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INTRODUCTION

Patients with advanced stage hidradenitis suppurativa (Hurley stages II and III), need surgical resection of the affected region in order to remove the infundibular terminal follicles affected by the disease. In the axillary region this means removing the whole hair bearing skin, often extending beyond its limits based of extension of the disease into the inner arm, lateral thoracic area, and pectoral region. Such resections create wide and deep surgical defects in an area located close to a joint, where surgical retraction can restrict movement. For this reason secondary healing and skin grafting as previously reported[1-3], are suboptimal options and a flap is best used in order not to restrict shoulder movements.

Since the disease is systemic, axillary involvement is often bilateral. Axillary reconstruction in these cases is usually performed with pedicled perforator flaps. The use of pedicled skin flaps such as the Thoraco Dorsal Artery Perforator (TDAP) flap[4,5], the lateral thoracic flap or other skin flaps[6-8] gives good functional results since supple tissue is brought in adequate quantities in order to preserve shoulder function. It has, however, two drawbacks. The first one is that bilateral cases need to be treated in two operations, since the operation is carried out in the lateral decubitus and the patient cannot lie on one flap while the other axilla is being operated[4]. The second one is that wide defects, extending beyond the axilla, require large flaps and, as a consequence, closure under tension causes unsightly scars in the scapular or lateral thoracic regions or even the need to skin graft the donor site[5].

The ideal technique for axillary reconstruction in hidradenitis suppurativa cases shall provide enough tissue to reconstruct large defects, with a thin flap that does not give bulk to the

axillary region and allows primary donor site closure with an acceptable scar. If, comparable results could be obtained in a single stage, that would be an added benefit.

We hypothesized that the Deep Inferior Epigastric Artery Perforator (DIEAP) flap could be a good donor for these cases since it provides large skin flaps still allowing primary donor site closure, with the possibility of harvesting two flaps for the same donor site in bilateral cases. The only drawback is thickness of the lower abdominal subcutaneous tissues, that we speculated could be overcome by flap thinning.

In this article we report on our experience with axillary reconstruction in hidradenitis suppurativa patients using bilateral and bipedicled DIEAP flaps.

PATIENTS AND METHODS

Between October 2008 and October 2018, 39 patients affected by Hurley Stage II-III axillary hidradenitis suppurativa were treated by the same surgeon (SDA). All patients were referred by the Hidradenitis suppurativa multidisciplinary team after failure of medical therapy. The patient are followed up lifelong.

Indications for a DIEAP flap reconstruction were:

1. Bilateral disease;

2. Flap needed too wide to close the donor site primarily/ Refusal of thoracic scar;

3. Skin redundancy in the abdomen;

4. Absence of lower abdominal disease;

Twelve patients met these criteria. Bilateral DIEAP flaps were used in 11 cases. A bipedicled DIEAP flap was used in one case for a unilateral defect in the right axilla that was too large to be reconstructed with a pedicled flap. The other side was reconstructed with a pedicled

TDAP in a previous operation in this case. There was a wound dehiscence due to closure under tension for a smaller defect covered with an 11cm wide flap. The left perforator was anastomosed to the lateral branch of the right Deep Inferior Epigastric Artery (DIEA), end-to-end, in this case. This means that a total of 23 flaps were transferred in 12 patients. Average flap size was 14x17cm for the bilateral flaps, while the bipedicled flap was 15x32cm. The recipient vessels were the Serratus branch in 7 patients (13 flaps) and the circumflex scapular vessels in 5 cases (10flaps). All patients underwent preoperative angioCT to locate and select the best perforator.

Patients data can be found in Table 1. There were 10 females and 2 males. Mean age was 33 years old. Seven patients were smokers, who all quit six months before surgery. Data on operative time, ischemia time, revisions, necrosis, hospital stay, complications, recurrences, secondary procedures were collected on an excel data sheet. Thinning was defined as primary when the flap was raised above Scarpa's fascia (6 patients, 12 flaps), secondary when the flap was thinned after harvest (3 patients, 6 flaps), tertiary when performed three months after the operation by means of liposuction (3 patients, 5 flaps).

SURGICAL TECHNIQUE

The surgical technique for primary and secondary thinning will be briefly described below.

