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A novel approach in breast reconstruction: The extended lateral thoracic flip-over flap combined with loops and lipofilling (ELT FOLL)

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Summary *Introduction:* The use of the thoracodorsal musculocutaneous flap has been limited to donor site complications, whereas the thoracodorsal fasciocutaneous flap spares the muscle and limits morbidities. Our objective is to describe a new technique of breast reconstruction using an extended lateral thoracic (ELT) flip-over flap combined with loops and lipofilling (ELT FOLL) to achieve better breast remodeling.
Methods: Between 2013 and 2018, 64 patients underwent breast reconstruction using an ELT FOLL. The flap is designed in an elliptical transverse pattern and extends 2 cm lateral to the back midline up to the breast axis at the level of the inframammary fold. The surgical technique consists of an infiltration and tunnelization of the breast recipient site and surrounding area, deepithelialization of the skin paddle, and additional preparation of the flaps and loops. Liposuction is performed using the power-assisted liposuction and lipofilling technique, and lipofilling is achieved throughout the thoracic cutaneous surface of the reconstructed site, particularly into the lower quadrant of the breast.
Results: Among the reconstructions, 73.4% was delayed and 92.2% was unilateral. A fourth of the patients were smokers, and 39.1% received radiotherapy. The total complication rate was 8.7%, the patient's shoulder function was not affected at long term, with the DASH score rising from 6.53 preoperatively to 11.32 at 6 weeks and 7.52 at 6 months. The average operative time was 57 min, and drains were removed at day one after surgery.

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Conclusion: The ELT FOLL should be considered a simple, safe, and reliable alternative for breast reconstruction.
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Introduction

Since its first description by Tansini in 1896,[1] the latissimus dorsi flap has been widely used in breast reconstruction.[2,3] To minimize complications related to muscle harvesting, namely seroma and alteration in shoulder function, many authors have advocated for sparing the muscle and using perforator flaps. Angrigiani was the first one to describe the thoracodorsal branch used for the thoracodorsal perforator flap[4], which was further developed by Hamdi to achieve partial and total breast reconstruction.[5-8] In the same manner, the intercostal perforator artery flap was mainly used to achieve partial breast reconstruction and was limited to lateral defects.[9] Based on the advances of vascular anatomy of the region and with the aim to simplify breast reconstruction while sparing the latissimus dorsi muscle, the senior author describes a new technique of breast reconstruction that is based on a thoracodorsal paddle turned in a flip-over pattern without perforator dissection and is associated with lipofilling and internal loops to achieve a total breast reconstruction.

Material and methods

Patients and study design

Seventy-five consecutive women who underwent primary or secondary breast reconstruction with ELT FOLL were evaluated from January 2013 to December 2018 in a retrospective study. Among those patients, seven (9.3%) were lost during the first postoperative year of follow-up and four (5.3%) were excluded due to severe skin problems caused by breast radiotherapy after mastectomy, which did not allow for a deepithelialization of the paddle. All 64 procedures (69 breasts) were performed by the same surgeon (the senior author). The patients who qualified for this study underwent a total mastectomy requiring an immediate or delayed breast reconstruction to obtain a moderate breast volume. Contraindications were severe cutaneous irradiation requiring an epithelialized flap, lean patients, and unbalanced diabetes. Patients were provided detailed information regarding the ELT FOLL surgical procedure outlining that this technique consists of a two- to three-step surgery, and the risks and benefits of various surgical options. All patients provided written informed consent. The medical charts of all 64 patients were reviewed. Preoperative and postoperative photographs of the patient were taken. The study is in accordance with the Declaration of Helsinki guidelines. Approval from an institutional review board or ethics committee was not obtained because all patients underwent surgical procedures in a private practice.

Data collection and analysis

Demographic data, including age, body mass index (BMI), smoking status, and comorbidities such as diabetes, hypertension, dyslipidemia, and other cardiovascular diseases were studied. History of radiotherapy, chemotherapy, or hormonal therapy was assessed. Breast reconstruction was classified as immediate or delayed and unilateral or bilateral.

