



ORIGINAL ARTICLE

# Reliability of zone IV in the deep inferior epigastric perforator flap: A single center's experience with 74 cases <sup>☆</sup>

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## KEYWORDS

Deep inferior epigastric perforator flap;  
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**Summary** From March 2000 to June 2002, 74 deep inferior epigastric perforator (DIEP) flaps were performed in 73 female patients for oncological post-mastectomy breast reconstruction in Chang Gung Memorial Hospital. The mean age was 44.2 years and mean body weight was 56.6 kg. Twenty-five breast reconstructions were immediate and 49 were delayed. The average size of the flap was 30.1 × 12.0 cm and the mean number of perforators was 2.2. The average weight of the harvested flap was 595 g and 85.6% (mean: 509 g) of the flap was used for shaping the new breast mound. Zone IV was not discarded, except in one case. Total flap failure and donor site morbidity was not encountered. Only one flap was revised due to venous congestion (1.4%) and successfully salvaged. Partial flap loss occurred in two patients (2.7%). Fat necrosis was detected in 10 cases (13.5%) and sizes ranged from 2 × 2 to 4 × 5 cm. The numbers of perforators and the percentage of the used flap weight/total flap weight were not related to the complications. The free DIEP flap and inclusion of zone IV is a reliable and valuable method of breast reconstruction and provides superior aesthetic outcomes.

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## Introduction

Post-mastectomy breast reconstruction with pedicled transverse rectus abdominis flap (TRAM) was popularized by Hartrampf in the early 1980s.<sup>1,2</sup> Although this flap has been proved to be largely reliable, the rate of partial necrosis may reach up to 25% because of the folding and tunneling of the flap to reach the chest wall. The free TRAM flap was

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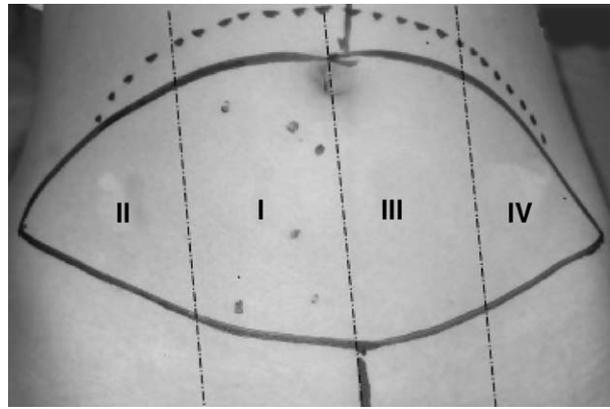
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developed as an alternative to circumvent the problem of partial flap necrosis; nevertheless, it still requires sacrifice of the rectus abdominis muscle, which may cause abdominal wall weakness.<sup>3-5</sup> In an effort to decrease donor site morbidity, the deep inferior epigastric perforator (DIEP) flap has recently emerged as a refinement of the free TRAM flap.<sup>6</sup> The DIEP flap not only provides the advantages of the free TRAM flap, but also decreases post-operative pain and recovery period, since the rectus abdominis muscle and fascia are protected. Abdominal asymmetries, hernias, and bulging are also minimized.<sup>7-9</sup> Long-term results are more predictable as there is no muscle atrophy involved.<sup>10,11</sup> However, some authors reported that distal zone IV of the DIEP flap is poorly perfused and the discarding of this part is associated with a lower incidence of partial flap loss and fat necrosis.<sup>7,10-15</sup> Therefore, it was recommended that the DIEP flap should preferably be used only for small breasts or for those breasts requiring less than 70% of the flap to achieve adequate shape and volume.<sup>11,12</sup> If the patient is thin or the contralateral breast is pendulous and large, restoration of symmetric breasts with adequate volume may require inclusion of zone IV. The objective of this paper was to retrospectively assess the reliability and safety of the DIEP flap especially when zone IV was included.

