Total Breast Reconstruction using Synthetic Implants covered by Thoraco-Dorsal Artery Perforator Flap (TDAP)

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Background
Implant-based breast reconstruction specifically with the thoracodorsal artery perforator (TDAP) flap was used with high success rate in partial breast reconstruction, and recently, we used it instead of latissimus dorsi flap with implant for total breast reconstruction to avoid the complications of latissimus dorsi flap and postradiotherapy complications of implant.

Patients and methods
This prospective study was done in the Department of Surgical Oncology, Oncology Center, Mansoura University (OCMU), Egypt, from October 2018 to November 2020. A total of 20 patients were enrolled in this study. All patients included had either modified radical, skin-sparing, or nipple-sparing mastectomy with axillary staging, followed by reconstruction using appropriately sized implant with the use of pedicled TDAP flap to cover the inferolateral part of the implant.

Results
We had six (30%) cases with breast sized cup A and 14 (70%) cases with cup size B. The cases with grade I ptotic breast were two (10%) cases, grade II were 16 (80%) cases, and grade III were two (10%) cases. Donor site complications were as follows: wound gap occurred in two (10%) cases, seroma in one (5%) case, and infection occurred in two (10%) cases. Recipient site complications were as follows: partial flap necrosis in two (10%) cases, infection in two (10%) cases, and wound dehiscence in two (10%) cases. Two cases developed persistent infection in the short postoperative period and needed implant removal.

Conclusion
TDAP can be safely used in implant-based breast reconstruction with more versatility, reliability, and low morbidity.

Keywords:
breast reconstruction, perforator flaps, synthetic implant

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Introduction

The main surgical lines for management of breast cancer are either partial mastectomy followed by radiotherapy (breast-conserving surgery) or total mastectomy±reconstruction [1]. Oncoplastic surgical techniques have been introduced combining plastic and oncologic technique to achieve good esthetic and oncologic outcomes. These techniques allow excision of large tumors with wider margins while using different techniques to preserve the shape of breast [2,3].

Mastectomy is indicated for patients who are not candidates for breast-conserving therapy, such as those with multicentric disease, diffuse malignant microcalcifications on mammography, or for other reasons such as mantle radiation for Hodgkin's lymphoma [4–6]. Total reconstruction of breast can be achieved using either autologous flaps or synthetic implants. Autologous flaps include latissimus dorsi flap (LDF) and transverse rectus abdominis myocutaneous (TRAM) flap or deep inferior epigastric perforator flap [7,8].

The advancement in implants and expander quality made the implant-based reconstruction safer and more viable alternative for breast reconstruction after total mastectomy. This technique is technically easy, is less time consuming, has obviously much less complications rate, and can be performed in one or two stages using permanent implant or tissue expander [9,10].

Synthetic implant still has high liablity for displacement; therefore, it should be inserted under proper coverage. However, the full implant coverage is

difficult to achieve, because the pectoralis major muscle has limited extension to cover the lower and lateral part of the implant. Moreover, serratus anterior muscle lifting is difficult to be done. Thus, breast surgeons began to use 'acellular dermal matrix' (ADM) [11–13] and surgical meshes [14–16] to support and cover the lower and lateral aspects of the implant pocket, allowing to have large space to prevent the implant displacement. ADM and surgical meshes have many complications such as seroma, infection, and masking the presentation of local recurrence; in addition, ADMs are not available in many countries with low resources [17].

Autologous flaps such as LDF have been used for implant coverage instead of an ADM. However, the incidence of donor site morbidity in LDF and its adverse effects made the use of perforator flaps, specifically the thoracodorsal artery perforator (TDAP) flap, more feasible. It is to be mentioned that TDAP was used with high success rate in partial breast reconstruction, and recently, we used it instead of LDF with implant for total breast reconstruction, which enabled us to avoid the complications of LDF and to avoid postradiotherapy complications of implant [18].

