CHAPTER 7.

BREAST RECONSTRUCTION WITH THE SUPERFICIAL INFERIOR EPIGASTRIC ARTERY FLAP

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INTRODUCTION

Autologous breast reconstruction using abdominal tissue has become the gold standard for patients seeking a natural and long-lasting alternative to implant-based reconstruction. Thanks to reliable vascular supply and excellent aesthetic outcomes, the deep inferior epigastric perforator (DIEP) flap nowadays represents the most common abdominal free flap for autologous breast reconstruction. Although the DIEP flap has minimal donor-site morbidity compared to the traditional traverse rectus abdominal muscle flap, it requires meticulous microsurgical dissection of perforators through the rectus abdominis muscle which may increase discomfort, operative time and technical complexity, with consequent weakening of the abdominal wall and increased postoperative pain.

According to these considerations, the superficial inferior epigastric artery (SIEA) flap could become a viable alternative in autologous breast reconstruction due to its ability to preserve the integrity of the rectus abdominis muscle and fascia. Unlike other flaps that involve the deeper abdominal structures, the SIEA flap relies solely on a subcutaneous pedicle, which makes it a muscle-sparing procedure with the potential for reduced donor site morbidity. This flap offers excellent-quality skin and adipose tissue, making it an "ideal" choice for reconstruction with minimal aesthetic and functional compromise at the donor site, and actually improving it by performing an aesthetic abdominoplasty.

Despite its advantages, the SIEA flap presents several challenges that limited its use in the past and still complicate its frequent application in breast reconstruction. It is common belief that the vascular anatomy of what is commonly considered the superficial inferior epigastric artery can be inconsistent, and the artery itself is often small, which may complicate the surgical procedure. Additionally, the pedicle of the flap is thought to be typically shorter, further complicating its dissection and inset. The SIEA artery is also more prone to vasospasm, which can affect blood flow and compromise flap viability.

Other vascular sources, such as the superficial circumflex iliac artery (SCIA), deep circumflex iliac artery and superficial external pudendal artery, supply the abdominal skin, but have less applications in autologous breast reconstruction for their off-center position, which contributes less to vascular supply of the central abdominal bulk. After the enormous popularity achieved by the superficial circumflex iliac perforator (SCIP) flap in recent years, we have gathered extensive experience with this flap, especially with the flap based on the superficial branch of the SCIA (SCIA-SB), for the reconstruction of various body regions. Observing a broad area of perfusion through indocyanine green angiography (ICGA), we decided to explore its application in breast reconstruction.

Our recent findings [1] suggest that a subcutaneous artery, irrespective of its name, can vascularize a sufficient amount of abdominal tissue to adequately reconstruct a breast mound in 100% of cases. Modification of flap design, aided by aesthetic surgical principles and imaging devices such as color-coded duplex sonography (CCDS)

and indocyanine green angiography (ICGA), was fundamental to achieving this goal. Despite these challenges, the SIEA flap can offer a valid reconstructive option with reduced donor-site morbidity and improved post-operative outcomes.
The aim of this chapter is to describe the indications, technical considerations, advantages, and limitations of the SIEA flap, expanding the range of abdominal options available for autologous breast reconstruction.

HISTORICAL OVERVIEW

Even though the SIEA flap is conceptually connected to breast reconstruction, its first clinical applications were described in other anatomical areas; the first mention was in 1863, when Wood used a pedicled SIEA flap to correct a severe burn contracture of the forearm of an 8 year-old girl [2].
In 1946, Shaw and Payne [3] used a pedicled tubed SIEA flap to reconstruct the hand, while in 1971 Antia and Buch [4] were the first to use the SIEA flap in microsurgical reconstruction of head and neck soft tissue, even though unsuccessfully. The first successful free skin flap based on the SIEA pedicle, the ileo-femoral flap, transferred in 1973 by Taylor and Daniel, opened the era of microsurgical transfer of skin flaps [5,6].
The use of free abdominal flaps for breast reconstruction has gained prominence due to the advantageous positioning of the vascular pedicle relative to the excess skin removed during an abdominoplasty, described for the first time for breast reconstruction by Grotting in 1991 [7].
The application of this technique in breast reconstruction has been extensively documented and discussed. However, the SIEA flap has not achieved widespread popularity, largely due to its vascular unreliability. The variability in vessel positioning, caliber, and perfusion potential significantly impacted its consistency and success in clinical practice [8,9].
Nowadays, however, events have occurred that have led to a reconsideration of the inguinal anatomical region: the popularity of the SCIP flap, the spread/improvement of available technologies (ultrasound and ICG) and greater familiarity with small vessels have led to an increased use of these vessels in microsurgery.
In our surgical experience, the DIEP flap has predominantly been the technique of choice for breast reconstruction, and the SIEA flap was rarely considered, except in selected and infrequent cases where the vessel was sufficiently large and reliable. However, we have achieved tangible experience with the SCIP flap for body reconstructions in various anatomical regions.
This experience has led us to realize that there is often no clear distinction between the superficial branch of the superficial circumflex iliac artery (SCIA-SB) and the SIEA, as the definitions of these vessels tend to overlap [10].

