穿通枝皮弁を用いた頭頸部の再建

Head and Neck Reconstruction with a perforator flap

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国立がんセンター東病院形成再建外科
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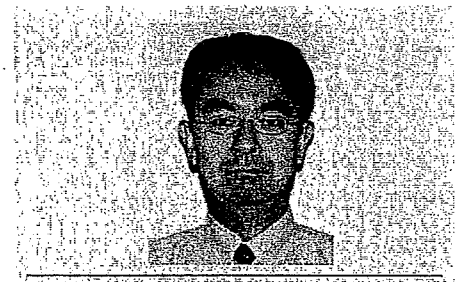

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Key Words:
頭頸部再建，マイクロサージャリー，前外側大腿皮弁，穿通枝皮弁

Abstract

従来，頭頸部再建においては腹直筋皮弁，広背筋皮弁などの筋皮弁が主に用いられてきた。しかし，近年穿通枝皮弁が開発され，再建外科医にとっては皮弁選択の幅が増え，より良質な医療が提供できるようになってきた。代表的な穿通枝皮弁として前外側大腿皮弁や腹直筋穿通枝皮弁，広背筋穿通枝皮弁などが挙げられる。これらの中でも，前外側大腿皮弁は数多くの利点を有し有用な皮弁である。しかし，その支配血管の解剖学的変異などの問題も指摘されている。前外側大腿皮弁を用いた頭頸部再建について，実際の臨床の場面における利用方法と問題点について報告する。

■はじめに

マイクロサージャリーを用いた頭頸部再建は，国立がんセンターでは1981年に第１例目が施行されて以来，今日までの様々な術式の改良に加え，顕微鏡や縫合糸といった手術用具の進歩により，安定した成績を収めることが出来るようになってきた。近年では，従来の筋皮弁移植に加えてKoshimaら[1)]の報告した腹直筋穿通枝皮弁を皮切りに，新しい皮弁が開発され，頭頸部再建でも皮弁選択の幅が広がっている。本稿では最近広く用いられる代表的な穿通枝皮弁である，前外側大腿皮弁による頭頸部再建の特長について報告する。

■対象と方法

国立がんセンター東病院において1997年から2006年までの10年間に当院で前外側大腿皮弁による頭頸部再建を行った症例207例を対象とした。症例の内訳は男性148例，女性59例で，平均年齢は60.5歳（21～89歳）であった。207例の原疾患は中咽頭癌が63例と最も多く，次いで舌癌49例，頬粘膜癌34例，口腔底癌16例，その他の順であった。207例中11例では初回の皮弁移植後の全壊死例に対する救済手術として前外側大腿皮弁が用いられていた。救済手術例と二次的頭頸部再建例を除く194例の原疾患の進行度は再発例が42例，初回治療例152例であった。初回治療例ではStageⅢ39例StageⅣ72例で，進行例と再発例を合わせて全体の73.9%と大多数を占めた（表）。

当院における，前外側大腿皮弁の挙上方法の詳細は既に報告した[2)]ので割愛するが，その要点は以下の通りである。手術時間の短縮を図るため，頭頸部再建の場合は原則として腫瘍の切除と皮弁の挙上を同時進行で行う。まず上前腸骨棘と膝蓋骨外側中央を結ぶ線の中点を中心として皮弁のデ

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表　前外側大腿皮弁による頭頸部再建の内訳

性　別	男／女		148／59 例
年　齢	平均		60.5±12.9 歳
原疾患	中咽頭癌		63例
	舌癌		49 例
	頬粘膜癌		34 例
	口腔底癌		16 例
	上顎癌		12 例
	下歯肉癌		12 例
	耳下腺癌		9 例
	その他		12 例
進行度など		初回治療例	152 例
		Stage II	41 例
		Stage III	39 例
		Stage IV	72 例
		再発例	42 例
		皮弁壊死後の救済	11 例
		二次的再建	2 例

ザインを行う。内側のデザインに沿って縦に皮膚を切開し，筋膜上または筋膜下に穿通枝の位置を確認し，必要があれば皮弁のデザインをしなおす。穿通枝直上の外側広筋を穿通枝に沿って切開しその走行を確認する。穿通枝が外側大腿回旋動静脈に合流している場合は，これを中枢側に向かって剥離し，皮弁を挙上する（図1）。この際必要に応じて外側広筋の筋体を同時に挙上する（図2）。皮弁採取部は可及的に縫縮する。

挙上した皮弁はただちに頭頸部の組織欠損部に移動し，皮弁の縫着を行う。原則として皮弁の縫着を行った後に血管吻合を行うようにしている。最後に口腔内，頸部を洗浄しドレーンを挿入し頸部の創を閉鎖する。

■結　果

移植皮弁は全例大腿部より採取したが，執刀時の計画通りに皮弁の挙上が出来ず，皮弁の種類を変更した症例が7例認められた。変更の内容は皮弁を前内側大腿皮弁にしたもの2例，大腿筋膜張筋皮弁にしたもの4例，同時に挙上する予定だった外側広筋弁を大腿直筋弁に変更したもの1例であった。変更の理由は穿通枝が確認できなかったもの3例，穿通枝の破格により挙上できなかったもの3例，穿通枝を術中に切断したもの1例であった。最終的に筋体を同時に挙上しない，いわゆる穿通枝皮弁として挙上したものは87例で，120例では外側広筋などの筋体が同時に挙上された。挙上した筋体は主として頸部郭清後の死腔を充填するために利用した。他に前外側大腿皮弁に併用した手技として，腓骨皮弁などの骨移植8例，下顎再建プレート5例などが用いられた。

術後の合併症として血管吻合部の血栓形成が12例（5.8％）で認められた。内訳は動脈血栓4例，静脈血栓が7例，動静脈両方の血栓が1例であった。これらのうち動脈血栓の3例と静脈血栓の2例で血管再吻合による救済手術を行い，それぞれ2例ずつで救済が可能であった。他の8症例は皮弁全壊死となり再手術を行った。これに加えて吻合部の血栓形成は認めないものの，穿通枝の圧迫などにより皮弁のうっ血を来たし，結果的に全壊死となったものを2症例で認めた。最終的に皮弁の全壊死を来たした症例は10症例で，皮弁生着率は95.2％あった。そのほか，皮弁部分壊死が19例，広範囲壊死3例で認められた全壊死例を除いた症例のうち，術後感染を来たした症例は54例（27.3％），咽頭皮膚瘻孔を来たした症例は35例（17.7％）例で，このうち追加手術の必要な大瘻孔は2例で認められた。

