The combined parascapular fasciocutaneous and latissimus dorsi muscle conjoined free flap.

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The Combined Parascapular Fasciocutaneous and Latissimus Dorsi Muscle Conjoined Free Flap

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Background: A combined flap composed of at the least two otherwise distinct territories, each retaining its independent vascular pedicle yet joined together by a common interface, is by definition a conjoined flap. If the vascular pedicles are branches of a common source vessel, even more specifically this combination would be a "branch-based [common]" conjoined flap.
Methods: The parascapular fasciocutaneous and latissimus dorsi muscle flaps can be raised together as a clinical example of a branch-based (common) conjoined flap. This combination allows the creation of an extremely large cutaneous flap from the dorsal thorax while ensuring survival of both the muscle and skin portions in their entirety.
Results: A series of eight parascapular fasciocutaneous and latissimus dorsi muscle conjoined free flaps in eight patients had total flap survival of all components. Major complications, none of which were related to flap viability, eventually occurred in two patients; that is, one patient had a persistent chronic tibial osteomyelitis and the other had the covered lower limb amputated.
Conclusions: The parascapular fasciocutaneous and latissimus dorsi muscle conjoined free flap is an extremely large, yet reliable flap. The anatomy is fairly consistent and already well known. In favorable situations, only a single recipient site is needed for the requisite arterial and venous microanastomoses. This combination can replace the need for multiple conventional flaps, yet violates but a single donor site. This series is the first clinical example of the branch-based (common) conjoined free flap. (*Plast. Reconstr. Surg.* 121: 101, 2008.)

Combined flaps have a unique niche in reconstructive surgery. Harii et al.[1,2] introduced this concept by encompassing two adjacent skin territories into a single large flap entwined together as the "myocutaneous microvascular flap." Similarly, Belousov et al.[3,4] defined any flap that extended beyond the vascular territory of a single vascular pedicle as a "megaflap." Nassif et al.[5] suggested the term "combined monoblock flap." In any event, this original type of compound flap, although better known by the lay term "Siamese" flap,[6–8] should more appropriately be called a conjoined flap.[9] More precisely, the conjoined form of combined flaps has "multiple flap territories, dependent due to some common physical junction, yet each retaining its independent vascular supply."[7]

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The prototype example used by Harii et al.[1,2] was a bipedicled latissimus dorsi musculocutaneous and groin flap, transferred with a fixed rotation point coinciding with either the thoracodorsal or superficial circumflex iliac vessels, respectively, while the other pedicle always required microanastomosis after flap insetting. Katsaros et al.[10] used this same latissimus dorsi musculocutaneous/groin conjoined flap as a distant bipedicled flap without the need for any microsurgery. Since the indications for such a huge flap with long reach are limited, so too have been the variations on this theme. Other examples are the latissimus dorsi musculocutaneous/superior gluteal perforator,[11] dorsal forearm (posterior interosseous) and lateral arm fasciocutaneous,[12] deltoid and radial forearm fasciocutaneous,[4] tensor fasciae latae musculocutaneous/lateral thigh perforator,[3] and

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anterolateral thigh and lateral thigh perforator[4] conjoined flaps. These are all examples of more traditional conjoined flaps, specifically "branch-based [independent]" conjoined flaps.[9] Nassif et al.[5], in addition to this traditional concept, hypothesized and then demonstrated in cadaver models the feasibility of a parascapular fasciocutaneous/latissimus dorsi muscle conjoined flap where the independent vascular pedicles to each component also arose from a common source vessel.

This model, now successfully utilized in this clinical series, is an example of a new subcategory of conjoined flap, the "branch-based [common]" conjoined flap,[9] where the branches ultimately have a common source pedicle.

