Journal of Plastic, Reconstructive & Aesthetic Surgery (2020) 000, 1–7

Review

Diep Flap Volume Augmentation: Literature Review and "Calzone" Flap Shaping Technique

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Received 3 December 2019; accepted 16 May 2020
Available online xxx

Summary Breast reconstruction with DIEP flap is a well-accepted and well-established technique for autologous breast reconstruction. In the past, this reconstructive option was typically offered to a limited group of patients as previous surgeries or low BMI were considered to be an obstacle to the success of the procedure or for the achievement of a satisfactory cosmetic outcome due to the lack of available tissue. Nowadays, this does not correspond to truth anymore and DIEP flaps are performed routinely on slender patients and on women who have undergone previous liposuction or abdominal surgeries. This paper analyzes current surgical options for volume recruitment in patients with scanty abdominal tissue or with abdominal scars and presents our standardized approach for DIEP volume augmentation with the "Calzone style" bipedicled DIEP flap.

Dr. Barbara Pompei: design and writing up of the paper, performance of surgery, collection and analysis of data, revision and submission. Prof. Farhadi: performance of surgery, collection of data, revision of the paper.

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https://doi.org/10.1016/j.bjps.2020.05.070
1748-6815/

Please cite this article as: B. Pompei and J. Farhadi, Diep flap volume augmentation: Literature review and "Calzone" flap shaping technique, Journal of Plastic, Reconstructive & Aesthetic Surgery, https://doi.org/10.1016/j.bjps.2020.05.070

Contents

Introduction

Breast reconstruction with DIEP flap was initially offered to a limited pool of patients only, excluding all the women not fitting into the ideal body pattern because of the lack of tissue or because of previous abdominal surgeries. As a matter of fact, for many years, the concept that only women with abundant and untouched abdominal tissue were eligible for this kind of reconstruction ruled out any attempt of alternative solutions. However, during the last decade, the increasing demand for autologous breast reconstruction with abdominal flaps has transformed this type of microsurgical procedure in routine surgery and it is performed everyday by trained surgeons all around the world. This has led to the acquisition of a deeper and more complete knowledge of the physiology and anatomy of the DIEP flap, pushing the limit for its indications. Not of secondary importance is also the modification of the female body habitus that happened over the last ten years in many countries; more attention to physical activity and to the diet, together with an evolution of the aesthetic model have changed the average weight and look of a relevant portion of the female population, resulting in a slimmer and more athletic version of the previous generation.[1]

For this reason, the original harvesting technique has been modified and improved in order to offer a good reconstruction to a wider group of patients, irrespective of the available abdominal tissue.

The aim of this paper is to present a review of the literature about the current approach for volume augmentation of the DIEP flap and, at the same time, to introduce our personal technique: the bipedicled DIEP flap in a "Calzone" style.

Stacked Flaps

The stacked technique can be described as a microsurgical sequential anastomosis of two pedicles belonging to two different flaps (the flaps can be of the same type or different) which are combined in a layered fashion and then inset into the breast pocket. A stacked flap is generally considered for patients who need a unilateral breast reconstruction but have either insufficient abdominal tissue or abdominal scars that might compromise the perfusion of a single perforator flap. The stacking technique was described for the first time by *Arnez et al.* in 1992.[2] *DellaCroce et al.*[3], in his review of 110 stacked flaps, suggests that women with Poland syndrome can also be especially good candidates for breast reconstruction with stacked flap, considering the unilateral breast deficiency these patients suffer from. The Author gives indication for stacked flaps when the estimated volume of one single side of the abdomen falls approximately between one-third and one-half of the desired final breast volume.

This technique, although more complex, can safely deliver a satisfying reconstruction in challenging cases. The stacked technique allows surgeons to safely harvest the whole abdominal pannus with a reliable blood supply. This has to be taken into account as many anatomical and functional studies agree that a single-sided pedicle is inadequate to perfuse the entire abdominal soft-tissue composite, causing fat necrosis in the under- perfused zones,[3-5] while two pedicles belonging to different areas of the flap can guarantee a generally good perfusion.