This study was done to evaluate the feasability to use a synthetic implant covered with TDAP in total breast reconstruction regarding the safety of technique, cosmetic outcome, patient satisfaction, and postoperative follow-up.

Patients and methods

This prospective study was done between October 2018 and November 2020 in the Department of Surgical Oncology, Oncology center, Mansoura University (OCMU), Egypt. A total of 20 patients with breast cancers planned for skin or nipple-sparing mastectomy were included in this study. Patients excluded from this study were those with metastatic breast cancer, tumor infiltrating the pectoralis muscles, previous axillary surgery that caused damage to the thoracodorsal bundle, previous irradiation, or patient refusal. Approval from the institutional review board of the Faculty of Medicine, Mansoura University (18.12.402) was received before starting this study. A written informed consent was obtained from all the patients included in this study.

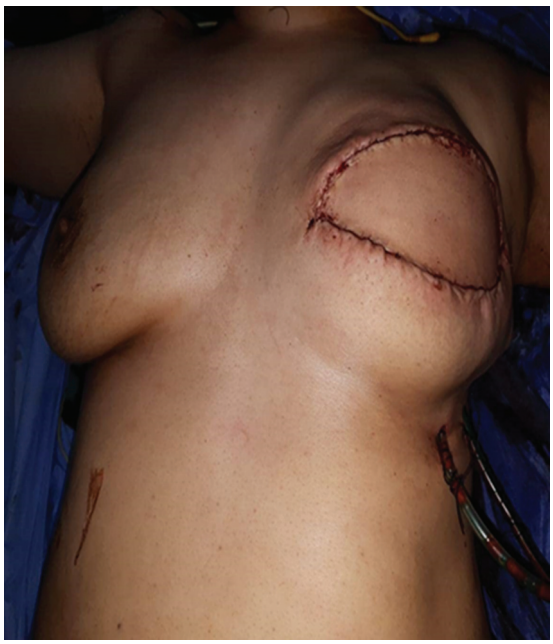
The main principles of oncoplastic surgery were applied during selection of procedures to ensure complete surgical excision of tumor with adequate margins and accepted cosmetic outcome. All patients were evaluated by a multidisciplinary team to achieve the optimal treatment plan depending on the preoperative clinical and radiological evaluation of the breast tissue to be excised and the breast volume.

The patients included were subjected to either modified radical (Fig. 1), skin-sparing, or nipple-sparing mastectomy with axillary staging, followed by reconstruction using appropriately sized implant inserted under pectoralis major muscle with use of pedicled TDAP flap to cover the inferolateral part of the implant as well as any skin defect. All perioperative complications were recorded and evaluated. The cosmetic results were evaluated both subjectively and objectively during the postoperative follow-up in the outpatient clinic.

