



A systematic review of donor site aesthetic and complications after deep inferior epigastric perforator flap breast reconstruction

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Background: The deep inferior epigastric perforator flap (DIEP) has gained widespread popularity in autologous breast reconstruction due to its natural aesthetic results and muscle-sparing design. However, donor site results regarding aesthetic outcome are often less favorable. Despite several studies on surgical technique and improvements of flap harvest, only a small number of studies addressing donor site aesthetic exist.

Methods: A systematic review was performed on donor site aesthetic after DIEP flap harvest according to the PRISMA guidelines. Secondary interests were abdominal wall morbidity and complication rates in general. The following electronic databases were included to identify relevant studies: Medline, Embase, PubMed, Cochrane, and Web of Science.

Results: The search yielded 95 articles for full-text analysis, with only four key studies found on donor site aesthetic specifically. Regarding complication rates, the overall rate of abdominal hernia ranges from 0 to 7.1%. Abdominal bulging occurs in 2.3% to 33%. Besides abdominal wall integrity, wound dehiscence (12–39%), seroma (1–48%), hematoma (1–15%), infections (1–12%), fat necrosis (0–11%) and umbilical necrosis (2–3%) significantly impair donor site aesthetic.

Conclusions: This systematic review reveals that the topic of donor site aesthetic and potential improvement of results has largely been neglected in the past decade. This study provides a thorough evaluation of potential problems that plastic surgeons may encounter and includes recommendations to improve results.

Keywords: Breast neoplasms; mammoplasty; mastectomy; postoperative complications

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Introduction

The deep inferior epigastric perforator flap (DIEP) has become a widely performed method for breast reconstruction in the past decade due to its assumed low donor site morbidity and natural aesthetic results (1-3). However, even though morbidity of the abdominal muscular wall itself tends to be lower compared to the harvest of a

transversus rectus abdominis muscle flap (TRAM) (4-6), the aesthetic of the abdominal donor site are often a cause of dissatisfaction (*Figure 1*) (7). The resulting long transverse scar is frequently placed relatively high on the abdomen or appears to “migrate” up during the postoperative course, making it visible and difficult to hide by undergarments (8). Since DIEP flaps are increasingly performed in less suited patients resulting in closure of the donor site under tension,

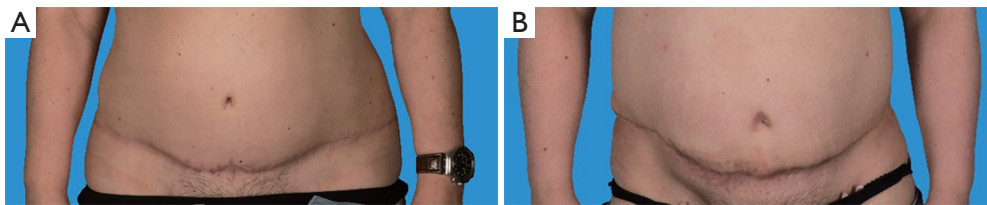


Figure 1 The abdominal donor-site is shown in patients after breast reconstruction with DIEP. Photographs were taken 12 months postoperatively. The scar can either be acceptable and located in the lower part of the abdomen (A) or asymmetrical and show a visible step-off, hypertrophy, bulging and dog ears (B). DIEP, deep inferior epigastric perforator.

wound healing complications have the tendency to occur more frequently (9). In addition, scars may be hypertrophic, atrophic, widened, retracted or asymmetrical and visible lateral fat depots or dog-ears may result. A number of patients also report pain in the scar area when wearing tight pants, belts etc.

To overcome those unfavourable donor site results some authors proposed to routinely perform aesthetic revision surgery on the abdominal scar during breast touch-up procedures (fat grafting, nipple-areola reconstruction, etc.) during the second stage of breast reconstruction (8). Others have designed a lower DIEP pattern, which may be associated with a higher flap complication rate due to the necessity to choose low and potentially not optimal perforators (10) or to include higher perforators by skin undermining (11).

