Breast Reconstruction with a Muscle-Sparing Free Transverse Rectus Abdominis Myocutaneous Flap: Comparison between Immediate and Delayed Groups

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Background: Breast reconstruction offers not only physical but also psychological rehabilitation. Autologous tissue transfer is a good option for breast reconstruction. The purpose of this study was to investigate the success rate, complications, and cosmetic outcomes following use of a muscle-sparing free transverse rectus abdominis myocutaneous (TRAM) flap for breast reconstruction.

Methods: Between August 1999 and February 2001, 15 consecutive patients underwent breast reconstruction using a muscle-sparing free TRAM flap after a mastectomy. Ten patients received mastectomies and immediately underwent breast reconstruction using muscle-sparing free TRAM flaps at Chang Gung Memorial Hospital. The remaining 5 patients first received a modified radical mastectomy and then underwent breast reconstruction.

Results: The mean age of patients was 43.9 (range, 32 to 50) years. Ten patients (67%) underwent immediate reconstructions, and 5 (23%) underwent delayed reconstructions. The overall success rate was 93.3%. Postoperative complications included 1 abdominal seroma and 1 small area of breast fat necrosis. Six of 10 patients with immediate reconstruction underwent both adjuvant chemotherapy and hormone therapy, while 3 patients received only chemotherapy. None of these adjuvant therapies were delayed by the reconstructive surgery. At a mean follow-up of 26.7 months, no local recurrence had been found, and 93% of patients were satisfied with the esthetic results.

Conclusions: A muscle-sparing free TRAM flap is a good option for breast reconstruction. Both the success rate and patient satisfaction are high. The subsequent adjuvant therapy need not be delayed following immediate reconstruction.
(Chang Gung Med J 2004;27:275-82)

Key words: **muscle-sparing free transverse rectus abdominis myocutaneous (TRAM) flap, mastectomy, breast reconstruction.**

The breasts are an important symbol of femininity in most cultures. A mastectomy without reconstruction causes breast deformity which affects not only physical aspects but also the psychological

Paper presented at the Annual Meeting of Surgical Association, R.O.C. March 24, 2002, Kaohsiung, Taiwan.
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Received: Jul. 7, 2003; Accepted: Jan. 8, 2004
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integrity of the female. Recent advances in reconstructive techniques allow reconstruction after breast ablative surgery which alleviates some physical and psychological concerns. Among various reconstruction methods, autologous tissue transfer has been described as 1 of the good options.[1,2] It provides a more-natural-looking breast and is reported to feel better.[3] There are fewer long-term complications, and costs are lower when a free flap is used for breast reconstruction.[4]

Since the first report by Hartrampf and Scheflan in 1982,[5] the pedicle transverse rectus abdominis myocutaneous (TRAM) flap has become the most popular autologous tissue breast reconstruction technique. Later, Harashina applied microsurgical techniques to replace the pedicle TRAM flap for breast reconstruction.[6] Although free TRAM flap reconstruction is technically more tedious and time consuming, the reported results of the free TRAM flap have been very promising. Advantages of the free TRAM flap technique include better maintenance of the inframammary crease as no subcutaneous tunneling is necessary and less postoperative abdominal bulging or hernia due to less muscle which has to be damaged or sacrificed.[7] This study reports on our early experience using a muscle-sparing free TRAM flap for breast reconstruction following a mastectomy.

METHODS

From August 1999 to February 2001, 15 consecutive patients underwent breast reconstruction using muscle-sparing free TRAM flaps after a mastectomy. Ten patients received a mastectomy and immediate breast reconstruction with muscle-sparing free TRAM flaps at Chang Gung Memorial Hospital. The type of mastectomy was determined by the pathology, invasion, size of the tumor, patient preference, and family history.[8] The remaining 5 patients first received a modified radical mastectomy and then later received breast reconstruction after some delay.

For the immediate reconstruction, the TRAM flap was harvested after completion of the tumor ablation surgery. In delayed reconstruction, a 2-team approach method was applied with 1 surgeon preparing the recipient site and the other harvesting the free TRAM flap. Once the 2-team approach was not available, the recipient site dissection was performed first. A breast pocket was created from a previous mastectomy wound medial to the sternal border, lateral to the anterior axillary fold, and inferior to the inframammary fold. The thoracodorsal vessel in the axilla was dissected out to its origin in the axillary artery to facilitate anastomosis on a superficial plane. In 1 case, the internal mammary artery and vein were dissected after removal of the 3rd costal cartilage over the sternal junction.[9] Vessels were ligated distally, and 1 cm of the internal mammary artery and vein were identified for preparation of the anastomosis. Harvesting the free TRAM flap began from the lateral and ran to the medial. After identifying the lateral raw perforators, the ipsilateral rectus abdominis sheath was incised 2.5 mm lateral to the perforators. The muscle was split 1 cm proximal to the perforators until the underlying fascia was exposed. The deep inferior epigastric vessels were then traced to their origin. One or 2 of the larger perforators and only minimal muscle and fascia around the perforators were included (Fig. 1), which is called a "muscle-sparing" technique.[10] The dissection proceeded above the fascia on the contralateral side.