Complications such as seroma, infection, necrosis, hematoma, major wound dehiscence, thread extrusion, shoulder function, and postoperative pain were recorded. Flap dimensions, operative time, hospital stay, and time before drain removal were also studied. A Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire was given to each patient preoperatively and at 6 weeks and 6 months postoperatively to evaluate the function of the upper limb. Postoperative pain was assessed in all patients through the Visual Analog Scale at day 1 postoperatively.

Preoperative and postoperative instructions

Instructions were imposed on all patients one month before and one month after reconstruction. These instructions include the prohibition of smoking, the reduction of alcohol consumption, and the interruption of anticoagulant/aggregating drugs (a few days before the operation or the day before the operation, depending on the drug and the patient's need for treatment).

Preoperative markings

The anterior and posterior midline axes are marked, followed by the anterior, medial, and posterior axillary axes as well as the inframammary fold (IMF). The paddle is drawn in an elliptical-transverse pattern with the patient in standing position. The upper limit of the paddle is located at the sixth rib and is represented by the line starting from the breast axis at the level of the IMF and extending to 2 cm lateral to the posterior midline. The lower limit is located at the eighth rib. A pinch test is performed to test wound closure. The largest dimension of the flap is at the midaxillary line. It is important to ensure that the distance between the midaxillary line and the posterior edge of the flap is equal to the distance between the midaxillary line and the medial border of the breast. (Supplemental Figures 1 A, B, and C).

Two loops are drawn on the reconstruction site. The first loop is designed in a circular fashion to obtain the same skin surface of the contralateral breast, to recruit tissues from the upper abdomen and the lateral thorax, and to define the breast footprint. Medially, it passes lateral to the anterior midline, inferiorly along the IMF, laterally it passes lateral

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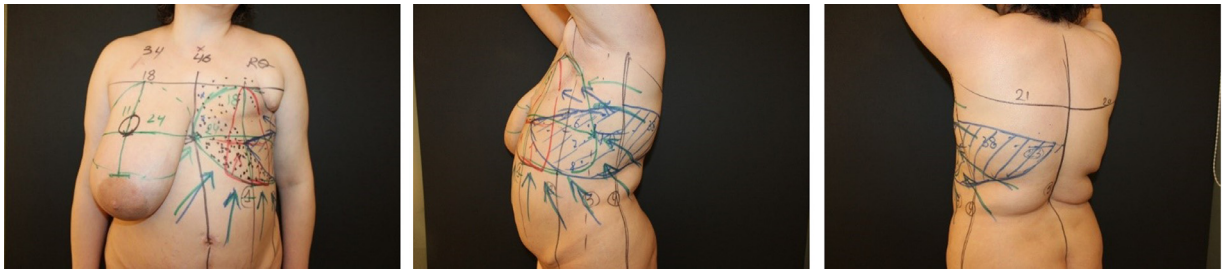

Figure 1 Anterior (A), lateral (B), and posterior (C) views showing the preoperative markings of the ELT FOLL flap, with the thoraco-dorsal paddle (blue), which will be turned on itself anteriorly (blue arrows), the loops (green and red circles) recruiting perimammary tissues and better defining of the new IMF (red and green arrows), and the lipofilling (black dots).

to the midaxillary axis, and superiorly 2 cm under the mid-clavicular line (Supplemental Figures 3 A, B, C, D, E, and F). The second loop is designed in a triangular fashion to better define and suspend the IMF along the breast axis. It passes along the IMF and reaches the summit located 2 cm under the mid-clavicular line (Supplemental Figures 4 A and B).

Zones of lipofilling in the whole breast skin surface are marked as well as zones of fat harvesting from the upper abdomen (Figure 1).

A video illustrating the markings is available to view in the appendix.

Surgical procedure

A Doppler echography can be performed preoperatively to locate the perforators facilitating the surgical procedure. The patients are operated under general anesthesia with tracheal intubation, first in the lateral decubitus position with the arm adducted at 90°.