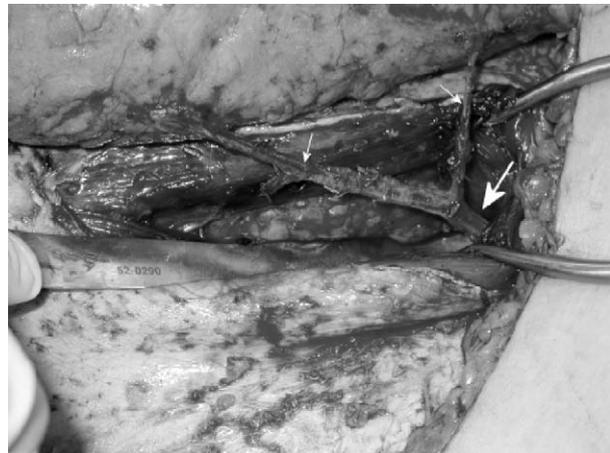
## Materials and methods

### Surgical technique

The dissection of the DIEP flap was performed as previously described by others.<sup>7,10,14</sup> The use of deep inferior epigastric vessels, ipsilateral to the defect site, was preferred and preoperatively perforators in zone I were marked by a hand-held pencil Doppler (Fig. 1). Flap zones ipsilateral to the defect site were called zone I and zone II while contralateral sites were named zone III and zone IV (Fig. 1). Flap elevation usually started from the ipsilateral border of the defect and perforators in the lateral row were identified. Five centimeters of superficial inferior epigastric vein stump was preserved as a 'lifeboat' as recommended.<sup>10,12,13,15</sup> Then the contralateral side of the flap dissection was performed and the medial and lateral rows of perforators on this side were ligated. The ipsilateral medial row perforators were exposed from the contralateral side. Once a good perforator was chosen, the anterior rectus fascia was incised at the rim of the gap through which the perforating vessels arise. If more than one perforator was



**Figure 1** Preoperatively marked perforators on the ipsilateral side of the defect (zone I).



**Figure 2** Perforators (indicated by smaller arrows) and exposed deep inferior epigastric vessels (indicated by the bigger arrow) following the split of the rectus abdominis muscle.

selected, the incision in the fascia was extended to reach the other perforator in the same row. A caudal extension of the fascia incision was done. The muscle was split following the direction of its fibers in order to expose and dissect the deep inferior epigastric artery and venae comitantes to an adequate length (Fig. 2).

The internal mammary artery and venae comitantes were the preferred recipient vessels. To expose the internal mammary vessels, 2 cm of costal cartilage of the third or fourth rib was resected. Thoracodorsal vessels could be used as recipient vessels when they were already available for anastomosis in immediate breast reconstruction or when the internal mammary vessels were not available.

By the time the recipient vessels were isolated, the deep inferior epigastric vessels were ligated

and the total flap weight (TFW) and its volume were measured by a sterile container device. The flap was then temporarily fixed to the thoracic wall and both arterial and venous microsurgical anastomoses were performed. The venous anastomosis was performed first, followed by the arterial anastomosis. The cephalic border of the flap was usually inset downward, pointing to the inframammary crease and zone IV of the flap was located on the superior-lateral area of the reconstructed breast (Fig. 3). After shaping and inseting the breast mound, the excised tissue from the flap was also weighed in order to calculate the weight of the used flap (FUW). A suction drain was placed and the wound closed in two layers. At the end of the operating procedure, the resected costal cartilage is kept in a subcutaneous pocket to be used for the nipple reconstruction later.

Anti-thrombotic agents were not routinely used. Patients were admitted to the microsurgery intensive care unit for 24–48 h and then transferred to the ward. After a hospitalization period of 5–7 days, patients were discharged and they were followed up in the outpatient clinic once a week in the first post-operative month and then once every 3 months.

## Patients

From March 2000 to June 2002, 73 patients underwent immediate or delayed breast reconstructions

with 74 DIEP flaps. Unilateral breast reconstruction was performed in 72 patients and bilateral reconstruction in one case. In the latter, one flap was used for breast reconstruction and the other flap for replacing a previous implant in the opposite breast.