However, so far only little attention has been given to the aesthetic aspect of the DIEP donor site, since the understanding of less-invasive, and thus more tedious harvesting techniques were the main focus of reconstructive surgeons in the past decade. After establishment of these concepts, the focus must change given the fact that the number of breast reconstructions increases and the patients' expectations rise.

Based on this, the aim of this study was to identify crucial factors influencing donor site aesthetic and evaluate present recommendations for donor site improvement by performing a systematic review of the existing literature. A secondary goal was to evaluate the morbidity of the abdominal wall and donor site complications after a DIEP flap harvest.

Methods

We performed a systematic review in accordance to the PRISMA guidelines (12) (*Table 1*). A review protocol was designed and registered on PROSPERO, the

international prospective register of systematic reviews http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018083859.

Study selection

A literature research was conducted on November 6th 2017 using the following databases: Medline, Embase, PubMed, Cochrane, and Web of Science. Language was restricted to English, German and French. For search terms and details of the systematic review, see the Appendix (*Table S1*).

Inclusion and exclusion criteria

All studies on aesthetic and complications of the donor site after DIEP flap harvest for breast reconstruction were included in a qualitative analysis. Clinical studies on other topics related to breast reconstruction, e.g., breast reconstruction with other flaps or with silicone implants were excluded. Reviews and experimental research (i.e., anatomical/experimental studies and animal studies) were not considered eligible.

Data selection

Concrete reviews of abstracts were performed by two authors independently to select potentially eligible studies. A full-text review of potentially relevant studies was performed with independent assessment of eligibility. Disagreement between the reviewers concerning the inclusion of particular studies was resolved through discussion with the third author.

Data collection process

Studies on the aesthetic outcome of the abdominal donor site after DIEP flap harvest were included in chronological

Table 1 Systematic review

Criteria	Definition
Eligibility	Studies on donor site morbidity and aesthetic after breast reconstruction with DIEP flap
Exclusion	Reviews, experimental studies, meeting abstracts, editorials, case reports
Literature search	The search was conducted on November 6th, 2017 in 5 libraries (Cochrane, Embase, Medline, PubMed, Web of Science)
Study selection	Two independent reviewers (NL/LG) included relevant studies by title and abstract. The full text of potentially eligible studies was retrieved and independently assessed for eligibility. Disagreement between the reviewers was resolved through discussion with an additional reviewer (JF)
Data collection	<p>Studies evaluating or describing techniques to improve donor site aesthetic were included for detailed analysis and data extraction (key articles). A narrative synthesis of each key article is provided. In addition, articles describing donor site morbidity in general or with respect to functional impairment (hernia, bulging, etc.) after DIEP flap harvest were evaluated.</p> <p>Inclusion criteria were as follows: (I) full-length article that provided data about aesthetic results after DIEP flap harvest, (II) full-length articles that provided sufficient data about donor site morbidity and/or complications, (III) prospective or retrospective trials, (IV) case series, (V) articles that provided a brief definition of outcome variables. Exclusion criteria were: (I) incomplete or insufficient data, (II) full text not in English, (III) case reports, review articles or letters to the editor</p>
Outcomes of interest	
Primary	Donor site aesthetic after DIEP flap harvest
Secondary	Complications and functional impairment of the abdominal wall after DIEP flap harvest

Table 2 Key studies on donor site aesthetic

Author, year	Study design/procedure	N	Main results
Akita <i>et al.</i> 2015	Retrospective study	23	Distance between umbilicus and scar
	Group I: low-rise scar DIEP/SIEA		I: 4.4±0.7 cm
	Group II: conventional DIEP		II: 8.4±0.7 cm
Eom <i>et al.</i> 2016	Retrospective study	43	Complications
	Group I: low SIEA/DIEP		I: 52 % (30% venous congestion)
	Group II: conventional DIEP		II: 13 %
Niddam <i>et al.</i> 2014	Retrospective study	50	Questionnaire on aesthetic result: 52% happy to very happy
	Conventional DIEP		Distance between umbilicus and scar: 8.8 cm
Stalder <i>et al.</i> 2015	Prospective clinical study	51	Distance scar lowered 5.93±0.77 cm
	Secondary abdominal donor-site revision		Complications 0%