Primary thinning. The flap is raised above Scarpa's fascia in these cases. As described for the Antero Lateral Thigh (ALT), Superficial Circumflex Iliac Artery Perforator (SCIAP), TDAP and Gluteal Artery Perforator (GAP) flaps[9,10], the DIEAP flap can be raised in a supra-Scarpa's plane as well.

The skin is incised to the level of the Scarpa's fascia. The SIEVs are identified and preserved and raised with the flap. We believe that the superficial veins are the limit for elevation of

large thin flaps and shall be included in the flap, at least for large flaps. Peripherally, once adequate traction is applied on the skin, the plane between the fat lobules can be clearly seen. Dissection is performed with 4.5x loupe magnification using a needle electrode in the cutting mode. This way all perforators can be clearly and directly visualized and all small vessels cauterized to proceed in a safe and bloodless plane. Once a large perforator is identified, it is followed to the level of the deep fascia, isolated circumferentially from the fat, taking care not to damage its branches in order to evaluate its calibre at the exit from the deep fascia. At this point, the deep fascia is exposed by opening the fat layer on top of it and dissection proceeds like in a conventional deep flap. In bilateral flaps the perforator is subsequently approached through the midline incision that divides the two flaps. If the flap is one large bipedicled flap, once both pedicles have been isolated this way, one of them is divided and dissection is carried out past the midline on the supra-Scarpa's plane until the other perforator is reached.

Secondary thinning. Once the flap pedicle is cut, the flap is put upside down on the table. A 3cm circle is drawn around the perforator to identify the potential branching area of the perforator. The fat is then removed from the flap on a plane superficial to Scarpa's fascia throughout the whole flap.

Tertiary thinning. At least three months after the first operation the flap is aggressively thinned by liposuction. If any skin excess is present, it won't be removed at this stage in order not to risk necrosis, but rather postponed at least three weeks after. No skin resection was necessary in this series.

RESULTS

Results are summarized in Table 2. Average operative time was 324 minutes, average ischemia time was 50 minutes. There were no revisions for microvascular problems, no flap necroses, no immediate postoperative complications. Mean hospital stay was 4 days. Four patients had complications: 2 had a dehiscence in the axilla, one in the abdomen, one had a pyoderma gangrenosum in both axillae and in the abdomen. The dehiscences were treated conservatively with local wound care. The pyoderma was treated as described previously and was promptly recognized due to the typical pattern with involvement of all surgical sites[11]. There was one recurrence after 2 years, unilateral and treated surgically. The three remaining patients whose flaps (5 flaps) were not thinned during the operation, needed tertiary thinning three months after the initial procedures. Follow-up ranged between 30 and 120 months (mean 64).

DISCUSSION

Based on this series, the DIEAP flap seems a reliable option for axillary reconstruction in selected cases of hidradenitis suppurativa. In bilateral cases, it allows simultaneous harvest of two flaps from the same donor site, while another surgical team is performing resection and harvesting the recipient vessels. All is done in the supine position and the donor site is closed primarily. In very large unilateral cases, a free bipedicled DIEAP flap allows reconstruction with a large flap still maintaining the ability to close the donor site primarily. The DIEAP flap has many unique features that make it a very versatile perforator flap. First of all it allows harvest of very large skin flaps while closing the donor site primarily. In this series, average flap width was 14cm. With other perforator flaps such as the ALT or the TDAP

flap, donor sites wider than 10-12 cm are either closed under high tension, resulting in widened or hypertrophic scars, or need skin grafting.

Second, it is a very versatile donor site: the abundancy of constant pedicles allows harvest of bipedicled flaps and multiple flaps[12-14].

 Although other donor sites such as the thigh allow harvest of two flaps from the same donor site[15], the lower abdominal skin has several constant pedicles that allow harvest of multiple flaps[16] while still maintaining the ability to close the donor site primarily without tension.

Third, it can be thinned out to overcome its main drawback: thickness. Thinning immediately after harvest of DIEAP flaps has already been described by Koshima[17]. Primary thinning is possible as well, like in other perforator flaps (Hong and Kim). Primary thinning has the advantage of leaving the fat in the abdomen behind, which is believed to improve donor site healing and reduce the risk for seroma formation[18].

