Review Article

Current status of autologous breast reconstruction in Europe: how to reduce donor site morbidity

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Contributions: (I) Conception and design: M Hamdi, AK Kapila; (II) Administrative support: M Hamdi, AK Kapila; (III) Provision of study materials or patients: M Hamdi, AK Kapila; (IV) Collection and assembly of data: M Hamdi, AK Kapila; (V) Data analysis and interpretation: M Hamdi, AK Kapila; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Autologous reconstruction techniques for breast reconstruction have significantly evolved in the last few decades in Europe. In the search of reducing the donor site morbidity, surgeons explored the possibilities to preserve the rectus muscle and its function, and a transition to deep inferior epigastric perforator (DIEP) flaps was started in the nineties. Throughout the years, and especially in the last decade, we have increasingly implemented aesthetic refinements for donor site handling in DIEP flap breast reconstruction. In our practice, autologous breast reconstruction provides an opportunity to effectively remodel the donor site, minimising functional morbidity, and maximising aesthetic satisfaction. To achieve this, careful patient selection, pre-operative preparation, meticulous intra-operative dissection, and a clear post-operative protocol are essential. The main goal in autologous breast reconstruction, and its biggest advantage, is to offer the patient a natural look and feel of the reconstructed breast. A second goal is to minimize the number of procedures needed to reach the desired breast shape, size, and volume. In most patients, the number of operations ranges between one and three. The third main goal is to minimize the donor site morbidity, both functionally and aesthetically. Functionally, this implies preserving as much of the rectus abdominis muscle as possible, limiting the fascia incision, preserving the motor branches to the muscle, ensuring an adequate fascial closure, and repairing the rectus diastasis is present. Aesthetically, we aim to have a low position of the scar, an aesthetically pleasing location of the umbilicus, and limited or no lateral skin excess or so called “dogears”. In this clinical practice review article, we provide an overview of current autologous reconstruction methods, with a focus on minimising donor site morbidity and enhancing the aesthetic result of the donor site. We discuss key concepts in autologous reconstruction and provide surgical pearls for performing the procedure effectively with optimal reconstructive and aesthetic result.

Keywords: Autologous reconstruction; abdominoplasty deep inferior epigastric perforator flap (abdominoplasty DIEP flap); aesthetic donor site closure

Submitted Jul 11, 2023. Accepted for publication Dec 04, 2023. Published online Dec 22, 2023.
doi: 10.21037/gs-23-288
View this article at: https://dx.doi.org/10.21037/gs-23-288

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Introduction

Autologous reconstruction techniques for breast reconstruction have significantly evolved in the last few decades in Europe. In 1979, Holmström described the first free transverse rectus abdominis (TRAM) flap for autologous breast reconstruction in Sweden (1). The pedicled TRAM flap was described by Robbins that same year, with technical refinements published in 1982 by Hartrampf *et al.* (2,3). Until the early 1990s, the TRAM flap remained the most popular choice for autologous breast reconstruction, along with the option of a composite reconstruction using a pedicled latissimus dorsi (LD) flap with a silicone implant (4). The main disadvantage of the TRAM flap was its significant donor site morbidity due to the sacrifice of a unilateral rectus muscle, and remains associated with a reduced abdominal wall strength and function with high risk of post-operative abdominal bulging (5,6).

In the search of reducing the donor site morbidity, surgeons explored the possibilities to preserve the rectus muscle and its function. Clinical findings, such as the angiosome concept and the finding that large skin islands could be based on para-umbilical perforators preserving the rectus muscle and only harvesting a part of the rectus sheath and fascia to include the desired perforators, formed the scientific basis for this transition (7,8). Koshima *et al.* described the first use of the inferior epigastric artery skin flap without rectus abdominis muscle in 1989 with a follow-up publication in 1992, reporting on 13 cases using a para-umbilical perforator flap (9,10). Two years later, in 1994, Allen and Treece published their experience with use of the deep inferior epigastric perforator (DIEP) flap in the United States in 15 breasts and reported good outcomes (11). That same year, Blondeel *et al.* published their experience with eight cases of DIEP flap breast reconstruction with a follow-up study in 1997 comparing the donor site morbidity between DIEP and TRAM flaps (12,13). TRAM flap patients were found to have a statistically significant reduction in strength to flex and rotate the upper trunk compared to the DIEP flap and control patients (13). Following this, a paradigm shift was initiated where attention was given to muscle preservation for improved donor site function and reduced morbidity. In 1999, we published our experience with the first 50 DIEP flaps and found a decreased donor site morbidity with no changes in clinical outcome and DIEP flap survival (14).

Challenges with DIEP flap breast reconstruction

Autologous breast reconstruction with DIEP flap presented itself with several challenges at the beginning. First and foremost, DIEP flap survival was in part dependent on the learning curve of flap harvest. Although early reports showed a high flap survival rate of 98%, these numbers were published by pioneers in the DIEP flap harvesting technique (14,15). Reports on early experience by other surgeons were lacking and the uptake all over Europe was gradual and required theoretical and surgical appreciation of the anatomy and the technique.

Another challenge was operative planning. Doppler flowmetry had been a useful tool since the early adaptation of the DIEP flap to determine the approximate location of the perforators on the skin surface pre-operatively and thus help with the flap design (16,17). Yet, a true game changer came in the early 21st century with more precise literature on the use of computed tomography angiography (CTA) for pre-operative DIEP flap planning (18-21). CTA was found to decrease flap loss, flap necrosis, donor site morbidity, as well as flap harvest time and total operative time (22). It soon became part of the standard pre-operative protocol throughout most centres in Europe. Besides the benefits in flap raise and planning, CTA also provided information on pre-existing abdominal wall herniation, myofascial laxity and pre-existing abdominal wall scarring, all of which remain important considerations in minimising donor site morbidity.