DIEP, deep inferior epigastric perforator; SIEA, superficial inferior epigastric artery.

order for detailed analysis and data extraction. With regard to studies on the aesthetic outcome of the donor site key studies were defined of which a narrative synthesis is included in the results section (*Table 2*). Studies reporting the functional morbidity of the abdominal wall and complications are summarized in *Tables 3,4*.

The parameters for data extraction were the following: number of patients, follow-up time, abdominal bulging, abdominal hernia, wound dehiscence, seroma, hematoma, infection, fat necrosis and umbilical necrosis. Two reviewers independently assessed the parameters and disagreements were resolved as previously discussed.

Table 3 Abdominal wall morbidity

Author, year	Study design	N	Mean follow-up (range)	Bulging	Hernia
Ingvaldsen <i>et al.</i> 2017	Prospective clinical study ^a	14	23.5 months (19–26 months)	NA	1 (7%)
Mennie <i>et al.</i> 2015	Retrospective chart review	5,144	30 months (28–37 months)	NA	63 (1.2%) ^c
Shubinets <i>et al.</i> 2016	Retrospective chart review	3,366	NS	NA	62 (1.8%) ^c
Uda <i>et al.</i> 2016	Prospective clinical study ^a	67	6	6 (9%)	NA
Tomouk <i>et al.</i> 2017	Retrospective chart review ^e	130	18	3 (2.3%)	4 (3.1%)
Futter <i>et al.</i> 2000	Prospective clinical study ^f	23	19	7 (33%)	0 (0%)

NA, not assessed; NS, not specified. ^a, assessment by pre- and postoperative abdominal CT; ^c, assessed as number of hernia repairs; ^e, reported by clinical examination; ^f, data reported by survey.

Table 4 Donor site complications

Author, year	Study design	N	Mean follow-up (range)	Wound dehiscence	Seroma	Hematoma	Infection	Fat necrosis	Umbilical necrosis
Tomouk <i>et al.</i> 2017	RCR	130	18 months	25 (19%)	63 (48%)	3 (2.3%)	5 (3.8%)	14 (11%)	NA
Ricci <i>et al.</i> 2017	RCR	868	NS	NA	NA	NA	NA	NA	29 (3.3%)
Mirzabeigi <i>et al.</i> 2015	RCR	332	NS	46 (14%) ^d	NA	NA	NA	NA	NA
Scheer <i>et al.</i> 2006	RCR	84	NS	NA	3 (3.6%)	1 (1.2%)	5 (6%)	NA	2 (2.4%)
Xu <i>et al.</i> 2009	RCR	113	12.4 months (6–54 months)	NA	1 (0.9%)	0 (0%)	3 (2.7%)	0 (0%)	0 (0%)
Hofer <i>et al.</i> 2007	RCR	159	21.6 months (3.6–51.6 months)	16 (12.2%)	NA	2 (1.2%)	1 (0.8%)	NA	NA
Garvey <i>et al.</i> 2006	RCR	96	15.2 months (3.1–35.1 months)	37 (38.5%) ^f	14 (14.6%) ^e	14 (14.6%) ^e	11 (11.5%)	NA	NA

RCR, retrospective chart review; NA, not assessed; NS, not specified. ^d, assessed as delayed wound healing >30 days; ^e, assessed as seroma and hematoma; ^f, assessed with skin necrosis.

Outcomes of interest

The primary interest of this study was to evaluate the aesthetic outcome of the donor site after DIEP flap elevation. The secondary outcomes were functional impairment of the abdominal wall and general complications after DIEP flap harvest.

Results

Search result

The systematic search yielded 1,472 discrete articles. After deduplication and following review of title and abstract, 95 articles were included in full-text review. The detailed

selection process is shown in *Figure 2*.