The incision is made according to the drawing. The flap is first deepithelialized before being dissected. The detachment of the fasciocutaneous paddle carrying the deep fascia is made distal to proximal until the midaxillary line is reached. At this point, a detachment of the breast pocket is achieved. The flap is then turned on itself in a flip-over fashion and attached medially to the chest wall (Supplemental Figures 2 A, B, and C).

The donor site is closed with a V-Loc suture in two planes. Quilting sutures are taken between the superficial fascia on both sides of the wound edges and the underlying muscle, followed by the superficial wound closure performed taking only the deep dermis (Supplemental Figures 2 D, E, and F). A drain is then placed in the reconstructed breast.

The patient is then repositioned in a supine position. Lipoaspiration and tunnelization beyond the loops markings are performed with a three millimeter three-hole cannula using the P.A.L.L. technique,[10] to facilitate the mobilization of tissues recruited from the upper abdomen and the lateral thorax. This step is realized as a two-team approach; the first team performing liposuction and the second team preparing the fat for lipofilling and starts decanting it in 50 mL syringes. Using a nonabsorbable suture, the first loop is passed transcutaneously with a three millimeter three-hole cannula. It spans the superficial subcutaneous tissues at the lower quadrants of the breast. At the upper quadrants, the thread is taken in the deep plane to act as an anchor for suspension, forming a loop. This procedure is performed twice to minimize the tension on the knot. This first loop is passed in a circular fashion recruiting the breast surroundings and increasing the breast's projection (Supplemental Figures 3 A, B, C, D, E, and F). This recruitment will increase the cutaneous surface in the reconstructed breast, reduce skin tension, and allow for a better intake of the injected fat. The second loop is passed in a triangular manner, which will better define and suspend the IMF, to obtain symmetry with the IMF of the contralateral breast (Supplemental Figures 4 A,B).

After decantation, the fat is reinjected using a three millimeters three-hole cannula throughout the breast cutaneous surface of the reconstructed site, particularly into the lower quadrant of the breast (up to 100 cc) (Supplemental Figure 4 C).

A second drain is placed at the reconstructed site for 24 h. Intraoperative antibioprophylaxis and 24-h coverage will be provided. To maintain the reconstructed breast, support dressings are placed in the inframammary area, and the patient is placed in a semi-sitting position. The patient will be able to wear her bras after 4 weeks.

Secondary and tertiary procedures are usually performed to better define the IMF, recruit perimammary tissue to increase the breast volume and projection, and reduce the remaining lateral fullness using a circular loop. Lipofilling of the new breast is also performed to add volume to the breast. Indeed, we consider that the injected fat constitutes one third of the final breast volume.

Videos illustrating this technique are joined in the appendix.

Results

A total number of 69 ELT FOLL flaps were performed for 64 patients. The patients ranged from 32 to 77 years of age (with an average age of 55 years), with BMIs varying between 18 kg/m^2 and 32 kg/m^2 (with an average BMI of 22.80 kg/m^2). Sixteen (25%) of the patients were active smokers, 5 (7.8%) patients were diabetic, and 20 (31.3%) patients suffered from other cardiovascular comorbidities. Twenty-five patients (39.1%) received radiotherapy, although none of them had chemotherapy or hormonal therapy. Most of the reconstructions were delayed (87.5%) and unilateral (92.2%) (Table 1).

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Table 1 Population characteristics.

Characteristics	ELT. F.O.L.L.
Number of patients	64
Number of flaps	69
Average age (years)	55 (32-77)
Average BMI (kg/m^2)	22.80 (18-32)
Smokers	16 (25%)
Diabetics	5 (7.8%)
Other comorbidities	20 (31.3%)
Radiotherapy	25 (39.1%)
Chemotherapy	0
Hormonotherapy	0
Immediate reconstruction	8 (12.5%)
Delayed reconstruction	56 (87.5%)
Unilateral reconstruction	59 (92.2%)
Bilateral reconstruction	5 (7.8%)

Other comorbidites: Hypertension, dyslipidemia, other cardiovascular diseases.