Murray et al.[6] suggest a classification system based on the type of pedicles harvested within the flap (defining a primary and secondary pedicle) and on the location of the recipient vessel. The choice of the pedicles is usually based both on preoperative CTa (mandatory when it comes to bipedicled flaps) and on intraoperative findings. Internal mammary artery and veins (IMA/IMV) are commonly chosen as recipient vessels (using both their antegrade and retrograde flow), while thoraco-dorsal ones are kept for lifeboat scenarios. The standardized use of IMA and IMV as double-side recipient vessels is a key point when it comes to bipedicled flaps, thanks to their reliability in size, central location, freedom of flap insetting, relative resistance to atherosclerosis, and preservation after radiation therapy and axillary surgery.[7,8] Additionally, to dismantle the old prejudice about the unreliability of the retrograde flow, a detailed hemodynamic study by *Salgarello et al.*[7] also demonstrates the complete safety of the use of retrograde IMA and IMV.

Stacking flaps have also proven to be a successful technique for patients having a paucity of abdominal tissue and requiring bilateral breast reconstruction,[9-11] although a four-free flap reconstruction is undoubtedly a task not accessible to every surgeon.

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Turbocharging technique

The turbocharge technique described by *Hallock*[12] also represents a valid approach when additional skin coverage or volume is needed but a single pedicled flap will not allow the harvesting of such an amount of tissue and, at the same time, when there is not more than one recipient vessel available in the recipient site. Unlike the concept of stacked flaps, this technique consists of recruiting poorly vascularized tissue at the periphery of the flap, including an additional vascular supply belonging to that same territory, in order to increase the vascularized and viable territory of the flap.[13] In this case, a branch of the major pedicle of the flap is joined to a minor pedicle coming from the same flap but from a distant zone that otherwise would not be perfused. *Hamdi et al.*[14] gives a classification of the type of anastomoses that can generally be used in a bipedicled flap, with particular attention to intra-flap anastomoses.

Implant augmentation

Recent advances in reconstructive microsurgery have transformed the previously presented techniques in an accepted reality; however, because of the complexity of the procedure, multiple anastomoses surgery cannot be performed routinely. Additionally, not all patients are keen on accepting tissue harvesting from more than one donor site, no matter how hidden the scars can be.

As a result, the use of implants has recently been associated with DIEP flaps reconstructions, both as immediate and delayed solution, for cases where simple autologous reconstruction could not guarantee a satisfactory volume.[15,16]

An indication scheme for technique and patient selection is outlined by *Figus et al.*[15] and *Roehl et al.*[16] In both studies, the subpectoral plane was the favorite plane for implant placement as it isolates the implant from the layer where the vascular pedicle runs, which is relevant when the implant is placed at the same time of the flap. Textured round silicone gel implants were used with the aim of achieving a simple volume augmentation without trying to affect the shape of the reconstructed breast, primarily dependent on the abdominal tissue transferred, but also different implants' models have been mentioned as suitable.

Good candidates for the combined use of flaps and implants are:

1) Slim patients with large-size breasts who need unilateral breast reconstruction and want to avoid back scars or functional morbidity as from an LD flap breast
2) Slim patients with previous breast augmentation requiring mastectomy
3) 3) Patients with large breasts requiring unilateral mastectomy with radical skin excision
4) Postoperative breast asymmetry after unilateral DIEP flap reconstruction
5) Bilateral reconstruction in slim patients with large breasts

Women who are likely to have postoperative irradiation are, of course, not good candidates for this type of reconstruction.[15]

No increase in flap-related complications, such as fat necrosis and partial or total flap failure, has been reported in the studies.

The higher infection and capsular contracture rate noticed in the immediate placement group was attributed to unrecognized implant contamination which happened at the same time as the flap reconstruction, as well as subclinical seroma/hematoma not detected in the postoperative period.[16]

Pre-expansion

Pre-expansion is a safe and established technique that has been used for decades by plastic surgeons to increase the amount of mobile tissue available in a certain area to cover a close by defect. Regarding DIEP flaps, this technique has been mainly applied to gain tissue for the coverage of large defect of the chest[17] and in lower limb reconstruction,[18] whilst has not been used for breast reconstruction.

Patients and methods

Based on the concept of stacked flaps and the supercharging technique, a series of 28 immediate breast reconstructions with bipedicled DIEP flaps in a "*Calzone Style*" were performed between the years 2014 and 2019 in St Thomas Hospital in London and Pyramid Clinic in Zurich. This series represents the largest one of this type of flap described so far. The name "*Calzone*" was suggested by the standardized way of folding the flap before the inset which resembles the well-known calzone dish.