Donor site aesthetic

Only a very small number of studies specifically focusing on the aesthetic aspect of the abdominal donor site after DIEP flap harvest were found in the review process. Based on this, four key studies were identified (*Table 2*). One review article of a single surgeon on donor site aesthetic was screened, but not included as a key study based on the exclusion criteria (13).

In 2014, Niddam *et al.* investigated patient satisfaction with the abdominal result after breast reconstruction with a single DIEP flap (7). Fifty patients were included in the

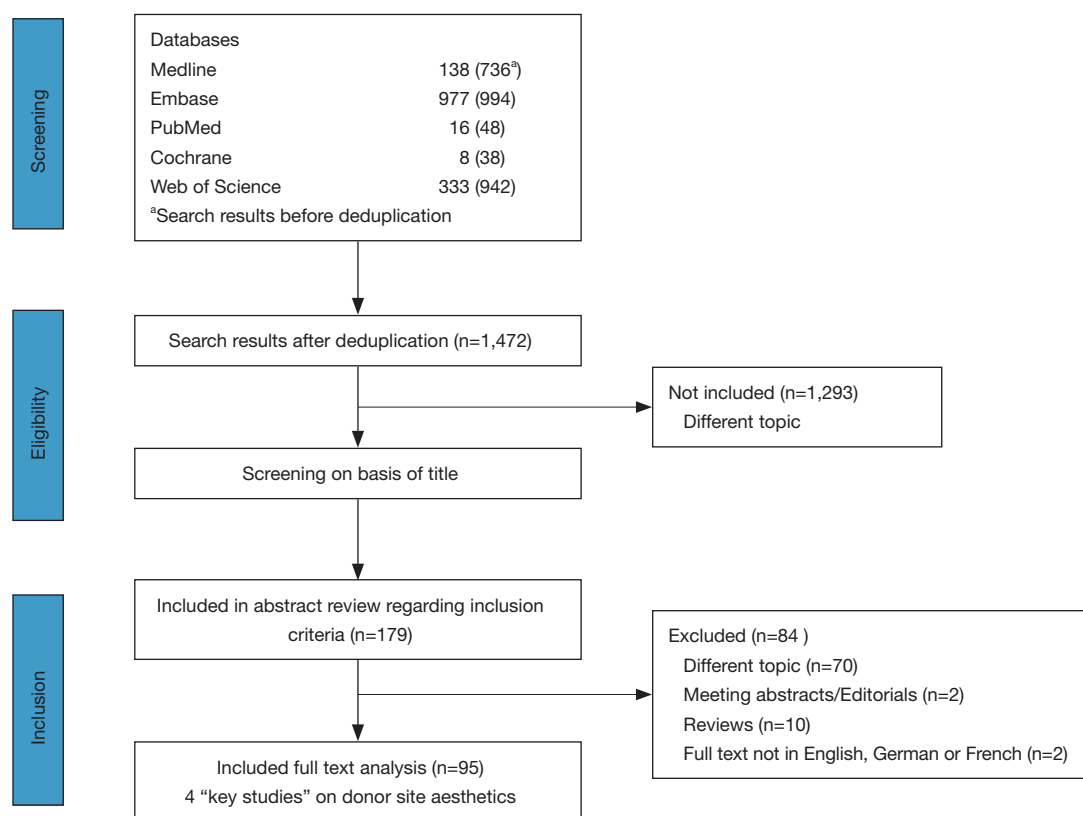


Figure 2 Systematic review.

study and seen in consultation by a senior surgeon (not the operator) for a semi-directive interview and standardized questionnaire. The most prominent area of concern for the patients were lateral dog-ears, which were present in 50% of the cases. In 40% of the cases, the abdominal scar could not be hidden by undergarments. Patients frequently complained about the loss of sensibility of the abdominal wall in 44% of the cases. Nevertheless, 70% of the patients reported to be either happy or very happy with the appearance of the scar. The final scar was measured to be about 10.6 cm above the commissure. The revision rate to improve the aesthetic results of the abdominal donor site, such as scar or dog-ear revision, was 46% in. The author states that his technique includes a double-strand suture of the rectus fascia without opposite plicature which might result in a lateral displacement of the umbilicus that needs to be revised during a second operation. Given the high patients' concern regarding dog-ears, they further recommend to approximate the skin edges from lateral to medial.

