The American Journal of Surgery (2008) 196, e60–e64

The American Journal of Surgery®

How I Do It

The bottom-up approach to the suprafascial harvest of the radial forearm flap

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KEYWORDS:
Radial forearm;
Flap;
Free;
Suprafacial;
Suprafascia;
Donor;
Morbidity;
Safety;
Reliability;
Technique;
Method

Abstract. Suprafascial radial forearm flaps cause far less donor morbidity compared with the conventional method of including the deep fascia. Here we describe our technique of harvesting the flap with a bottom-up approach, which simplifies flap elevation and is safe and expedient. The radial artery pedicle is ligated distally and secured to the flap. Gentle traction on the pedicle presents the inferior surface of the pedicle, facilitating dissection. The superficial layer of the deep fascia is taken with the flap, together with a generous cuff of subcutaneous tissue above the pedicle in which vessels nourishing the flap are located. It is crucial to preserve the conjoin of the deep layer of the deep fascia to the fascia covering the brachioradialis laterally and flexor carpi radialis medially. This fascial layer prevents bow-stringing of the tendons during wrist and finger flexion and allows the use of a full-thickness skin graft to close the donor site. The latter delivers superior cosmetic results than can be achieved with a split-thickness skin graft.

Since its first description by Yang et al[1] in 1981, the radial forearm flap has become the workhorse flap and is probably one of the most commonly used flaps.[2,3] This flap was described as a fasciocutaneous flap and, conventionally, the deep fascia of the forearm is included with it. One of the major drawbacks of this flap, however, is the potential for significant donor site morbidity. Webster and Robinson[4] and Wei et al[5] pioneered modifications of this flap by introducing a suprafascial harvest of the flap that was aimed primarily at reducing donor site morbidity. The suprafascial technique results in the harvest of a purely cutaneous flap, preserving and leaving the deep forearm fascia completely in situ. Subsequently, many have clearly demonstrated that the suprafascial technique cause far less donor morbidity when compared with the conventional method of harvesting the flap in the subfacial plane.[4–7] Despite these reports, the suprafascial harvesting technique remains underused because the anatomic details of the suprafascial flap remains poorly understood. This coupled with the ease of harvesting the flap in the subfascial plane has resulted in this method of harvesting the radial forearm flap being ignored despite its clear advantage. This article describes the anatomic details of the distal forearm fascial compartments and the bottom-up approach to suprafascial flap harvest that was developed at our institution. The dissection starts from the underside of the pedicle to scoop-out the pedicle, which is in contrast to the more conventional method in which one needs to dig into the pedicle from the sides with the inherent risk of damaging the radial artery pedicle as well as the

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Manuscript received December 7, 2007; revised manuscript February 12, 2008

0002-9610/$ - see front matter © 2008 Published by Elsevier Inc.
doi:10.1016/j.amjsurg.2008.02.010

small cutaneous vessels supplying the overlying skin. We found this to be an intuitive approach that provided the most optimal exposure and visualization of the relevant anatomy in this area while minimizing dissection between the pedicle and the overlying subcutaneous tissue where the tiny vessels supplying the flap are located.

Surgical anatomy

The radial forearm is a type C fasciocutaneous flap, deriving its blood supply from multiple direct cutaneous perforators from the radial artery in the distal forearm.[8,9] In the proximal two thirds of the forearm, the artery is located in the lateral intermuscular septum between the flexor carpi radialis (FCR) and the brachioradialis (BR) muscles. One to 3 septocutaneous vessels traverse this septum to supply the overlying skin in the proximal forearm.[10] In the distal third of the forearm, the artery comes to lie more superficially between the tendons of the FCR and the BR. Here, the deep fascia split into 2 conjoined layers that enclose the pedicle.[5] Called the *superficial* and *deep layers* of the deep fascia respectively, this tight fascia compartment completely encases the radial artery in its distal course (Fig. 1).