Operative technique

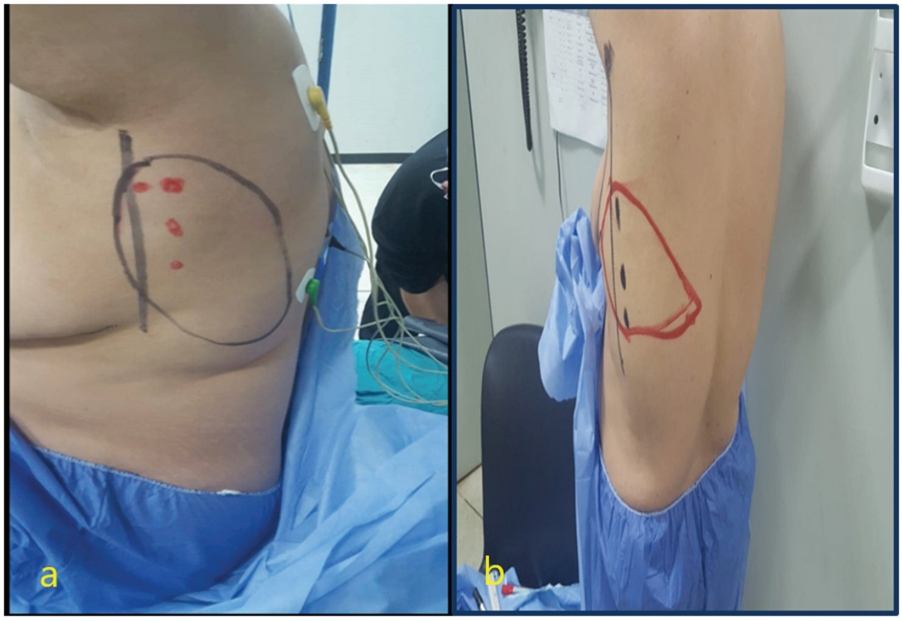
Preoperative perforator mapping and marking of the perforators was done in lateral position performed with the Doppler imaging or based on anatomical landmarks (Fig. 2). In this study, the implant used was with round base, smooth surface, and central projection, filled with cohesive form stable silicone gel. Implant was made by Polytech, Dieburg, Germany. The pocket of the implant was created by division and elevation of the pectoralis major muscle from below, and an adequate size of the implant was chosen that was symmetrical with the other breast (Fig. 3).

Figure 1



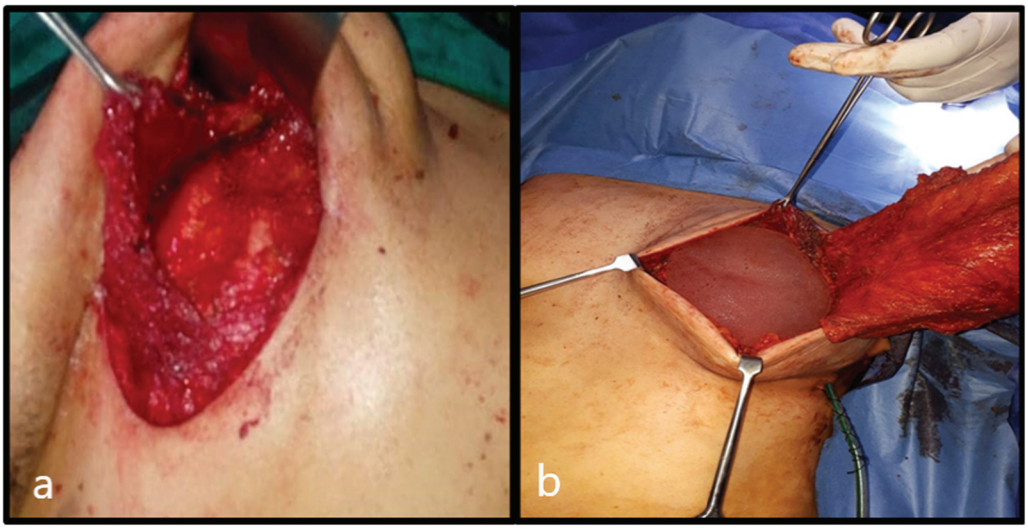
Total breast reconstruction using implant covered with TDAP after modified radical mastectomy. TDAP, thoracodorsal artery perforator.

Figure 2



Preoperative perforator mapping and marking of the TDAP flap. (a) The oblique design. (b) The transverse design. TDAP, thoracodorsal artery perforator.