In 2015, Akita *et al.* proposed a new design with a low-

rise scar for DIEP flap harvest in effort to improve donor site aesthetic (11). In this technique, the skin island is caudally located with a narrow vertical width regardless of the location of dominant perforators. A larger amount of adipose tissue is elevated to obtain enough volume for breast reconstruction and the skin is cranially undermined in order to harvest the dominant perforator, which was not in the area of the skin paddle in 9/12 cases in the study. They found that the distance between the umbilicus and donor site scar was significantly reduced in the low-rise DIEP group compared to standard DIEP (4.4 versus 8.4 cm) and the scar length significantly shorter. They reported that no vascular thrombosis or partial skin or fat necrosis occurred. However, with this technique an additional vertical scar in the midline resulted at the site where the umbilicus was excised.

In a similar approach, Eom *et al.* proposed a low DIEP flap in 2016 (10), which differs from the low-rise DIEP flap with respect to perforator selection. In this technique, a perforator always at the level of the low skin island was selected, and no flap undermining to include a potential

dominant perforator further cranial was performed. The perforator was either a dominant perforator that was located lower than usual or a second dominant perforator that seemed to be able to nourish the whole flap. When compared to conventional DIEP flaps, all early complications occurred in the low DIEP flap group. Venous congestion requiring surgical intervention occurred in 30.4% of the cases and flap loss rate was 4.3%. Direct closure without umbilical repositioning was possible in most cases. The scar was 1–2 cm above the pubic rim and concealed by underwear in all cases. The pedicle was approximately 4 cm shorter than in a conventional flap. Based on this, the authors proposed to use the low DIEP flap when there is a dominant perforator more than 4 cm below the umbilicus or when there is second dominant perforator more than 4 cm below the umbilicus that is still large enough to nourish the whole flap. In addition, they proposed that if the low DIEP flap is based on a small perforator in the lower abdomen, venous supercharging with a superficial vein should be performed.

In 2015, a different approach by Stalder *et al.* recommended a two-step approach to achieve satisfying donor site results after DIEP flap harvest (8). They performed abdominal revision surgery on all patients during the second stage of breast reconstruction three months after the initial operation. During the procedure liposuction was performed to reduce the thickness of the cranial flap and fat depots on mons pubis or flanks. The scar was lowered to a point 4 to 7 cm from the commissure of the labia majora, depending on the stature of the patient. The umbilical stalk was transected during cranial flap mobilization, and the umbilicus raised as part of the superior abdominal flap. Any residual fascial defect was closed and the umbilicus relocated inferiorly and anchored to the fascia. If rectus diastasis is present, the fascia was plicated at this time to further improve the abdominal contour. The authors claim that the described technique for lowering the donor-site scar consumes 27 minutes on and provides reproducible, aesthetically pleasing results without wound healing problems.

In summary, a surprisingly low number of studies have been published up to date that are primarily concerned with the aesthetic improvement of the abdominal donor site after DIEP flap harvest.

Functional morbidity of the abdominal wall

As a secondary interest outcome, we evaluated studies

reporting functional donor site morbidity (*Table 3*). Functional donor site morbidities may include reduced abdominal strength, abdominal pain, and abdominal bulging or hernia. Based on the included studies, the overall rate of abdominal hernia ranges from 0 to 7% for DIEP flap procedures (2,14–17). Regarding abdominal bulging, the overall incidence seems to be even higher, ranging from 2.3% to 33% (2,16,18). However, the validity of these reported rates is limited by the different study designs (retrospective chart review *vs.* prospective study based on questionnaires) as well as the fact that several studies do not differentiate between abdominal bulging and hernias (2). Regarding abdominal strength, Uda *et al.* could observe a complete recovery of abdominal muscle function at 6 months postoperatively.