Surgical technique

The Calzone flap has been thought to address the problem of breast reconstruction of medium/large size breasts in women with either scanty abdominal tissue or previous abdominal scars that would limit a safe harvesting of the whole pannus, based on a single perforator.

In planning a Calzone flap, preoperative study of the abdominal wall with CTa has primary importance as the flap is based on the nourishment of two vascular pedicles. The two pedicles can be both represented by vessels belonging to the deep inferior epigastric or to the superficial inferior epigastric system, or by a combination of the two.

As much tissue as possible is included in the territory of the flap, starting from the marking of the patient. The superior line of incision, going from one anterior superior iliac spine to the opposite, is outlined with a vague S-shape course to include the subcutaneous tissue proximal to the umbilicus (where the convex limb of the line starts). The flap harvesting technique follows a fixed and meticulous sequence in order to minimize surgical time and complications.

After circumferential dermis incision, the cranial dissection is extended 6-8 cm above the navel in order to harvest part of the sub-scarpal fat together with the flap; care has to be taken to not thin the abdominoplasty flap too much.

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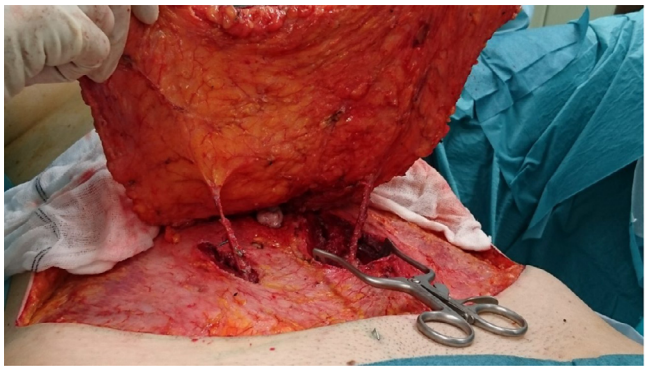

Fig. 1 Calzone flap isolated on two DIEA/DIEV perforators.

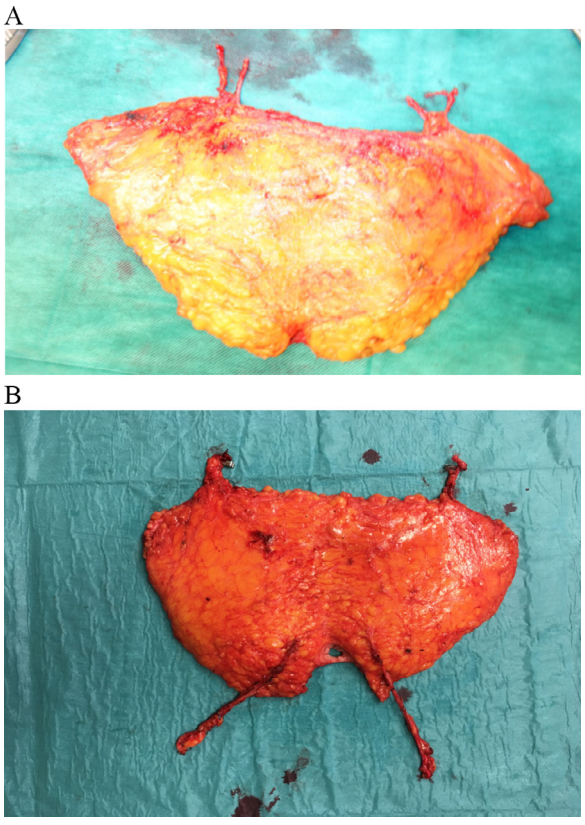

Fig. 2 Calzone flap based on (A) two SIAE/SIAV pedicles and (B) two DIEA/DIEV pedicle.

The procedure continues with bilateral dissection of the superficial inferior epigastric arteries and veins until sufficient calibre of the vessels is reached; the SIE pedicle has been used in 1/3 of the cases as second pedicle, together with the DIEA/DIEV pedicle, for the perfusion of the flap. Standard dissection of DIEA/DIEV perforators is then performed.