SURGICAL ANATOMY

The anatomical details and recognition of the potential for multiple combinations and permutations of flaps from the subscapular axis are already so well known[13] that a brief recapitulation should suffice. The subscapular vessels arise from the third part of the axillary artery and soon thereafter branch into the circumflex scapular and terminal thoracodorsal vessels.[14] The latter vessel is the dominant vascular pedicle to the latissimus dorsi muscle. The circumflex scapular vessels course medially toward the scapula, giving off multiple muscle and osseous branches. Through the triangular space bordered by the teres minor superiorly, the teres major inferiorly, and the long head of the triceps muscle laterally, a cutaneous perforator pierces and then arborizes over the dorsal thoracic fascia.[15] A distinct descending branch consistently descends to follow the lateral border of the scapula to its tip and is the vascular pedicle to the parascapular flap, a type B "fasciocutaneous flap," using the terminology of Cormack and Lamberty.[16] According to Nassif et al.,[5] it can have a pedicle up to 14 cm long, with a mean vessel caliber of 4.5 mm, if the subscapular vessels are included. This skin flap can safely have dimensions up to 25 to 30 cm long and 15 cm wide, which still allow direct donor-site closure.[5]

Unfortunately, in about 4 percent of cases, the circumflex scapular vessels arise or empty into the axillary vessels directly and are not part of the subscapular axis.[14,17–19] In addition, the exit point of the cutaneous perforator of the circumflex scapular vessels can be quite variable. Sometimes it is extremely lateral or medial within the triangular space, but it is always within a region contiguous to the middle third of the lateral border of the scapula. Caution should also be observed in that the descending branch could arise from the circumflex scapular vessels before reaching the triangular space as a completely separate perforator; even more disconcerting is that the latter

Table 1. Demographics of Parascapular/Latissimus Dorsi Conjoined Flaps

Case	Age/Sex	Defect	Cause	Size (cm)	Anastomotic Site	Complications (flap/overall)
1	56/F	Open left knee joint	Infected TKR	4 × 30	PTa: e-s ×2v: e-e,e-s	CSV arose independently from axillary vessels/none
2	40/M	Pelvic and parasacral unstable skin grafts	Pressure sores (paraplegic)	60 × 25	CF a: e-s CF v: e-s	Donor-site skin graft/none
3	55/M	Exposed heart, lung	Gunshot	8 × 32	IM a: e-e IM v: e-e	None/hematoma under flap from DVT prophylaxis
4	41/M	Segmental gap left tibia	Boating accident	5 × 35	Per a: e-s Per v: e-s	None/limb amputation 1 year later due to bone graft failure
5	43/M	Proximal tibia fracture, exposed Achilles tendon	Motorcycle accident	6 × 30	Pop a: e-s Pop v: e-s	None/chronic osteomyelitis tibia
6	26/F	Degloved thigh, open femur fracture	Motor vehicle accident	8 × 30	PTa: e-s v: e-e	None/none
7	12/M	Posterior thigh cavity, open femur fracture	Hunting accident	8 × 25	SFa: e-s v: e-s	None/none
8	58/M	Exposed femur and sciatic nerve	Industrial accident	7 × 30	SFa: e-s v: e-s	None/none

M, male; F, female; TKR, total knee replacement; MVA, motor vehicle accident; DVT, deep vein thrombosis; a., artery; v., vein; e-e, end-to-end; e-s, end-to-side; CF, common femoral; Per, peroneal; Pop, popliteal; PT, posterior tibial; IM, internal mammary; CSV, circumflex scapular vessels; SF, superficial femoral.

could descend to exit below rather than above the teres major muscle[18,19] before penetrating the dorsal thoracic fascia.

MATERIALS AND METHODS

During the past two decades of an experience with more than 500 free flaps, a parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap has been used in clinical cases in eight patients (Table 1). The usual indication was the need for an immensely large or very long cutaneous flap needed for skin closure, and/or a malleable muscle flap simultaneously needed to fill a contiguous large void.