ARTERIAL ANATOMY

Since the first studies by Taylor, vessels originating from the femoral artery and coursing cranially in the subcutaneous tissue over the inguinal ligament were shown to exhibit considerable variability (Fig. 1). Although rare reports [11,12] describe the SIEA as running upward and inward towards the umbilicus, most authoritative and frequently cited works on the SIEA claim a clear lateral trajectory for this vessel. In our opinion, this misconception led to attributing part of its unreliability to the SIEA flap.
Seminal works by Taylor [13], Grotting [6], Holm [14], Rozen [15], and Tregaskiss [16] reinforced the concept that the SIEA has a medio-lateral course, rather than a latero-medial one.
Studying the literature, we noted that the SIEA and the SCIA-SB are often used interchangeably. The possibility of the SIEA originating from a common origin or parent vessel with the SCIA has been considered to amount to up to 65% in a landmark article by Taylor and Daniel. For the above-mentioned reasons, the available characterizations of SIEA and SCIA-SB clearly overlap: what some authors call SCIA-SB is being called SIEA by others (Fig. 2A).

VENOUS ANATOMY

The SIEA/SCIA-SB flap benefits from drainage through multiple veins (Fig. 2A-B). Among these, the SIEV is often regarded as the primary drainage for the lower abdominal skin and fat. Typically located in a plane superficial to Scarpa's fascia and

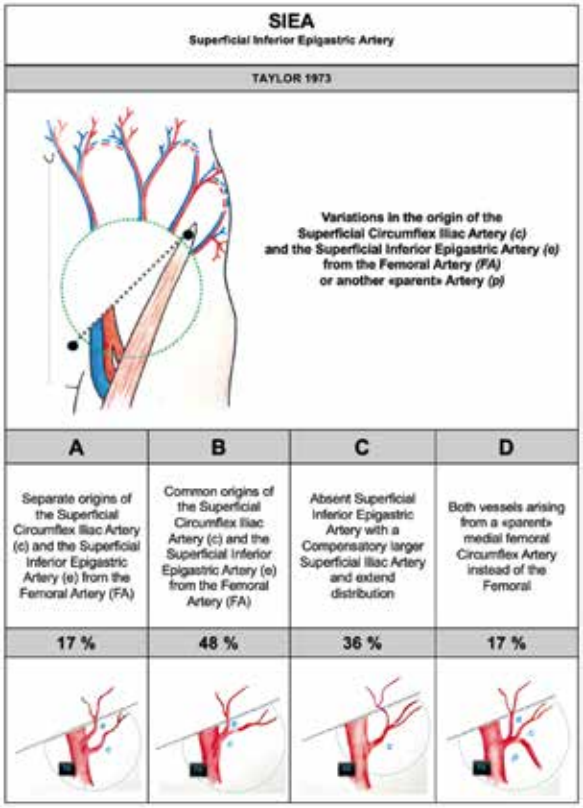

FIGURE 1. Variations in the SCIA and SIEA origins as described by Ian Taylor's publication of 1973, in which he describes the angiosome concept. As he reported in his book "...It also sowed the seeds of one of our forthcoming angiosome concepts: "Vessels have a constant destination, but may have a variable origin.