The key technique in the suprafascial harvest of the radial forearm flap is to open this compartment by incising the superficial layer of the deep fascia (which forms the roof of the compartment) while preserving the conjoin of the deep layer of the deep fascia with the rest of the deep fascia of the distal forearm. On the radial side the deep fascia covers the FCR and on the ulna side the deep fascia covers the BR. Maintaining the anatomic integrity and continuity of this deep fascial layer is essential in preventing tenting or bow-stringing of the flexor tendons and in providing a relatively immobile and healthy bed for skin grafting. Compromising or damaging the conjoin conversely results in bow-stringing of the tendons during flexion, and the mobility of the tendons at the base of the bed may reduce skin graft take. Furthermore, the bottom-up approach ensures the preservation of the delicate vessels supplying the flap segmentally arising directly from the radial artery by avoiding overzealous dissection in the area between the superficial layer of the deep fascia and the overlying subcutaneous tissue.

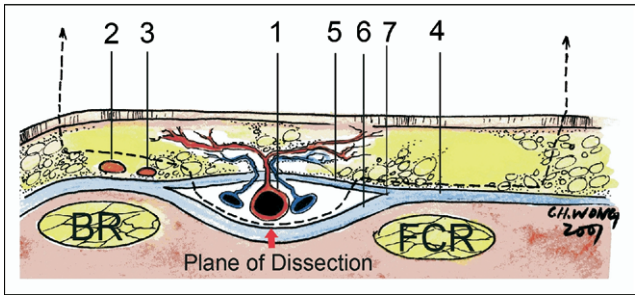

Figure 1 Surgical anatomy of the distal radial artery. 1, radial artery and its vena comitantes; 2, superficial branch of the radial nerve; 3, lateral antecubital nerve; 4, deep fascia of the forearm; 5, superficial layer of the deep fascia; 6, deep layer of the deep fascia; and 7, the conjoin of the deep and superficial layer of the deep fascia. This structure must be preserved to maintain the continuity of the deep layer of the deep fascia and the fascia over the FCR and BR. This in turn is important in maintaining proper functioning of the flexor tendons and in providing a good bed for skin grafting.

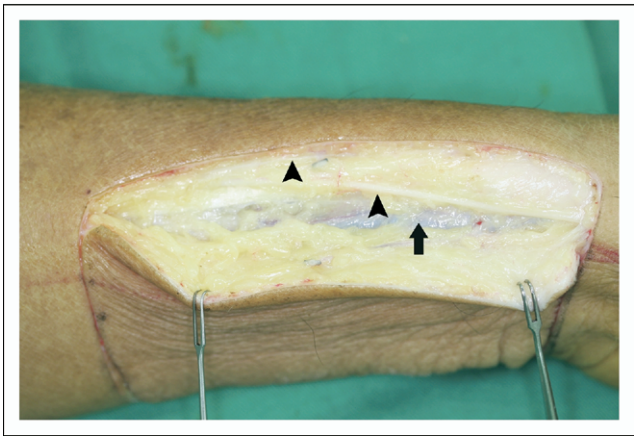

Figure 2 On the radial side, the superficial radial nerve and the lateral antecubital nerve (arrowheads) are identified in the subcutaneous plane and preserved. The flap then is elevated suprafascially until the ulnar border of the BR (arrow) is reached.

Surgical technique

Preoperatively the Allen's test is performed to ensure adequate collateral supply to the hand via the ulna artery. The radial artery is palpated and marked. The needed dimensions of the flap then are drawn on the distal forearm with the distal boundary of the flap at the proximal wrist crease. In the anatomic position, the radial side of the forearm is exposed. The flap should not be placed too radially to minimize visibility of the donor site in this natural position. The flap is elevated under a tourniquet inflated to 250 mm Hg. Loupe magnification (2.5× to 3.5×) should be used by the surgeon for accurate and timely identification of fine structures.