Table 2 Complication data.

Complication	Number of flaps (%)
Seroma	0
Infection	1 (1.4)
Necrosis	0
Hematoma	0
Wound dehiscence	2 (2.9)
Thread extrusion	3 (4.3)
Total	6 (8.7)

Table 3 Donor site morbidity outcome.

Characteristics	Average
Preoperative DASH Score	6.53
DASH Score at 6 weeks	11.32
DASH Score at 6 months	7.52

We have reported one case of infection treated with antibiotics, two cases of wound dehiscence over 2 cm in the donor site treated with wound dressings, and three cases of suture extrusion. The overall complication rate was 8.7%. There was no case of total or partial necrosis of the flap. This has been verified clinically, steatonecrosis being defined as a palpated mass in the breast, and infection being characterized by a painful erythema or pus. The patients were followed every week during the first month after the operation, and every two weeks during the following months. Furthermore, an annual breast ultrasound and mammography were performed as part of an oncological follow-up of breast cancer (Table 2).

The shoulder function was assessed through a DASH score ranging from 6.53 preoperatively to 11.32 and 7.52, respectively, at 6 weeks and 6 months, postoperatively (Table 3).

The flap dimensions ranged between 28 and 44 cm for the horizontal lengthening and between 8 and 17 cm for the vertical width, with an average of 35.08 cm and 12.95 cm, respectively. The operative time (from incision to wound closure, without taking into account patient repositioning) ranged from 41 to 72 min with an average of 57.70 min. The hospital stay and time before drain removal both ranged from 1 to 2 days with an average of 1 day. Postoperative pain at day 1 was assessed through the visual analog scale, ranging from 3 to 5 with an average of 3.52 (Table 4).

Table 4 Results.

Characteristics	Average (range)
Horizontal length of the flap (cm)	35.08 (28-44)
Vertical length of the flap (cm)	12.95 (8-17)
Operative time (minutes)	57.70 (41-72)
Hospital stay (days)	1 (1-2)
Time before drain removal (days)	1 (1-2)
Pain (Visual Analog Scale [VAS])	3.52 (3-5)

All patients had additional one to two sessions of fat grafting. The mean injected volume during the first additional session was 180 cc and 150 cc during the second session (Table 5).

Figures 2 and 3 illustrate the results of patients who underwent the technique described in the present article.

Discussion

The latissimus dorsi flap has been considered as a keystone in breast reconstruction for many years. It was first described by Tansini as a muscular or musculocutaneous flap for the reconstruction of head and neck defects.[1] The desire to reduce the morbidity associated with muscular flap harvesting, and the refinement of knowledge about the cutaneous vascularization, allowed the introduction of perforating flaps. Thus, the perforating thoracodorsal (TDAP) flap was born.[4]

In our study, we used a modified version of the thoracodorsal flip-over flap described by Angrigiani.[11-13] Our paddle is mainly vascularized by the lateral intercostal vessels. In fact, these vessels are located mainly between the sixth and the eighth ribs, and our paddle is centered on these vessels. The anterior part of this flap is also vascularized by the perforators of the anterior intercostal arteries, lateral thoracic artery, and the superior epigastric artery. However, the classical branch described by Angrigiani[4], which is based on the thoracodorsal perforator flap, is more posterior, preventing the flap from filling the breast pocket, and reaching the anterior midline when using the flip-over pattern. Thus, this branch was not included in our paddle. Finally, an anastomotic network between the intercostal and thoracodorsal branches has been demonstrated in the literature, playing a key role in our flap's vascular supply through the subdermal plexus.[14] This abundant vascular network makes our flap an interesting option in patients with cardiovascular morbidities.