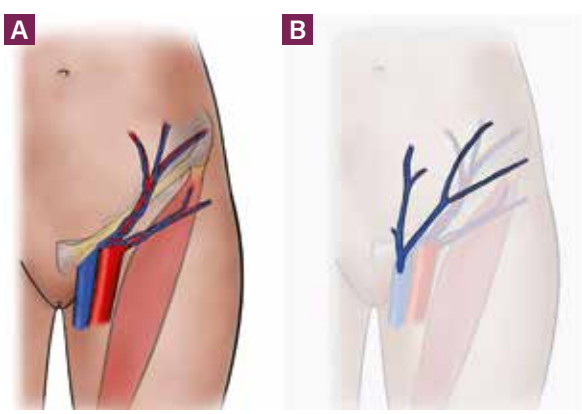

FIGURE 2. (A) Anatomy of the subcutaneous artery and comitant veins; **(B)** Superficial vein anatomy, with the SIEV and SCIV joining into the saphenous bulb.

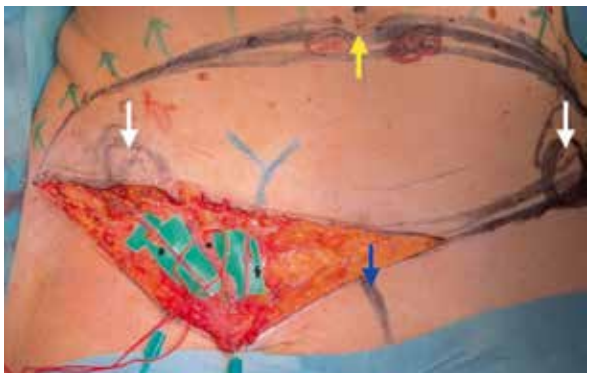

FIGURE 3. Vascular anatomy of the SCIP/SIEA flap. The artery and accompanying veins (*), as well as the SCIV (#) and SIEV (§), are shown emerging from the femoral triangle and proceeding cranially, superficial to the inguinal ligament. White arrows indicate the ASIS, the yellow arrow points to the umbilicus, and the blue arrow marks the midline just cranial to the vulvar cleft. The identified artery (*), according to the literature, may be referred to as either the SIEA or the "superficial branch" (or "medial perforator") of the SCIA. Some authors classify this artery as a perforator, specifically a "direct" or "septo-cutaneous" perforator.

medial to the SIEA, the SIEV lacks accompanying arteries and drains into the saphenofemoral junction. In addition to the SIEV, another key venous drainage route for the flap is through the venae comitantes of the SIEA/SCIA-SB. These veins, closely connected with the artery, usually drain into the superficial circumflex iliac vein (SCIV), SIEV, or less frequently, directly into the common femoral vein. In some cases, the venae comitantes may be anatomically hypertrophic and take over the role of the SCIV, which is typically positioned more laterally. Based on our experience, we strongly recommend ensuring at least two venous drainage pathways between the comitantes, the SIEV and the SCIV, to enhance venous outflow (Fig. 3). We have found that venous congestion is an extremely rare complication with a dual venous drainage system.

FLAP MARKINGS

The patient is marked while standing, and instructed to pull the abdominal skin upward and inward with both hands during the marking process

FIGURE 4. Preoperative marking of the inferior incision of the flap. The patient is asked to pull her abdomen up with both hands. Two lines are drawn, defining the upper margin of the underwear at rest and while pulling upward. The ASIS is marked similarly under traction.

(Fig. 4). This technique helps to position the lower incision low on the abdomen, approximately 7 cm from the pubis, ensuring it remains hidden beneath the underwear. This approach is influenced by the "high lateral tension abdominoplasty" (HLTA) principles, which are commonly applied in aesthetic abdominoplasties [17,18].

In fact, by modifying the standard abdominal flap design, expanding it laterally and keeping it low, we can improve abdominal tissue perfusion, maximizing the amount of tissue vascularized for a satisfying autologous breast reconstruction.

The lower incision should not extend too much into the femoral triangle to avoid excessive removal of lymphatic tissue. The femoral artery's pulsation serves as a crucial anatomical landmark, providing key information: the flap's arterial supply originates here, with the femoral vein located medially to the pulsation and the femoral nerve laterally. The inguinal ligament lies just superior to the pulsation and marks the area where the pulsation fades. While the pubic tubercle is sometimes used as a reference, it is less reliable due to the difficulty in locating it compared to the femoral pulsation.