Figure 3



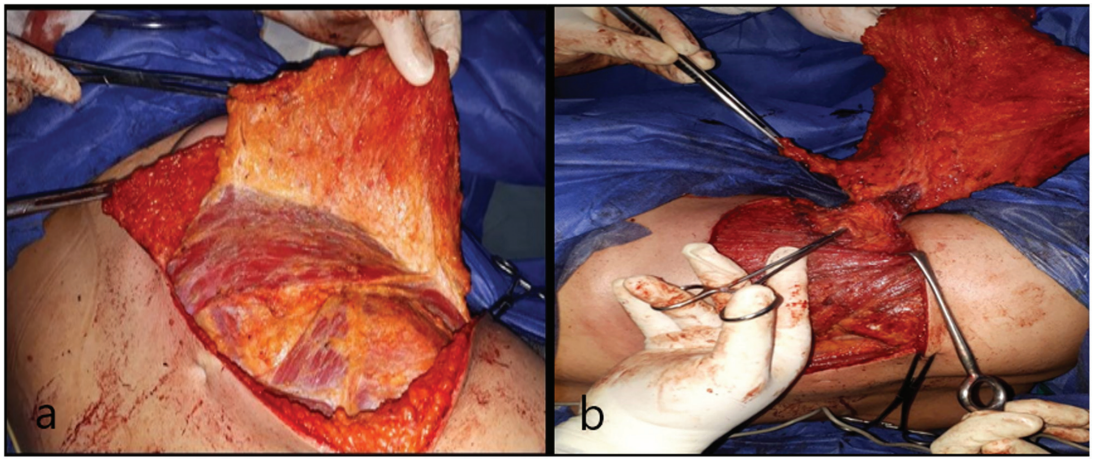
Formation of the implant pocket. (a) Division of pectoralis major muscle. (b) The implant inserted inside the pocket.

Complete covering of the implant was achieved using the divided pectoralis major muscle at the upper and medial parts of the implant and the TDAP flap to cover the inferior and lateral parts of the implant. The advantages in using the TDAP flap with the divided pectoralis major muscle are flexibility in implant insertion, adequate breast contour, and improvement of the cosmetic outcome.

The TDAP flap was separated from the underlying muscles (Fig. 4a) and based totally on the thoracodorsal perforator (Fig. 4b) and then transferred into the breast defect. Therefore, its anterior border becomes the medial or inferior part of the defect. The most distal part of the flap is sutured to the lower most medial part of the breast, the lower border of the flap is sutured to the inframammary fold (Fig. 5a) and laterally sutured to the chest wall, and the upper border of the flap is sutured to the lower border of the divided pectoralis major muscle (Fig. 5b).

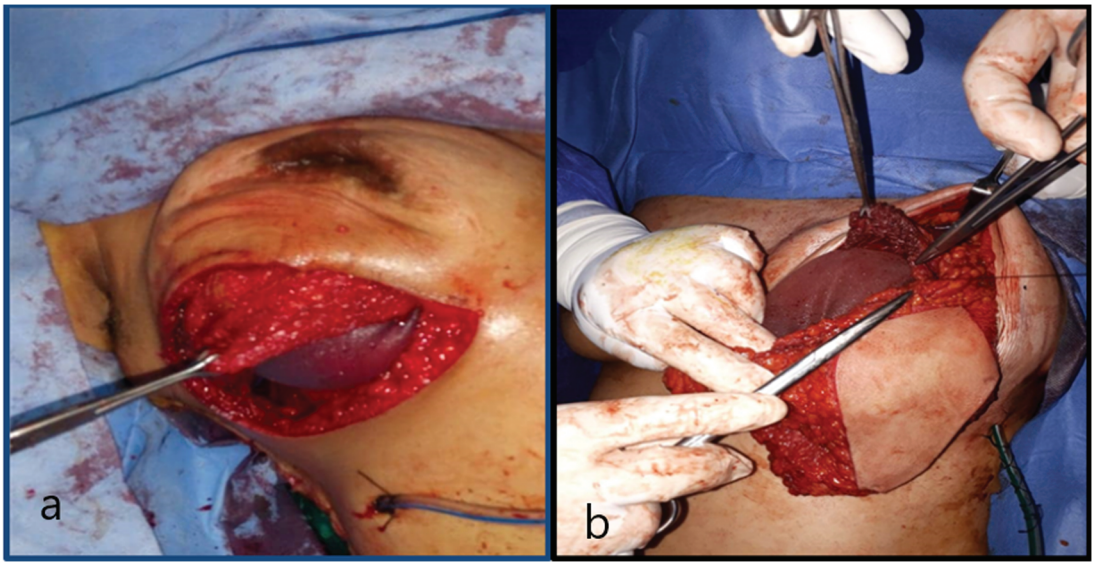
The follow-up schedule was weekly in the first month and then monthly (Fig. 6). Patients were assessed physically to detect early postoperative complications

