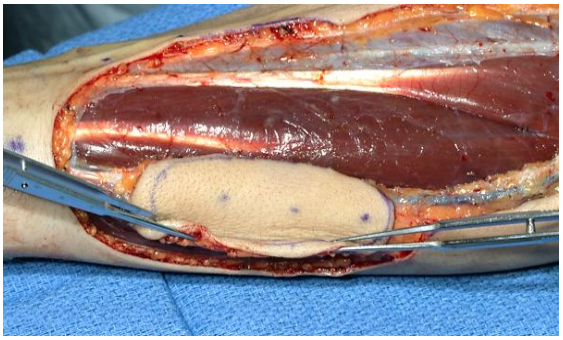

Figure 11: On the ulnar side the dissection is carried out down to the flexor carpi ulnaris

Figure 12: Perforators are seeing coming from the ulnar artery going to the skin and should be preserved. Perforators coming off from the deep aspect need to be carefully divided and controlled

- Identify the ulnar artery, vena comitantes, and ulnar nerve between the flexor digitorum superficialis and flexor carpi ulnaris, taking care taken to maintain the attachment of the septum to the skin paddle and vascular pedicle
- The distal vascular pedicle is ligated

- Elevate the vascular pedicle and skin paddle off the underlying flexor digitorum profundus and adjacent ulnar nerve, which lies in close association with the vascular pedicle *(Figure 13)*

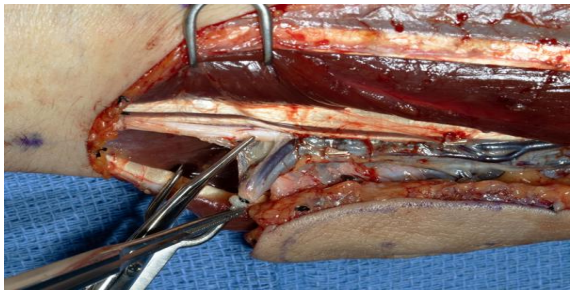

Figure 13: After ligating the distal artery, the ulnar nerve can be identified between the flexor digitorum superficialis and flexor carpi ulnaris in close association with the ulnar artery

- Carefully divide perforating vessels to the surrounding muscles *(Figure 12)*
- Release the flap from the surrounding soft tissue working in a distal-to-proximal direction
- Dissect the proximal vascular pedicle until the take-off of the interosseous artery *(Figure 14)*

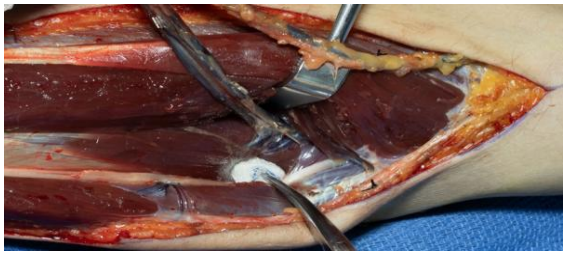

Figure 14: The proximal pedicle is dissected up to the cubital fossa

- The median antebrachial vein or the basilic vein are dissected proximally into the cubital fossa where connecting branches may be identified between the vena comitantes and the superficial system
- Our preference is to use the median antebrachial or the basilic vein for the venous anastomosis, as the size match is often more favourable. Occasionally two venous anastomoses may be performed
- Release the tourniquet, and confirm perfusion of the flap
- Take care to control any bleeding from side-branches of the pedicle and on the flap with bipolar or clips, prior to disconnecting the flap
- After the recipient vessels in the neck have been dissected and prepared the donor vessels are divided to release the flap from the forearm *(Figure 15)*
- Ensure haemostasis of the forearm donor site *(Figure 16)*