術後放射線治療を行った17例を除く190症例の，在院日数は9日から110日で平均26.4日，中央値21日であった。

■考　察

頭頸部再建の最大の目的は，頭頸部癌の切除によって生じた，機能や形態の損失を再建手術により修復し，患者のQOLの維持向上に寄与することである。そのためには適切な皮弁を選択することが重要である。選択の基準はいくつか考えられるが，Kimataら[3]は舌全摘亜全摘症例の再建術式について検討し，再建する舌の形態が隆起型の方が，術後機能が良好であることを報告している。この場合，隆起型の再建を行うために必要な皮弁の容量が，皮弁選択の基準のひとつとなる。また，採取できる皮弁の厚みは患者ごとに異なるため，皮

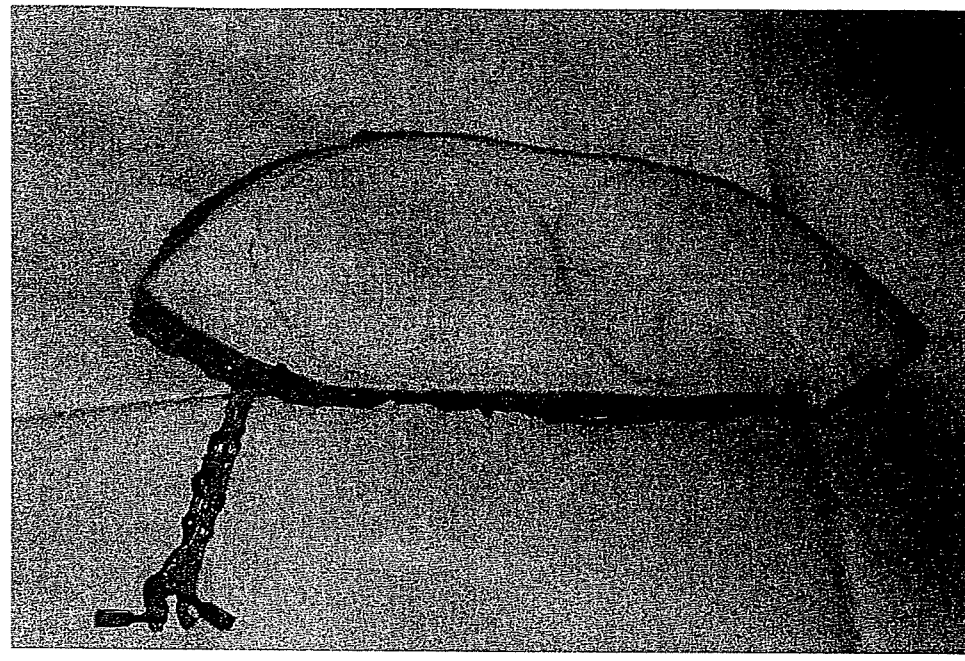

図1　皮島と穿通枝を含む血管柄のみで構成される皮弁。

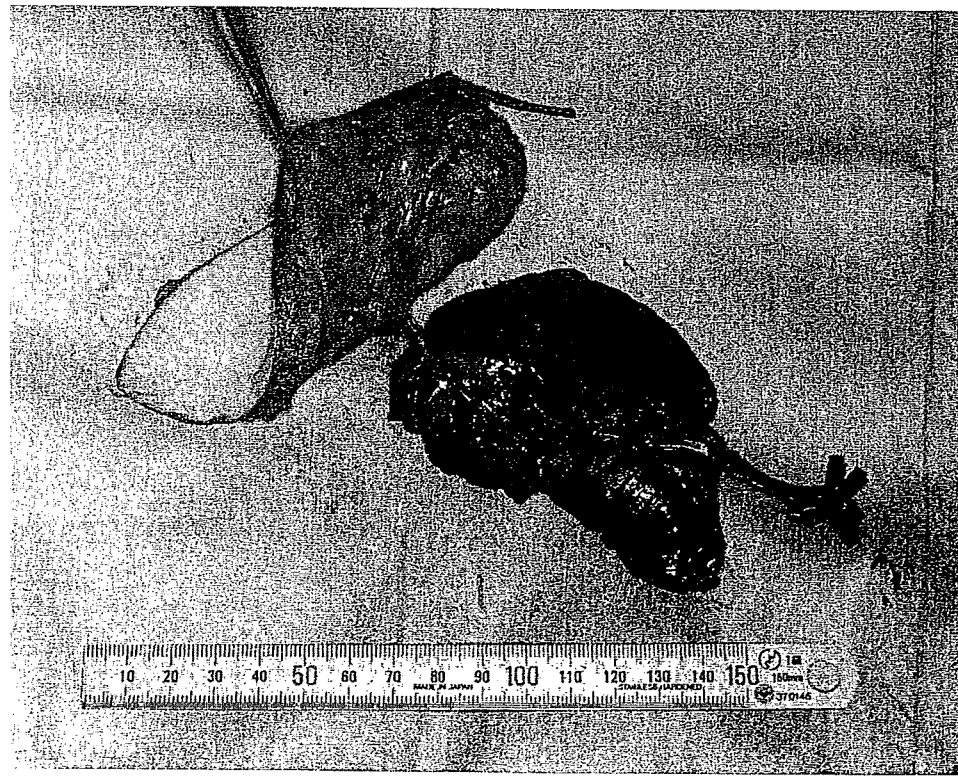

図2　皮島と血管柄に加えて，外側広筋を同時に挙上した皮弁。

弁の厚みも選択基準のひとつとなる。前外側大腿皮弁は，厚みのある皮弁の代表である腹直筋皮弁と，薄い皮弁の代表である前腕皮弁の中間的な厚みを有し，選択肢の一つとして重要な皮弁であると考えられる。

前外側大腿皮弁の特徴はこれまで数多く報告されているが，特に頭頸部再建においては前述のように適度な厚みを有する点が第一の利点として挙げられる。再建の対象部位としては207症例のうち中咽頭癌症例に最も多く用いられていたが，中でも中咽頭側壁から軟口蓋にかけての再建に有用である。舌癌においては舌半切または半切をやや超える程度の亜全摘例が最も有用である。しかし，舌亜全摘以上の切除では容量が不足するため適切

ではない。また皮弁のthinningによる厚みの調節が可能であるため頬粘癌切除後や，下顎辺縁切除後のような，薄い皮弁が必要な部位の再建にも有利である。薄い皮弁としては前腕皮弁の利用も考えられるが，主要血管を犠牲にすることや皮弁採取部に植皮が必要であることなどから，当院ではほとんどの場合，前外側大腿皮弁を選択している。