The anterior superior iliac spine (ASIS) is then marked. The ASIS as a landmark for flap design has its pros and cons. In lean patients, the skin adheres closely to the underlying tissues, making the ASIS easily palpable. However, in patients with higher BMI, the skin above the ASIS becomes more mobile and floating. According to our experience, marking the ASIS while the patient is standing, without manually lifting the skin, is not as effective because gravity causes the abdominal tissues to naturally fall. It is more accurate to mark the ASIS while the patient supports the abdominal tissues with their hands, mimicking the abdominal tension that will occur at the end of the procedure.

Preoperative vessel identification

In the supine position, CCDS is performed using a 6 to 15 MHz linear probe to visualize the subcutaneous arteries running cranially over the inguinal ligament, confirming their inclusion in the flap design (Fig. 5). It is important to identify and mark all vessels con-

FIGURE 5. After marking the inferior incision, on this line, subcutaneous vessels are meticulously mapped. Arteries and veins are then marked on the skin.

tributing to the pedicle, including the artery running cranially from the femoral artery in the subcutaneous layer (SIEA or SCIA-SB) and the veins (comitant veins, SIEV and SCIV). Additionally, CCDS helps to assess whether the vessels have an adequate caliber. While some surgeons use angio-CT, we find it difficult to visualize and interpret small structures, especially those less than one mm in size. Difficulty in clearly identifying by CDDS the artery suggests that the case might be more complex, and a DIEP flap or an alternative might be considered.
The final flap design is adjusted based on the identified vessels and rechecked for symmetry with the patient standing. Since both the SIEA and SCIA-SB typically follow a lateral path, the design extends laterally to maximize the use of adipocutaneous tissue in the flank region, lateral and superior to the ASIS (Fig. 6). This is because the angiosome of the SCIA-SB/SIEA is more robust in the lateral area than in the medial portion. Additional supero-lateral beveling is planned to allow inclusion of more tissue within the flap, helping to reduce the thickness mismatch between the superior and inferior abdominal flaps. Following these steps, especially in thin patients, the flap design is often placed much lower than in a traditional DIEP flap. This means that the design may not extend to the umbilicus in the mid-portion, potentially leaving a small vertical scar along the midline.

FIGURE 6. Typical design of an abdominal flap based on subcutaneous artery. Green markings stand for flap bevelling, which are needed to recruit more tissue into the flap. The angiosome is extended laterally, as marked in this case following the arterial course in the subcutaneous tissue.

FLAP HARVEST

All vascular structures should be marked on the skin before surgery. Identifying them early on will make it easier to protect them, and the rest of the preparation will proceed smoother. There are technical adjustments and tips and tricks to try to overcome all the issues that characterize the SIEA flap. Unfortunately, some of these anatomical features remain insurmountable, such as the caliber and delicacy of the artery on which the flap is based.
The amount of skin that can be removed from the lateral part of the flap is limited in lean patients. In these cases, beveling the flap margins comes into play: if the skin incision is planned to close the donor site, the adipose tissue that can be harvested goes beyond this line. The beveling can be aggressive, leaving 1-2 cm of practically only skin before deepening the incision to reach the deep fascia.
Both arteries and veins encountered during preparation can be fully dissected and perfusion tests performed with indocyanine green (Fig. 7). If perfusion is significantly better by including one more