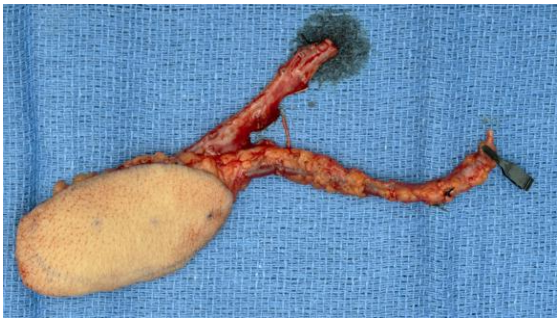

Figure 15: Ulnar flap pedicle ligated and detached from the arm. Note the separate basilic vein and vena comitantes

Figure 16: Donor site following closure and prior to skin grafting, demonstrating no exposed tendons in the grafting site, reducing donor site morbidity

- Close the proximal arm incision primarily in layers
- Attempt a primary closure of the donor site skin and, place a suction drain

- If a primary closure is not possible, close the defect with a split thickness skin graft harvested from the thigh, or alternatively a full thickness skin graft or local flap
- Apply a bolster dressing or wound vac over the skin graft

Transfer and inset of flap

- If required, create a tunnel from the recipient vessels in the head and neck to the defect site
- Ensure that there is no bleeding from the tunnel, the flap or the pedicle before transferring it to the neck
- Refer to chapter: Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery

Suprafascial flap elevation

The main reason for elevating the UFFF in a suprafascial plane is to reduce the failure rate of the skin graft over the donor site by maintaining a fascial covering over the exposed tendons. It also allows the flap to be thinned in patients with very thick subcutaneous fat layers (extreme caution should be taken). Only the lateral and medial parts of the flap may be thinned of the deep fat, as more extensive thinning of the flap may interrupt critical perforator blood supply.

- Elevate the flap medially, including the basilic vein or the medial antebrachial vein, which lie superficial to the fascia
- Maintain a superficial dissection plane up onto the flexor carpi radialis muscle
- Incise the deep fascia at the lateral edge of the tendon
- Continue the dissection from the flexor carpi radialis muscle as previously described
- On the radial side, elevate the flap in a suprafascial manner until the flexor digitorum superficialis muscle is encountered
- Incise the fascia over the flexor digitorum superficialis
- Complete elevation of the flap as previously described
- Following complete elevation of the flap, it is often possible to approximate the two edges of the cut deep fascia to achieve complete fascial closure

Optimising donor site morbidity

- Attempt to advance skin to cover the exposed tendons
- Skin grafts
  - Maintain epitenon over tendons
  - Bury tendons by oversewing with deeper muscles
  - Always fix and immobilise skin graft with sutures and appropriate dressings
  - Optional: May use a volar splint to restrict movement of flexor tendons beneath skin graft
  - Negative pressure wound therapy of the donor site for 1 week
  - Avoid using meshed skin grafts
  - Skin graft size can be reduced with purse-string sutures to reduce the size of the defect
- Suprafascial flap elevation
- Flap reconstruction of smaller defects
  - V-Y rotation-advancement flap
  - Hatchet flap
  - Keystone flap

Flaps described in *The Open Access Atlas of Otolaryngology Head & Neck Operative Surgery*

- *Pectoralis major flap*
- *Cervicofacial flaps*
- *Deltopectoral flap*
- *Buccal fat pad flap*
- *Buccinator myomucosal flap*
- *Nasolabial flap*

- *Temporalis muscle flap*
- *Submental Artery Island flap*
- *Supraclavicular flap*
- *Upper and lower trapezius flaps*
- *Latissimus dorsi flap*
- *Paramedian forehead flap*
- *Local flaps for facial reconstruction*
- *Full thickness lip reconstruction*
- *Radial free forearm flap*
- *Anterolateral thigh (ALT) free flap*
- *Rectus abdominis flap*
- *Free fibula flap*
- *Lateral scapular border free flap*
- *Thoracodorsal artery scapular tip (TDAST) flap*
- *Gracilis microvascular flap*
- *Medial sural artery perforator (MSAP) flap*
- *Ulnar Forearm Free Flap*
- *Principles and technique of microvascular anastomosis for free tissue transfer flaps in head and neck reconstructive surgery*

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