The surgical technique differs little from that for elevation of the standard parascapular[5] or latissimus dorsi muscle flap.[20] The patient is typically placed in a lateral decubitus position. The anterior border of the latissimus dorsi muscle can usually be palpated (Figs. 1 through 3). The scapula is also marked. Beginning at the middle third of its lateral border and proceeding toward the cupola of the axilla, an audible Doppler probe is used to identify the location of the circumflex scapular cutaneous perforator.[21] The dimensions of the parascapular flap must be drawn according to the requirements of the recipient site. The superior border of this flap should be a few centimeters above a horizontal line passing through the

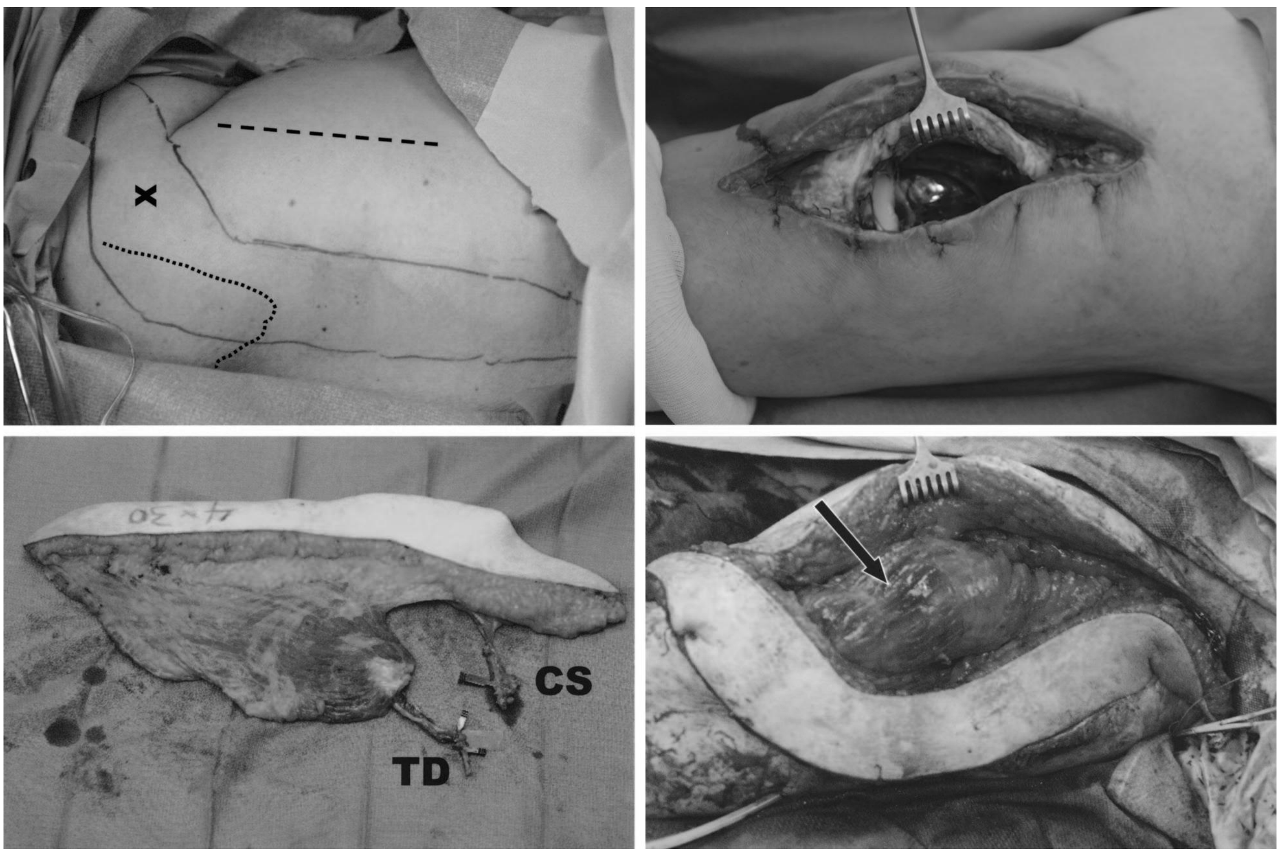

Fig. 1. Case 1. (*Above, left*) Surface landmarks for planning the parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap include marking the palpable anterior border of the latissimus dorsi muscle (*hashed line*) and scapula (*dotted line*). With an audible Doppler probe, the cutaneous perforator (*x*) of the circumflex scapular vessels is found exiting the triangular space, contiguous to the middle third of the scapula. The boundaries of the parascapular flap (*solid line*) extend above that point and parallel the lateral scapular border. (*Above, right*) Exposed left total knee prosthesis, surrounded by indurated and inelastic skin after multiple prior joint infections. (*Below, left*) The combined free flap, including a long, narrow parascapular flap with a proximal extension (*at right*) planned to reach anteriorly around the tibia for coverage of the medial leg vascular recipient site; the attached latissimus dorsi muscle is on its undersurface. The only vascular anomaly in this series is shown here, where the circumflex scapular branch (*CS*) to the skin component and the thoracodorsal (*TD*) branch to the muscle each arose independently from the axillary vessels. (*Below, right*) After transfer, the muscle (*arrow*) as a separate layer was used to encase the joint prosthesis, and then the skin defect was closed without tension using the parascapular flap.

Fig. 2. Case 1. A healed left knee without evidence of reinfection 3 months postoperatively.

Fig. 3. Case 1. In this case, primary donor site closure was possible.