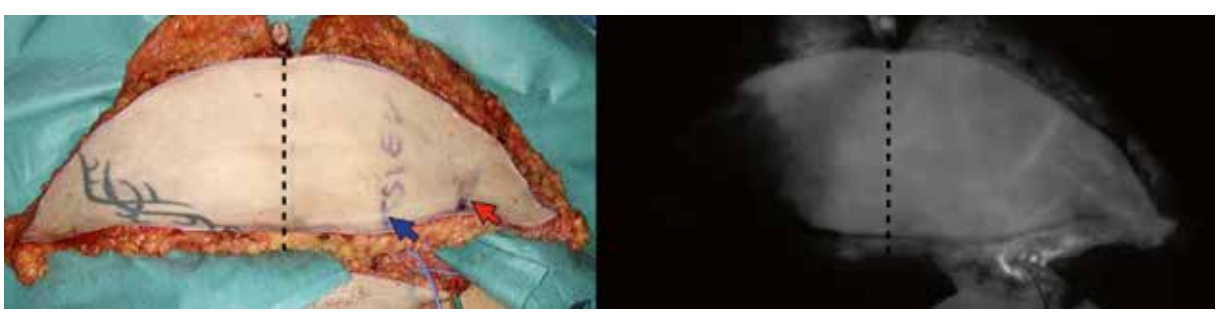

FIGURE 7. ICG angiography of an abdominal flap based on a subcutaneous artery. In most cases, if the artery is not mishandled during harvesting, the angiosome extends beyond the median line.

vein, it will be included, and this is generally the case, especially in lean patients where optimizing available tissues is crucial. The vessels are traced back to the femoral vessels in all cases, trying to minimize lymphatic damage. Even minimal pressure, traction, or desiccation can induce spasm, significantly reducing or eliminating their flow, making it difficult for the surgeon to assess their usability. If the pedicle is mishandled, intraoperative evaluation with ICGA can be severely compromised. During this test, DIEA perforators are temporarily clamped and, lastly, ligated if vascularity of the flap through the subcutaneous pedicle is deemed adequate.

ANASTOMOSIS

In most of cases, arterial and venous mismatch with internal mammary vessels is present. The arterial anastomosis can be performed either to a side branch of the internal mammary artery or to the internal mammary artery itself. When more than a 2 to 1 mismatch is encountered, arterioplasty of the recipient artery is carried out to minimize potential blood flow turbulence (Fig. 8). Flap veins are anastomosed to the antegrade internal mammary vein (IMV). When more than 1 vein anastomosis is required, the larger vein is anastomosed to the antegrade IMV, and the second, smaller vein (e.g., comitant vein or superficial inferior epigastric vein [SIEV] or superficial circumflex iliac vein [SCIV]) is anastomosed to a side branch of the first vein (intraflap anastomosis [19]). The venous anastomoses are always carried out with a coupler device to ensure their patency and handling venous mismatch, which is often encountered.

CONCLUSIONS

The DIEP flap has always been considered the gold standard in breast reconstruction. However, nowadays, thanks to technical considerations and a more accurate understanding of the anatomy of the area, the SIEA flap can be a viable alternative in selected cases. We observed that by modifying the standard abdominal flap design, expanding it laterally, and keeping it low, similarly to the planning of a high lateral tension abdominoplasty, it is possible to optimize the abdominal tissue perfusion (Fig. 9), maximizing the amount of tissue vascularized by subcutaneous vessels (SIEA or SCIA-SB). Although this modified flap design significantly extends the scar toward the lumbar and gluteal regions compared with a traditional DIEP