To transfer a sufficient volume to the reconstruction site, the size of the paddle is essential. The classical dimensions of thoracic flaps used in total breast reconstruction have ranged in size from an average of 19.7 cm × 11.4 cm (for classical LD flaps)[15] to 39.5 cm × 9.5 cm (for extended TDAP flaps).[11] In terms of dimensions, the paddle we are using is

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Table 5 Dimensions of thoracic flaps used in total breast reconstruction.

Flaps	LD Flap	MS-LD Flap	TDAP Flap	Extended TDAP	ELT. F.O.L.L. Flap
Dimensions horizontal x vertical length (cm)	19.7×11.04[15]	23×8.8[5]	20×8[6]	39.5×9.5[11]	35.08×12.95

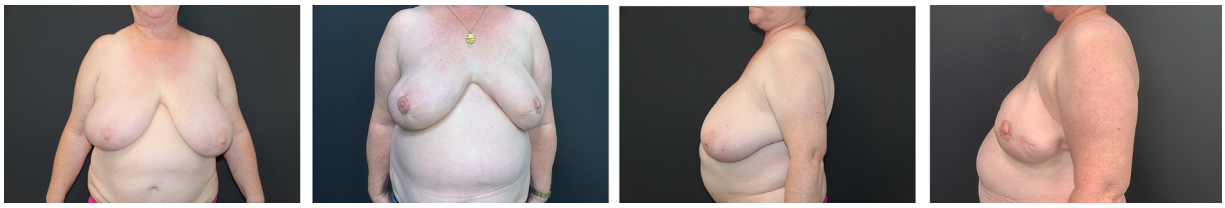

Figure 2 This 67-year-old patient presented for an immediate left breast reconstruction following a total left mastectomy and a right breast reduction. She underwent a left breast reconstruction using the ELT FOLL flap (100 cc), and two sessions of loops and lipofilling (200 and 160 cc) at 4 months and 8 months. Preoperative views (A and C) and follow-up at 1 year (B and D). Note the absence of lateral bulging on the lateral views (C and D).

Figure 3 This 57-year-old patient presented for a delayed bilateral breast reconstruction following a bilateral total mastectomy and received radiotherapy on her right breast. She underwent a bilateral breast reconstruction using the ELT FOLL flap (100 cc), and two sessions of loops and lipofilling (180 cc and 120 cc) at 4 months and 8 months. Preoperative views (A and C) and follow up at 1 year (B and D).

similar to the deepethelialized thoracodorsal musculocutaneous flap described in 2013 by the senior author[16], except we are no longer excising the muscle. The flap's dimensions ranged from 28 cm × 8 cm to 44 cm × 17 cm (average of 35.08 cm × 12.95 cm), thus allowing a large volume to be transferred to the breast (Table 5). Nevertheless, this technique is contraindicated in lean patients. In those cases, a muscular-cutaneous flap would be required to bring sufficient volume.

This is an easily feasible flap for breast reconstruction. After harvesting of our flap in a flip-over fashion and attaching it to the chest wall, remodeling of the reconstructed breast is performed by passing a nonabsorbable thread transcutaneously and forming loops. Literature about the use of internal threads in the breast is scarce.[17-20,27] Khouri introduced them in a scarless fashion in breast augmentation and reconstruction through his reverse abdominoplasty and fat transfer and for breast mastopexy[17-19]. More recently, Hamdi also reported his experience with threads in the reconstruction of the IMF, enhancement of breast projection and stabilization of the breast footprint using percutaneous purse-string sutures in breast reconstruction using fat grafting or a flap.[20]

The footprint loop we used in our technique recruits tissues from around the breast, to reduce the footprint diameter and increase the skin surface. Furthermore, it increases the breast volume and decreases the skin tension. Because of the gain in the cutaneous surface and the loss in skin tension, an immediate lipofilling is easily realizable with a reduced resorption rate.

Even though the circular loop might cause tension on the intercostal perforators while passing one to two centimeters posteriorly to the midaxillary axis and pulling the flap more medially, we consider that the blood supply was not interrupted. Indeed, none of our flaps suffered from partial or total necrosis and this was confirmed clinically and radiologically.