第2の利点は必要に応じて，外側広筋や外側大腿皮神経などの同時採取が可能である点が挙げられる。今回の症例では120例（58.0%）の症例で外側広筋などの筋体を同時に挙上している。この筋体を死腔充填に利用することで術後の瘻孔形成や感染を予防する事が可能である。また神経を同時に採取した場合は，4症例で血管柄付き神経移植として顔面神経の再建に，4症例で皮弁内の神経を移植部の知覚神経と吻合することで，知覚を有する皮弁の移植に用いており，利用価値が高い。

第3の利点は必要に応じて，皮島の数を増やすことが可能である点が挙げられる。外側大腿回旋動脈下行枝から皮膚へ向かう穿通枝は複数本認められることも多く，これを利用して2～3皮島を有する皮弁の作成も可能である。207例中21例で2皮島を，1例で3皮島を有する前外側大腿皮弁が挙上された。これらは，主に口腔咽頭の内側面と皮膚側の両面の再建が必要な場合に特に有用であった。また一方の皮島を術後観察しにくい部位の血流モニターとして利用する事や，一方を脱上皮して死腔の充填に利用することも可能である。

第4の利点は長い血管柄を利用可能な点である。頭頸部再建においては過去に放射線治療や手術が行われている場合も多く，欠損部の近傍の移植床血管が利用できない場合もある。その際反対側の頸部や，鎖骨に近い部位での血管吻合が必要になる。この様な症例は207例中12例（5.8%）で認められたが，最長で22cm程度の血管柄の長さが得られる前外側大腿皮弁は，血管柄の余裕を持って移植床血管との吻合が可能で非常に有用であった。

第5の利点は血管柄の分岐を利用したキメラ型の皮弁の移植が可能である点である[4]。移植床の血管が一本しか得られない場合に，2つ以上の皮弁を組み合わせて移植する必要がある場合に有用である。この様な複合的な大欠損はそれほど多くないが，今回は5症例で腓骨皮弁など他の皮弁と組み合わせたキメラ型の再建を行った。

一方，前外側大腿皮弁の利用に当たっては，その支配血管の解剖学的変異による困難さを指摘する論文は多い[5, 6]。その頻度は1～5%程度と考えられるが，今回の207例中7例（3.4%）で解剖学的変異により術式の変更が必要であったことから，その取り扱いには注意が必要であると考えられる。また，穿通枝は非常に細く脆弱であるため，術中に誤って切断する可能性もある。更には，皮弁の挙上に問題が無くても，頭頸部に移植した際に，圧迫や屈曲などにより容易に血流障害に陥る事があるため，術後も慎重な経過観察が必要である。

■結語

以上のように数多くの利点を有する前外側大腿皮弁は，頭頸部再建において非常に有用な皮弁である。しかし皮弁による再建が必要な頭頸部癌の患者は，再発または進行がんの症例が多く，生命予後が厳しい場合が多い。術後に一度合併症を引き起こすと，その回復のために患者に多大な負担をかけ，患者のQOLは著しく低下する。前外側大腿皮弁による頭頸部再建を行う場合には，その特性を理解して慎重な取り扱いが必要と思われる。

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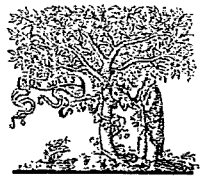
Journal of Plastic, Reconstructive & Aesthetic Surgery (2008) 61, 1516–1519



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CASE REPORT

Successful management of giant ischial decubitus ulcers complicated with urethral disorder

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Received 2 August 2006; accepted 24 May 2007

KEYWORDS
Total ischiectomy;
Urethra;
Decubitus ulcer;
Sensory plantar flap

Summary We report a case of bilateral ischial pressure sores complicated with urethral fistula, caused by previous complete ischiectomy. Successful reconstruction was achieved after closure of the bladder neck. The large defect in the bilateral ischium and perineum was covered simultaneously with a free total plantar flap. The paucity of suitable recipient vessels for microvascular anastomoses was resolved by the creation of an arteriovenous loop, when the closure of bladder neck was performed in a supine position.
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Despite the diversity of wheelchair cushions currently in clinical use, pressure on ischial tuberosities continues to be a major problem for wheelchair-bound patients. In the sitting position most of the body weight is accepted by tissue overlying the ischial tuberosities. Since Kostrubala and Greeley[1] emphasized removal of bony prominence underlying weight-bearing areas, ischiectomy has become part of the surgical management of ischial decubitus ulcers. Even the prophylactic excision of the contralateral side ischial tuberosity was advocated when unilateral ischial decubitus ulcer developed.[1] However, long-term follow up has revealed unusual urethral abnormalities associated with subtotal or total ischiectomy.[2,3] Although the occurrence of a perineal urethral disorder is not uncommon after ischiectomy, little attention has been paid to this issue by reconstructive surgeons.[4,5] We present here a case of an intractable pressure sore in the bilateral ischial region complicated with urethral fistula, caused by previous multiple-stage ischiectomy and local tissue transfer.

Case report

In 1982, at the age of 31, the patient suffered from a compression fracture of the 12th thoracic vertebra and a spinal cord injury in a traffic accident. One year later, he developed a pressure sore in the bilateral ischial area. Multiple surgical procedures were performed for bilateral recurrent ischial decubitus, including partial bilateral

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doi:10.1016/j.bjps.2007.05.018

ischiectomy and local flap repair. He also developed lumbosacral pressure sores, for which there had been several reconstructive attempts with local skin flaps and gluteus maximus musculocutaneous flaps. In October 1999, he developed a perineal urethrocutaneous fistula through a right ischial decubitus ulcer. After a percutaneous cystostomy, he was referred to our department for radical reconstructive surgery.

The bilateral ischial decubitus ulcer extended to the gluteal and perineal fistulae (Figure 1). Urinary leakage was frequently noted from the right-side ischial ulcer, due to inadequate urinary drainage and bladder neck dysfunction. His remaining buttock was markedly scarred from previous surgical procedures. A pelvic roentgenogram revealed total defects of the bilateral inferior pubic ramus and ischium to the acetabular rim (Figure 2). Simultaneous retrograde urethrogram and cystogram revealed a large fistula on membranous urethra that communicated with the right ischial ulcer. With these findings, we judged that the reconstructive procedures should be performed after creating a definitive urinary diversion.

At the first stage, bladder neck closure associated with suprapubic cystostomy was performed. In addition, we produced an arteriovenous shunt transferring the right great saphenous vein and anastomosing the distal end to the superficial femoral artery in end-to-side fashion, because difficulties were predicted when preparing suitable recipient vessels in a radical reconstructive operation. The apex of the venous loop was placed at the posteromedial aspects of the upper thigh, facilitating the vascular anastomoses in the second-stage operation.

