Super-Thinned Iliac Flap for Major Defects on the Elbow and Wrist Flexion Creases

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Four free iliac flaps were used to treat or prevent flexion contracture at the elbow or wrist flexion crease. Flap size ranged from 13 × 6 cm to 18 × 8 cm. Two flaps were used for primary coverage, and the other 2 flaps were used to treat established flexion contractures. All flaps survived without vascular complications. Full range of motion was obtained at the elbow and 40° of active extension was obtained at the wrist. The flap has a very thin dermis with minimal panniculus that can be thinned as required, making it ideal to cover flexion creases. Despite the fact that anatomic variations are common in the inguinal region, the flap can be expeditiously and safely elevated. If needed, pedicle length can be up to 8 to 10 cm. The donor site is comparable with that of a full-thickness skin graft harvested from the groin. The donor artery, however, can be very small. *(J Hand Surg 2008;33A:1899–1904. Copyright © 2008 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Contracture, elbow coverage, free iliac flap, groin free flap, microsurgery.

ACLAND[1] IN 1979 DESCRIBED THE iliac flap, a lateral extension of the classic groin free flap[2] (Fig. 1). Compared with its parent flap, the iliac had a longer pedicle, lesser panniculus, and contained the least hair of the whole abdomen.[1] It shared the same inconspicuous donor site, resulting in a scar at the groin crease. The flap was, however, difficult to dissect because of the considerable vascular variations[1,3,4] and was difficult to revascularize because the artery was in the range of 1 mm, sometimes less.[3] These drawbacks together with the fact that other safer flaps, such as the latissimus dorsi, appeared in the literature made both the groin flap and the iliac flap fall into disuse.

Since those early days, things have changed a great deal in flap surgery and in microsurgery. On the one hand, anastomosis of very small vessels no longer proves to be an impossible feat.[5] On the other, thanks to the perforator era, we have become used to raising flaps in non-cookbook fashion.[6] In this setting, it was not surprising that several authors[7–9] championed the renaissance of the groin free flap on the grounds of minimal donor-site morbidity. Additionally, Kay and Lees[10] described a method for quick elevation of the flap irrespective of the anatomic variations to the origin of the donor artery at the groin.

Concomitantly, our ability to aggressively tailor flaps has also moved a long way since the early axial pattern flaps.[11] Hyakusoku and Gao described the so-called pedicled super-thinned flap to treat burn contractures at the neck.[12] The concept expanded quickly to free flaps where several techniques of *micro-thinning* have been described.[13–17] Large ultra-thinned free flaps can be harvested, but donor-site morbidity can be considerable.[18]

The iliac flap combines the advantages of a naturally thin flap with a long pedicle and minimal donor-site morbidity. Furthermore, the dermis is much thinner than that of other possible thinned skin flaps (such as the lateral thigh or scapular)[19] making it ideal for adaptation to flexion creases. From a personal experience of 21 consecutive free iliac flaps, 4 were used to treat or prevent flexion contracture at the elbow (3 cases) or the wrist (1 case) and are the subject of this article. Despite

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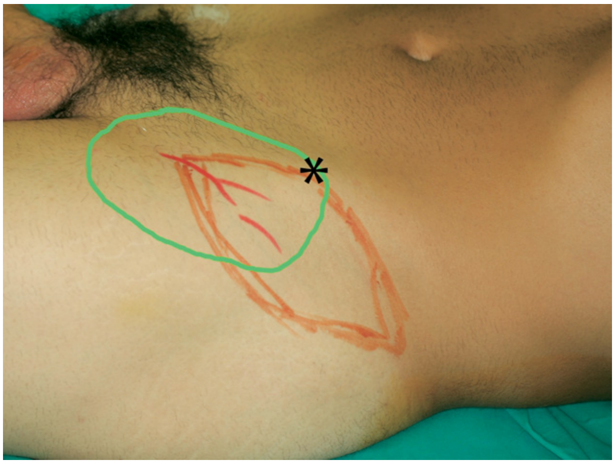

FIGURE 1: The outlines of the iliac flap are lateral to the classic free groin flap (silhouetted in green). *, anterosuperior iliac spine.

the fact that the iliac flap is very thin, the tolerance of the elbow and wrist flexion creases to minor volume increments is so minimal that some fat excision is always required. The technique of flap thinning is also discussed.