Despite their muscle-sparing nature, surgeons still reported issues of bulging, herniation and abdominal wall weakness after DIEP flap harvesting (23-25). Furthermore, donor site issues with DIEP flap reconstruction were not only limited to functional issues of bulging, but also included complications of wound healing, infection, and seroma (26). Additionally, aesthetic considerations were increasingly highlighted by patients (27).

Throughout the years, and especially in the last decade, we have increasingly implemented aesthetic refinements for donor site handling in DIEP flap breast reconstruction. Technical and flap design implementations were increasingly used to avoid remaining dog ears, to prevent body contouring deformities such as residual abdominal overhang, and to ensure meticulous scar placement. These have now become an inherent part of our daily practice in autologous breast reconstruction. Especially with an increase in genetically predisposed women requesting

risk-reducing mastectomy and immediate autologous reconstruction, our patient population has changed and includes younger patients with different expectations and higher aesthetic demands. More so than ever, it is crucial to pay attention to donor site morbidity and closure, as the remaining scars, body contour and muscle function may influence patient satisfaction, despite a successful breast reconstruction. Paying attention to and quantifying patient reported outcomes thus remain important for the surgeon to learn from past cases and continuously improve their surgical technique.

In our practice, autologous breast reconstruction provides an opportunity to effectively remodel the donor site, minimising functional morbidity, and maximising aesthetic satisfaction. To achieve this, careful patient selection, pre-operative preparation, meticulous intra-operative dissection, and a clear post-operative protocol are essential. These are described in detail below.

Pre-operative considerations in autologous reconstruction

During the consultation, it is important to understand the patient's wishes and expectations. Some patients prefer implant-based breast reconstruction, possibly because they have been advised by their friends or breast surgeon that the operation is shorter, less invasive and has a quicker recovery. It is important to listen to them, clarify any misconceptions they may have, and clarify the peri-and post-operative course of free flap surgery. We, as plastic surgeons, do recognise that free flap surgery may be a longer procedure than alloplastic reconstruction and carries the trade-off of a donor site scar. Nonetheless, multiple studies have shown that autologous reconstruction carries a more durable, natural and aesthetically pleasing result with higher satisfaction rates for patients (28-30). Autologous reconstruction has further been found to be more cost-effective when compared to implants (31).

It is important to take a thorough history of the patient, including medical history (such as diabetes, previous radiotherapy, pregnancies, and weight loss), as well as smoking history. Previous operations at the potential donor site need to be checked (most importantly liposuction and abdominoplasty), as these can have an impact on the DIEP perforators and flap viability (32,33). Body mass index (BMI) is important as well, as a BMI over 35 kg/m^2 may increase the risk of complications, especially at the donor site (34-36).

The clinical examination includes a full examination of the breast, previous scars, degree of ptosis, and position of the nipple-areola-complex (NAC). Whether or not the NAC needs to be moved upwards, is relevant in both risk-reducing mastectomies, as well as nipple-sparing mastectomies with immediate reconstruction, as the psychological importance of NAC preservation cannot be underestimated in breast cancer patients (37-39). In case of grade 3 ptosis, a two-stage approach may be required in cases of risk-reducing mastectomy. During the first stage, a skin-only mastopexy can be performed, followed by bilateral nipple-sparing mastectomy and autologous reconstruction in a second stage (usually 3 months later). The footprint of the breast is examined as well, especially in the case of previous mastectomy with/without tissue expander placement and adjuvant radiotherapy. Issues such as a displaced footprint, capsular contracture, and skin shortage may influence the choice of reconstruction and donor site.

During the evaluation of potential donor sites, attention is given to previous scars, presence of adequate subcutaneous tissue, and laxity for donor site closure. In addition, the amount of required skin and the requested breast volume (either for bilateral cases or to match the contralateral breast in a unilateral case) play a role in choosing the ideal donor site. The DIEP flap remains the gold standard, with the superficial inferior epigrastric artery (SIEA) flap as a valuable choice in certain cases. This may even be decided during surgery, when no adequate perforator can be found and the SIEA has an adequate size and length. During the abdominal examination, it is important diagnose any myofascial laxity, rectus muscle diastasis, hernias and bulging, as this should be repaired during donor site closing. To determine the degree of abdominal wall reinforcement and final position of the scar, the surgeon must also consider the patient's age, previous or future pregnancies, the position of the patient's normal underwear, and the patient's expectations. Young patients with a genetic predisposition, may have a different morphology and higher aesthetic expectations, which may challenge the surgeon to optimize scar location and final abdominal contour.

In case of multiple scars on the abdomen or if the CTA does not show suitable perforators, a different donor site should be explored. Similarly, if there is no possibility of doing an adequate donor site closure of the abdomen in slim patients, we must look elsewhere. Alternative free flap options include the profunda femoris artery perforator (PAP) flap and transverse myocutaneous gracilis (TMG) flaps (both harvested from the upper inner thigh), the

lumbar artery perforator (LAP) flap (from the lower back), the superior gluteal artery perforator (SGAP) and inferior gluteal artery perforator (IGAP) flaps (from the buttocks), and the lateral thigh perforator (LTP) flap (from the upper lateral thigh) (40).

When an autologous free perforator flap is planned, a pre-operative CT or magnetic resonance angiography (MRA) is routine practice in our centre, as this can delineate the best perforator accurately by our group of trained radiologists. This saves times in procedure planning and execution. In our centre, CTA is used in most cases, as this is readily available and a fast examination, however, involves a radiation dose to patients. MRA, with its longer waiting list and examination time, is only performed in selected cases when CTA is contra-indicated. For patients with contrast allergy, renal impairment or concern regarding radiation exposure, MRA thus remains a valuable alternative (41).