The dermis is incised over the planned skin markings. The ulna border of the flap first is elevated in the suprafacial plane and dissection is stopped once the radial border of the FCR is reached. Further dissection towards the radial artery should be deferred until the radial artery pedicle has been secured. The radial border then is incised. Dissection here should be performed initially with a pair of dissecting scissors to identify branches of the superficial radial nerve and the lateral antecubital nerve, which are located just above the deep fascia. Once identified, suprafascial dissection can commence medial to these nerves, taking care to preserve these nerves (Fig. 2). The flap is elevated suprafascially until the BR tendon is seen. The distal incision then is made down to the deep fascia, ligating all superficial veins encountered along the way. A small window then is incised in the deep fascia directly over the site

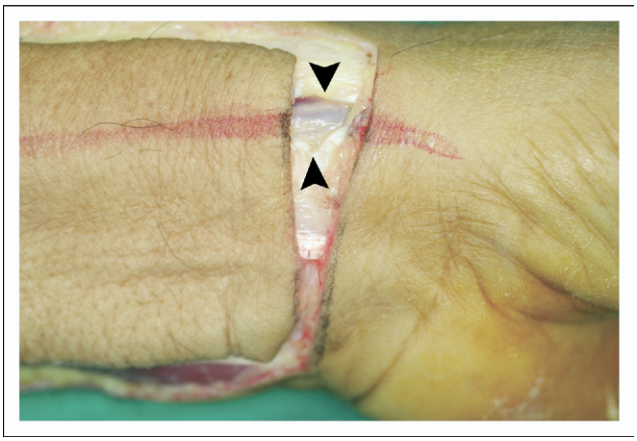

Figure 3 The radial artery and its vena comitantes (arrows) is identified in the distal forearm by incising the superficial layer of the deep fascia that encases the pedicle in the distal forearm.

where the radial artery was palpated preoperatively. The radial artery and its vena comitantes would be found immediately below this fascia (Fig. 3). It is mobilized circumferentially and then ligated. A traction suture then is placed in a skin-pedicle-skin manner as illustrated in Fig. 4. Gentle traction on this suture presents the inferior surface of the pedicle for bottom-up dissection while preventing the pedicle from being sheared off the skin paddle. The transverse fibrous bands seen at the base of the tunnel-like structure encasing the pedicle is the deep layer of the deep fascia (Fig. 5). The roof of the tunnel located between the pedicle and the subcutaneous tissue is the superficial layer of the deep fascia. This layer can be cut to lift the flap. The deep layer of the deep fascia at the base of the pedicle together with its conjoin attaching it to the fascia covering the FCR on the ulna side and the BR on the radial side should be preserved carefully (Fig. 6). This is crucial in maintaining proper functioning of the flexor tendons (Fig. 7). Branches from the pedicle passing through the deep layer of the deep fascia to supply the underlying bone and to the surrounding muscle

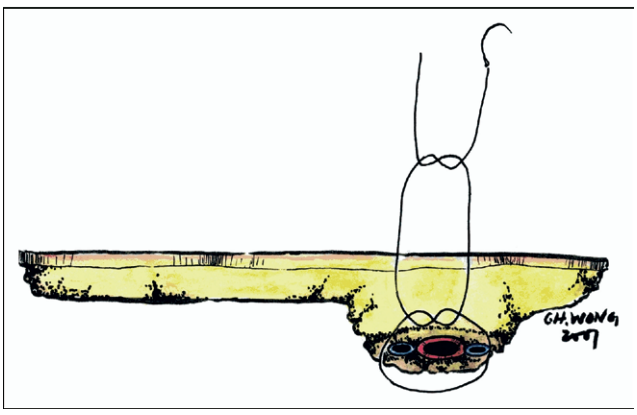

Figure 4 Schematic illustration of a traction suture placed securing the pedicle to the skin flap. This suture allows traction to be applied to the pedicle safely while preventing the pedicle from being sheared off the skin flap during flap elevation.