Two weeks later, the second-stage operation was performed for total reconstruction of the intractable pressure sore in the bilateral buttock, ischium and perineal region in a prone position. Two teams conducted the second surgery. The first team excised any pressure sores, fistulae, scar tissue and bursa. The dead spaces locating the bilateral gluteal regions were covered with gluteal thigh flaps. When the right gluteal thigh flap was elevated, the apex of the arteriovenous loop was easily isolated, providing suitable vessels for arterial and venous microanastomoses (Figure 3).

Figure 2 Pelvic roentgenogram. Note the total defects of bilateral inferior pubic ramus and ischium to the acetabular rim.

In addition, the 10th intercostal nerve was dissected as a recipient nerve through an incision at the right lateral lumbar region. The second team performed elevation of the total plantar flap sized 20 × 9 cm (Figure 4). In order to ensure better blood flow and sensory function, the flap included the posterior tibial artery, medial plantar artery, lateral plantar artery and cutaneous branch from the tibial nerve to the plantar area, as well as abductor hallcis, abductor digit quinti, flexor digitorum brevis and plantar aponeurosis. Proximal dissection of the posterior tibial artery and tibial nerve was achieved until the length of the pedicle increased up to 25 cm. The posterior tibial nerve was separated from the motor branches longitudinally in order to reduce the calibre mismatch to the intercostal nerve. After elevation of the flap, the donor site was closed with a thin split-thickness graft. Then, the flap was placed in the bilateral ischial and perineal region, and the vascular anastomoses were performed with a prefabricated vascular loop (Figure 5). The tibial nerve was tunneled subcutaneously to the right lumbar region and sutured to the 10th intercostal nerve.

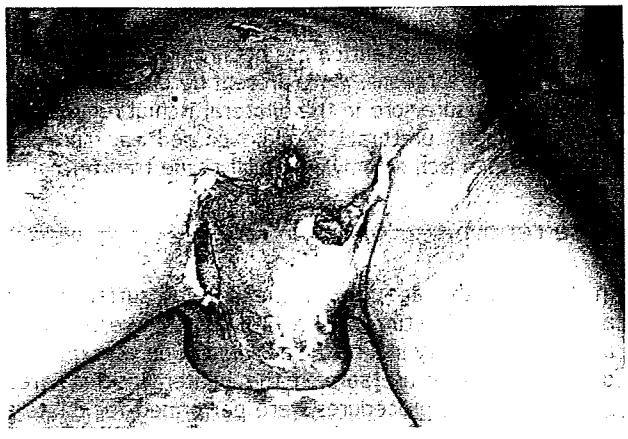

Figure 1 The bilateral ischial pressure sores extending to the perineum and gluteal region. The arrow indicates the urethrocutaneous fistula.

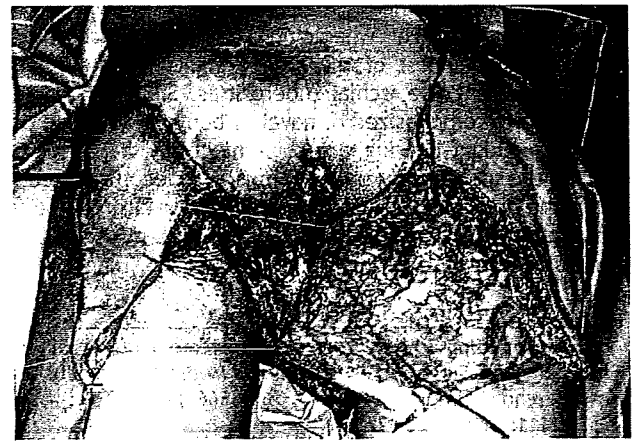

Figure 3 The bilateral gluteal regions were covered with gluteal thigh flaps. The apex of the arteriovenous loop was retracted by vessel tape.

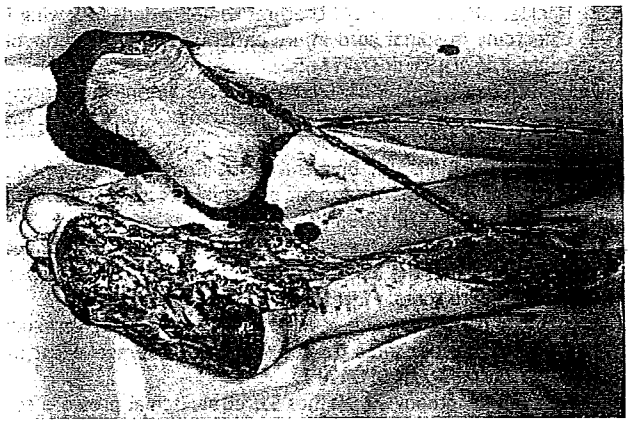

Figure 4 A total plantar flap was elevated with posterior tibial vessels and tibial nerve.

Persisting seroma beneath the total plantar flap was noted postoperatively, requiring puncture and aspiration several times. The amount of fluid was gradually reduced, and the patient was discharged from our hospital 26 days after reconstruction. Tinel's sign was exhibited in the transferred flap 6 months after surgery, and sensory recovery was confirmed with a 6.65 Semmes-Weinstein monofilament, 16 months after surgery. Long-term follow up over a 6-year period revealed consistently durable soft-tissue coverage at the ischio-perineal region without any recurrence of pressure sore (Figure 6). Although unsightly scarring and partial breakdown were noted at the donor site, they did not restrict the patient's daily life wearing socks (Figure 7).

Discussion

Perineal pressure sore with urethrocutaneous fistula has previously been reported in paraplegics as a late complication following bilateral ischiectomy.[2–4] After bilateral ischiectomy, the pressure in the sitting position shifts to the perineum, and pressure usually borne by the ischial tuberosities is transmitted to the membranous and proximal bulbous urethra. Hackler and Zampieri[2] reported that the urethral pressure in patients with complete ischiectomy

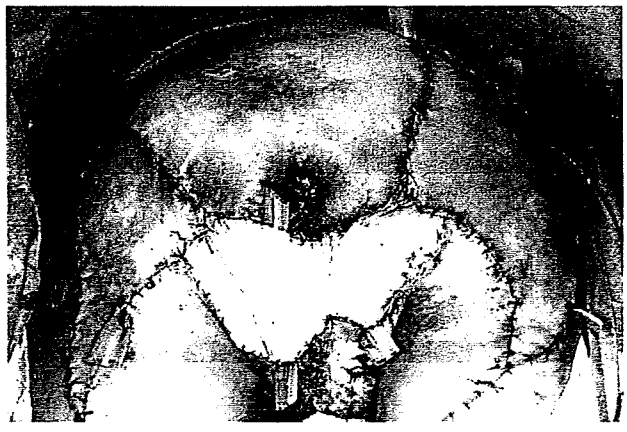

Figure 5 Immediately after surgery.