As a result of the dissection, a flap isolated on two perforators is obtained with the possible combinations already mentioned before (Figs. 1-2).

Two perforators nourishing complementary area of the flap allow the harvesting of a flap with a volume that, in our series, has shown to be usually at least equal to the weight of the mastectomy, even in thin patients.

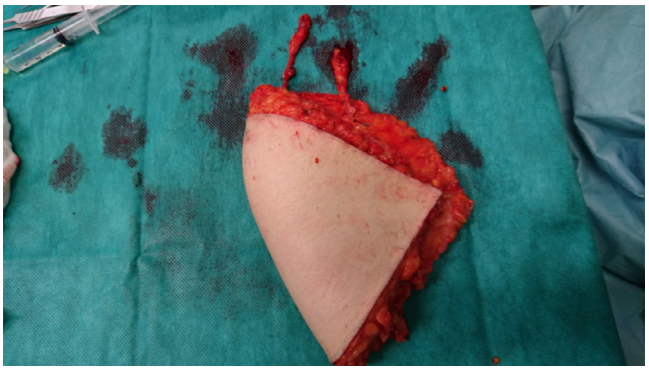

Fig. 3 The flap folded on a side table in a Calzone style.

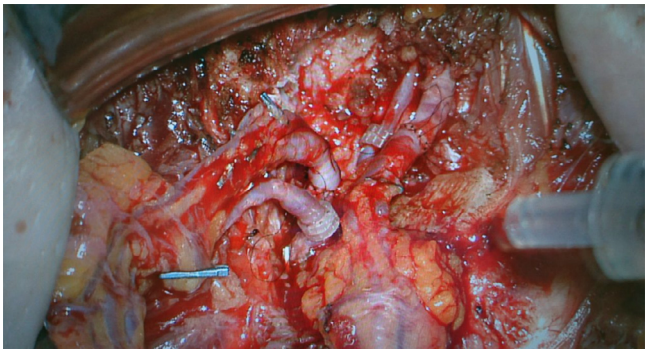

Fig. 4 Double anastomoses with internal mammary vessels.

Once the flap is disconnected, further cleaning of the vessels is performed on a side table. The flap is then folded in two, with each pedicle facing its opposite; a few loose stitches are given to stabilize the flap in this position.

This particular arrangement of the flap has inspired the name "calzone" for this kind of double pedicled DIEP, as the shape is akin to the famous calzone pizza which is an Italian dish made of two layers of pizza pastry with variable filling inside (Fig. 3). With the flap folded in two and still on a back table, the side of the calzone destined to face the chest wall is de-epithelialized. Depending on the skin envelope left by the mastectomy, the other side of the flap can also be partially de-epithelialized, leaving just a small skin area to be used as a monitor island.

As visible in Fig. 3, thanks to the folding of the flap, the two pedicles are close to each other and aligned towards the chest recipient area on a side of the calzone.

During the harvesting, a second surgeon prepares the chest vessels in order to shorten the surgical time. A portion of the rib cartilage is removed in order to give optimal access to the IM vessels; the exposed length of the IM vessels has to be enough to allow the anastomoses with both pedicles without tension. In all the cases performed, IMA and IMV were the recipient vessels of choice thanks to the reliable two-direction flow. The antegrade and the retrograde limbs of the internal mammary vessels have been used as recipient vessels for the Calzone flap pedicles for each case without complications (Fig. 4).

Venous couplers were used for all the venous anastomoses.

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Fig. 5 Flap inset.

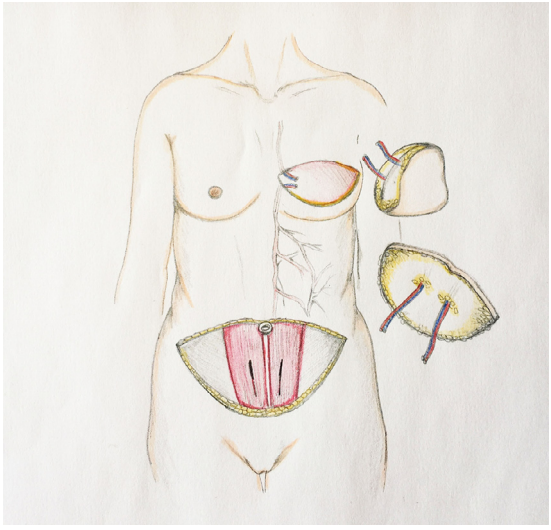

Fig. 6 Flap harvesting and folding process.