After division of the vascular pedicle, the flap was transferred to the chest and was inset before the microsurgical anastomosis (Fig. 2). Microsurgical end-to-end anastomoses of the deep inferior epigastric vessels to the thoracodorsal or internal mammary vessels with 10-0 nylon were then performed. The abdominal wall was closed after re-approximating

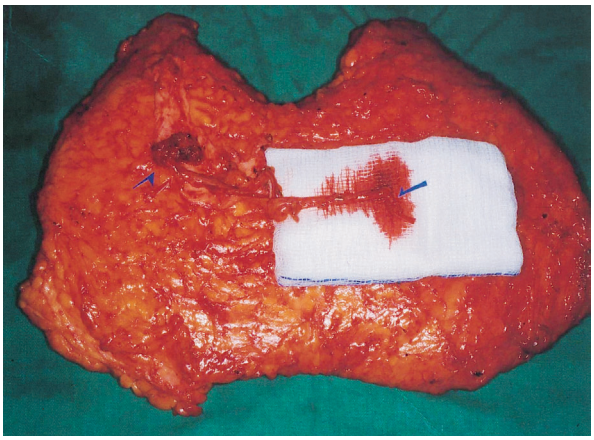

Fig. 1 Muscle-sparing technique. The left arrow indicates inclusion of a small piece of the rectus abdominis muscle and fascia around the perforators in the harvested free TRAM flap.

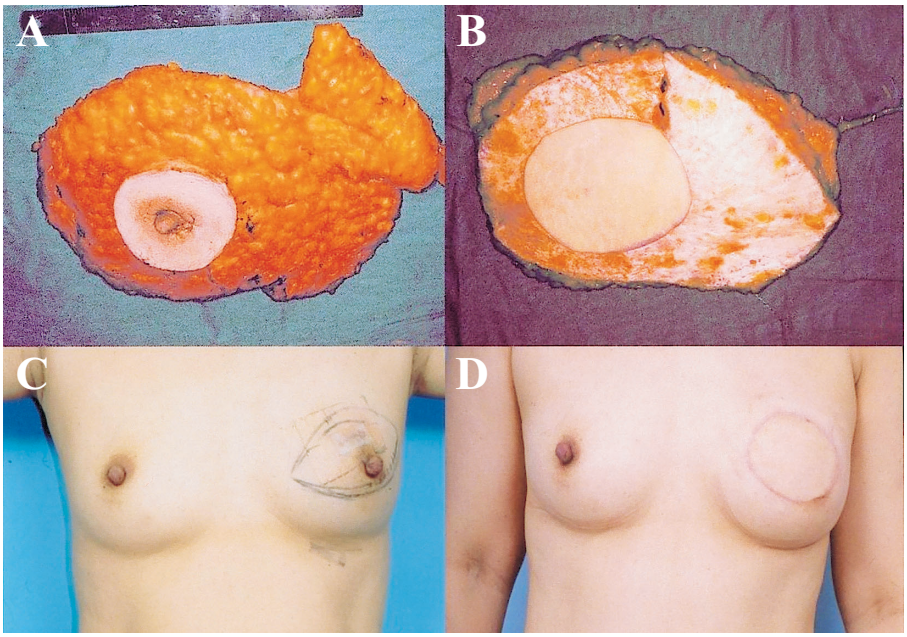

Fig. 2 (A) Breast tissue including the axillary fat pad removed by the modified radical mastectomy. (B) A trimmed and partially de-epithelialized free TRAM flap. The zone IV area of the free TRAM has been totally removed, and portions of zone II and zone III areas have also been removed. (C) A 50-year-old female with left breast cancer (invasive ductal carcinoma stage IIa pre-operative), (D) 6 months after a modified radical mastectomy and immediate reconstruction using a muscle sparing free TRAM flap.

the fascia. No mesh graft was required. The skin was closed in layers after placement of Jackson-Pratt drains.