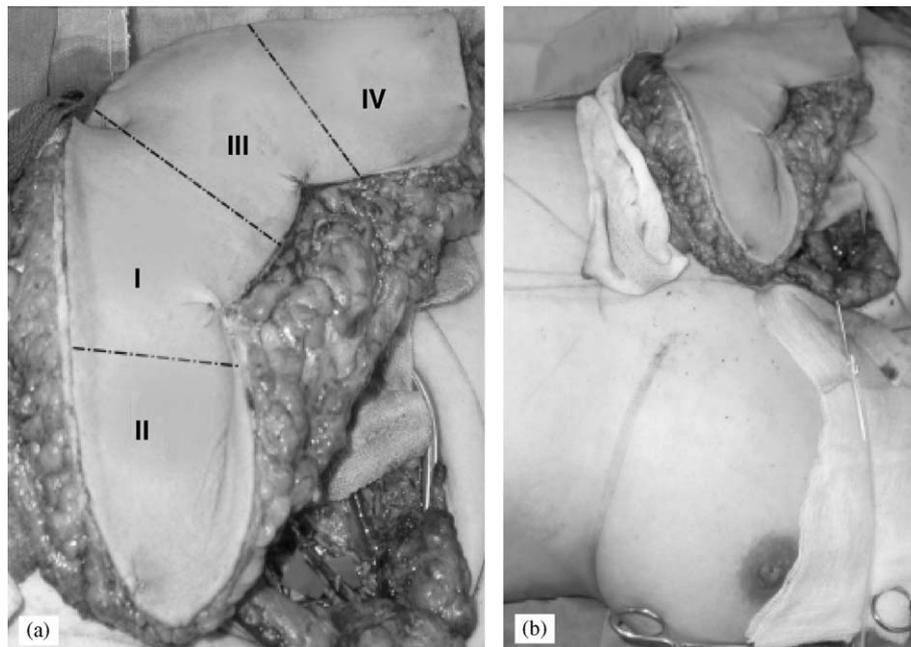
Mean age at the time of surgery was 44.23 years (range 27–65 years), mean body weight was 56.6 kg (range 40–80 kg), and mean body mass index (BMI) 22.4 (range 16.6–31.3). Forty-nine cases (66.2%) had modified oncological radical mastectomy and delayed breast reconstruction after a mean period of 72 months (range 1–312 months). Twenty-five cases (33.8%) underwent oncological skin sparing

**Table 1** Preoperative risk factors and complications.

	Patient number	Partial flap loss	Fat necrosis
Smoking	2	0	0
Obesity*	2	0	0
Radiation	3 <sup>†</sup>	1	1
Abdominal scar	3 <sup>†</sup>	1	2
Total	9	2	3

\*The BMI of the two obese patients was 31.3 and 28.3.

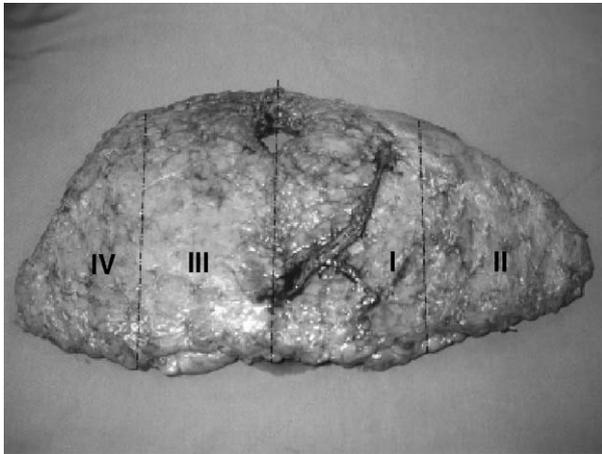
<sup>†</sup>One patient had both preoperative radiation and a previous abdominal scar.



**Figure 3** (a) Homogenous and satisfactory perfusion of all the zones (I–IV) of the DIEP flap following the completion of anastomosis. (b) The cephalic border of the flap was inset downward, pointing to the inframammary crease and zone IV of the flap was located on the superior-lateral area of the reconstructed breast.

mastectomy and immediate reconstruction. There were 36 and 38 reconstructions for left and right breasts, respectively.