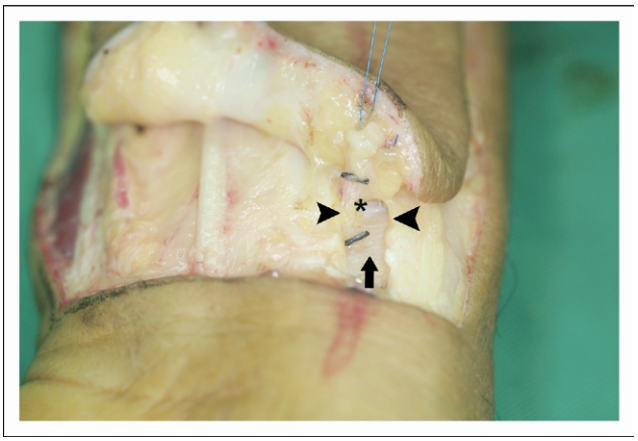

Figure 5 Once the pedicle is secured, gentle traction on it presents a clear view of the anatomy of this tight space. The transverse bands at the base of the tunnel are the deep layer of the deep fascia (arrow). Its attachments to the deep fascia covering the BR laterally and FCR medially at the conjoin areas (arrowheads) must be preserved to maintain the integrity of the facial compartments of the distal forearm. The superficial layer of the deep fascia separates the pedicle from the overlying flap and divides it medially and laterally to mobilize the flap. As dissection progresses, branches from the radial artery supplying the surrounding tissue and radius come into view (*). These can be clipped and ligated.

can be seen clearly as dissection progresses and can be ligated with hemoclips or cauterized with bipolar cautery. We do not routinely include the cephalic vein with our flap once we have determined that the vena comitantes accompanying the radial artery are of adequate size and are a good match with the recipient veins.[11] Proximally the pedicle is located in the lateral intermuscular septum between the BR and the FCR and these can be retracted to facilitate mobilization. If a flap of a greater longitudinal dimension extending into the proximal forearm is needed, care should be taken to include the septocutaneous vessels supplying the

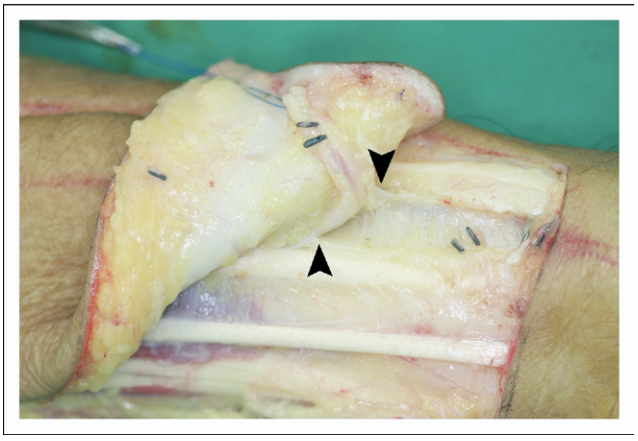

Figure 6 Mobilizing of the flap by incising along the superficial layer of the deep fascia (arrowheads) ensures the preservation of the conjoin that binds the deep layer of the deep fascia to the fascia covering the FCR and BR.

Figure 7 Suprafascial radial forearm flap harvested, preserving the fascial compartmentalization of the distal forearm.

flap proximally to maximize the vascularity of the flap. These vessels are located in the septum between the substance of the BR and FCR muscles and are visualized easily in the subfascial plane proximally.[10] Occasionally, they may have a short intramuscular course in the BR muscle before joining the radial artery and can be mobilized safely by intramuscular dissection. The pedicle is traced to achieve the desired length and size. The donor site is closed with a full-thickness skin graft taken from the groin.

Comments

At Chang Gung Memorial hospital, we have performed 1,543 radial forearm flaps between 1985 and 2006. Since 1996 we have used the suprafascial technique exclusively because of the problems we noted with the conventional technique in our earlier experiences. The technique described here represents a technique that has evolved over this cumulative experience that we have found to be safe, simple, and expedient. This flap can be harvested within an hour in most hands and can be readily learned even by relatively inexperienced surgeons.