Figure 4



(a) The TDAP flap was separated from the underlying muscles. (b) The TDAP flap is based totally on the thoracodorsal perforator. TDAP, thoracodorsal artery perforator.

Figure 5



The flap fixation. (a) The lower border of the flap is sutured to the inframammary fold. (b) The upper border of the flap is sutured to the lower border of the divided pectoralis major muscle.

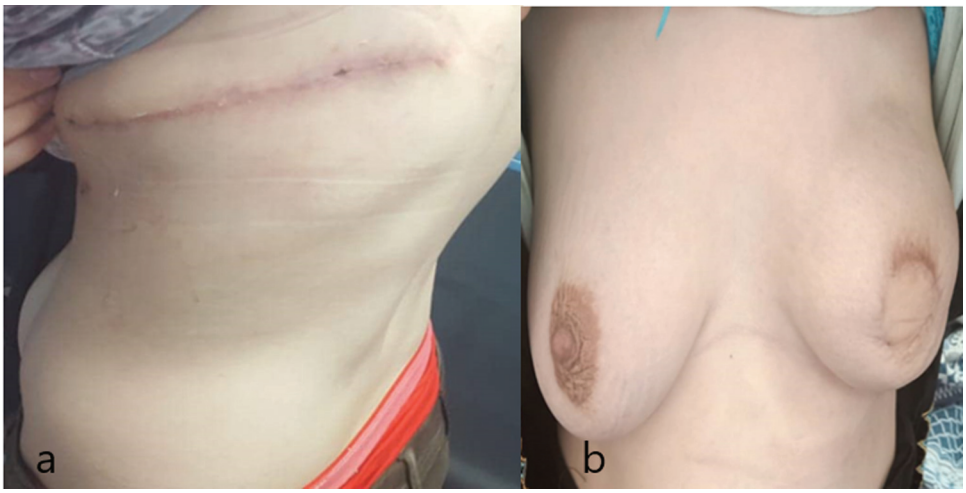
including donor site, recipient site, and implant-related complications. Donor site complications included infection, hematoma, seroma, and wound problems. Recipient site complications included total and partial flap loss, venous congestion, infections, hematoma, seroma, fat necrosis, and wound problems. Implant-related complications included migration, capsular contracture, infection, and pain.

The cosmetic outcome was evaluated by independent surgeons during the follow-up period, and photographs were reviewed by a panel of three observers. The cosmetic results were rated according to a five-point scale (excellent: 5, good: 4, fair: 3, poor: 2, and bad: 1) based on a series of parameters: volume symmetry, shape of breast mound, symmetry of nipple–areolar complex, and postirradiation changes. All patients were referred to medical oncology and nuclear medicine departments to receive their adjuvant chemo-radiotherapy according to the postoperative tumor stage, and local recurrence or distant metastasis was recorded.

Results

Between October 2018 and November 2020, 20 patients with breast cancer with small-sized and medium-sized breasts were offered total breast

Figure 6



Follow-up after 6 months of skin-sparing mastectomy and reconstruction with synthetic implant covered with TDAP flap. (a) The donor site. (b) The recipient site. TDAP, thoracodorsal artery perforator.

Table 1 Patients' demographics

Parameters	*N*=20 [*n* (%)]
Age (years; mean, range)	40.3 (32–46)
BMI (kg/m^2; mean, range)	31.7 (25–38)
Comorbidities	
No	16 (80)
DM	4 (20)
Breast size	
Cup A	6 (30)
Cup B	14 (70)
Breast ptosis	
Grade I	2 (10)
Grade II	16 (80)
Grade III	2 (10)
Preoperative chemotherapy	
No	12 (60)
Yes	8 (40)
Timing of reconstruction	
Immediate	18 (90)
Delayed	2 (10)

DM, diabetes mellitus.