Nine patients had known risk factors for breast reconstruction surgery. Two women (2.7%) were smokers and obesity was present in two cases (2.7%; BMI: 31.3 and 28.3). A previous abdominal scar was present in three patients (4.0%); one of them had a longitudinal laparotomy midline scar in the lower abdomen and the other two had an



**Figure 4** A deep inferior epigastric perforator (DIEP) flap with two perforators in zone I.

appendectomy scar. Three cases had a history of previous post-mastectomy radiotherapy (4.0%) and one of these had an appendectomy scar (Table 1).

The average size of the abdominal fat-skin paddle was measured as 30.1 × 12.0 cm (range 19–40 × 10–16 cm). Fourteen DIEP flaps (18.9%) were perfused by only one perforator, 33 flaps (44.6%) by two (Fig. 4), 24 flaps (32.4%) by three, and three flaps (4.1%) by four perforators (Table 2). The correlation between number of flap perforators and the complications was explored (Table 2).

Internal mammary artery and venae comitantes were used as recipient vessels (93.2%) in 21 of the 25 immediate and 48 of the 49 delayed reconstructions. Thoracodorsal vessels were chosen as recipient vessels in four cases of immediate reconstruction and in delayed reconstruction of one case with a primary absence of the internal mammary artery.

## Results

Mean flap ischemia time was 96.1 min (range 40–152 min). After dissection of the perforator(s) and before division of the pedicle, perfusion of the 73 flaps was adequate including the distal area (zone IV). Only the patient with a midline

**Table 2** Correlation between the numbers of perforators and partial flap loss/fat necrosis.

Number of perforators	Number of flaps (%)	Complications		Complication rate (%)
		Partial flap loss	Fat necrosis	
1	14 (18.9)	0	2	14.3
2	33 (44.6)	2	4	18.2
3	24 (32.4)	0	4	16.7
4	3 (4.0)	0	0	0

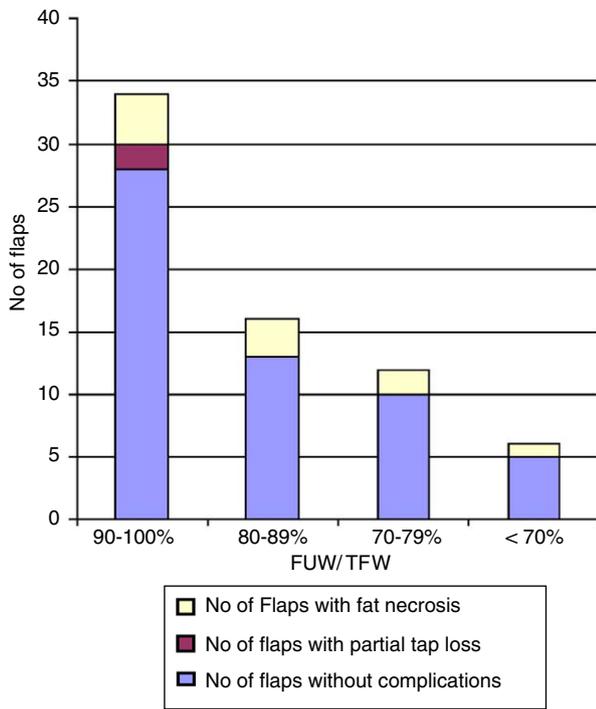
**Table 3** Comparisons of the complications in different percentages (FUW/TFW) of 68 DIEP flaps for breast reconstructions.

FUW/TFW (%)	Number of flaps (%)	Partial flap loss (%)	Fat necrosis (%)	Complication rate (%)
90–100	34 (50)	2/34 (5.9)	4/34 (11.8)	17.6
80–89	16 (10.3)	0/16 (0)	3/16 (18.8)	18.8
70–79	12 (5.9)	0/12 (0)	2/12 (16.7)	16.7
<70	6 (8.8)	0 (0)	1/6 (16.6)	16.7
Total	68 (100)	2/68 (2.9)	10/68 (14.7)	17.6