roof of the axilla, and centered about the site of the identified perforator. Its axis in general should parallel the lateral border of the scapula, but again can vary somewhat toward or away from the anterior border of the latissimus dorsi muscle, depending again on the demands at the recipient site, especially with regard to unencumbered insetting of the muscle component, which will remain attached to its undersurface.

Although Nassif et al. suggest that the parascapular flap be raised in a retrograde fashion to maximize recognition of associated vascular anomalies as they are encountered,[5] with this conjoined flap, this is impossible, since by definition the muscle cannot be separated from the overlying skin component. Instead, the superior and medial borders of the skin flap are raised, proceeding primarily inferiorly at a level below the deep fascia but above the muscle fascia. Once the inferior border of the teres minor muscle is found, dissection can then proceed laterally within the triangular space until the cutaneous perforator is isolated. If necessary, the skin boundaries at this point can be redrawn. All remaining borders can then be rapidly incised down to the underlying latissimus dorsi muscle, which is itself then completely exposed up to its anterior and posterior margins.

The latissimus dorsi muscle is dissected toward its origin inferiorly at least to the inferiormost aspect of the skin flap, and farther if needed. The muscle flap origin is then divided and the muscle raised on its undersurface toward the axilla in the usual fashion. The thoracodorsal vessels are followed under the teres major muscle until the circumflex scapular branches are found. In a retrograde fashion from above, the parascapular cutaneous perforator is followed into the septum between the teres major and minor muscles, with ligation of side branches until the thoracodorsal vessels are reached. Since both flap entities will also remain attached to each other by this common vascular junction, further elevation usually is simplified by division of the teres major muscle, preferably at its origin from the scapula to allow later reattachment. If a longer pedicle is essential, the now common subscapular source vessel can then readily be followed back to the usual origin from the axillary vessels.

After division of the subscapular vessels, the combined free flap can then be transferred and microanastomoses completed as per routine. Usually, the muscle dissection has resulted in enough undermining of the back to allow primary donor-site closure, but a very large skin component will still require a skin graft (Figs. 4 and 5).