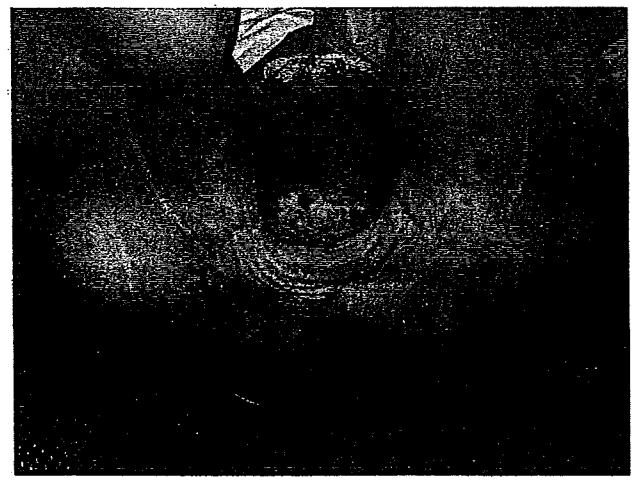

Figure 6 Findings 6 years after surgery. There was no sign of recurrent pressure sore.

was 111 cmH_2O, whereas that in non-ischiectomy patients was only 16 cmH_2O while in a sitting position. In order to resolve the urethral complication, dissection of the bladder neck prior to total reconstruction of ischial decubitus was essential for successful management in this case. In view of the pressure shift, the transferred tissue should be placed to cover the bilateral ischium and perineum simultaneously.

For large complex wounds of the perineum and bilateral ischial tuberosity, although local flaps and musculocutaneous flaps may be available for some patients, the incidence of recurrence is high.[6–8] When patients have multiple ulcers, previous attempts at each exhausted local possibility leave a wide scarred region with little soft tissue in the vicinity of the sore. Under such circumstances, distant tissue transfer utilizing a microsurgical technique is our method of choice.

To date, several methods using free tissue transfer have been reported for ischial decubitus ulcers.[9–11] Among several conceivable donor sites for microsurgical reconstruction, the plantar region offers a long-term solution for the following reasons. This region has the most resilient skin pad, while the ischio-perineal region accepts enormous

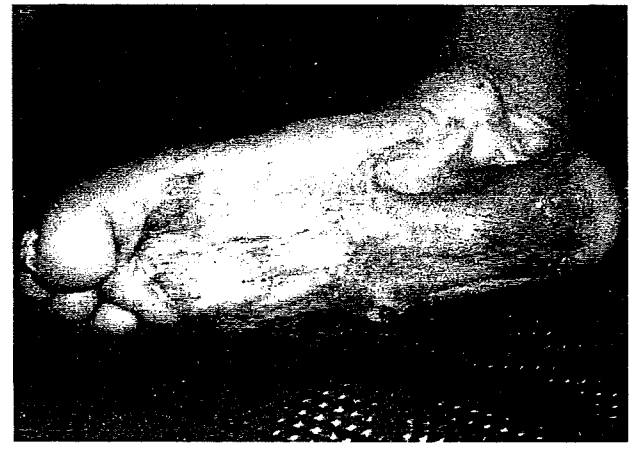

Figure 7 Donor site 6 years after surgery.

pressure. In addition, it provides good sensory recovery contributing to long-term flap viability. The procedure of the free sensory plantar flap for the ischial region was well documented by Sekiguchi et al.[9] However, they limited utilization of the plantar skin within the instep region, necessitating use of the other side plantar flap for the bilateral ischial pressure sore. We used a total plantar flap to cover the entire ischio-perineal region.

Free-tissue transfer is complicated by the paucity of suitable vessels in the region for microsurgical anastomosis. In a perineal reconstruction using free tissue transfer, a lithotomy position is preferable due to the availability of reliable recipient vessels such as superficial femoral vessels, deep inferior epigastric vessels and the great saphenous vein.[12] In this case, however, the fistulous extension of the ischial pressure sore necessitated a prone position for radical debridement. Although the gluteal vessels[13] and posterior intercostal vessels[9] were available as recipients in this positioning, the location and size of these vessels were considered to be potential problems. Temporary arteriovenous shunt loop is a valuable tool in microsurgical free-tissue transplantation when recipient vessels are limited.[14] In the present case, the first-stage operation was essential not only to secure the urinary diversion but also to create readily available recipient vessels during the definitive reconstructive procedure.

Careful planning along with staged reconstructive procedures is most important to achieve long-term durability in patients with a complicated ischial pressure sore. The total plantar flap is a reasonable alternative when the bilateral ischial pressure sore is complicated by a urethral disorder.

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Monitoring the Changes in Intraparenchymatous Venous Pressure to Ascertain Flap Viability

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Background: Disruption of venous outflow can lead to tissue necrosis. Thrombosis of a venous channel at the coaptation site in instances of free tissue transfer could cause death of the transplanted tissues. Although various techniques have been used to monitor the viability of transferred tissues, there has been no technique designed specifically to check the flow within and the patency of the venous channel. The authors have devised an approach with which to monitor the changes in venous pressure in a composite tissue transferred by means of microsurgical technique for bodily reconstruction.
Methods: The status of the venous system in various composite tissue grafts was monitored at the time of surgery or for 3 days after the completion of surgery by placing a small-caliber catheter in the vein within the transferred tissue. A total of 52 patients participated in the study.
Results: The venous pressure noted in grafts with a patent venous channel remained constant within a range between 0 and 35 mmHg. Venous insufficiency was detected in three of the 52 cases, with unmistakable findings of an elevated venous pressure of over 50 mmHg.
Conclusions: The technique of measuring the venous pressure by means of an indwelling venous catheter to monitor changes was found to accurately assess the patency of the venous channel and, by inference, the viability of the transferred tissue. No morbidity was associated with the technique. (*Plast. Reconstr. Surg.* 119: 2111, 2007.)

The success rate of free tissue transfer has been improved since its introduction more than three decades ago. Increasing experience among microsurgeons, the development of more reliable flaps, and improved microsurgical techniques and instruments have contributed to reduce the failure rate of free tissue transfer. Despite improved initial success rates of over 95 percent,[1–3] anastomotic failure may occur on either the arterial side or the venous side and remains a major cause of tissue loss. Because necrosis of a transferred tissue is a costly disaster and salvage of the affected tissue largely depends on the time to reexploration,[1,3] accurate assessment of flap circulation is essential.