General complications

Abdominal wound complications can be a significant cause of postoperative morbidity after DIEP flap harvest. Studies showing the results of general donor site complication are summarized (*Table 4*). These include wound dehiscence, that occurs in 12% to 39% (16,19–21), as well as seroma (1–48%) (16,21–23) and hematoma (1–15%) (16,20–22). Furthermore infections (1–12%) (15,16,21–23), fat necrosis (0–11%) (16,23) and umbilical necrosis (0–3%) (22–24) might significantly impair the donor site appearance.

Discussion

Since it was first introduced nearly 20 years ago, the DIEP flap has become a popular technique for autologous breast reconstruction (3,25). While it became clear that the aesthetic results regarding the restoration of the breast with soft natural tissue are usually excellent and aesthetically pleasing (26), the appearance of the abdominal donor site remains a factor of dissatisfaction for patients and plastic surgeons alike (8). Microsurgical reconstruction of the breast has become a very safe and reliable method in the hands of the experienced surgeon and much attention has been given to successful results. In marked contrast to this stands the still largely neglected appearance of the donor site, which is usually expected to be tolerated by the patients.

Patients often choose breast reconstruction with an abdominal flap as they desire an improvement of the abdominal contour and the additional benefit of an abdominoplasty “for free” (7). However, this is often not

the case. On the other hand, cosmetic abdominoplasty has also been associated with a high incidence of patient dissatisfaction and litigation for surgeons (27) and has a revision rate between 14–43% in literature (28,29). Stewart *et al.* analyzed 278 consecutive abdominoplasties and found dog-ears in 12%, localized fat excess in 10%, and unsatisfactory scars in 8% (30). Salgarello *et al.* reported in a meta-analysis of complications after DIEP flap harvest *vs.* elective abdominoplasty, that seroma was present in significantly more patients after abdominoplasty (16.1%) when compared to DIEP flap harvest (3.7%) (31). Given this relatively high proportion of unfavorable results after cosmetic abdominoplasty, the undesirable appearance of the donor site after DIEP flap harvest which involves an additional incision of the rectus fascia is not surprising. It is also not clear, which role functional abdominal morbidity plays in donor site aesthetic and wound healing. Certainly, the presence of additional bulging or even hernia will not improve aesthetic results after DIEP flap harvest.

The DIEP flap has increasingly replaced the free TRAM flap for breast reconstruction because it has been shown to shorten inpatient hospital stays, cause less postoperative pain and fewer donor site morbidities (15,32) especially regarding abdominal wall integrity. Although the DIEP flap contains less rectus muscle than a TRAM flap, harvest of the perforating vessel and the inferior epigastric artery may however still cause dysfunction of the abdominal wall and damage to the intercostal nerves through crossing of the vessels during harvest (33,34). The resulting contour of the abdominal wall is not only determined by abdominal bulging and hernia, but can also be significantly impaired by a visible step-off above the scar caused by difference in flap thickness, lateral dog-ears, lateral fat accumulations, sagging or bulky appearance of the mons pubis as well as displacement of the umbilicus. In order to improve donor site aesthetic, Tillet and Wilson observed a reduction of 26.2% in abdominal wound healing complications after the introduced a new regime of abdominal closure involving three layers of Monocryl to close the skin and subcutaneous tissues, with either the senior author supervising a senior trainee or performing the procedure himself (35). This dramatic reduction in complications indicates that donor site closure should not be taken lightly.

Local wound complications are an additional crucial factor that will determine the aesthetic outcome. Although local complication rates of the donor site show a wide range which is mainly due to the heterogeneity of included studies, a wound dehiscence at the donor site tends to be the

most frequent local complication and especially accounts for an impaired aesthetic outcome. In this context, Mirzabeigi *et al.* observed an association of delayed wound healing with obesity, smoking, bilateral reconstruction and preoperative chemotherapy (19).