PERTINENT VASCULAR ANATOMY

The iliac flap is the lateral extension of the groin flap and like the latter is irrigated by branches of the superficial circumflex iliac artery (SCIA). The vascular anatomy is somewhat variable laterally (where the irrigating vessels of the flap are) as well as medially (the pedicle area).

Variations regarding the origin of the SCIA proper have been well known since the very early days of microsurgery.[3] At times, the SCIA takes off directly from the femoral artery, but it may originate from a common trunk with the superficial epigastric artery or even the deep circumflex iliac artery or other local vessel. Dealing with these variations is both frightening and time consuming; about 2 hours are required to elevate the flap from medial to lateral[7] as recommended by most authors.[1,2,7,8,] However, this anatomy bears no importance when the groin flap is dissected from lateral to medial (see later).

More laterally, the SCIA divides, in most cases, into a superficial branch and a deep branch.[1,19,20] The superficial branch goes directly to the skin and may play a major role in the blood supply of the iliac flap.[1,19,20] The deep branch continues laterally deep on the groin. Close to the medial border of the sartorius fascia, the deep branch usually gives off a medial cutaneous branch[1,3,7,8,10,19] and progresses by perforating the medial edge of the sartorius fascia. On its way, it irrigates this muscle and ends perforating the fascia laterally and sending a branch (lateral branch) to the skin, named by Koshima et al. the "iliac perforating branch."[21]

The iliac flap can be irrigated by: the superficial branch of the SCIA, the medial perforating branch of the deep branch, or the lateral perforating vessel of the deep branch, or by combinations of the three, as there is a competitive situation among them (Fig. 2A, B). Usually, the lateral branch can be discarded as the other 2 are sufficient; this expedites the dissection to a great extent. Furthermore, the lateral branch may perforate the fascia lateral to the lateral femoral cutaneous nerve, and its inclusion will require sacrifice of the latter, adding to donor-site morbidity. This maneuver is not recommended, and if faced with the situation where the nerve crosses the artery more superficially, we would rather cut the vessel and accept a shorter pedicle than risk creating an iatrogenic meralgia paresthetica. The nerve in this area is covered by the sartorius fascia, and by keeping the dissection in the suprafascial plane, the nerve will stay out of harm's way.

The venous drainage is dual: a superficial system (the superficial epigastric vein) that follows the path of the deep artery in a more superficial location, and a deep system (vena comitantes) that accompanies the artery.[3,4] The veins of the deep system are flimsy and about 1 to 1.2 mm in diameter, whereas the superficial ones are large (about 2 mm), and with a robust wall. Either can be absent or of a diameter useless for transfer. However, if it is of sufficient diameter, the deep system is preferred,[19,20] as otherwise the flap cannot be thinned medially (where it is thicker). Nevertheless, before sacrificing the superficial system, one should make sure that the deep veins are at least 1 mm in diameter.[20]

To summarize, the arterial supply can be triple (superficial branch of the SCIA, lateral and medial perforators of the deep branch of the SCIA) or single (one of those vessels is dominant). Before sacrificing any of the branches, the surgeon should make sure that the others are self-sufficient by alternate microvascular clamping if doubt exists. The preferred venous drainage is the venae comitantes.[19,20]

SURGICAL TECHNIQUE

The course of the SCIA is traced with a unidirectional Doppler probe, approximately 2 to 5 cm below and parallel to the inguinal ligament. Quite often, the take-off of the medial perforating branch can be heard as a louder sound at the medial border of the sartorius. The flap is centered on the course of the artery; as a rule, one half to two thirds of the flap are located lateral to the