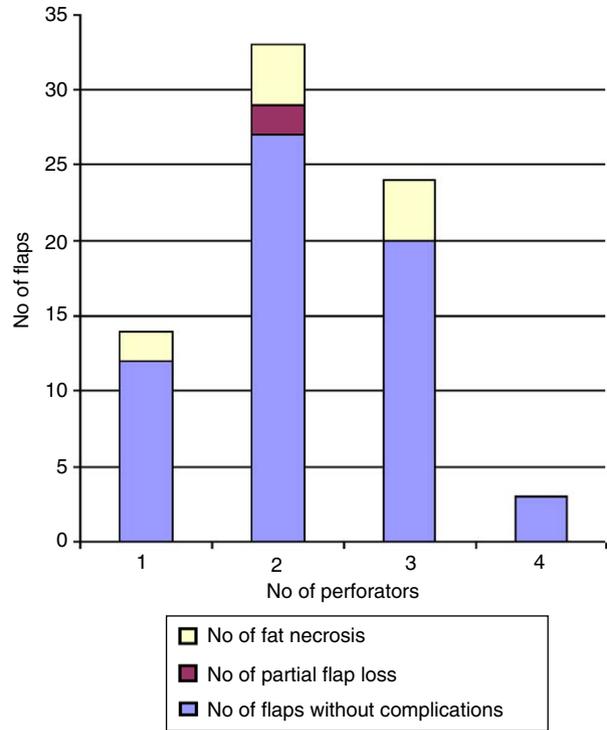
FUW = weight of the used flap.

TFW = total flap weight.

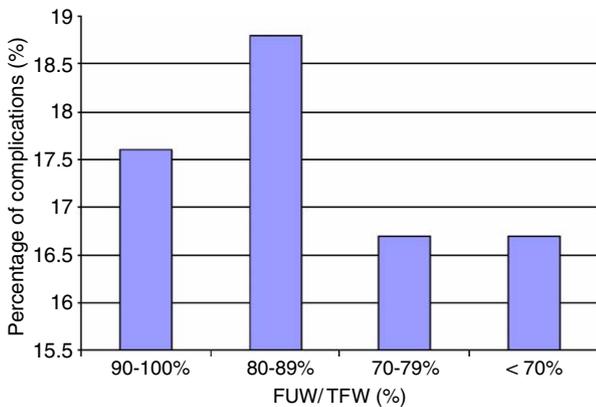
DIEP = deep inferior epigastric perforator.



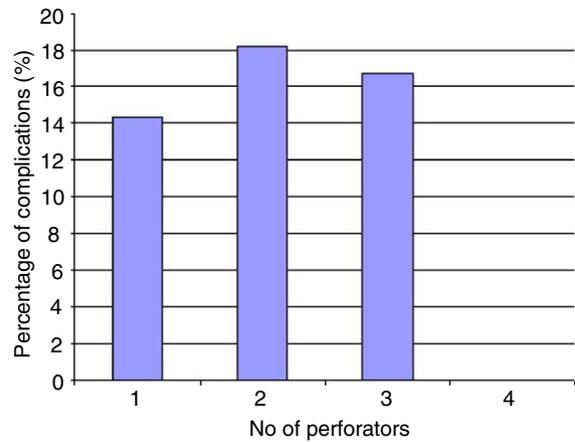
**Figure 5** Number of flaps with different percentages of weight of the used flap/total flap weight (FUW/TFW) and associated partial flap and fat necrosis.



**Figure 7** Number of perforators and associated partial flap and fat necrosis.



**Figure 6** Different percentages of FUW/TFW and associated overall complication rate.



**Figure 8** Number of perforators and associated overall complication rate.

abdominal scar showed a sign of congestion in zone IV and subsequently this zone was discarded.