In this series 23 flaps in 12 patients were harvested. Bilateral reconstructions could be carried out in one stage and an extensive defect, extending beyond the axilla in the inner arm and lateral thoracic area, could be reconstructed with a single, bipedicled DIEAP flap still closing the donor site primarily.

No flap related complications were observed. The wound healing problems and recurrences observed are not infrequent with this disease and can be observed with any other technique.

Treatment of advanced stage (Hurley II and III) hidradenitis suppurativa is surgical. It involves wide excision, with radical removal of all affected skin. Several methods can be available for

reconstruction, from secondary healing, to vacuum assisted closure, to skin grafts and various type of flaps[1-3, 6-8]. The best outcomes are obtained with perforator flaps that avoid scar contracture and functional impairment often related with the use of secondary healing techniques or skin grafting[19,20].

The TDAP flap is considered the gold standard for axillary reconstruction after hidradenitis suppurativa, since it allows effective reconstruction, with like with like skin, a pedicled flap without the need for microsurgery and excellent functional outcomes[4,5].

Relative drawbacks are that the donor site scar can widen or become hypetrophic when wide (>12cm) flaps are needed, that large flaps needed in cases of extensive disease extending beyond the axilla might not allow primary donor site closure[5], and that bilateral cases shall be staged in two operations since the patient cannot lie on one flap while being operated in the lateral decubitus for the contralateral axilla[4].

The technique described in this article can overcome these drawbacks in selected cases. Since the disease is systemic, multiple sites are often involved. When advanced stages disease (Hurley II and III) is present in both axillae and a bilateral operation shall be performed, a bilateral DIEAP is an option if there is enough laxity in the abdomen and the lower abdomen is free from disease. This technique shall also be offered as an alternative if a patient prefers a lower abdominal scar over two dorsal/thoracic scars. Although bilateral DIEAP flaps axillary reconstruction involves a microsurgical operations, there are several benefits that outweigh the added complexity in these selected cases. The operation can all be carried out in the supine position with the arms abducted 90 degrees: no patient's position changes are needed. Two teams can work simultaneously: one team performs resection and recipient vessels harvest while the other harvests the DIEAP flap. These two teams work best on contralateral sides (i.e. left axilla, right abdomen), in order not to

interfere with each other, and then exchange sides. The Abdomen is then closed while microsurgical anastomosis for the second flap is being performed. Average operative time with this approach was 324 minutes, which can be acceptable compared to the average 210 reported for a unilateral TDAP[4]. Complication rates are low: the DIEAP flap is a very reliable flap and so are recipient vessels from the subscapular system. The donor site is always closed primarily and the scar does neither widen nor become hypertrophic. Large flaps, up to 15x32cm, can be consistently closed primarily.

A very large unilateral defect was also reconstructed with a DIEAP flap in this series. It was a patient who already had a contralateral reconstruction with a large TDAP with a donor site wound dehiscence due to excess tension requiring prolonged wound care, and an unsightly resulting scar. In this case the contralateral defect (even wider than the first one) was reconstructed with a large bipedicled DIEAP (15x32 cm). We have extensive experience with TDAP flaps as well and large flaps are always difficult to close primarily.

Besides the added complexity, one of the drawbacks of the DIEAP flap in this application is excess thickness when compared to a TDAP flap. In this series, the five unthinned flaps all required tertiary thinning performed by means of liposuction three months after the operation, thus still requiring two operations for a bilateral reconstruction. When primary or secondary thinning was performed, no reoperations for thinning have been required in this series, making this a true one stage technique. In this series, we haven't observed partial or total necroses in thinned flaps. We believe that preserving the superficial veins makes thinning safer in large flaps, although we have no data to prove this.

Suprascarpa's harvest of perforator flaps is an established technique[9,10]. Although it has – to the best of our knowledge – never been reported for a DIEAP flap before, we find it even easier than a TDAP, ALT or SGAP since the vertical fibrous septa are looser and less

numerous, the lobules larger and the perforators constantly of large calibre, thus easy to visualize. The use of angio CT scan allows to visualize perforator course in the subcutaneous tissue preoperatively, providing useful information for dissection.