RESULTS

In all eight clinical cases where a parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap was used, the entire muscle and skin component survived completely, with complications not related to flap viability itself (Table 1). One patient developed a persistent chronic tibial osteomyelitis requiring intermittent antibiotic therapy. Another had his leg am-

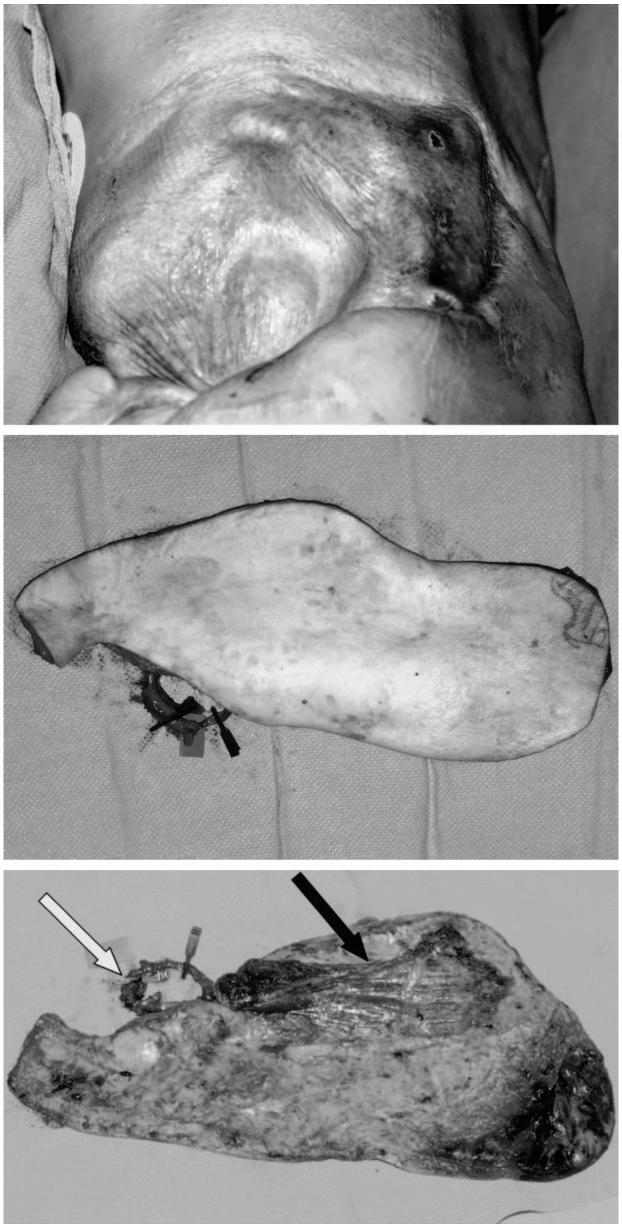

Fig. 4. Case 2. (*Above*) Skin grafts had initially been used to cover a large flank avulsion from a motorcycle accident after a failed free flap elsewhere. Recurrent ulcerations occurred, especially over the prominences of the vertebral column and left iliac wing, in this now paraplegic man, due to intolerance from unavoidable shear stresses. (*Center*) A huge cutaneous free flap was needed to replace the entire skin-grafted region, here based on the subscapular axis (*lower left in microclamps*). (*Below*) This version of a parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap retained only a narrow strip of the posterior portion of the muscle (*black arrow*). Note the common origin of the thoracodorsal and circumflex scapular branches from the subscapular vessels (*white arrow*).

putated 1 year later after failure of a delayed bone graft.

Four flaps were needed for a large skin defect, with the typically more malleable muscle

Fig. 5. Case 2. A total resurfacing of the skin-grafted flank 4 months postoperatively. The donor site of the upper back had to be skin grafted due to the large skin flap.

separately used to fill a deep void (cases 1, 3, 7, and 8) (Figs. 1 through 3). In three additional cases also requiring a long flap to cover a narrow skin defect, the muscle was independently used to wrap around an open fracture site (cases 4 through 6). In the final case (case 2), an extremely large cutaneous flap encompassing more than half the upper thorax was essential to replace multiple areas of unstable skin grafts over the pelvis, sacrum, and vertebral column in a paraplegic patient. Only a posterior strip of the latissimus dorsi muscle was included, with the anterior portion left in situ to ensure function preservation.[22] The intent was to augment the large cutaneous flap via captured musculocutaneous perforators (Figs. 4 and 5).