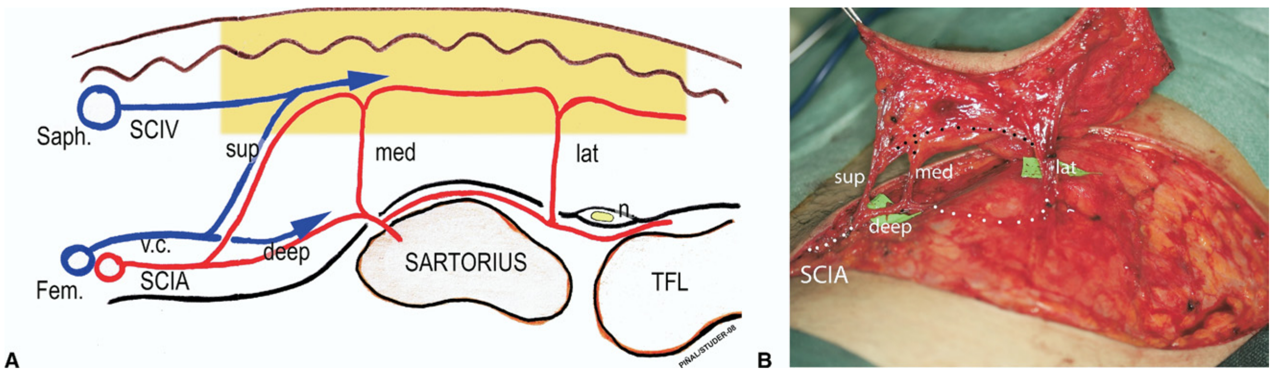

FIGURE 2: A Schematic representation of the triple arterial inflow and dual venous outflow of the iliac flap (in orange). **B** Corresponding clinical case (same patient as that of Fig. 1). Notice that the medial and lateral perforating vessels are connected by a superficial arcade (black dots) and a deep arcade (white dots under the sartorius fascia). Saph, saphenous bulb; SCIV, superficial epigastric vein; Fem, femoral vessels; VC, vena comitantes; Sup, superficial branch of the SCIA; med, medial branch of the deep SCIA; Lat, lateral perforating branch of the SCIA; n, lateral femoral cutaneous nerve.

anterosuperior iliac spine as in this area the flap is thinner. A towel placed under the ipsilateral hip facilitates the dissection when a long pedicle is needed.

The flap is incised on its lateral half and dissected from lateral to medial in a suprafascial plane. The first part of the elevation proceeds rapidly with a cautery. On the lateral border of the sartorius, the lateral perforating branch is sought by dissecting with scissors. If small, this vessel is ligated at this time, otherwise it is preserved until the contribution of the other 2 vessels to the flap's blood supply is clarified. The dissection proceeds medially in a suprafascial plane at all times. This is the most stressful moment of the operation as the surgeon has already elevated half of the flap, and the blood supply of the flap is still not clear. However, if one perseveres dissecting medially, the anatomy will reveal itself: the medial arterial inflow (the superficial branch and/or the medial perforating branch of the deep SCIA) becomes evident on the undersurface of the flap, and at the same time the deep branch of the SCIA becomes exposed. If either of these vessels is sizable, the lateral perforating branch (if not previously ligated) is temporarily clamped with a microclamp to assess its contribution. If minor, it is ligated, allowing the flap to be pedicled on the medial vessels. The flap harvesting finishes by ligating the deep branch, distally to the take-off of the medial perforating branch, and dissecting the SCIA trunk proximally as necessary. When a long pedicle is required (6–8 cm can be obtained), the incision needs to be prolonged medially up to the femoral vessels. Utmost care should be taken while dissecting the pedicle to avoid leaving untied side branches as this may cause irreversible spasm. Tiny branches should be coagulated with bipolar cautery, whereas larger ones are freed for some distance before ligating them with 5-0 silk.

If the medial vessels are small, one has to assume that the dominant vessel of the flap is the lateral perforating branch. This has occurred only once in our experience with 21 flaps and in none of the cases reported here. In this situation, the lateral perforating branch has to be tracked under the sartorius fascia, to its parent deep branch, and finally to the SCIA proper. The dissection of this anatomic variant is more cumbersome, but the pedicle obtained is longer.

At this stage, a decision has to be made regarding the venous drainage. If the venae comitantes are of sufficient caliber, the remaining medial half of the flap is incised with impunity, as the pedicle, already fully dissected, can easily be protected on the undersurface of the flap. Otherwise, the flap's medial corner is dissected carefully until the superficial iliac vein is isolated and dissected for the required length. This maneuver is never too complicated as this vessel is quite large and the dissection plane is superficial.