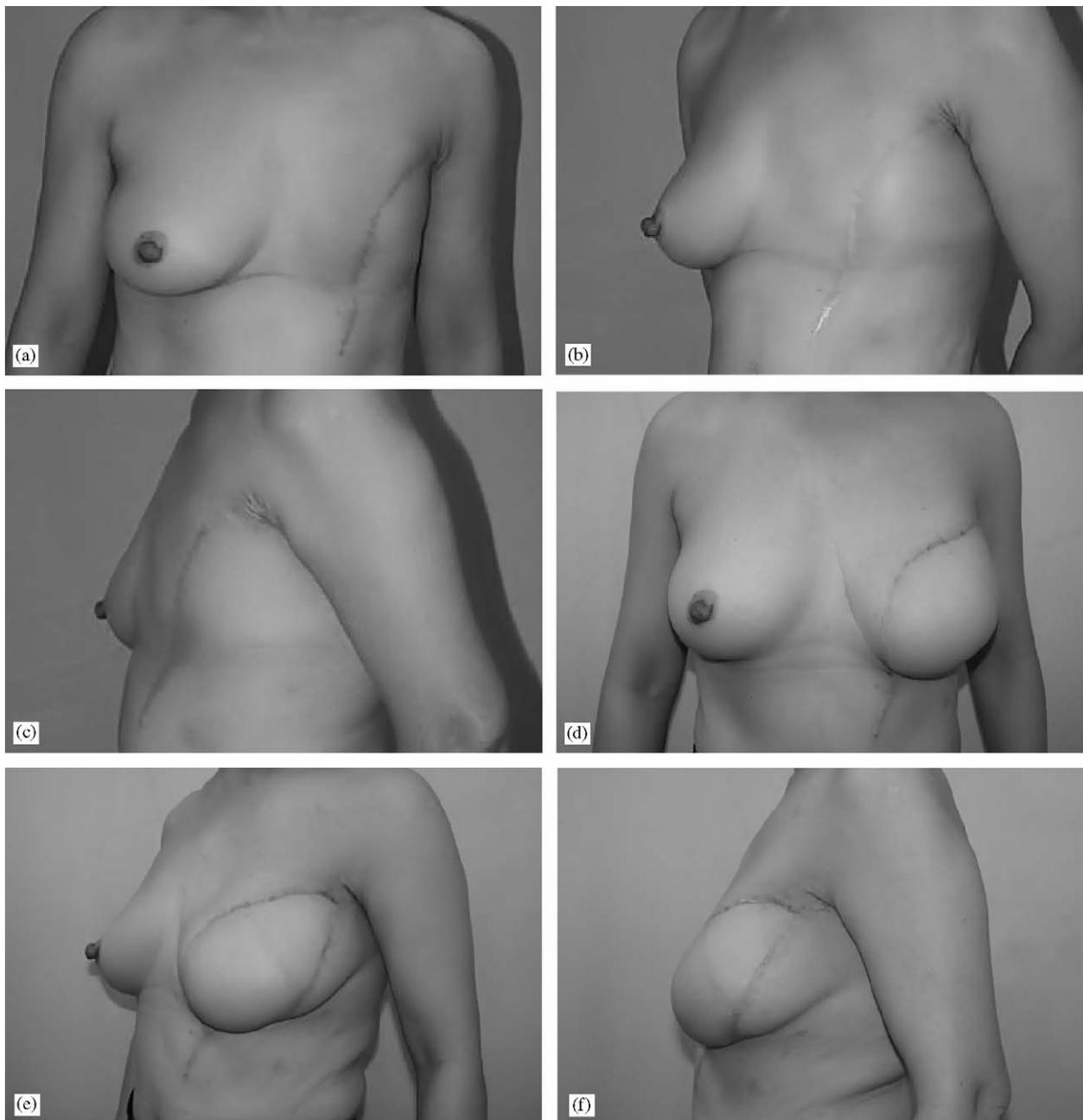
All flaps survived immediately after surgery. There were no major peri-operative complications. Venous congestion was observed in two patients during the first 24 post-operative hours. In one of them, removal of some stitches was enough to relieve the venous drainage problem. In the other patient, a second venous anastomosis was performed between the other

deep inferior epigastric vein and the distal internal mammary vein stump in a retrograde drainage fashion. However, as the congestion persisted, the superficial inferior epigastric vein was anastomosed to the medial internal mammary vein with a 6-cm vein graft. The flap was then successfully salvaged. Six minor complications occurred (8.1%) including chest wall hematoma in four cases, abdominal seroma in one patient, and umbilical infection in one patient.

“FUW” was defined as the actual flap weight used for reconstruction after removal of the excess parts when shaping the breast. Six cases with incompletely documented TFW (total flap weight) or FUW were excluded from the analysis (Table 3). The mean FUW was 508.9 g (range 175–975 g), which was 85.6% of the mean TFW (594.8 g). The harvested flap was entirely used in seven cases (10.3%). Thirty-four breast reconstructions needed 90% or more of the TFW to fulfill the adequate

tissue volume (Table 3). Only two patients required less than 70% of the TFW to achieve the symmetry.