This study has some weaknesses. It is a retrospective case series with a mixed population and also mixed techniques (12 flaps were thinned primarily, 6 secondarily, 5 Tertiarily). No comparison with other techniques has been reported. However, it is a single surgeon's experience with a long follow-up and consistent results. We believe it can be a useful addition to the reconstructive surgeon's armamentarium for treatment of hidradenitis suppurativa. The safety and reproducibility of bilateral and bipedicled DIEAP flaps has been demonstrated in the past by several authors, and the same holds true for thin flaps[9,10, 12-17]. Thus this is just another application of a well established technique.

CONCLUSIONS

Bilateral cases of Hurley stages I and II hidradenitis suppurativa might be treated in a single stage with thin bilateral DIEAP flaps. The abdominal donor site consistently allows harvest of large flaps while closing the donor site primarily with a linear scar. A Single, bipedicled flap can be used in case of large defects. The added complexity of a microsurgical operation is, in our opinion, outweighed by the ability of performing a single operation or, in unilateral cases, by the ability of closing the donor site primarily.

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FIGURE LEGENDS

1. **Figure 1**: Left. Preoperative view of the right axilla of a 19 year old girl (Case 1, Tables 1 and 2) affected by axillary hidradenitis suppurativa, Hurley Stage III. The disease presents with nodules, fistulae and retractile scars, it extends beyond the axilla in the inner arm and beyond the anterior and posterior axillary lines. Right. Surgical defect after radical excision, deep to the axillary lymphnodes that were partially involved by the disease. The surgical defect measured 16x16cm.

2. **Figure 2**: Left. Preoperative view of the left axilla of the 19 year old girl shown in figure 1, affected by hidradenitis suppurativa, Hurley Stage III. The disease presents with nodules and fistulae that involve the inner arm and extend well beyond the anterior axillary line. Right. Surgical defect after radical excision, deep to the axillary lymphnodes that were partially involved by the disease. The surgical defect measured 14x16cm.

3. **Figure 3.** Intraoperative view of left flap harvest showing the plane of dissection. A needle tip cautery is used. Vertical traction on the flap allows clear visualization of the Suprascarpa's plane. Please note the amount of fat that is left behind, that is likely responsible, as postulated by Saldanha [18] for faster healing, since the fat adheres more and glides less than deep fascia.

4. **Figure 4.** Close-up view of the left DIEAP after completion of pedicle dissection. Note thet, cranially to the perforator, the flap is thicker. After visualization of the pedicle, its branching pattern in the subcutaneous tissue is observed (that can be anticipated based on the preop angioCT). There was a branch going cranially below scarpa's fascia in this case, that has been included together between the fat superficial to it. Dissection around the perforator has to be adjusted to each perforator's anatomy. The green contrast is placed underneath the DIEA and veins. The motor nerve crossing it is visible, intact, on top of the pedicle just distal to the perforator. Dissection is carried out further distal to the perforator for 2cm, in order to provide a stump for eventual venous supercharging, shall this be needed.

5. **Figure 5.** Left flap on table. Upside down. The suture is placed on the lateral corner (left hand side of the picture). Note the homogeneous thinnes on the flap and the thickening cranial to the perforator shown in fig. 4. Please also note the long stump cranial to the perforator as explained in fig. 4.

6. **Figure 6.** Right flap on table. Please note the thinnes of the flap and, again, the additional thickness around the perforators that follows its branching pattern, as explained in figure 4.

7. **Figure 7.** 2 years postoperative frontal view of the axillae with arms abducted. Note the widened scars around the flaps: this patient had a postoperative pyoderma that eventually healed after cortisone therapy.

8. **Figure 8.** Wide Frontal view with arms abducted. The disease is still present in the presternal area and in the groin and labia majora, but it is under control with medical therapy. Please note the excess flap in the left axilla, due to a skin excess. Since the flap is thin and it is just a skin fold, the patient has no functional discomfort and has refused revision. The breast asymmetry was present preoperatively.

Table 1. Patients data.