Care should be taken during flap elevation to reduce the amount of fat harvested in the periphery of the flap. Despite this and the fact that this flap is already quite thin, further thinning medially is required in all individuals and may have to be quite radical in overweight patients for crease flexibility at the elbow or wrist. Our preferred method to debulk the flap is that originally described by Itoh and Arai[14] and Kimura and Satoh[15] and later refined by Yan et al.[17] It consists of excising with scissors the deep fat lobules (much larger and yellower) preserving the superficial fat lobules (smaller and more compact) as the latter contain the subdermal plexus (Fig. 3). The procedure is done with the flap

Surgical Technique

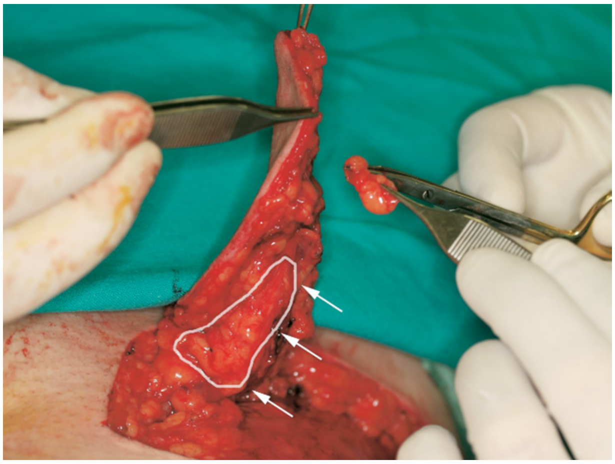

FIGURE 3: Debulking of the distal half of the flap is nearly finished. A deep lobule is being excised with scissors. Silhouetted in white is the deep fat that will be removed from the proximal flap. Arrows point to the course of the pedicle. The final result is shown in Figure 4.

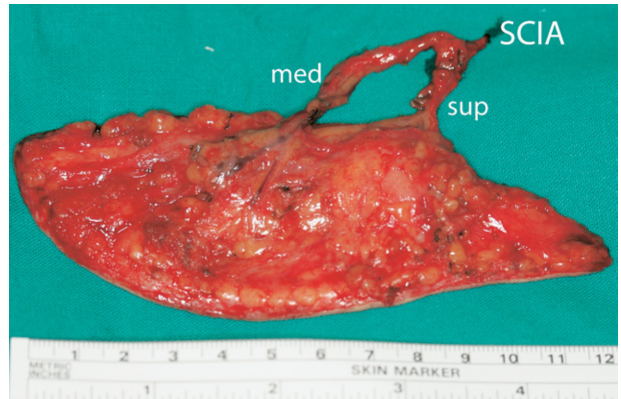

FIGURE 4: The undersurface of this flap is shown to highlight the degree of radical thinning carried out. Notice that the vessels going to the flap have been skeletonized and that practically all deep fat (large lobules) has been excised (same patient as that in Fig. 5). med, medial branch of the deep SCIA; sup, superficial branch of the SCIA.

totally elevated but still connected by the pedicle. This permits control of any excessive bleeding that may later cause hematoma putting the whole flap at risk. In general, we proceed medially from the periphery and stop 1 cm from the perforator. More recently, Kimura[16] refined a method to dissect the perforator itself, with the help of the microscope, but this has the risk of undue pulling on the perforator itself.[17]