Well-trained, specialized nurses monitored the flap by evaluating standard parameters including temperature, color, texture, and capillary refilling each hour. The standard medications included a 100-ml bolus infusion of dextran-40 intraoperatively and 20 ml/h postoperatively for 3 days. Prophylactic antibiotics including Cefamezine and gentamicin were also used for 3 days. After discharge, patients were routinely followed-up by the general surgeon, a plastic surgeon, and an oncologist. Six patients in the immediate reconstruction group continued on postoperative chemotherapy, and 3 patients had hormone therapy. None of these adjuvant therapies was delayed by the reconstructive surgery.

Patient satisfaction was evaluated by mains of a postoperative questionnaire adopted from the Michigan Breast Reconstruction Outcome Study.[11] The questionnaire (Table 1) had 2 subscales, including 7 items assessing both general satisfaction with the reconstruction (5 items) and esthetic satisfaction (2 items). Patients were asked to respond to each item using a 5-point Likert scale. Item responses ranged from 1 (very unsatisfied) to 5 (very satisfied). Responses for each of the subscales were

Table 1. Questions Related to Satisfaction with the Reconstruction

Subscale: general satisfaction
1. Knowing what I know today, I wound definitely choose to have breast reconstruction.
2. Knowing what I know today, I wound definitely choose to have the type of reconstruction I had.
3. Overall, I am satisfied with my reconstruction.
4. I would recommend the type of reconstructive procedure that I had to a friend.
5. I felt that I received sufficient information about my reconstruction options to make an informed choice between either the TRAM or an implant procedure.
Subscale: esthetic satisfaction
1. The size and shape of my breasts are the same.
2. My reconstructed breast(s) feel soft to the touch.

Adopted from the Michigan Breast Reconstruction Outcome Study (Alderman AK, et al. Plast Reconstr Surg 2000;106:769-76).

dichotomized into "satisfied" versus "dissatisfied" using the following criteria: scores of "satisfied" or "very satisfied" (a "4" or "5" on the 5-point Likert scale) for all subscales were considered to be "satisfied"; all other scores were considered to be "dissatisfied".

RESULTS

The mean age of patients was 43.9 (range, 32 to 50) years. Average ischemia time was 140 min, and the average operative time was 8.5 hours. The mean ICU stay was 5.5 (range, 3 to 7) days, and the mean hospitalization time was 10.7 (range, 7 to 20) days. Breast reconstructions were performed on the right side in 9 patients, and on the left side in 6 patients.

Among the 15 cases, 10 (67%) were immediate and 5 (23%) were delayed reconstructions. In the immediate reconstruction group, 4 (40%) were stage I, 3 (30%) were stage IIa, and 3 (30%) were stage IIb breast cancer. All of the patients received a modified radical mastectomy for the cancer surgery except for 1 patient who received a skin-sparing mastectomy.[12] In the delayed group, the modified radical mastectomies were done during a previous operation. Three of 5 patients received that operation at our center, among which 2 were stage IIa and 1 was stage IIb breast cancer. One of the patients received postoperative radiation therapy. The remaining 2 patients had received an operation at another hospital, and the cancer staging was not available.

There were no statistically significantly differences between the immediate and delayed reconstruction group regarding age, ICU stay, hospital stay, or ischemia time (Table 2). However, the operative time was significantly longer in the delayed reconstruction group. The delayed reconstruction took an average of about 195 min longer than the immediate reconstruction. The reasons were probably due to the difficulty in recipient site pocket preparation, donor vessel dissection, and insetting of the flap. As it is very difficult to dissect the thoracodorsal vessels due the severe scarring after radiation therapy, using the internal mammary vessels as recipient vessels may be a good alternative.[9]

There was 1 flap failure, giving a 93.3% (14/15) success rate. The failed flap occurred 2 weeks after discharge. It was probably due to overstretching of the pedicle or compression by the pectoris major muscle. There was neither partial skin flap (mastectomy or abdominal) necrosis nor wound infection in this series. Seroma was found in 1 donor site. A small area of breast fat necrosis was noted in 1 patient by palpation. The fat necrosis resulted in a 1.5×1-cm hard mass over the lateral upper quadrant of the reconstructed breast. Routine postoperative follow-up with examinations ruled out the possibility of tumor recurrence.

At a mean follow up of 26.7 (range, 19 to 36) months, there was no abdominal bulging or hernia. All of the wounds had healed well. The postoperative chemotherapy or hormonal therapy was not delayed. To the time of this writing, no tumor recurrence had been found during regular follow-up.