Various methods have been described for assessing the adequacy of blood flow to a transplanted tissue. These include laser Doppler flowmetry,[2,4,5] color duplex sonography,[6,7] noninvasive ultrasound Doppler,[8] implantable Doppler,[9,10] hydrogen clearance,[11] pH measurement,[12] photoplethysmography,[13] transcutaneous oxygen tension,[14] and temperature.[15] An ideal monitoring method should be continuous, instantaneous, reliable, reproducible, and easily interpretable. Although the above methods have proven useful in judging the adequacy of the arterial blood flow, they have not specifically indicated blood flow disturbance in venous channels.

Veins are susceptible to trauma of various sorts because of their thin walls and fragile structures. It is well known that venous thrombosis is more common[1] and more harmful to a flap than arterial thrombosis.[16,17] Because the very first event that occurs after venous occlusion is an increase in venous pressure, monitoring this parameter may provide instantaneous information about venous insufficiency after free tissue transfer. Pressure changes within a venous channel can be monitored by placing a catheter inside the vein. We used this technique in 52 patients who un-

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Received for publication July 27, 2005; accepted November 7, 2005.
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DOI: 10.1097/01.prs.0000260594.94139.4a

derwent free flap transplantation between 1999 and 2004 to determine the usefulness of venous pressure measurement and monitoring as a method for ascertaining venous channel patency. The experience gained from this group of patients formed the basis of this report.

PATIENTS AND METHODS

Between 1999 and 2004, a total of 52 patients underwent free tissue transfer with monitoring of the intraparenchymatous venous pressure. There were 19 female patients and 33 male patients. Patient ages ranged from 17 to 76 years, with a mean age of 54 years. Initially, we used this method for patients who developed venous thrombosis postoperatively, and the catheter was inserted during the reoperation, with the intent of salvaging the transferred tissue. Recognition of the versatility and safety of venous catheterization subsequently led us to expand the indication to primary cases with free tissue transfer, especially those considered to be at high risk of venous thrombosis. The criteria for indication of in situ venous catheterization included heavy smoking, tissue with irradiation sequelae, reconstruction of traumatized lower extremities, buried flap, bony reconstruction, intraoperative vascular thrombosis, and usage of long-vein grafting for venous anastomosis (Table 1). The specific donor sites used and their distribution among the recipient sites are listed in Tables 2 and 3.

Table 1. Indications for Monitoring the Intraparenchymatous Venous Pressure

Indication	No. of Occurrences (%)
Reexploration for venous thrombosis	8 (15.4)
Intraoperative thrombosis	7 (13.5)
Traumatized lower extremity	14 (26.9)
Buried flap	9 (17.3)
Bony reconstruction	5 (9.6)
Vein grafting	5 (9.6)
Postirradiation therapy	7 (13.5)
Heavy smoking	8 (15.4)

Table 2. Types of Transferred Tissue

Flap Type	No. of Patients
Rectus abdominis	12
Radial forearm	8
Anterolateral thigh	7
Groin	6
Fibula	5
Latissimus dorsi	4
Jejunum	3
Deep inferior epigastric perforator	3
Omentum	2
Saphenous	1
Fillet	1
Total	52

ALT, anterolateral thigh; DIEP, deep inferior epigastric perforator.

Table 3. Flap Destination

Flap Location	No. of Patients
Head and neck	20
Trunk	14
Upper extremity	4
Lower extremity	14
Total	52

Description of Indwelling Venous Catheter Placement

The patients were fully informed concerning the reasons, the technique of catheter placement, the details of the monitoring procedure, and the consequences and possible complications associated with catheter placement. The possible problems included bleeding, hematoma formation, and persistent pain.

After completion of vascular anastomoses, an intravenous catheter (3 French, 1.0-mm outside diameter; Atom Medical Co., Tokyo, Japan) was inserted into a side branch of the anastomosed vein. The more peripheral side branch was preferable, provided that the catheter could be inserted. In the case of a radial forearm flap or a fibular osteocutaneous flap, the catheter was inserted by means of the distal end of a comitant vein of the radial or fibular artery.

Pressure Measurement

The venous catheter was connected to a fluid pressure transducer (P23ID; Statham Gould, Oxnard, Calif.) and to a physiologic recorder (BSS-9800; Nihon Kohden Co., Tokyo, Japan). Zero calibrations were taken at the level of the right atrium. To ascertain the functional integrity of the monitoring system, the venous outflow was occluded manually at a site proximal to the coaptation site once the catheter was in place (Fig. 1).

The venous pressure monitoring was performed in conjunction with local delivery of an anticoagulant agent using a flushing device. The line solution of the venous catheter contained heparin (10 units/ml) in 0.9% sodium chloride, and the flow rate of the flush solution was approximately 3 ml/hour,[18] resulting in continuous infusion of the heparin at 720 units/day. Three days after surgery, the catheter was locked and disconnected from the transducer but left in position for a further 4 days. Thereafter, the catheter was

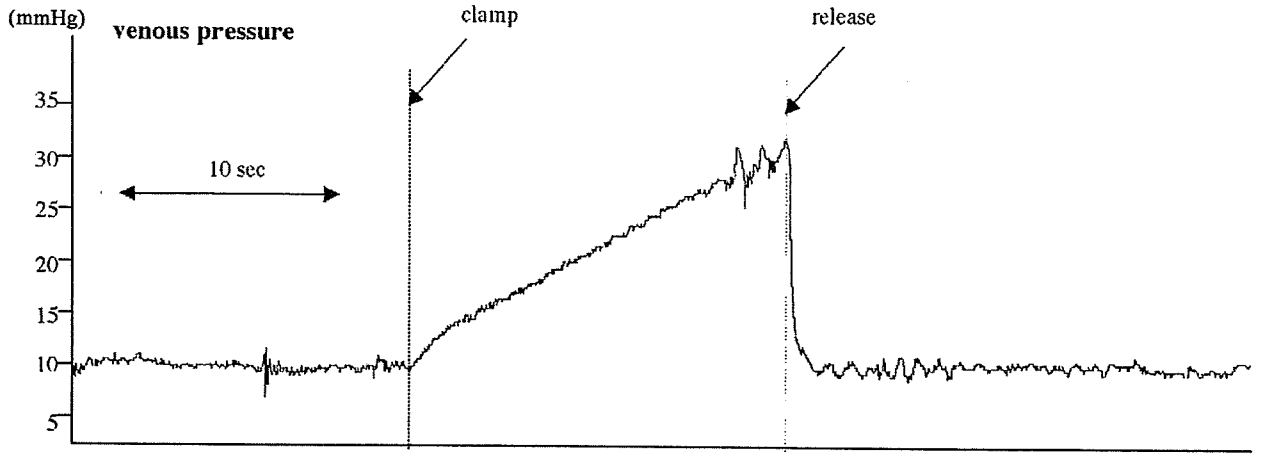

Fig. 1. Transient clamping of an anastomosed vein gradually increased the venous pressure. Release of the venous clamp led to an immediate drop in the venous pressure to the baseline level.

gently tugged at and withdrawn from the flap. No bleeding occurred.