Patient	Age	Sex	Smoker	Length (cm)	Weight (kg)	Axylla	Recipient vessels
1	19	F	0	176	68	bilateral	Serratus Branch
2	37	M	1	178	90	right	Serratus Branch
3	35	F	1	167	52	bilateral	Serratus Branch
4	38	F	1	167	62	bilateral	Circumflex scapular
5	22	F	1	173	70	bilateral	Serratus Branch
6	32	F	0	162	54	bilateral	Circumflex scapular
7	29	F	0	162	47	bilateral	Serratus Branch
8	44	M	0	173	86	bilateral	Serratus Branch
9	41	F	1	158	62	bilateral	Serratus Branch
10	36	F	1	162	48	bilateral	Circumflex scapular
11	31	F	1	155	51	bilateral	Circumflex scapular
12	30	F	0	171	59	bilateral	Circumflex scapular

Table 2. Results. Thinning is included in the results to give an idea of the secondary operations needed.

Patient	Ischemia time (minutes)	operating time (min)	Hospital stay (days)	Revision/flap necrosis	dehiscence axylla	dehiscence abdomen	Other complications	Recurrence	Primary thinning	Secondary thinning	Tertiary thinning
1	58R, 56L	450	4	0	0	0	pyoderma	0	0	1	0
2	46R, 46L	466	5	0	0	0	0	0	0	0	1
3	48R, 45L	519	4	0	0	1	0	0	1	0	0
4	55R, 42L	485	4	0	0	0	0	0	1	0	0
5	44R, 48L	496	4	0	0	0	0	0	1	0	0
6	53R, 53L	438	3	0	1	0	0	0	0	1	0
7	45R, 42L	325	4	0	0	0	0	1	1	0	0
8	64R, 38L	510	4	0	0	0	0	0	1	0	0
9	58R, 61L	439	5	0	0	0	0	0	0	0	1
10	51R, 43L	592	4	0	0	0	0	0	0	0	1
11	57R, 45L	425	4	0	1	0	0	0	1	0	0
12	?	465	4	0	0	0	0	0	0	1	0

Left. Preoperative view of the right axilla of a 19 year old girl (Case 1, Tables 1 and 2) affected by axillary hidradenitis suppurativa, Hurley Stage III. The disease presents with nodules, fistulae and retractile scars, it extends beyond the axilla in the inner arm and beyond the anterior and posterior axillary lines.