Moreover, the loops better define the IMF. If the position of the IMF is lower than the contralateral breast, it can be further elevated during secondary procedures using loops to achieve a symmetrical position of the IMF. Thus, the final breast volume is based on our ELT paddle, the perimammary fat recruited by the loops, and the lipofilling.

The main technical limitation of the flip-over flap is the difficulty of the paddle positioning. In our series, the mild lateral fullness was encountered after the first intervention but was successfully treated after the second or third surgical procedure. This was mainly due to the placement of the loops that helped in bringing the lateral part of the paddle more medially and defining the lateral limit of the breast. Indeed, the patients were informed that this technique requires in most of the cases up to two sessions of loops and lipofilling (Table 6).

Regarding all fat-grafting breast reconstructions, several sessions are required. However, the initial procedure (Flap + Fat grafting + Loops) reduces the number of sessions required to build up the breast. Actually, a second or third session of fat grafting is a part of the technique. In another word, without the skin recruitment by the flap and the

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Table 6 Fat grafting sessions with amount of injected fat.

Number of sessions	Flap + Lipofilling	1	2
Number of patients (%)	64 (100%)	64 (100%)	59 (93%)
Average volume of injected fat (cc)	100	180	150

loops, one might need 4–6 sessions to complete the breast reconstruction by solely lipofilling.

A second limitation corresponds to the fact that this flap mostly fills the upper half of the breast. Hence, we performed lipofilling in the whole skin surface of the breast and more importantly in the lower part to increase the entire breast's matrix.

This is a retrospective study in which medical charts were reviewed, and minor complications might have been unnoticed thus explaining the low complication rate.

We consider that the injected fat represents one third of the total breast volume, but it has not been assessed by an appropriate radiological examination. Further radiological studies should be considered to evaluate the components rate of the final breast volume.

Our flip-over flap is a simple and fast procedure. It does not require significant detachment or meticulous microsurgical dissection, because the dissection is discontinued once the midaxillary axis is reached. This shortens the duration of the surgical procedure. Indeed, in our series, the operating time for the extended laterothoracic flap (57 min) is less than the operating time of a perforated thoracodorsal flap in which a total dissection of the perforator is performed (80 min of flap harvesting).[6] The ELT FOLL flap is thus an interesting option for patients at risk for long anesthesia. Nevertheless, our technique does not replace the TDAP flap surgery, but it is just an alternative technique in the hands of nonmicrosurgeons.

The hospital stay and time before drain removal are 1 day on average. This is due in particular to a shorter duration of intervention due to a limited detachment as well as a lower rate of complications. Indeed, we assessed a total complication rate of 8.7% in our series, and none of our patients had seromas. In the literature, the occurrence of seroma in a classical LD flap varies between 5% and 80%.. It is mainly related to the volume of muscle removed, the extent of dissection, and the removal of lumbar fat. The preservation of the superficial fascia, the limitation of the dissection, and the quilting to reduce the empty space are all factors allowing a reduction in the risk of seroma occurrence[21-23]. In our study, the lower occurrence of seroma is attributed to the minimal dissection of the paddle, the preservation of the muscle and of the superficial fascia as well as the quilting sutures performed during the wound closure.

Another important element in breast reconstruction using the ELT flap is the mobility of the arm and shoulder. We used the DASH questionnaire to assess disability in the upper limb. In our study, the DASH score was higher at 6 weeks postoperatively, meaning that there was a short-term dysfunctionality of the upper limb. These results correlate with those of the literature. While some studies showed that there is no impairment of shoulder mobility[25], other studies have shown that movement limitation is probably due to other factors.[24,26]

Conclusions

The ELT FOLL should be considered a simple, safe, and reliable alternative for breast reconstruction following mastectomy with or without irradiation, particularly in high-risk patients. Its main advantages include having a large paddle well vascularized through one main and two accessory vascular axes, the fact that it is easily dissectible without sacrificing the underlying muscle, and its subsequent low complication rate.

Declaration of Competing Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjps.2020.10.024.

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