Laser Doppler Flowmetry

In addition, the blood flow was continuously monitored in 23 of the patients using a laser Doppler flowmeter (Laserflo BPM 403; TSI, Inc., St. Paul, Minn.) with a standard right-angle probe with a head diameter of 19 mm (model P-430). This apparatus measures a Doppler shift in reflected laser light, which is related to the number and velocity of moving red blood cells, providing flow values in milliliters per minute per 100 g of tissue. Inherently, this method could not be applied to cases of a buried flap or mucosal reconstruction, unless the grafted tissue was partially exteriorized.

Data Acquisition

Both the venous pressure and surface blood flow were continuously recorded with a computerized data acquisition system (PowerLab; AD Instruments Pty. Ltd., Australia) for later analysis. The recording of the parameters was continued for 3 days, and the mean values for each 24-hour period were analyzed with the software. The alarm for an elevated venous pressure was set at 50 mmHg using the physiologic recorder. Because the parameters were automatically recorded, the nurses did not need to record the venous pressure or the flow values manually. They were instructed to check the monitoring devices and flap color, in cases with a cutaneous component, every 2 hours for 3 days.

The values for the venous pressure and laser Doppler flowmetry on each postoperative day are reported as means ± SD. Statistical evaluation was performed using analysis of variance with repeated measures across time. A value of $p < 0.05$ was considered statistically significant.

RESULTS

Of the 52 flaps, two developed venous thrombosis intraoperatively, and another case developed venous thrombosis 15 hours after surgery. In these three cases, venous insufficiency was detected easily on the basis of an elevated venous pressure of over 50 mmHg, and reanastomosis of the vein led to complete survival of the transferred tissue. There were no cases of free flap loss.

The normal pressure range in uncomplicated free tissue transplants was established by analyzing the data. Among the multiple tissue types and recipient sites, the venous pressure value was relatively constant within the range of 0 to 35 mmHg. The venous pressure during the first postoperative day was 17.5 ± 8.8 mmHg (Fig. 2). The venous pressure tended to decline on days 2 and 3, although it did not reach statistical significance (Fig. 2). The flow rate with laser Doppler flowmetry varied from 0.8 to 13.1 ml/minute/100 g tissue. The flow rate during the first postoperative day was 3.75 ± 1.97 ml/minute/100 g. The flow rate was virtually unchanged during the next 2 postoperative days (Fig. 3).

A 55-year-old woman presented with intraosseous carcinoma arising from an impacted third molar. A fibular osteocutaneous flap was used to reconstruct the bony and soft-tissue defect that resulted from segmental mandibulectomy with concomitant radical neck dissection (Fig. 4). Because the cutaneous flap was

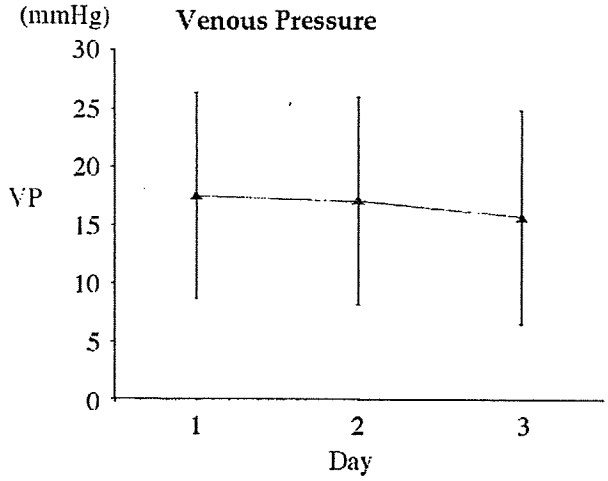

Fig. 2. Changes in intraparenchymatous venous pressure after free tissue transfer. Values are given as means ± SD (n = 51).

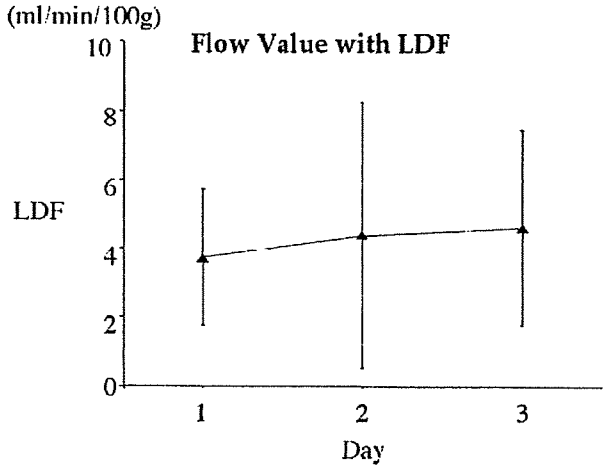

Fig. 3. Changes in surface blood flow as represented by flow value with laser Doppler flowmetry (*LDF*; in milliliters per minute per 100 g) after free tissue transfer. Values are given as mean ± SD (n = 23).

located in the oral cavity, laser Doppler flowmetry was not applicable. Therefore, we inserted a catheter into the distal end of the peroneal artery and the comitant vein (Fig. 4). Although the venous pressure was found to be stationary at approximately 25 mmHg for the first 15 hours after surgery, it began to rise incrementally over the next 2 to 3 hours (Fig. 5). We decided to reexplore the wound at 18 hours after surgery because of venous hypertension, even though the color of the flap was judged to be normal. A thrombotic occlusion at the venous coaptation site was found during reexploration of the wound (Fig. 6).

During the reoperation, venous pressure was monitored continuously using the catheter, which was also useful for flushing the vessel in an attempt to remove the clot from inside the vasculature. The venous hypertension disappeared after the clot was removed from the lumen. The continuity of the venous channel was reestablished by using a vein graft. The patient showed no further signs of venous flow impediment, and recovery from the procedure was uneventful (Fig. 7).