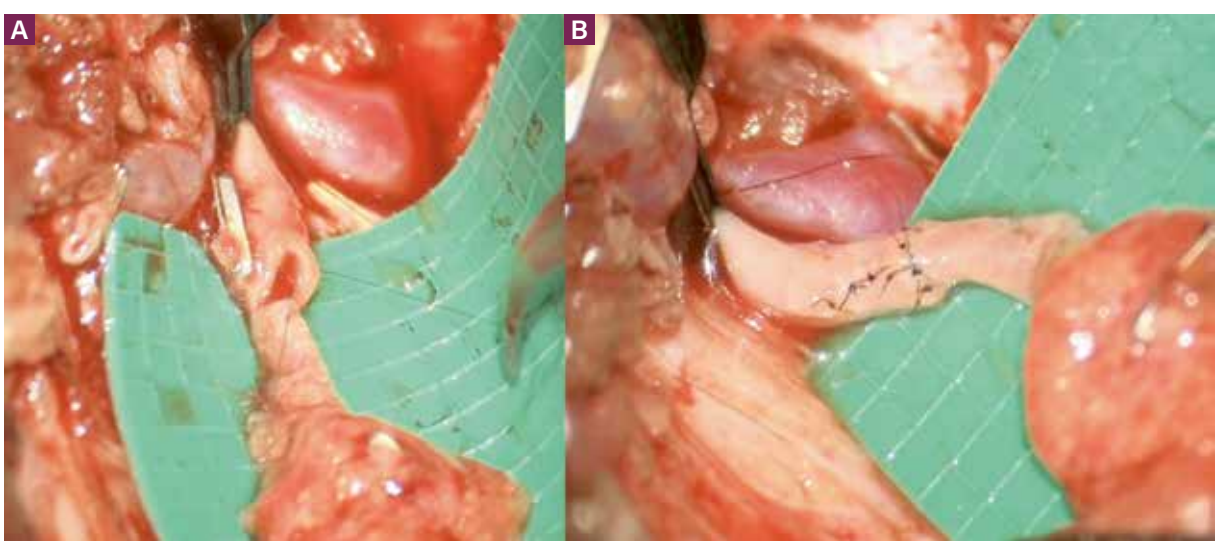

FIGURE 8. Arterioplasty. The arterial anastomosis is completed on the back wall first. When redundancy of the anterior wall is encountered, a wedge excision of the recipient artery is performed as needed **(A)**. The walls are then sutured in a conventional method **(B)**.

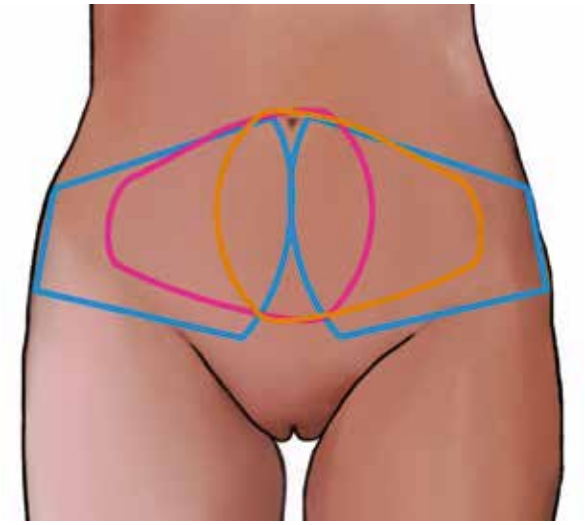

FIGURE 9. Vascular zones served by left and right SCIA-SB/SIEA (blue), right DIEP (pink) and left DIEP (orange). The overlapping of DIEP vascular zones and the maximum optimization of abdominal tissues perfused by subcutaneous pedicles can be noted.

FIGURE 10. Preoperative picture of a patient prior to left nipple sparing mastectomy and immediate reconstruction with an abdominal flap **(A)**. Marking of the vessels on the skin **(B)**. 1-month postoperative picture with monitoring skin island in place **(C)**. 3 months post monitoring skin island removal **(D)**.

flap, it facilitates concealment of the scar beneath the underwear line and the recruitment of enough tissue for breast reconstruction with the proper angiosome (Fig. 10). Even though the SIEA flap is still rarely used for breast reconstruction, we believe in its diffusion in the future.

Key Points & Pitfalls

- The SIEA flap provides a satisfying and aesthetic breast reconstruction with low donor site morbidity in selected cases.
- Abdominal wall anatomy and vascular supply vary greatly between patients.
- The flap is still not that popular because of its variable vascular anatomy, insufficient pedicle length, small vessel diameter and insufficient blood supply for the complete lower abdominal region and it is rarely used for breast reconstruction.
- Clear and collectively recognized definitions in the literature regarding the SIEA and SCIA-SB are still absent, and the definitions mostly overlap.
- Pre-operative imaging and accurate pre-operative planning is mandatory to achieve successful outcomes (Pre-operative Duplex Color Sonography is extremely useful in flap planning).
- In case of intra-operative inappropriate diameters or absent SIEA vessels, we can continue by harvesting a DIEAP flap or *ms*-TRAM flap
- Tips and tricks in preoperative drawing and dissection help to achieve successful breast reconstruction in selected patients ("high lateral tension abdominoplasty" (HLTA).
- Dual venous drainage pathways between the comitantes, the SIEV and the SCIV, enhance venous outflow and reduce venous congestion risk.