A second pre-operative consultation is usually planned after the CTA or MRA is performed, so the final flap decision can be made based on the scan. In addition, patient comprehension and motivation is checked, as well as the results of other pre-operative tests. Any remaining questions can then be answered, and the surgery can be planned well in advance.

Goals of breast reconstruction with autologous tissue

The main goal in autologous breast reconstruction, and its biggest advantage, is to offer the patient a natural look and feel of the reconstructed breast. The softness, warmth, and natural feeling of a flap-based breast reconstruction is unmatched, compared to any implant-based reconstruction. The main considerations remain its lengthy and more complex procedure, and donor site morbidity. Maintaining adequate sensation with nerve-sparing, along with nipple preservation, are part of providing patients with natural breasts, both in look and feel (42).

A second goal is to minimize the number of procedures needed to reach the desired breast shape, size, and volume. In most patients, the number of operations ranges between one and three (43). A nipple-sparing mastectomy with immediate breast reconstruction may give an aesthetically pleasing result in one go and is likely one of the most elegant all-in-one procedures in plastic surgery. In most patients, a second operation is foreseen 3 months after the breast reconstruction, which may entail one or several of the following procedures: nipple reconstruction (in case of skin-sparing mastectomy), contralateral breast symmetrisation (breast augmentation, mastopexy or reduction), breast fat grafting, flap liposuction (in case of excess volume or partial fat necrosis), scar corrections (at the breast and/or donor site), and adjustments to the footprint. In a limited number of patients, a third operation may be planned for additional fat grafting or smaller adjustments. Any necessary procedure beyond this may likely be due to poor indication or insufficient operative planning.

The third main goal is to minimize the donor site morbidity, both functionally and aesthetically. Functionally, this implies preserving as much of the rectus abdominis muscle as possible, limiting the fascia incision, preserving the motor branches to the muscle, ensuring an adequate fascial closure, and repairing the rectus diastasis is present. Aesthetically, we aim to have a low position of the scar, an aesthetically pleasing location of the umbilicus, and limited or no lateral skin excess or so called “dogears”. The final scar position mainly depends on the position of the perforator; the lower the main perforator, the lower the final scar position will be). Whenever indicated, we aim to include some additional aesthetic procedures, such as a monsplasty (during donor site closure) or additional waistline liposuction (during the secondary procedure) (44).

Achieving all three main goals is not only a responsibility of the main surgeon. It is, as always, a team effort where operation efficiency, intensive training, and strict protocols are indispensable. A two-team approach is recommended to keep the total surgery time to a minimum.

Step-by-step DIEP flap breast reconstruction with aesthetic closure of the abdominoplasty flap donor site

Pre-operative protocol and markings

This section is illustrated by cases presented in *Figures 1-5*. A CTA is performed for all patients on a multi-slice CT scanner using a specific protocol that focuses on the abdominal wall perforators, as reported in our previous publication (21).

Marking begins with the patient in standing position and is usually done the evening before surgery (*Figure 1A*). The midline, breast footprint, and previous scars are marked, as well as the planned incision on the breast in case of a mastectomy with immediate breast reconstruction. In case of a skin-sparing mastectomy, an inverted T incision line is preferred with removal of the NAC, however, a horizontal