Intra-flap anastomosis (flap turbocharging technique[13]), although representing an alternative approach to the use of two different sets of anastomoses, has not been used in this Calzone flap series.

Once the microsurgical anastomoses are done and the flow is re-established, the flap can be inset in the breast pocket.

Precise arrangement is followed. The flap is positioned with the thickest portion (the folded one) to recreate the lower/lower-lateral pole in order to give the reconstructed breast the projection of a normal one (Figs. 5-6).

The portion of the flap positioned in the upper pole (opposite to the folded portion) can be partially de-bulked if too thick, although all the cosmetic refinements are usually kept for a second surgical stage, to avoid damages to the pedicles or to the perfusion of the flap.

Anchoring stitches are given (superiorly and medially) between the flap and the chest wall to avoid pedicles stretching as a result of the weight of the flap and to maintain the flap in the desired position.

Depending on the patient and on the oncological procedure, one or two 10 F Redivac drains are left in the pocket and/or in the axilla.

When a satisfying inset is reached, the breast pocket is closed and a doppler signal of the perforator is searched on the skin paddle surface and marked with a prolene stitch.

Results

Twenty-eight cases of DIEP flap in a Calzone style have been performed in 4 years in the two institutions indicated.

The mean age of the study population was 49.5 years $\pm$ 6.4, with a median age of 52. The BMI of the patients resulted to be 23.3 $\pm$ 2.45 (median 22.4).

Mastectomy specimens were weighted immediately after the resection; the average weight was 516 g $\pm$ 212 (median 578 g) while the mean weight of the Calzone flap reached 623 g $\pm$ 141 (median 598 g). The weight of the Calzone flap has been calculated before the insetting and not after the harvesting. The weight corresponds to the effective weight of the tissue put into the breast pocket (Fig. 7).

No flap failure was observed in the series, and only one patient was taken back to theatre for a review after the flap started to look congested on Day 1. Microsurgical anastomoses appeared pristine; the flap was repositioned in the breast pocket after small resection of upper portion. No further problems were observed in the postoperative follow up.

No complications were observed regarding the donor site in any of the patients; no positioning of abdominal meshes was required after the flap harvesting or during the following years. Ancillary procedures of cosmetic refinements such as fat necrosis resection (4 cases), lipofilling (5 cases), and mastopexy of the contralateral breast (6 cases) were performed in a range of time of 6-12 months after the procedure.

Discussion

This study evaluates prospectively the outcome of an innovative surgical technique for DIEP flap volume augmentation. While stacked and turbocharged flaps have been already widely described in many papers in the last decade, limited published reports can be found regarding the technique described above.[19] Furthermore, regarding the bipedicled folded flap technique, no standardized technique was identifiable in the other series previously described.

The mean BMI observed in the population of the study can be considered largely within the lower-normal range of the general female population (median European female BMI= 24.5), confirming that this kind of procedure can also be offered to slender patients, and not necessarily to only those that have an abundant abdominal pannus, as traditionally required for DIEP flap reconstruction.

What appears most relevant is the comparison between the mean weight of the mastectomy specimens (516 g) and the weight of the bipedicled Calzone flaps (623 g). These values demonstrate that in every case the weight of the flap was equal or even greater than the resection specimens. This result would have been impossible to achieve by harvesting only half of the abdominal pannus with a sin-