Once the thinning has been completed, the flap is ready to be transferred (Fig. 4). The donor site is closed in 2 layers, usually without a drain. If necessary, the thigh can be flexed to help in this respect. The flap is then revascularized at the recipient site. Our preference when dealing with vessels that small is to carry out end-to-end anastomosis. In the cases of this article, we selected a muscular branch of the brachial artery and a side branch of the radial artery of a matching caliber to the donor. In most cases, we used continuous suturing with a 9-0 or 10-0 nylon suture (in a 140-μm or 100-μm needle, respectively) depending on the size and thickness of the vessel. Conversely, end-to-side anastomoses of a small artery such as the SCIA to a large artery (particularly lower limb arteries) are extremely difficult because of the dissimilar thicknesses of the vessel walls and are to be avoided at all costs. Venous anastomoses were end-to-end to local veins and bore no difficulties. As reported previously,[22] spasm is quite common when dealing with free flaps with small donor vessels. Avoiding dryness of the vessels seems important for its prevention. We use topical verapamil to revert it. In addition, just before clamp release, a bolus of 1500 U heparin is injected intravenously. Thereafter, a continuous infusion of heparin diluted in Ringer lactate at a rate of 250 to 500 U per hour is given for 4 days, which is reduced to half on the 5th day. Patients are discharged on day 6 receiving low molecular weight heparin for an average of 2 more weeks. (We have removed dextran 40 from our protocol because of the risks of systemic complications, as no clear benefits have been reported).

We have used the "super-thinned" iliac flap in 4 cases for elbow (3 cases) and wrist (1 case) flexion crease coverage. All were manual workers, and the injury occurred at work. In 2 cases, the operation was carried out acutely, and the other 2 flaps were done at referral several months after the injury. Patient age varied from 23 to 54 years. Flap size varied from 13 × 6 to 18 × 8 cm. Pedicle length varied from 4 to 6 cm (although pedicle length can be longer if needed, up to 8 cm in our experience or more according to Kimura[19]). In every case, the donor artery was the SCIA.

Regarding the venous drainage, in 2 cases only the vena comitantes were used, in 1 case the superficial iliac vein as the deep system was hypoplastic, and in the final case both systems were used. Flaps healed uneventfully, and contractures did not recur (Fig. 5).

DISCUSSION

The normal bulk and thickness of soft tissue cover over the elbow or the wrist flexion crease is negligible, approximating the thickness of a full-thickness skin graft. However, when full-thickness grafts are placed at skin folds, they have a high risk of flexion contracture, and even more so if a split-thickness skin graft is used.

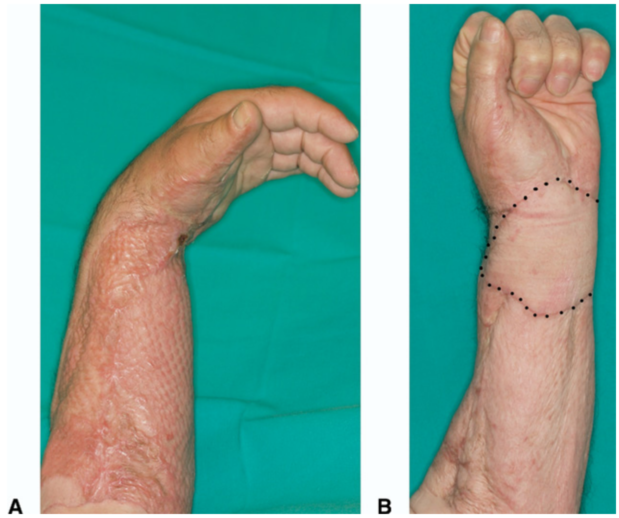

FIGURE 5: A Preoperative condition showing maximal wrist extension and finger flexion (notice chronic unhealed volar ulcer). **B** Postoperative result 4 months after the operation (the flap is the same as that shown in Figs. 3, 4).