A reasonable formula by Nassif[23] states that the reliable safe length of a parascapular flap standing by itself varies directly with the height of the patient: *maximum length flap* (cm) = 16.5 × *height* (meters). Since none of the patients in this series exceeded 1.78 meters (5′10″) in height, the predicted viable skin flap length should not have exceeded 29 cm. The actual length of the corresponding skin component of this parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap superseded that expected (Table 1).

DISCUSSION

Although combinations of the parascapular flap and latissimus dorsi muscle together as free flaps[24] have been utilized many times before as so-called chimeric flaps,[7,9] their deployment as a conjoined flap has previously only been hypothesized.[5] The reach of this example of a branch-based (common) conjoined flap[9] is not significantly extended, contrary to the purpose of the original concept exemplified by Harii et al.[1,2] Instead, the length at least for the parascapular flap portion exceeded expectations (see Results) and was a major consideration for designing this combination.

Augmentation of this conjoined flap theoretically is due to enhanced nourishment of the most distal portion of the parascapular flap via musculocutaneous perforators from the attached latissimus dorsi muscle, in a fashion "supercharging" the skin component.[17] Conversely, it is also known that Belousov et al.[4] resolved congestion in the distal portion of a failing latissimus dorsi musculocutaneous flap by enhancing inflow using microanastomosis to a retained secondary intercostal perforator. In essence, by the known phenomenon of reversal of flow through these same musculocutaneous perforators[25,26] in a similar manner now via the parascapular flap without the need for microsurgery, muscle congestion and eventual necrosis, often seen at the origin in the isolated latissimus dorsi flap, was here also avoided. This observation may also be related to a "capacitance" phenomenon, as seen in arteriovenous cross-flow flaps (conjoined flaps by definition), where greater viability is seen than expected for any single flap as somehow flow is drawn from one adjoining part across to the other.[27]

In addition to providing a flap of great length and size for closure of long and wide defects (Figs. 4 and 5), the parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap allows the simultaneous and independent ability to use the muscle component to fill a deep void (Figs. 1 through 3) or surround other relatively avascular structures where the malleability of this vascularized tissue is its greatest attribute. Since the vascular pedicle to both flaps usually arises from a common source vessel (i.e., the subscapular), another advantage is that only a single arterial and venous microanastomosis is required, much the same as with a chimeric flap.[7,9] Unfortunately, anomalies are not uncommon; they not only require caution during flap elevation but may also necessitate additional recipient sites for the rare occasion that the independent pedicles of each component part have a different origin (e.g., case 1; Figs. 1 through 3).

The loss of latissimus dorsi muscle function inherent with this specific combination can be avoided if instead a thoracodorsal artery muscle perforator flap is substituted,[28] although major perforators to the latter are more likely to be found near the vascular hilum and not the distal origin of the muscle, where such perforators are more desirable to gain overall flap length. The loss of latissimus dorsi muscle function or even that of teres major if it had to be divided, may not be so much a concern even in paraplegics,[17] as long as other agonists remain.

As with the majority of conjoined flaps, indications for the parascapular fasciocutaneous/latissimus dorsi muscle conjoined free flap will be limited. Nevertheless, this new "megaflap"[4] can solve unusual problems without the need for multiple conventional flaps.

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Future Meetings of the American Society of Plastic Surgeons

The following are the planned sites and dates for future annual meetings of the American Society of Plastic Surgeons:

2008	Chicago, Ill.	October 31 to November 4
2009	Seattle, Wash.	October 23 to 28
2010	Toronto, Canada	October 1 to 6
2011	Denver, Colo.	September 23 to 28
2012	Washington, D.C.	November 1 to 7