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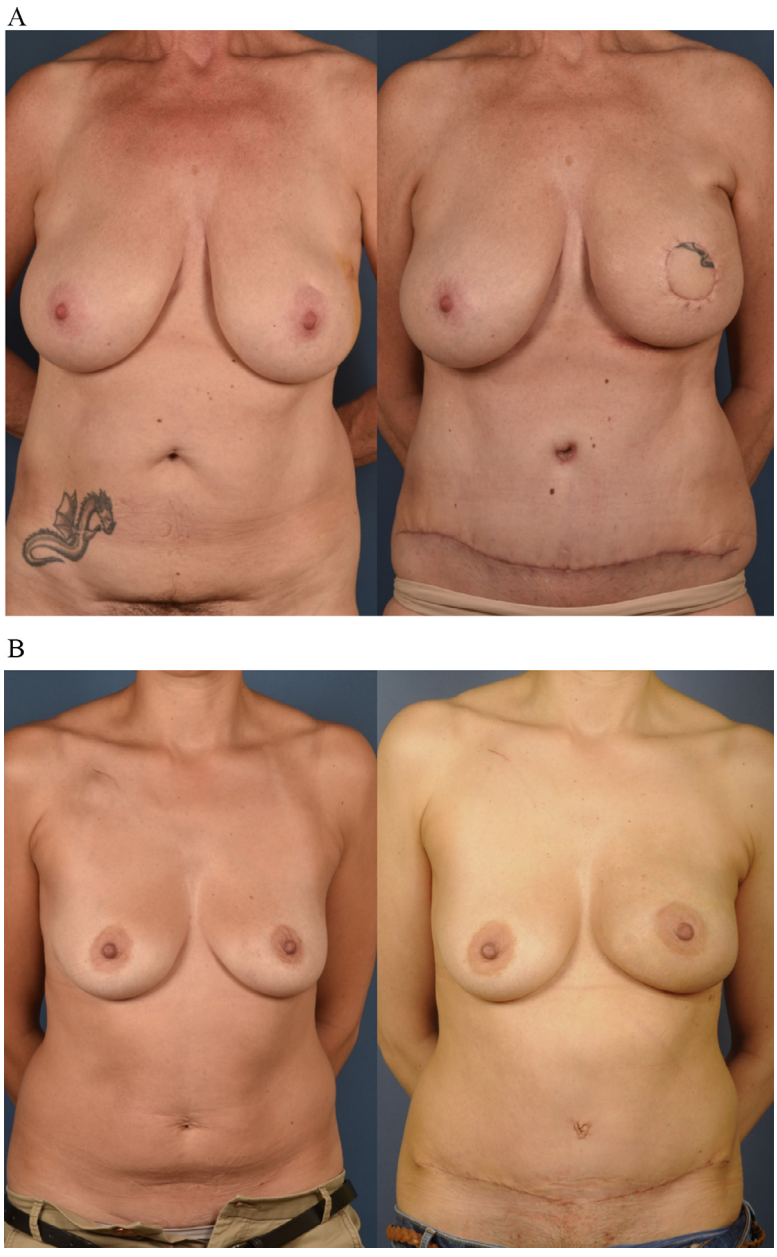

Fig. 7 (A;B): Preoperative and postoperative pictures.

gle pedicled flap in a slender patient with a BMI similar to the one in the study.

Also to be noted is the capacity for achieving a satisfying volume of the reconstructed breast in a single procedure with minimal necessity of further surgical adjustments, meaning less discomfort for the patient and a substantial reduction in hospital costs.

Further, another extremely relevant observation is of the different projections that can be achieved with this type of folded flap in comparison to the stacked flap which is usually separated along the abdominal midline and then only layered in the breast pocket. As a matter of fact, lack of projection in the lower pole is a common problem when it comes to autologous breast reconstruction, as it is very difficult to reproduce the natural volume of the breast in that area while avoiding the use of implants.[20] With the Calzone flap folding technique, maximal projection is achieved, as all the tissue belonging to the central portion of the tummy (where the majority of the bulk of the pannus is located) is maintained in continuity and doubled, creating a shape that mimics that of the breast mound very well.

The bipedicled DIEP flap Calzone style can also be considered to be a safe approach to breast reconstruction, as only one patient needed surgical review in our series. Additionally, with two independent pedicles nourishing and draining the flap, issues related to an insufficient inflow or outflow of the tissue are observed less often than with normal unipedicled DIEP or SIAE flaps.

As mentioned in other studies, the increased complexity of bipedicled flaps can be pointed out as a downside of

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this kind procedure. However, the impressive and otherwise not easily achievable results reached are a solid reason for the use of the Calzone flap instead of other, more common, autologous reconstructive options.

Financial Disclosure Statement

Dr. Pompei has nothing to disclose.
Prof. Farhadi has nothing to disclose.

Ethical approval

N/A

Declaration of Competing Interest

None declared.

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