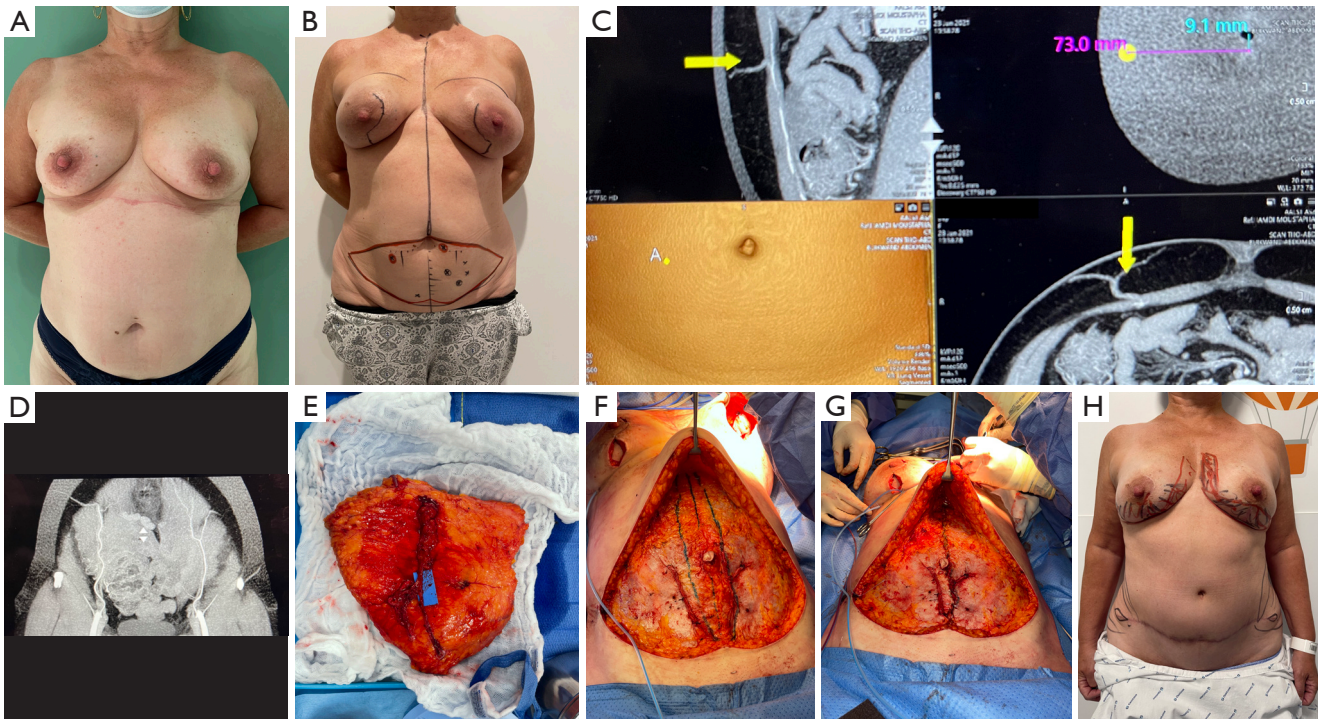

Figure 1 A 56-year-old patient with difficult screening for breast cancer requiring multiple biopsy procedures. A decision for prophylactic mastectomy was made with implant-based reconstruction. However, following the initial reconstruction, the patient decided for autologous breast reconstruction using free DIEP flaps. (A) Before bilateral mastectomies and implant insertion. (B) The patient marking for implants removal and bilateral DIEP flap breast reconstruction. (C) CT-angio scan image of the right dominant perforator. The arrows show the chosen perforator, on axial, sagittal and coronal views, on which the flap will be harvested. (D) The left side has two average size perforators. (E) Left harvested DIEP flap with two perforators. (F) The deep fascia was closed then the muscle plicature was marked. (G) The muscle facia was done in two layers: first with separate non-absorbable suture, then with a running barbed absorbable suture. (H) The outcome at 3-month postoperatively. Fat grafting was planned with dog-ear scar correction. DIEP, deep inferior epigastric perforator; CT, computed tomography.

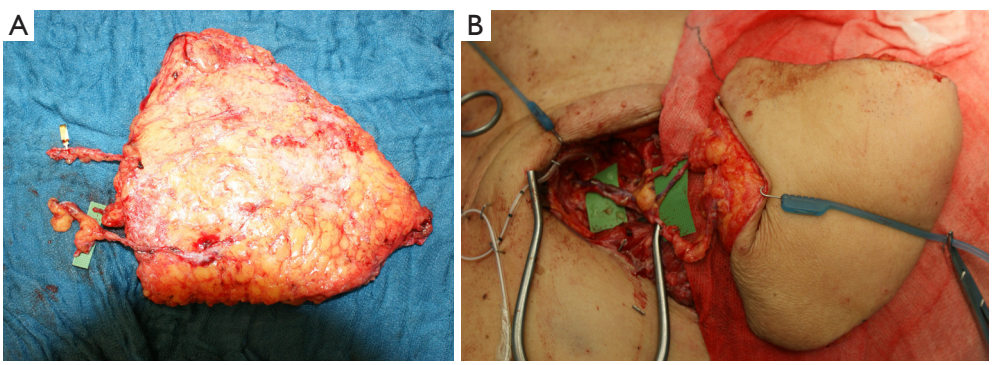

Figure 2 The dissection of the SIEV with enough length in order to reach a recipient vein. (A) The SIEV was dissected and preserved. (B) The SIV was hooked to the one of the collateral deep inferior epigastric vein after performing the main anastomosis to the internal mammary vessels. SIEV, superficial inferior epigastric vein; SIV, superficial inferior vein.

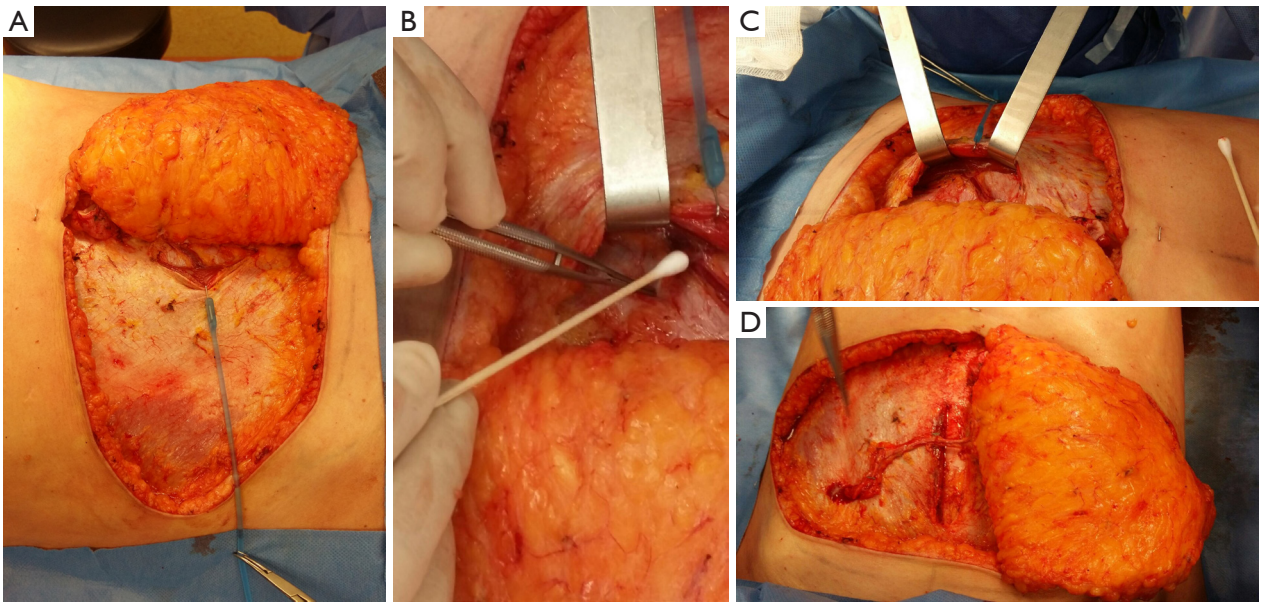

Figure 3 The surgical perforator dissection. (A) The perforator is freed for muscle and deep fascia and muscle is retracted using Lone Star Elastic Hook. (B) A cotton Q-tip is very useful to free perforator and intercostal nerves from the rectus muscle. (C) The main pedicle is dissected under the rectus abdominis muscle using surgical retractors without extending the deep fascia incision. (D) The perforator/pedicle dissection with 6 cm fascia-incision which is usually closed towards the midline in order to be included in the rectus abdominis plicature suture.