Fourteen patients were evaluated by the questionnaire of 7 items that was divided into 2 subscales. For 13 of the patients, all 7 items were above 4 Likert points and they were classified into the "satisfied" group. Only 1 of the 14 patients was classified into the "dissatisfied" group, because 3 of the 7 items for this patient were below 4 points. In this limited series, the satisfactory rate was high 93%

Table 2. Breast Reconstruction with Free TRAM Flaps

Reconstruction	Immediate	Range	Delayed	Range	*p*
No. of cases (persons)	10		5		
	M±SD		M±SD		
Mean age (year)	43.0± 6.13	(35- 56)	45.6± 5.86	(42- 52)	0.446
Mean ICU stay (day)	5.6± 1.17	(4- 7)	5.2± 1.64	(4- 8)	0.594
Mean hospital stay (day)	10.5± 3.89	(8- 20)	11.0± 5.05	(8- 13)	0.835
Mean ischemic time (min)	144 ±41.60	(87-180)	134 ± 38.47	(75-180)	0.348
Mean operative time (min)	432 ±99.70	(385-665)	627 ±100.04	(595-840)	0.003*

Abbreviations: TRAM: transverse rectus abdominis myocutaneous; M: mean; SD: standard deviation.

* $p < 0.05$ by 2-samples *t*-test.

(13/14), and there were no statistically significantly differences between the immediate and delayed reconstruction group.

DISCUSSION

Breast reconstruction with autologous tissue has gained in popularity since Hartrampf et al. reported the first case using transverse rectus abdominis myocutaneous (TRAM) island flap in 1982,[5] which is called pedicle or conventional TRAM flap nowadays. Subsequently, Taylor et al. and Boyd et al. used the inferior epigastric artery as the dominant blood supply of the rectus muscle and the skin paddle in 1984.[13,14] Harashina later performed breast reconstruction using a TRAM flap with microsurgical techniques in 1988.[6] In the past 2 decades, both pedicle and free TRAM flap breast reconstructions have been well described.[1,10,14-26] The latter is less common than the former probably due to the need for microvascular expertise, the longer operation time, and the risk of whole or partial flap loss. However, free TRAM flap reconstruction has advantages including less partial flap loss, less fat necrosis, less distortion of the inframammary fold, less postoperative pain, and less rectus muscle weakness. Breast mound revision is also easier with a free TRAM flap.[1,10,14-19]

The blood supply of the zone IV area of free TRAM flap is less robust which may lead to inadequate perfusion. The supply originates from the subdermal plexus and the superficial subcutaneous tissue crossover system of the contralateral inferior epigastric vessels.[27] The venous system of zone IV area is quite variable, and 36% of patients had no crossing branches in 1 study.[28] This absence of crossing branches may explain why survival of the zone IV portion of such flaps is so variable and unpredictable. The inadequate circulation may result in fat necrosis. So, during shaping and insetting of the muscle-sparing free TRAM flap, we removed the territory of zone IV and the margin which bled a dark-reddish color. Sometimes, a portion of zone IV was preserved because of a good blood supply and a larger volume needed.

The complication of the abdominal seroma was probably due to early removal of the single suction drain and early ambulation. Repeated aspiration of the abdominal seroma resulted in a 20-day hospital stay. Methods for avoiding abdominal seroma are (1) multiple drain placement, (2) meticulous hemostasis, (3) adequate drainage, and (4) abdominal compression.[29,30]

Complication rates reported from different institutions are compared in Table 3.[1,10,20-22] Our complication rate, which was lower than that of Kroll's early experience (20 cases), probably results from an accumulation of more microsurgical experience other than breast reconstruction. We have not encountered the complication of abdominal weakness or hernia. This reflects advantages of the muscle-sparing technique,[10] which allows direct fascia closure without tension. The fewer postoperative complications, both in the donor site and recipient sites, caused no delay in initiation of the postoperative chemotherapy, or hormonal or radiation therapy.

Complications of pedicle TRAM flaps for breast reconstruction in the literature are reviewed in Table 4.[22-26] Rates of partial flap loss, abdominal weakness/hernia, and fat necrosis are relatively lower for

Table 3. Complications of Free TRAM Flaps Reported by Various Authors

Authors, Year (No. of cases)	Cheng et al. 2000 (15)	Kroll et al. 1992 (20)	Arnez et al. 1991 (50)	Kroll et al. 1994 (211)	Banic et al. 1995 (123)	Kroll et al. 2000 (936)
Total loss	6.7%	10%	5%	1.5%	6%	0.9%
Partial loss	0 %	-	8%	-	4%	1.4%
Skin flap loss	0 %	20%	-	2%	-	1.5%
Infection	0 %	10%	-	1%	4%	3.2%
Seroma	6.7%	10%	-	3%	-	6.2%
Abdominal wall weakness/hernia	0 %	10%	22%	5%	4%	5.7%
Fat necrosis	6.7%	0%	8%	7%	-	5.9%
Delayed chemotherapy or radiotherapy	0 %	-	2%	2%	-	-

Abbreviations: TRAM, transverse rectus abdominis myocutaneous.