84x127mm (300 x 300 DPI)
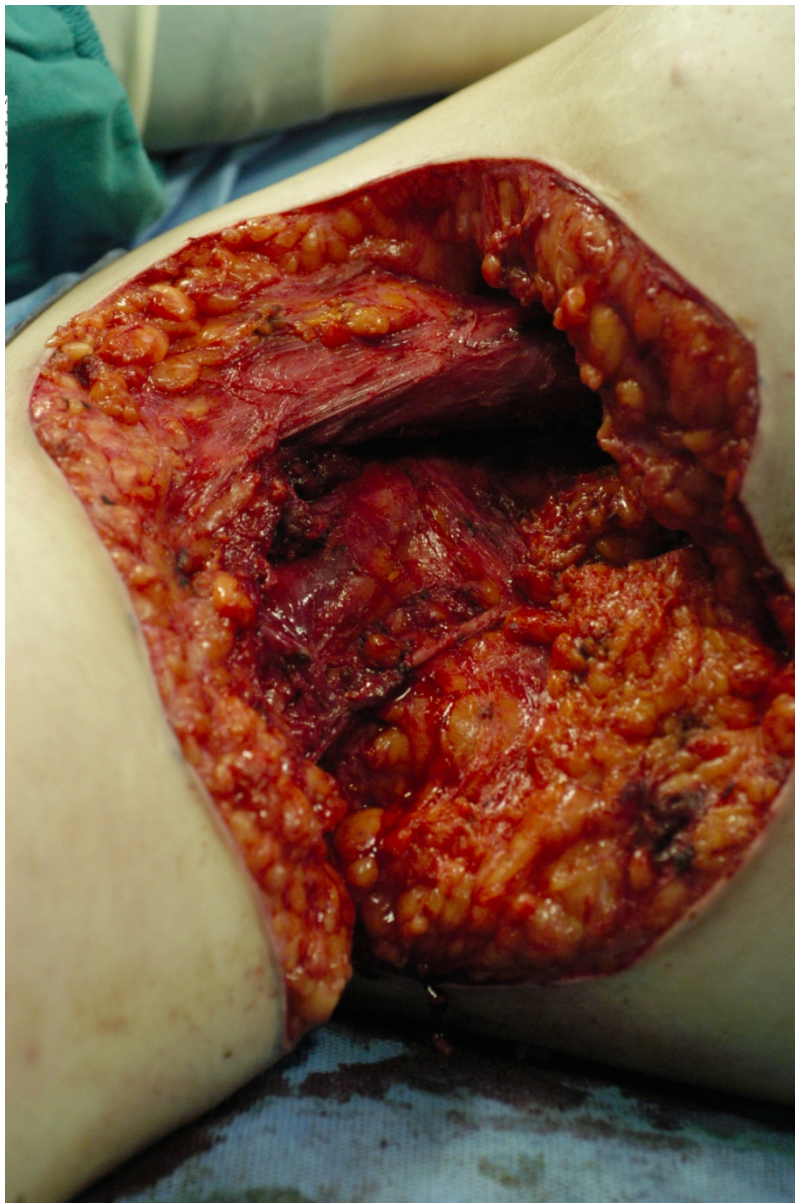
Right. Surgical defect after radical excision, deep to the axillary lymphnodes that were partially involved by the disease. The surgical defect measured 16x16cm.
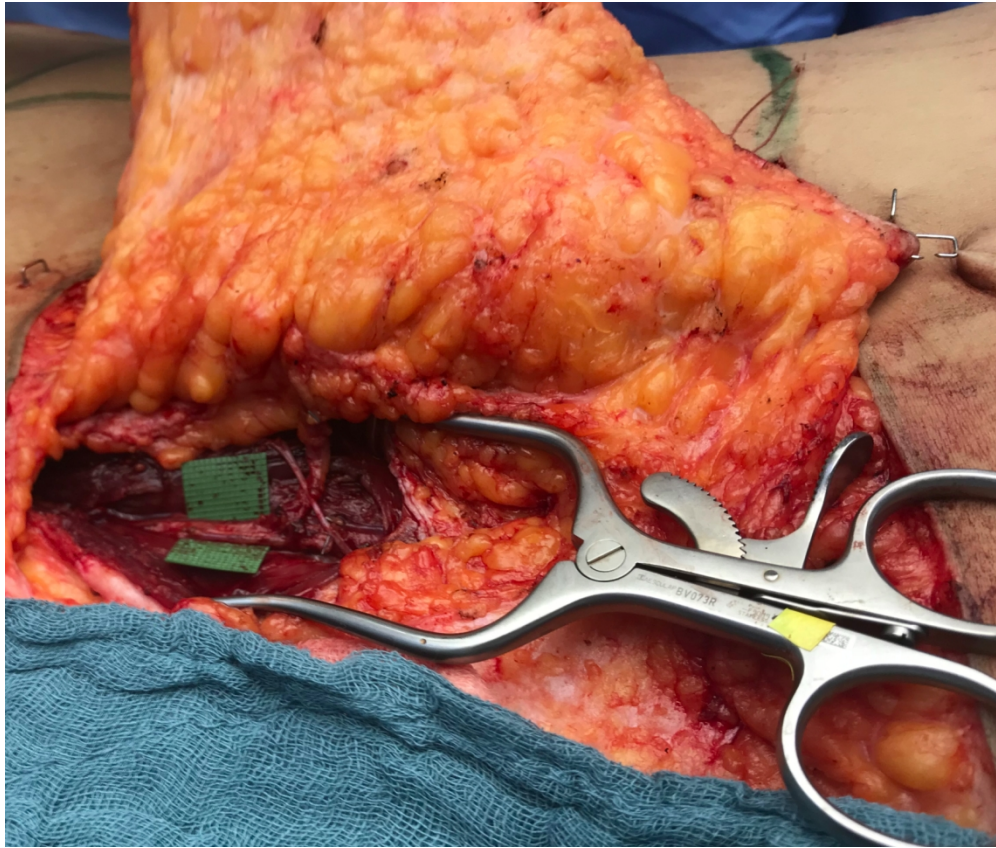
84x127mm (300 x 300 DPI)

Left. Preoperative view of the left axilla of the 19 year old girl shown in figure 1, affected by hidradenitis suppurativa, Hurley Stage III. The disease presents with nodules and fistulae that involve the inner arm and extend well beyond the anterior axillary line.