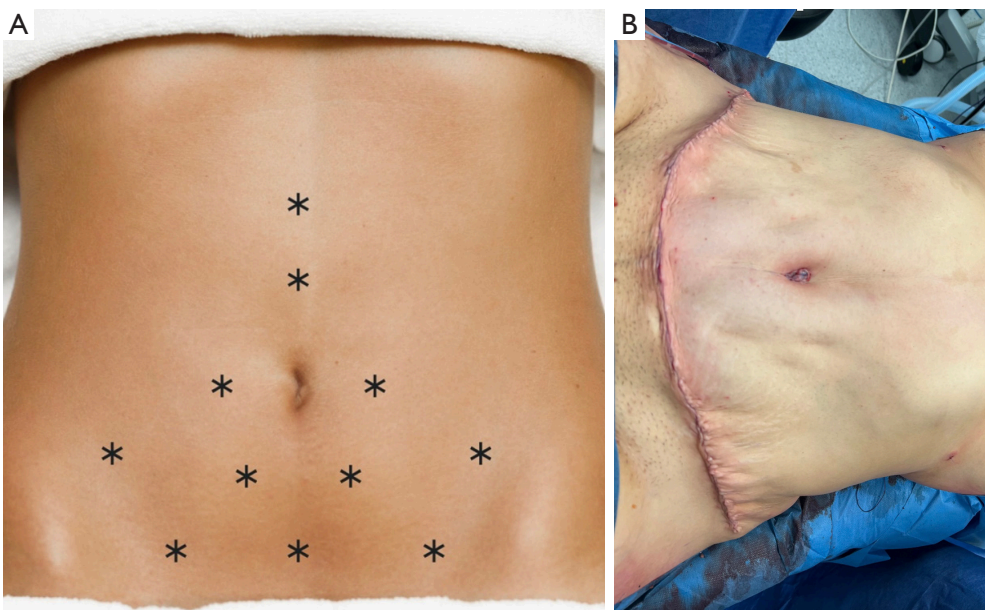

Figure 4 The umbilicoplasty with routine position of the progressive tension suture in closure of the abdominoplasty DIEP flap. (A) The location of the progressive tension sutures. This is illustrated by the asterisk marks, which show the exact placement of the interrupted progressive tension sutures. (B) The aspect of the donor site at the end of the surgery. DIEP, deep inferior epigastric perforator.