Conventionally, the radial forearm flap is harvested in the subfascial plane. Elevating the flap in this plane has the benefit of creating a clear dissection plane and ease of identification of structures. Because the radial artery pedicle is encased completely by the deep fascia in the distal forearm, subfascial harvest naturally includes the pedicle with the flap. This can be facilitated further by retracting the FCR and the BR for better exposure, which is not feasible in suprafascial harvest because the tendons would be bound in their native position. As a result of these advantages, the subfascial radial forearm flap has rightfully earned a reputation as a reliable and a relatively easy flap to perform. However, the inclusion of the deep fascia with the flap is unnecessary and has several notable disadvantages and potential problems for which this flap is well noted.[12–15] In the forearm, the deep fascia is a functionally important structure that holds the tendons in place to enable them to glide efficiently. Sacrificing the deep fascia therefore results in tenting and bow-stringing of the tendons during wrist and finger flexion. Numbness of the dorsal thumb caused by injury to the superficial radial nerve and branches of the lateral antecubital cutaneous nerve, which is located above the fascia, also can be disturbing to the patient. Suprafascial harvest affords the opportunity to visualize these nerves clearly as they run above the deep fascia. More importantly, skin grafting often is necessary to close the donor defect. Preserving the deep fascia leaves a healthy, well-vascularized, and an immobile bed for the skin grafting. In contrast, grafting directly on tendons, even if the paratenon is preserved meticulously, often is frowned on because the mobility of these structures during tendon excursion hinders graft take. Failure of graft take in these circumstances results in exposure of tendons and significantly impairs hand function. Furthermore, the more favorable bed from preservation of the deep fascia has allowed the use of a full-thickness skin graft to close the defect. This is superior to the use of a split-thickness skin graft because the thicker dermis in the former reduces the depression in the donor site (Fig. 8). The full-thickness skin graft can be harvested easily from the groin, and can be concealed easily and well tolerated. This is in contrast to the split-thickness skin graft donor site, which may cause persistent pain and itch, and the scar is quite unsightly.

Clinical studies clearly have shown that suprafascial radial forearm flaps significantly reduce donor site morbidity and have much better functional recovery compared with the subfascial approach.[4–7] We previously prospectively evaluated the donor site morbidity of 95 consecutive suprafascial radial forearm flaps and found a complete skin graft take rate of 94%, with the remaining 6% noted to have minor skin losses.[6] This compared favorably with the 19% to 54% rate of graft loss and delayed healing reported with the conventional subfascial technique.[5] When evaluated at 6 months postoperatively, we found that patients with com-

Figure 8 Long-term, 3-year postoperative result of the suprafascial radial forearm flaps closed with a full-thickness skin graft from the groin. Note the contour of the forearm with minimal depression over the skin-grafted site and the absence of bow-stringing of the tendons during tendon excursion.

plete graft take had no significant change in grip strength and wrist range of motion.

However, raising a suprafascial radial forearm flap is technically more demanding. As one approaches the radial artery there is a real risk of transecting the tiny perforators from the radial artery that supply the skin flap because one easily can go past the radial border of the FCR and the vessels are not seen easily in the exsanguinated arm under tourniquet, even under loupe magnification. Webster and Robinson[4] advocated incising the superficial layer of the deep fascia once the surgeon is lateral to the FCR and medial to the BR. This top-down approach, however, may injure the radial artery or its cutaneous branches, which all are located in close proximity within this tight space. The conjoin of the deep layer of the deep fascia to the fascia over the BR and FCR also may be cut inadvertently because it is difficult to clearly determine its exact location from the top. Approaching the dissection from the inferior aspect of the pedicle with the bottom-up technique easily circumvents these problems by clearly presenting the anatomy of this area. This ensures the harvest of a complete subfascial flap while also completely preserving the integrity of the fascial compartment of the distal forearm. This technique is easy to perform and we found it to be the most intuitive way to harvest this flap.

Conclusions

The radial forearm flap should be harvested suprafascially because this clearly has been shown to reduce donor morbidity. The bottom-up approach to the elevation of this flap provides a simple, effective, and safe method of performing this procedure. This technique can be readily adopted by both experienced and training surgeons. With the technical refinements described in this article, the suprafascial radial forearm flap can be harvested safely and reliably.

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