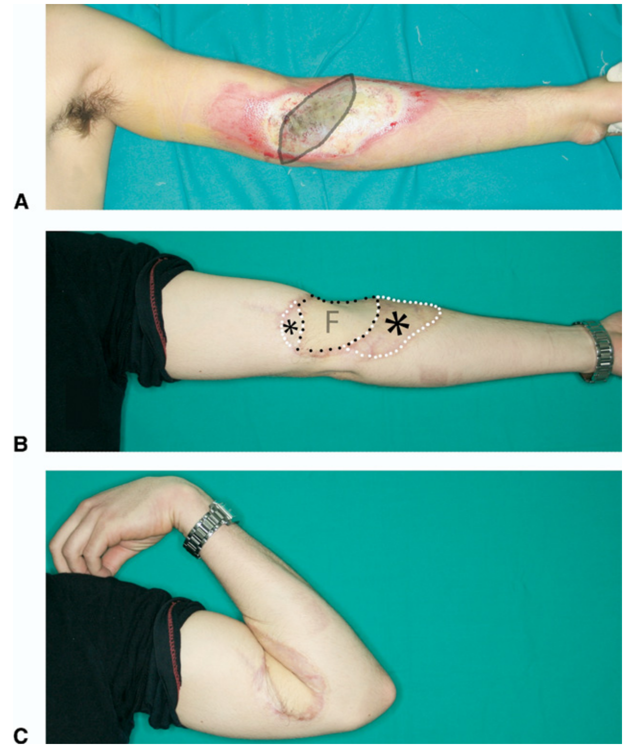

FIGURE 6: A Preoperative burn in the elbow flexion crease. To obtain a better contour, the flap should be reserved for the skin fold only (outlined in black). **B** and **C** Result at 1 year. The outlines of the flap **F** have been dotted in black. The skin grafted areas are highlighted with white dots (asterisk).

Hence, although ideally a skin flap should be used to treat defects at those areas, the bulkiness of the flap itself will cause incomplete flexion and an unsightly result. To overcome the latter problems, Hyakushoki and Gao[12] presented the possibility of creating super-thin pedicle flaps from the torso for treating contractures at the neck. This concept was a refinement of the "Colson dermo-epidermal flaps" that behave nearly like vascularized full-thickness skin grafts[23] but are much larger and have the possibility of revascularization by microanastomosis. Shortly afterwards, several authors developed techniques to create super-thin free flaps: anterolateral thigh, thoracodorsal, and periumbilical perforator flaps were among the most popular choices.[13–18,24] Those flaps, however, do not have a negligible donor site, particularly if a skin graft is needed to cover the donor site.[18]

The dermis of the inguinal area is quite thin compared with that of the thigh or back, making it ideally suited for pliability and contour reconstruction as required in a flexion crease.[19] However, even in thin individuals, the groin flap may be too thick for use on a flexion crease. Kimura and Satoh considered the groin flap a risky flap for thinning as the perforators had an oblique course toward the skin.[14] Recently, these same authors have also published a method to thin the groin flap with a microdissecting technique.[19]

The iliac flap has several advantages over the classic groin flap: the pedicle is longer and is much thinner, compensating the drawbacks of a short pedicle embedded in a fat environment, which made the groin flap so unpopular. For an expeditious flap elevation, the dissection should be carried out from lateral to medial as recommended by Kay and Lees.[10] The whole flap elevation time ranged in our experience from 35 to 70 minutes depending on the required pedicle length, the anatomic variations, and the degree of thinning needed. This compares favorably with the 2 hours needed to raise the flap when the dissection is carried out from medial to lateral.[7] Additionally, we recommend a suprafascial dissection at all times as otherwise the flap becomes too bulky medially.

A final consideration for achieving an optimal result is to harvest a flap to cover only the fold itself. Neighbor losses do not tend to retract and can usually be covered with a nonmeshed skin graft giving a better contour (Fig. 6). In all our cases, we were able to achieve a full range of motion at the elbow and 40° of active extension at the wrist.

The worrisome anatomic variations of the iliac flap (and its parent, the groin flap) presented above should not outshine its advantages: minimal donor-site sequelae and a thin nonhairy flap ideal for skin folds. It should be cautioned that the donor artery can be at times in the super-microsurgery range (1.0–0.5 mm). Therefore, one has to be prepared to deal with vessels of this size and free-handing at the time of flap elevation. Despite these drawbacks, we have had a positive experience with this flap. Of 21 flaps (9 for upper limb), we have had 1 acute venous thrombosis that was salvaged by draining a hematoma and redoing the anastomosis and 1 partial loss due to a late venous thrombosis. However, no total losses were noted.

In summary, current advances in flap surgery and microsurgery have made this flap a safe alternative compared with others, such as the anterolateral flap, that are "easy" to dissect but have a more obtrusive donor site. One may accept higher risks when using this flap, as the loss in the event of failure is limited to a hidden scar in the groin, which is a quite tolerable trade-off.

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