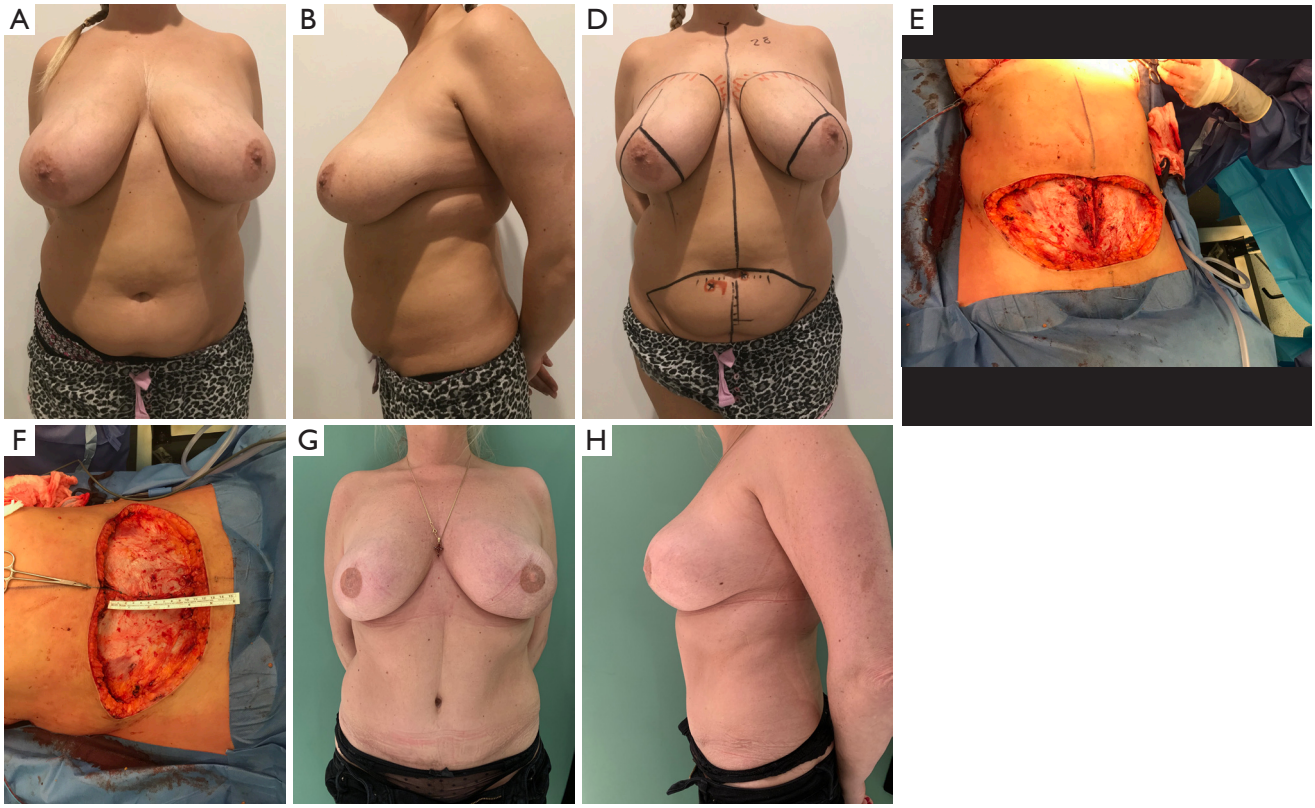

Figure 5 A 47-year-old patient with BRCA1 genetic mutation. A bilateral skin-sparing mastectomy was done with immediate DIEP flap breast reconstruction. (A) Preoperative anterior view shows large ptotic breasts. (B) Lateral preoperative view. (C) Planning of the bilateral skin sparing mastectomies with inverted T incision. The perforators are marked on the abdominal and flap was designed with low incision line. (D) Donor site after harvesting both flaps based on one perforator each side. The fascia incision kept short and parallel to the midline. (E) Plicature of the rectus muscles done after fascia closure. (F) The results of the abdominoplasty flap breast reconstruction at 3 years. (G) The lateral view shows significant improvement in the abdominal contouring. DIEP, deep inferior epigastric perforator.

elliptical incision can be done in high-risk patient (including significant ptotic breast, heavy chronic smoker, and diabetic patient). In case of a nipple-sparing mastectomy, either a medial areolar-vertical or inverted-T incision is used in large breasts; or an inframammary fold incision for small size breasts (*Figure 1B*). Where possible, inframammary fold incisions are made more laterally to avoid sacrificing the fifth anterior intercostal artery perforator and maximising the blood flow to the mastectomy flaps (45). Respecting the footprint of the breast is important to avoid peri-operative detachment of the inframammary fold ligament or medial breast attachment, which may influence final breast shape and position.

Marking of the abdominal flap usually starts with locating the perforators, based on the pre-operative CTA (*Figure 1C,1D*). The patient is placed in supine position and the X-Y coordinates of all relevant perforators are marked and checked with a vascular Doppler. The course of the SIEA and vein is marked as well. The best deep inferior epigastric artery (DIEA) perforator on each side is highlighted.

After locating the perforators, the flap itself is marked, making sure to include the main perforator on each side. Depending on their position in relation to the umbilicus, the flap may be shifted higher or lower, which may influence the final scar position. Taking into account the aesthetic principles of an abdominoplasty, we aim to place the inferior incision 7 cm above the anterior commissure and extend it laterally towards the anterior superior iliac spine (ASIS), following the natural fold of the lower abdomen. The lateral limit of the incision depends on the desired flap volume and is placed in a way to minimize or avoid dogears. It is important to explain to the patient that the final scar position is determined by the vertical height of the perforator and flap. In most cases, this will be covered

by normal underwear. However, as an increasing number of younger patients opt for autologous reconstruction after risk-reducing mastectomy, the surgeon must always strive for a low scar position. The position of the upper incision is determined by the location of the perforators and by using a pinch test to estimate the flap volume that can safely be excised without compromising donor site closure. The cranial subcutaneous dissection is usually bevelled to incorporate more flap volume, which is marked as well (*Figure 1B*).

Patients are given a prophylactic dose of low-molecular weight heparin 12 hours prior to their procedure, as well as a fleet enema. The pubis and axillae are shaved the day before surgery and patient are showered with Hibiscrub.

Intra-operative technique

A two-team approach is preferred, especially in bilateral cases, where one team prepares the breast pocket and dissects the recipient vessels (usually the internal mammary artery and vein), and the other team dissects the DIEP flap.

DIEP flap harvest follows a standardised procedure with a specific order of technical steps. The dissection begins by freeing the umbilicus, incising the cranial marking and dissecting down to the abdominal fascia with gentle bevelling (as mentioned before), followed by dissection of a central tunnel towards the xyphoid process. More bevelling may be required in bilateral reconstruction, and in younger, thinner patients to include more flap volume. It is also recommended in case of a very cranial perforator and may help to avoid a mismatch between the cranial abdominal flap and the caudal tissue flap upon abdominal closure. We prefer to complete the upper dissection at the start of the procedure, so the second team is not disturbed during recipient vessel dissection.

Next, the caudal marking is incised, thereby carefully preserving the superficial inferior epigastric vein (SIEV). If the pre-operative CTA showed small perforators, the SIEV may be dissected longer to allow venous supercharging (*Figure 2*). In case that the SIEA has an adequate diameter, a SIEA flap may be preferred; done in about 10% of our cases. This may be an elegant solution in case of a bilateral breast reconstruction (to avoid a second fascia incision) or if a hemi-flap would be sufficient. It is, however, rarely our first choice, as the SIEA vascular supply is often limited and its angiosome does not cross the midline (46,47).

Once the flap's circumference is completely freed, dissection towards the perforators can be performed. Pre-operative CTA preparation allows us to efficiently select the best perforator and dissect it down to its origin. Knowing which perforator to aim for, significantly increases efficiency and wins time for this kind of surgery, as there is no time lost exploring other, less suited perforators. Perforator dissection requires adequate muscle relaxation and adequate exposure. We use Lone Star Elastic Stays (CooperSurgical Inc., Trumbull, CT, USA) and a self-retaining retractor to visualise the trajectory of the perforator, dissect the pedicle, and to stabilise the rectus muscle (*Figure 3A*). In some cases, topical lidocaine may help as well in case of remaining muscle twitches. Adequate exposure and complete muscle relaxation is crucial to allow the identification of side branches and intercostal motor nerves. Preservation of the motor nerves is essential, as damaging them can lead to muscle atrophy, myofascial laxity, and bulging. Using fine instruments such as atraumatic forceps and bipolar cautery is essential. Q-tips are very useful to free perforators and nerves as well (*Figure 3B*). Earlier studies found that the rate of donor site morbidity was similar between muscle-sparing TRAM flaps and DIEP flaps (48-50). The main culprits were: muscle damage in case that multiple perforators were harvested throughout the width of the rectus muscle; damage to the motor nerves coming laterally into the rectus abdominis; and scarring due to surgical manipulation (51). It is exactly here where we must avoid damage, to truly optimise and justify doing a DIEP flap over a muscle-sparing transverse rectus abdominis myocutaneous (MS-TRAM) flap, otherwise its benefit is nullified. This requires adequate perforator selection, careful muscular dissection, preservation of all nerves crossing the pedicle, and gentle tissue handling. Once the intramuscular dissection is complete and the posterior surface of the rectus muscle is exposed, it is important to limit the caudal extent of the fascia incision with use of good retraction to dissect the remaining retro-muscular course of the pedicle (*Figure 3C*). Having the patient in a slight Trendelenburg position may help in pushing the intestines cranially, reduce the peritoneal bulging and provide a better exposure. A shorter fascia incision decreases trauma and reduces the risk of abdominal wall herniation (*Figure 3D*) (52).