Table 2 Tumor characteristics

	N=20 [*n* (%)]
Tumor side	
Right	12 (60)
Left	8 (40)
Tumor site	
UOQ	6 (30)
LOQ	2 (10)
LIQ	2 (10)
Multicentric	10 (50)
Pathological type	
IDC	14 (70)
ILC	4 (20)
DCIS	2 (10)
Staging	
Stage IA	2 (10)
Stage IIA	6 (30)
Stage IIB	6 (30)
Stage IIIB	6 (30)
Molecular subtyping	
Luminal A	14 (70)
Luminal B	4 (20)
Triple negative	2 (10)
Indications of mastectomy	
Multicentricity	10 (50)
Peau d'orange	6 (30)
Paget's disease of nipple	2 (10)
Patient counseling	2 (10)

DCIS, ductal carcinoma in situ; IDC, invasive duct carcinoma; ILC, invasive lobular carcinoma; LIQ, lower inner quadrant; LOQ, lower outer quadrant; UOQ, upper outer quadrant

reconstruction using TDAP with implant. The median follow-up period was 8 months (range, 1–15 months). Patients' demographics data are shown in Table 1. Overall, six (30%) cases were breast sized cup A and 14 (70%) cases were cup size B. The cases with grade I ptotic breast were two (10%) cases, grade II represented 16 (80%) cases, and grade III represented two (10%) cases. Tumor characteristics are shown in Table 2, and operative details are shown in Table 3.

Donor site morbidities were as follows: wound gap occurred in two (10%) cases; both had diabetes mellitus, and all these cases were managed by resuturing under the umbrella of antibiotics. Seroma was seen in one (5%) case and infection occurred in two (10%) cases.

Recipient site morbidities were as follows: partial flap necrosis occurred in two (10%) cases, which were

Table 3 Operative and postoperative outcomes

	N=20 [*n* (%)]
Type of mastectomy	
Modified radical mastectomy	6 (30)
Skin-sparing mastectomy	8 (40)
Nipple skin mastectomy	6 (30)
The mastectomy time (min; mean, range)	60.1 (45–90)
The flap harvest time (min; mean, range)	130.5 (110–150)
The implant and flap insert time (min; mean, range)	100 (90–120)
Total operative time (min; mean, range)	240 (210–300)
Estimated blood loss (ml; mean, range)	285.7 (200–400)
Donor site complications	
Wound gap	2 (10)
Seroma	1 (5)
Infection	2 (10)
Recipient site complication	
Partial flap necrosis	2 (10%)
Total flap necrosis	0 (0%)
Infection	2 (10%)
Wound dehiscence	2 (10%)
Implant removal	2 (10%)

Table 4 Esthetic outcome

	N=20 [*n* (%)]
Patient self-assessment results	
1 (very poor)	0
2 (poor)	2 (10)
3 (satisfactory)	2 (10)
4 (good)	10 (50)
5 (excellent)	6 (30)
The overall cosmetic results (panel evaluation)	
Excellent	10 (50)
Good	8 (40)
Fair	2 (10)

managed by debridement and resuturing. Total flap necrosis was not detected. Infection was seen in two (10%) cases and wound dehiscence in two (10%) cases. Two cases developed persistent infection in the short postoperative period and needed implant removal. Moreover, one case of the 14 cases that received postoperative radiotherapy presented with persistent fever that needed surgical removal of implant. No cases developed capsular contracture of the implant during the follow-up period.