Two flaps (2.7%) developed small partial flap loss (5% and 3% of the flap). Both cases had received more than 90% of the total harvested flap weight for reconstruction. One of the cases with partial flap loss in zone IV had had previous radiotherapy and an appendectomy scar. There were no risk factors in the other patient. The percentage of the FUW/TFU was not robustly associated with overall complication rates (Figs. 5, 6).



**Figure 9** Preoperative (a–c) and post-operative (d–f) views of breast reconstruction with the DIEP flap at 8 months post-operatively with satisfactory aesthetic outcome. (a, d) Anterior view; (b, e) oblique view; (c, f) lateral view.

At a mean follow-up of 12.3 months (range 3–30 months), fat necrosis developed in 10 patients (13.5%) and was identified by either physical examination or mammography. Following the excision of fat necrosis, the final breast shape and volume remained adequate and aesthetically satisfactory. None of those patients required additional tissue or implant.

Patients with a history of tobacco smoking and obesity did not have any complications in this series. Two of the three radiated patients developed partial flap loss or fat necrosis (Table 1). Partial flap loss occurred in one patient who had had both previous radiotherapy and an appendectomy scar.

Most of the DIEP flaps (44.6%) had two perforators and the number of the perforators ranged from one to four. There was no correlation between the overall complication rates and the number of perforators included (Table 3, Figs. 7, 8).

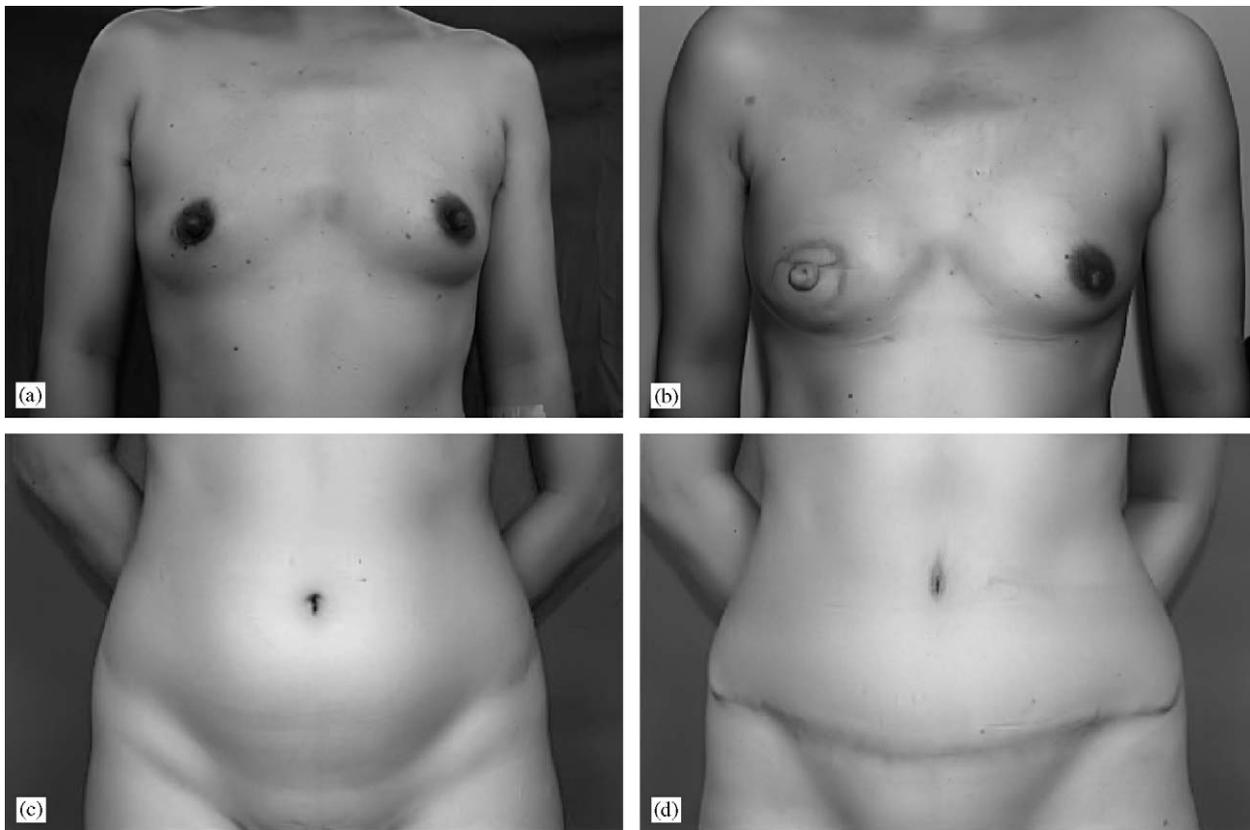
Fourteen nipple areolar reconstructions were performed as secondary procedures. No abdominal weakness, bulginess or hernia was detected. The patients were highly satisfied with the aesthetic outcomes (Figs. 9–11).