The micro-anastomoses are performed using the microscope with separate sutures Ethilon 9/0 (Ethicon, Johnson&Johnson, Raritan, NJ, USA) for the artery and vein. Patency is checked, after which the flap is shaped and fixed inside the pocket with separate sutures Vicryl 2/0 (Ethicon, Johnson&Johnson) as described in previous publications (53-55). Zone IV and part of zone III are

routinely removed. Indocyanine green imaging is used to assess for flap perfusion in cases of doubt and has become a useful tool in recent years (56-58).

In the last decade, the most important innovations in autologous breast reconstruction have been focused on aesthetic donor site closure. Besides careful planning, correct marking and meticulous technique with nerve preservation as described above, an aesthetically pleasing donor site closure is the signature of a successful microsurgical reconstruction. We incorporate aesthetic principles of body contouring surgery in the closure of the abdomen, to maximise abdominal wellbeing in terms of its functionality as well as its aesthetics. Closure starts with adequate two-layer muscle plication to repair rectus diastasis. We routinely use figure-8 polyester braided sutures (Ethibond by Ethicon, Johnson&Johnson), followed by a running barbed suture (V-Loc 0) (*Figure 1F,1G*). During pedicle dissection, we limit the fascia incision to 7 cm or less and place it as medial as possible, to incorporate it into the rectus sheath plication. The fascia incision itself is closed with a running horizontal matrass Ethibond 0 suture. Bearing in mind that an aesthetic umbilicus is shallow, vertically oriented and oval shaped, with superior hooding, we aim to create an appealing umbilicus incorporating these aesthetic ideals (59). Using 2-0 Vicryl, the cranial part of the umbilicus is sutured halfway from its stalk height to the fascia, and the caudal part is sutured from the deep dermis of the stalk to the fascia, to recreate the natural inclination of an aesthetic umbilicus. 3-0 Vicryl sutures are placed from the rectus fascia to the dermis of the umbilicus at the 2 o'clock, 6 o'clock, and 10 o'clock positions, which will ultimately be fixed on the deep dermis of the abdominal skin, once the new umbilical position has been determined. This allows the creation of a natural umbilical depression once these sutures are tied and will avoid widening of the umbilicus. The donor site is closed similar to abdominoplasty with progressive tension sutures with 0 Vicryl which are placed in a standardized fashion (*Figure 4*). This helps in decreasing tension on closure, eliminating the dead space, minimizing the risk of post-operative seroma and allows for a drainless closure.

Post-operative considerations

Post-operatively, patients are mobilised on day 2 following the procedure. The urinary catheter is removed the same day, as well as one of the two breast drains. The remaining drain is usually removed on day 3 and patients are generally discharged on day 4 or 5 post-operatively. Low molecular weight heparin is continued for 10 days post-operatively, and an abdominal compression garment is kept for 4 to 6 weeks. The patient is advised to avoid heavy lifting and exercise for 6 weeks after the procedure. Patients are recommended to commence physiotherapy 2 weeks post-operatively to avoid stiffness of the shoulders, and to help in their recovery.

Outcome

The abdominoplasty flap breast reconstruction was used by the first author since 2010. Thanks to the flap marking, perforator/pedicle meticulous dissection technique and careful deep fascia closure, bulging/hernia was not encountered in our patients. Furthermore, high patient satisfaction was reported because of the aesthetic refinements of the donor site (*Figure 5*).

Complicated DIEP flap reconstruction

In some cases, a standard DIEP flap may not be technically feasible. This is the case if patients have large breasts and do not wish a reduction in size. In these cases, a unipedicled flap may not be sufficient, and a bipedicled design may be required. In our 2007 paper, different strategies were proposed for a bipedicled configuration, and any of these can be used to augment the vascular supply throughout the flap (53). A rare possibility is when there is deep inferior epigastric (DIE) pedicle interruption, for which we have proposed an algorithm with various strategies, including the use of the contralateral side, use of the superficial system and use of interposition grafts (54,60).

Alternative donor sites for autologous reconstruction

Previous abdominal procedures are no contra-indication for DIEP flap reconstruction (32,61). CTA is essential in such cases to identify the presence of adequate perforators. If we encounter a significantly scarred abdomen with lack of adequate perforators, then we look for other options. Similarly, if the patient is too slim and lacks adequate abdominal tissue for an abdominoplasty, then use of the abdominal donor site is avoided.