Esthetic outcome

The esthetic outcomes are shown in Table 4. Patient self-evaluation and satisfaction was assessed through a score of 5 to 1 (5=excellent, 4=good, 3=satisfactory, 2=poor, and 1=very poor) after evaluation of the following parameters: breasts symmetry, breast shape, NAC symmetry, and the scars.

Observer evaluation (panel evaluation) was done by breast surgeons not from the operating team. A questionnaire was used to assess the cosmetic outcome of the treated breast and compare it with the normal one, including seven items using the four-point Liker scale, based on the questionnaire in the form of I: breast shape, II: breast volume, III: breast deformity, IV: nipple position, V: appearance of the surgical scar, VI: skin alterations, and VII: overall cosmetic result.

Discussion

Autologous breast reconstruction is acceptable for patients who can tolerate it with the associated complications. Breast reconstruction using implants is technically easy, less traumatic, and less time consuming. Nevertheless, there are some problems associated with implants use that has caused restriction in its use in breast reconstruction [19].

Breast reconstruction does not affect the disease-free or overall survival with no effect in recurrent disease presentation. Moreover, immediate breast reconstruction does not affect adjuvant chemotherapy delivery or its dose intensity [20]. However, postoperative breast irradiation after implant placement is associated with increased rate of capsular contracture in contrast to autogenous tissue reconstruction [21].

It is to be mentioned that autologous reconstruction has certain complications. The most important of these are loss of muscle function leading to affection of shoulder girdle movement in LDF and weakness of anterior abdominal wall and hernia formation in TRAM. Moreover, there is a high incidence of infection, seroma formation, as well as formation of large scars. Moreover, there is high incidence of flap loss with TRAM and deep inferior epigastric perforator [22–26].

The implant is usually inserted underneath the pectoralis muscle with high rate of displacement, as the space between the chest wall and pectoralis muscle is limited in size and has strong tension. Capsular contracture of the implant after radiotherapy may cause discomfort to the patient [27–29]. Therefore, ADM was used to decrease the capsular contracture and implant discplacement. Moreover, ADM preserves

the natural contour and shape of reconstructed breast with preservation of the inframammary fold [11].

The use of ADM simplifies immediate breast reconstruction as it dose not need to elevate the serratus anterior muscle for implant coverage in its inferolateral aspect. Usage of ADM is safe for implant-based breast reconstruction with the achievement of esthetic outcomes that more closely resemble patients' natural breasts [12]. The ADM use reduces the amount of expansion needed for the pectoralis muscle, especially in ptotic breast reconstruction, to match the preoperative breast shape in creating a natural breast ptosis with inframammary fold preservation and optimization of the inferior pole projection. Moreover, it allows more compensation for the radiation-induced fibrosis by lengthening the muscular tissue plane [13].

Surgical meshes are also used for supporting and maintaining the position of breast implants. It has several disadvantages including technical difficulties and interference with recurrent breast cancer detection. The meshes are not readily available in many countries with low resources, which made the option of autologous implants to be considered in these countries [14]. Latissmus dorsi myocutanous flap has been used for coverage of both the whole muscle and implant. Implant-based breast reconstruction using LDF will thicken the overlying flap with better cosmetic outcome and feeling of the breast [2,8,30].

TDAP flap has been widely used in recent years. This is owing to its versatility, reliability, and low morbidity. It is used usually in partial breast reconstruction with few reports of its use in total breast reconstruction [1,18,31].

The main advantage of TDAP over LDF was reduction of donor site morbidities, mainly the early postoperative seroma, which may persists for extended periods. This is attributed to the preservation of muscle without creation of potential dead space created after LDF [30,31]. Implant covered with TDAP flap can be used for immediate or delayed reconstruction as a single-stage breast reconstruction providing proper covering of the inferolateral part of the implant with good esthetic outcome and decreasing implant-related complication such as capsular contracture, displacement, and exposure and decreasing radiotherapy-related complications.