## Discussion

Due to unreliability, the routine discarding of distal zone IV has become common practice in breast reconstruction in women.<sup>10–15</sup> This report is the first to present the reliability of zone IV in a large series. In this study, all patients were Asian with characteristically thin body habitus and abdominal fat thickness less than western women. There exists the possibility that increased BMI may negatively impact the microcirculation and hence choke vessels in the midline. For instance, increased abdominal fat may alter intravascular pressures leading to readjustment of flow and changes in the size of the areas able to be perfused. Consequently, unilateral deep inferior epigastric vessels turn out to be inadequate to supply the adipocutaneous tissue in the most distal flap zone (zone IV). There have been no studies to date investigating the effect of BMI on delicate free perforator flaps. It is worthwhile further investigating and clarifying this issue. In this respect, this study contributed noteworthy information that may encourage the trend toward using zone IV for a better aesthetic outcome.



**Figure 10** Preoperative (a, b) and post-operative (c, d) views of breast reconstruction with the DIEP flap at 11 months post-operatively with satisfactory aesthetic outcome. (a, c) Anterior view; (b, d) oblique view.



**Figure 11** (a) Preoperative view before right breast skin-sparing mastectomy. (b) Twelve months after reconstruction of the breast with a DIEP flap (immediate reconstruction) and following the restoration of the nipple areolar complex. (c) Preoperative view of the donor site. (d) Post-operative view of the donor site with a fine scar and satisfactory aesthetic result.

It is a common thought that due to insufficient blood supply, partial flap loss and fat necrosis usually occur in zone IV. In our series, the overall complication rate, including partial flap loss (2.7%) and fat necrosis (13.5%), was no more than in other series advocating the discarding of zone IV<sup>10,11,14</sup> (Table 3). Although smoking and obesity are well-known risk factors for free flap failure,<sup>4,11,12,16</sup> our study did not support this observation, probably due to the small numbers of smokers and obese patients. On the other hand, radiation and previous abdominal scars seemed to be obviously detrimental to flap survival and cause fat necrosis, and were responsible for 50% of these complications (5/10; Table 1).

Theoretically, multiple perforators provide better perfusion of the flap, but one good perforator is usually sufficient for flap survival.<sup>8,10,11,14</sup> Our results confirmed the reliability of one perforator for a flap since there were no overt correlations between the complications and the number of perforators in the flaps (Table 3, Figs. 7, 8).

Taking into account that venous congestion might happen, including the superficial inferior epigastric vein, is routine in our practice, as recommended by other surgeons,<sup>8,10,12,13,15</sup> and through this practice we were able to salvage one flap with patent but inadequate venous drainage.

## Conclusion

The DIEP flap is a reliable and safe procedure for post-oncological breast reconstruction. The donor site morbidity and complication rates are low. Inclusion of zone IV is highly reliable, even though one perforator is incorporated, and provides superior aesthetic outcomes. The overall complication rate (rate of partial flap and fat necrosis) is not related to the number of flap perforators and the ratio of FUW/TFW. Rather, radiation and previous abdominal scars seem to be detrimental to flap survival and cause fat necrosis, and these patients should be carefully judged preoperatively.

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