In such cases, our second choice for autologous reconstruction is the inner thigh. To minimize donor site morbidity, we pay careful attention to minimise the

risk of wound dehiscence by limiting the flap height to 8 cm. Analogous to the DIEP flap, we bevel our dissection caudally, once we have incised the skin, to include more subcutaneous tissue in the flap. The TMG flap provides adequate bulk of both muscle and adipocutaneous thigh tissue and may be considered over the PAP flap in thin patients. The gracilis muscle is not an essential adductor muscle and can generally be sacrificed without noticeable functional morbidity. Nonetheless, donor site infection and wound dehiscence remain more common when compared to the abdominal donor site (62). The PAP flap provides a longer pedicle and a larger diameter, however in thin patients may only provide limited bulk. In patients who have more vertical and caudal adipocutaneous excess, a banana-shaped PAP flap is usually the preferred option in our practice as its perforators are located more postero-inferiorly as compared to the TMG, which must be considered during flap drawing (63). The banana-shaped design minimises closure under tension and reduces the risk of wound dehiscence. In a horizontally designed TMG or PAP flap, some degree of caudal scar migration is unavoidable and should be discussed pre-operatively with the patient. Limiting the flap height, keeping the cranial incision slightly below the inguinal crease and fixing the caudal flap to the Lockwood ligament upon donor site closure may avoid scar migration to a certain degree. However, experience has taught us that gravity always wins, and, over time, the scar often ends up 1 to 2 cm below the inguinal crease.

The lumbar area is another excellent donor site, providing thick tissue for autologous breast reconstruction. The LAP flap is an excellent match for breast tissue and provides ample volume. Issues with the LAP flap are its short pedicle length as dissection is limited to the transverse vertebral processes to avoid injury to the spinal nerves, thereby requiring interposition grafts [usually the deep inferior epigastric artery and venae comitantes (DIEA/V) are used]. Furthermore, the LAP flap has a smaller vessel calibre, tedious dissection, high seroma rate, and requires patient repositioning (64). A more experienced surgeon may complete the full surgery in the lateral position; however, this can be trickier for less experienced surgeons. We previously did these cases in the lateral position. However, with increased efficiency in position changes and better surgeon comfort, our current practice is to perform the procedure in supine-prone-supine. The supine position initially allows chest vessel preparation and interposition graft harvest. Hereafter, the patient is placed prone for flap dissection, and then again supine for anastomosis and flap inset.

The gluteal area also provides a donor site for breast reconstruction, with both SGAP and IGAP flaps being well described (65,66). However, gluteal artery perforator flaps carry significant donor site morbidity to the buttock and are rarely performed in our practice for breast reconstruction. With increasing influence of social media, the buttock shape carries an increasingly significant role in society, and the "shark bite" appearance of the donor site may be deemed unacceptable for many (67).

Besides this, plastic surgeons have pioneered flaps from virtually every possible donor site to allow reconstruction of the breast. The lateral thigh flap is based on septocutaneous perforators running between the tensor fascia lata and gluteus medius at the level of the pubic bone (68). This can be a useful flap in patients with mainly lateral thigh volume excess, providing adequate bulk for breast reconstruction, and carrying the additional benefit of contouring the lateral thigh.

With increasing microsurgical skill and imagination, endless configurations are achievable with autologous tissue. Stacked flaps, bipedicled flap and/or conjoined flaps are all possible with the above flaps (69-72). Nevertheless, the key to a successful microsurgical procedure remains the combination of achieving all reconstructive goals, whilst minimizing donor site morbidity.

Future considerations

Recent innovations may help us even more in minimising donor site morbidity. Robotic flap harvesting can further reduce the size of the rectus sheath incision for perforators with a short intramuscular course (73). Robotic flap harvest carries a learning curve for plastic surgeons inexperienced in robotic and laparoscopic surgery and requires more time initially for the set-up and harvest. However, with improved knowledge, uptake and refinement of robotic consoles, this will likely be the next step in the process of flap harvest (74). Furthermore, the advent of artificial intelligence (AI) can play a crucial role in pre-operative planning, perforator selection, and patient counselling in the near future (75-77). Multiple centres, including ours, are working towards embracing AI in improving patient care.

Conclusions

Autologous reconstruction is the gold standard of breast

reconstruction in Europe, providing natural and durable results in the long term. In recent years, there has been a focus on improving surgical techniques, reducing operative time, minimising donor site morbidity, and enhancing patient satisfaction. Especially the reduction of donor site morbidity has been a topic where significant progress has been made. Specifically in DIEP flap reconstruction, the abdominal donor site provides an excellent opportunity to contour the trunk into an aesthetically pleasing and desirable shape and enhancing the patient satisfaction.

Pearls from the authors

- ❖ Ensure appropriate planning: this includes a thorough clinical examination, donor site selection and planning of aesthetic closure, thorough CTA study, and peri-operative care.
- ❖ Ensure the procedure is done efficiently with a logical sequence of steps.
- ❖ Avoid damaging muscle, nerve, and other structures. The dissection should be neat, meticulous, and purposeful without disturbing adjacent tissue.
- ❖ Closure of the donor site is of utmost importance as mentioned above. Make sure this is done in a proper way. Do this yourself or teach your residents on how to do this in a proper manner.
- ❖ Lastly, have a well-trained team right from the front office till the discharge lounge. Everyone should be aware of the procedure and know how they can contribute to making every patient journey a success.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Tine Engberg Damsgaard, C. Andrew Salzberg and Jørn Bo Thomsen) for the series "Hot Topics in Breast Reconstruction World Wide" published in *Gland Surgery*. The article has undergone external peer review.

Peer Review File: Available at https://gs.amegroups.com/article/view/10.21037/gs-23-288/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-23-288/coif). The series "Hot Topics in Breast Reconstruction World Wide" was commissioned by the editorial office without any funding or sponsorship. M.H. reports that he serves as the National Expert for the Superior Council in Belgian Minister of Health (MoH) and is a consultant to Polytech for scientific activities. The authors have no other 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. All clinical procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for the publication of this article and accompanying images.

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Cite this article as: Hamdi M, Kapila AK, Waked K. Current status of autologous breast reconstruction in Europe: how to reduce donor site morbidity. Gland Surg 2023;12(12):1760-1773. doi: 10.21037/gs-23-288