In this study, 20 patients with breast cancer with breast sizes varying from small to medium sized were offered total breast reconstruction after mastectomy using implant covered with TDAP without ADM, as it is not available and expensive. No cases developed capsular contracture of the implant during the follow-up period. When it comes to cup size, in this study, cup B was seen in 70% and cup A in 30%. We had best esthetic outcome with small-sized to medium-size breasts with high patient satisfaction and breast symmetry with the other side.

Diabetes mellitus was seen in 4/20 cases, which plays a major role in complications. Børsen-Koch *et al.* [32] had 2/38 cases with diabetes mellitus. The indication of mastectomy in this study was variable: six (30%) cases had Peau d'orange, 10 (50%) cases had multicentric breast cancer, two (10%) cases with Paget's disease of nipple, and two (10%) cases preferred mastectomy owing to strong family history. However, in the study by Hamdi *et al.* [18], two cases underwent mastectomy: one with multiple failure of expander and one after necrosis of free flap.

Total breast reconstruction (immediate or delayed) was done in all cases in this study: 18 cases with immediate reconstruction and two cases with delayed reconstruction. However, Børsen-Koch *et al.* [32] reported 43 delayed reconstructions in 38 women, where 33 cases had unilateral reconstruction and five cases had bilateral reconstruction. While Hamdi *et al.* [18] had reported 4 cases with unilateral TDAP reconstruction, 2 cases with immediate reconstruction and 2 cases with delayed reconstruction. On the contrary, in the study by Brackley *et al.* [33], 14 patients had unilateral reconstructions and four patients had bilateral reconstructions, where 6 of them had immediate reconstruction and 12 were delayed.

In this study, the flap was designed in transverse manner in 12 (60%) cases and oblique manner eight (40%) cases. Transverse design was used in all cases of the study by Brackley *et al.* [33]. The flap was raised in the modified manner to preserve both muscle and vessels in eight (40%) cases. If perforator less than 5 mm and not palpable, we raised cuff of muscle around the perforator (MS-LD type 1, 2, and 3) in 12 cases. Børsen-Koch *et al.* [32] had raised the flaps and preserved both muscle and vessels in 32/43 reconstructions, and in the remaining cases, they raised a cuff of muscle around the perforator.

The mean reconstruction time in this study was 240 min (range: 210–300 min), whereas in the study

by Børsen-Koch *et al*. [32], it was 190 min (range: 110–360 min). Hamdi *et al*. [18] had an operative time of 190 min (range: 135–260 min).

In this study, eight patients received neoadjuvant chemotherapy before surgery. All patients needed adjuvant chemotherapy, hormonal therapy, or radiotherapy with no apparent delay or complications during the short follow-up period. One case had persistent pain and fever 4 months after finishing radiotherapy necessitating surgical intervention to remove the implant with no significant improvement regarding the pain and fever for unknown reasons.

Complications in this study that required surgical intervention included partial flap necrosis in two cases, resulting in excision of the distal part of the flap, so implant was covered by skin only at the most inferomedial part, eventually leading to wound gap, implant exposure, and removal of implant. Seroma was seen in one case at the donor site, as this patient was diabetic and had iatrogenic injury of the main perforator, so LDF was used for coverage. Therefore, one of the advantages to use TDAP is that LDF remains available as a salvage at any time.

Moreover, two patients presented with wound gap and necrosis of the back wound and needed secondary closure, and implant removal was done in the two cases with persistent infection in the short postoperative period. The complications reported by Børsen-Koch *et al*. [32] included one case with hematoma, one case with partial flap necrosis, and one case with flap venous congestion. They reported no cases with infection, total flap necrosis, or seroma in the reconstructed breast or the donor site.

Conclusion

TDAP is a safe method used in implant-based breast reconstruction with more versatility, reliability, and low morbidity. It can be used in total breast reconstruction for small- to medium-sized breasts and in immediate or delayed reconstruction with good cosmetic outcomes and minimal implant-related or radiotherapy-associated complications.

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Conflicts of interest

There are no conflicts of interest.

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