Table 4. Complications of Pedicle TRAM Flaps Reported by Various Authors

Authors, Year (No. of cases)	Scheflan 1984 (140)	Hartrampf 1986 (300)	Kroll et al. 1988 (82)	Franklyn 1992 (86)	Watterson 1992 (556)	Keith et al. 1998 (257)
Total loss	0%	0.4%	0%	1%	0%	0 %
Partial loss	4%	6.4%	3%	15%	5%	11.3%
Abdominal wall weakness/hernia	11%	1.6%	15%	3%	9%	5 %
Fat necrosis	9%	7%	-	10%	11%	11.3%
Skin flap loss	-	0.4%	-	2%	-	8.2%
Infection	3%	1.8%	1%	3%	5%	3.5%

Abbreviations: TRAM, transverse rectus abdominis myocutaneous.

the free TRAM flap compared to the pedicle TRAM flap. Although recurrence rates of 7.6% to 8% were reported,[31-33] and the mean recurrence time after reconstruction ranged from 16.8 to 22.8 months, we have encountered none in an average 26.7 months of follow-up. Delayed breast cancer treatment due to reconstruction was reported for 2% of cases,[4,19] but there was none in our series. Concerns about a possible delay in detecting cancer recurrence have been found to be ungrounded.[31,32] The high satisfaction rate (93%, 13/14) with this breast reconstruction technique reflects the psychological benefits of body image restoration and the low complication rate of the reconstruction.[34]

These good results have encouraged us to continue performing breast reconstruction. Now, we have updated and advanced our technique to free deep inferior epigastric perforator (DIEP) flaps, free superior gluteal artery perforator (S-GAP) flaps, free superficial inferior epigastric artery (SIEA) flaps, etc., which require more-delicate dissection techniques. The sequence of the donor site morbidity in regard to the type of flap used is pedicle TRAM > free TRAM > free DIEP > free SIEA. Because only 34% of SIEA flaps have an adequate blood supply, the DIEP flap is now the main flap we use for breast reconstruction.[35-38] The internal mammary vessels are now the most popular vessels that we have adopted for the recipient because the more-vigorous blood supply area is placed more medially to the breast mound.[39]

A muscle-sparing free TRAM flap is a good option for post-mastectomy breast reconstruction. Both the success rate and patient satisfaction were high in this series. It plays an important role in the physical and mental rehabilitation of breast cancer patients, and it is an oncologically safe procedure.

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以自由式肌肉保留橫腹直肌皮瓣重建乳房：立即性及延遲性重建之比較

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背 景： 乳房重建不僅能在外表上將失去的乳房還原，對於病患心理上的重建格外具有意義。以自體組織的自由皮瓣來重建乳房是一種好的選擇。本研究的目的在探討以自由式肌肉保留橫腹直肌皮瓣重建乳房的成功率，併發症及外觀結果。

方 法： 自1999年8月至2001年2月期間，共有15位乳癌病患接受乳房切除後，以自由式肌肉保留橫腹直肌皮瓣來重建乳房。10位病人於長庚紀念醫院接受乳房切除及立即性自由式肌肉保留橫腹直肌皮瓣重建，5位先前於他院接受乳房切除的病人則接受延遲性重建。

結 果： 平均年齡爲43.9歲。手術成功率爲93.3％。術後併發症包括一例腹部組織液瘤，一例小部份乳房脂肪壞死。10位立即性重建的病人中有6位接受術後化學及賀爾蒙治療，3位僅接受術後化學治療。腫瘤的術後化學治療均無受到重建手術的影響。在爲期平均26.7個月的追蹤當中，並無發現腫瘤再發，且病人的滿意度爲93%。

結 論： 以自由式肌肉保留腹直肌皮瓣重建乳房是一種很好的選擇。不僅成功率高，病人的滿意度也高。同時立即性重建也不會影響腫瘤的輔助治療。

(長庚醫誌 2004;27:275-82)

關鍵字： 自由式肌肉保留橫腹直肌皮瓣，乳房切除，乳房重建。

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受文日期：民國92年7月7日；接受刊載：民國93年1月8日。
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