References

1. Franchi A, Patanè L, Hummel CE, et al. The Preferential Use of Subcutaneous Arteries (SCIA-SB and SIEA) in Abdominal-based Autologous Breast Reconstruction with a Modified Flap Design. Plast Reconstr Surg Glob Open 2024;12(10):e6252. https://doi.org/10.1097/GOX.0000000000006252
2. Wood J. Case of Extreme Deformity of the Neck and Forearm, from the Cicatrices of a Burn, cured by Extension, Excision, and Transplantation of Skin, adjacent and remote. Med Chir Trans 1863;46:149-159. https://doi.org/10.1177/095952876304600114
3. Shaw DT, Payne RL Jr. One stage tubed abdominal flaps; single pedicle tubes. Surg Gynecol Obstet 1946;83:205-209.
4. Antia NH, Buch VI. Transfer of an abdominal dermo-fat graft by direct anastomosis of blood
5. vessels. Br J Plast Surg 1971; 24(1):15-19.
6. Taylor GI, Daniel RK. The free flap: composite tissue transfer by vascular anastomosis. Aust N Z J Surg 1973;43(1):1-3. https://doi.org/10.1111/j.1445-2197.1973.tb05659.x
7. Franchi A, Patanè L, Bolletta A. The Taylor First Free Flap and the Groin Flap: a Historical Clarification. Plast Reconstr Surg Glob Open 2024;12(10):e6256. https://doi.org/10.1097/GOX.0000000000006256
8. Grotting JC. The free abdominoplasty flap for immediate breast reconstruction. Ann Plast Surg 1991;27(4):351-354. https://doi.org/10.1097/00000637-199110000-00011
9. Sarik JR, Bank J, Wu LC, et al. Superficial inferior epigastric artery: learning curve versus reality. Plast Reconstr Surg 2016;137:1e-6e.
10. Selber JC, Samra F, Bristol M, et al. A head-to-head comparison between the muscle-sparing free TRAM and the SIEA flaps: is the rate of flap loss worth the gain in abdominal wall function? Plast Reconstr Surg 2008;122:348-355.
11. Franchi A, Patanè L, Hummel CH, et al. Confusion Regarding the Anatomy of the Superficial Inferior Epigastric Artery and the Superficial Circumflex Iliac Artery Superficial Branch. Plast Reconstr Surg Glob Open 2024;12(4):e5714. https://doi.org/10.1097/GOX.0000000000005714
12. Wood J. Case of Extreme Deformity of the Neck and Forearm, from the Cicatrices of a Burn, cured by Extension, Excision, and Transplantation of Skin, adjacent and remote. Med Chir Trans 1863;46:149-159. https://doi.org/10.1177/095952876304600114
13. Fuse Y, Yoshimatsu H, Karakawa R, et al. Novel classification of the branching patterns of the superficial branch and the deep branch of the superficial circumflex iliac artery and the superficial inferior epigastric artery on computed tomographic angiography. J Reconstr Microsurg 2022;38:335-342.
14. Taylor GI, Daniel RK. The anatomy of several free flap donor sites. Plast Reconstr Surg 1975;56(3):243-253. https://doi.org/10.1097/00006534-197509000-00001
15. Holm C, Mayr M, Höfter E, et al. The versatility of the SIEA flap: a clinical assessment of the vascular territory of the superficial epigastric inferior artery. J Plast Reconstr Aesthet Surg 2007;60(8):946-951. https://doi.org/10.1016/j.bjps.2005.12.066
16. Rozen WM, Chubb D, Grinsell D, et al. The variability of the Superficial Inferior Epigastric Artery (SIEA) and its angiosome: a clinical anatomical study. Microsurgery 2010;30(5):386-391. https://doi.org/10.1002/micr.20750
17. Tregaskiss AP, Goodwin AN, Acland RD. The cutaneous arteries of the anterior abdominal wall: a three-dimensional study. Plast Reconstr Surg 2007;120(2):442-450. https://doi.org/10.1097/01.prs.0000267414.66623.6e
18. Lockwood T. High-lateral-tension abdominoplasty with superficial fascial system suspension. Plast Reconstr Surg 1995;96:603-615.
19. Rosenfield LK. High tension abdominoplasty 2.0. Clin Plast Surg 2010;37:441-465.
20. Franchi A, Patanè L, Gogh B, et al. Summarizing the advantages of the intraflap versus cranial-caudal anastomoses in stacked free flap breast reconstruction. Arch Plast Surg 2024;51:441-444.