We have experienced, that besides the appearance of the scar, i.e., color, hypertrophy/atrophy, retraction, and widening, the localization of the scar and thus the possibility to hide the scar by undergarments is crucial regarding the final aesthetic outcome. In this context, the authors have observed that the scar is often intentionally placed low on the abdomen and still appears to move cranially in the healing process. One reason for this may be the actual tension on the skin, under which the donor site is closed. Since skin is stretchable and will adapt, the relatively soft skin on the mons pubis may yield to the cranial pulling forces and the scar will migrate cranially. Thus, cautious patient selection and donor site closure with as little tension as possible is important. In the authors experience, typically, patients with a normal to slightly elevated BMI and local fat deposition in the lower abdomen and some skin laxity may be the best candidates. In addition, previous pregnancies seem to have a positive influence on perforator perfusion and thickness.

Given the small number of studies dealing with the aesthetic aspect of the donor site, only a few recommendations for improvements of the donor site exist. These include plicature of the opposite rectus fascia and fixation of the umbilicus to the fascia to prevent any lateral displacement, either during the initial operation (7) or secondary as proposed by Stalder *et al.* (8). Based on the authors experiences, a very low scar about 5–7 cm above the commissure of the labia majora (Figure 3) and meticulous donor site closure in three layers, as proposed by Tillet and Wilson, has proven its worth in terms of wound healing and scar localization. Special attention should also be given to exactly mark the midline from the xiphoid to the labial commissure and secure the markings at the beginning of the operation with staplers.

Regarding abdominal wall morbidity, the incision of the fascia to harvest the perforator vessel should be as short as possible (Figure 4) and motor branches of the intercostal nerves should be preserved. The design of a low-rise scar DIEP is reasonable in terms of scar localization but marred by its increased incidence of local complications and venous congestion (10,11). Nevertheless, the performance of secondary corrections as proposed by Stalder *et al.* during the second step of breast reconstruction remains a valuable option to further improve the aesthetic result (8).

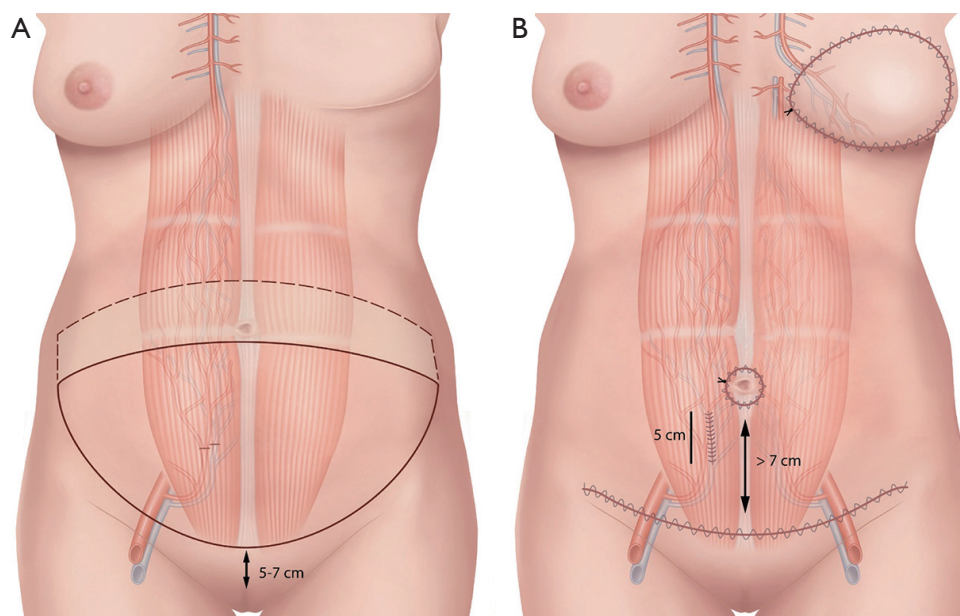


Figure 3 Recommendations for DIEP flap harvest. (A) Preoperative flap design with a low scar 5–7 cm above the anterior vulva commissure. Cranially, the flap can be undermined in order to keep the incision low and to gain more volume; (B) the fascia incision should be kept as small as possible and the umbilicus should be located at least 7 cm above the final scar. DIEP, deep inferior epigastric perforator.