84x127mm (300 x 300 DPI)

Right. Surgical defect after radical excision, deep to the axillary lymphnodes that were partially involved by the disease. The surgical defect measured 14x16cm.

84x127mm (300 x 300 DPI)

Intraoperative view of left flap harvest showing the plane of dissection. A needle tip cautery is used. Vertical traction on the flap allows clear visualization of the Suprascarpa's plane. Please note the amount of fat that is left behind, that is likely responsible, as postulated by Saldanha [18] for faster healing, since the fat adheres more and glides less than deep fascia.

108x127mm (300 x 300 DPI)

Close-up view of the left DIEAP after completion of pedicle dissection. Note thet, cranially to the perforator, the flap is thicker. After visualization of the pedicle, its branching pattern in the subcutaneous tissue is observed (that can be anticipated based on the preop angioCT). There was a branch going cranially below scarpa's fascia in this case, that has been included together between the fat superficial to it. Dissection around the perforator has to be adjusted to each perforator's anatomy. The green contrast is placed underneath the DIEA and veins. The motor nerve crossing it is visible, intact, on top of the pedicle just distal to the perforator. Dissection is carried out further distal to the perforator for 2cm, in order to provide a stump for eventual venous supercharging, shall this be needed.

150x127mm (300 x 300 DPI)
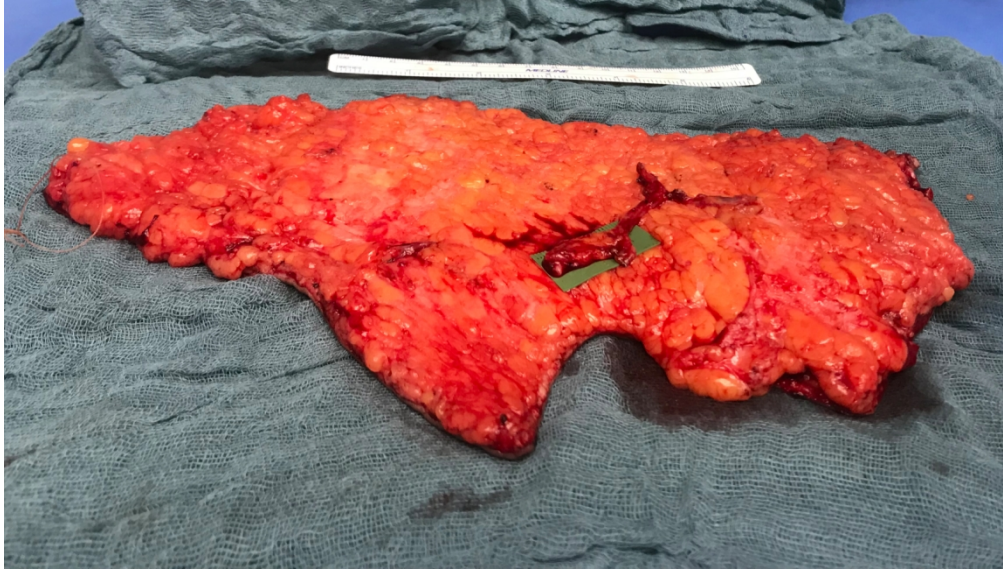
Left flap on table. Upside down. The suture is placed on the lateral corner (left hand side of the picture). Note the homogeneous thinnes on the flap and the thickening cranial to the perforator shown in fig. 4. Please also note the long stump cranial to the perforator as explained in fig. 4.

144x82mm (300 x 300 DPI)

Right flap on table. Please note the thinnes of the flap and, again, the additional thickness around the perforators that follows its branching pattern, as explained in figure 4.

189x127mm (300 x 300 DPI)

2 years postoperative frontal view of the axillae with arms abducted. Note the widened scars around the flaps: this patient had a postoperative pyoderma that eventually healed after cortisone therapy.

191x127mm (300 x 300 DPI)

Wide Frontal view with arms abducted. The disease is still present in the presternal area and in the groin and labia majora, but it is under control with medical therapy. Please note the excess flap in the left axilla, due to a skin excess. Since the flap is thin and it is just a skin fold, the patient has no functional discomfort and has refused revision. The breast asymmetry was present preoperatively.

127x191mm (300 x 300 DPI)