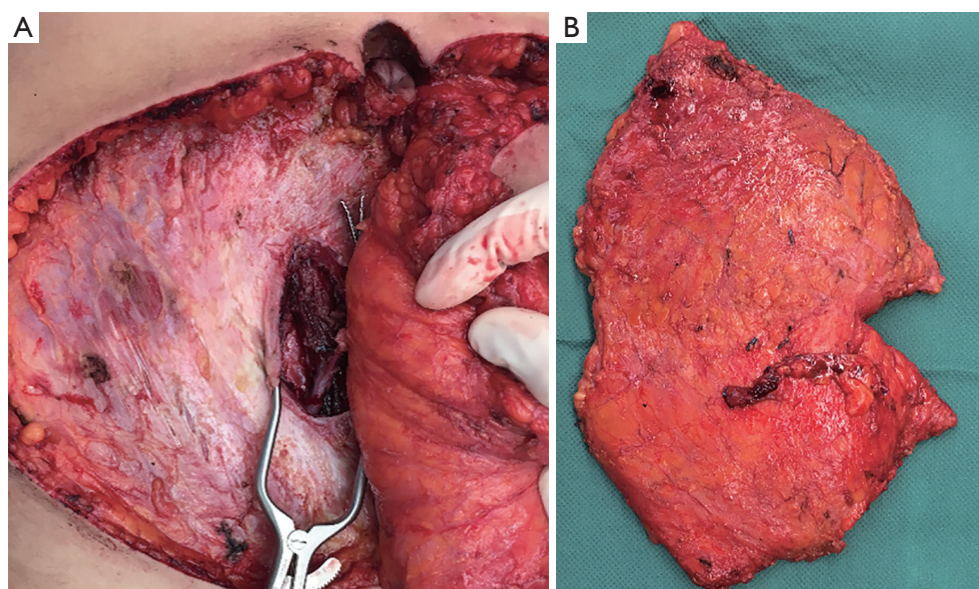


Figure 4 Limited incision (A) of the rectus fascia (5 cm) with harvest of a (B) single perforator DIEP flap with a long-intramuscular course. DIEP, deep inferior epigastric perforator.

In conclusion, the presented study reveals that the topic of donor site aesthetic and potential improvement of results has largely been neglected in the past decade. This study provides a thorough evaluation of potential problems the plastic surgeon may encounter and recommendations to improve results.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Table S1 Search protocol

Search history	Results
1. exp Mammoplasty/ or (breast adj3 (reconstruction* or operation*)).ti,ab. or mamm#plast^.ti,ab. or mastoplast^.ti,ab.	16,305
2. exp Perforator Flap/ or exp Abdominoplasty/ or deep inferior epigastric perforator.ti,ab. or deep inferior epigastric artery perforator.ti,ab. or DIEP.ti,ab. or abdominoplast^.ti,ab or (abdomen adj3 (operation* or plast^)).ti,ab.	3,877
3. Exp Patient Satisfaction/ or exp Esthetics/ or (patient^ adj3 (satisfaction or dissatisfaction or survey* or report*)).ti,ab. or (donor site adj3 (morbidity or complication*)).ti,ab. or (esthetic* or aesthetic*).ti,ab. or outcome*.ti,ab. or complication*.ti,ab. or ((unnoticeable or low-rise or lower or shorter) adj3 scar).ti,ab.	2,251,146
4. 1 and 2 and 3	758
5. 4 not (animals not humans).sh.	757
6. Limit 5 to (English or German or French)	736