DISCUSSION

Early surgical intervention to eliminate any blood flow impediment is the key factor in "rescuing" an ailing flap.[1] Clinical indications for wound reexploration, however, are difficult to define. Over the years, many methods have been advocated for monitoring the blood flow in a transplanted flap.[3–15] However, the information obtained with those various monitoring techniques is rarely helpful to surgeons in determining the need for reexploration of the operative site, especially if a venous outflow disturbance is involved. It is essential, in this regard, for surgeons to have a monitoring technique that is simple and yields information that clearly defines the indication for wound reexploration.

Of the various modalities advocated for postoperative monitoring of flap circulation, the laser Doppler flowmetry technique was thought to be the most useful for assessing interstitial blood flow. It is noninvasive and designed to monitor capillary perfusion. Although this method can deliver objective data, the flow values vary greatly depending on the patient, type of tissue, equipment, type of probe, and recipient site.[2,4,19] Therefore, one must not rely on absolute values, and current reports emphasize the importance of observing the trend of the perfusion value rather than the absolute value.[2,4] This is particularly important in the case of venous occlusions, for which experimental studies have shown that the drop in flow values is not as abrupt and steep as in the case of arterial obstructions.[20] In the clinical setting, Mailaender et al.[19] demonstrated the difficulties in diagnosing venous thrombosis by means of laser Doppler flowmetry caused by nonspecific alterations in the laser Doppler flowmetry signals. In addition, difficulty in placing the monitoring probe in certain parts of the body, as in our patient with intraoral structure reconstruction, can render the use of this technique impossible.

It is well known that venous congestion is more common[1] and more harmful[16,17] than arterial insufficiency. Considering the difficulty in early detection of venous thrombosis with previous monitoring methods, it makes sense to focus on venous thrombosis, attempting to reduce the failure rate of free tissue transfer. Hudson et al.[21] reported the use of a catheter inserted into a side branch of the vein in the transferred tissue. Through this catheter, heparin (500 units/hour) was infused effectively to the venous anastomotic site.[21] However, we believed that the infusion rate for catheter heparinization (30 units/hour) was sufficient to

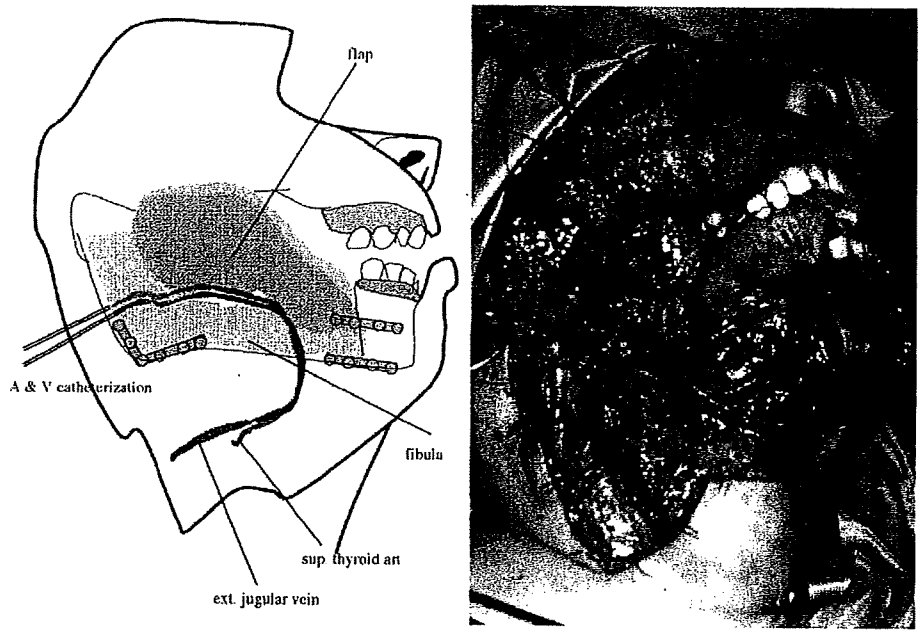

Fig. 4. Free osteocutaneous fibular flap with intraparenchymatous arterial and venous pressure monitoring.

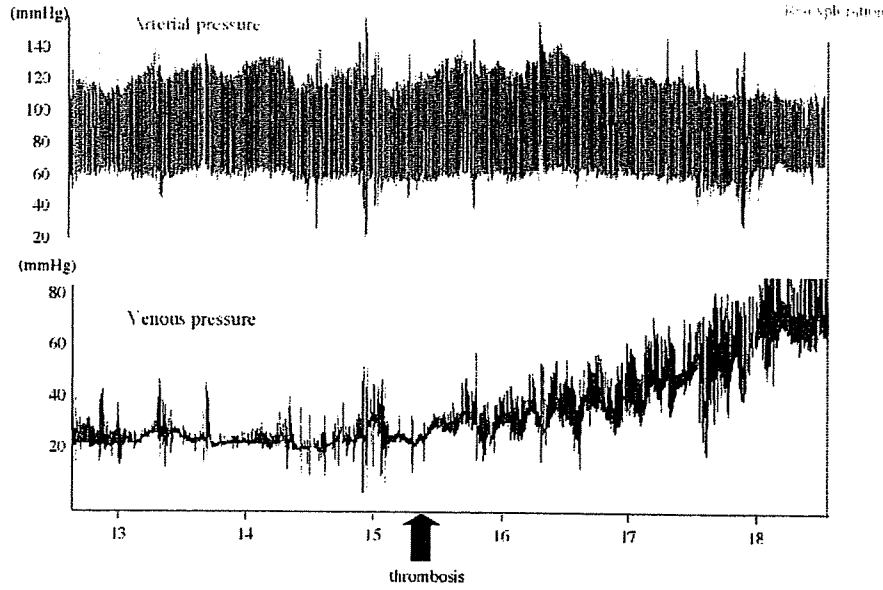

Fig. 5. Changes in intraparenchymatous arterial and venous pressures after venous thrombosis.

reduce coagulability at the local anastomotic site, because the blood flow perfusing the transferred tissue was less than 5 ml/minute in most cases (data not presented). Moreover, we considered that this catheter could be used as a sensitive monitoring device to detect venous thrombosis after free tissue transfer.

In contrast to laser Doppler flowmetry, venous pressure monitoring was able to provide us with instantaneous evidence of venous occlusion. In all three flaps that sustained venous occlusion, the venous pressure elevated to over 50 mmHg before any clinical signs became obvious. The absolute values for venous pressure were easily interpretable even by the nursing staff and inexperienced residents. In addition, continuous monitoring of venous pressure allowed us to identify the onset time of venous pressure elevation, as noted in the described case.

Fig. 6. Venous thrombosis detected during the reoperation.

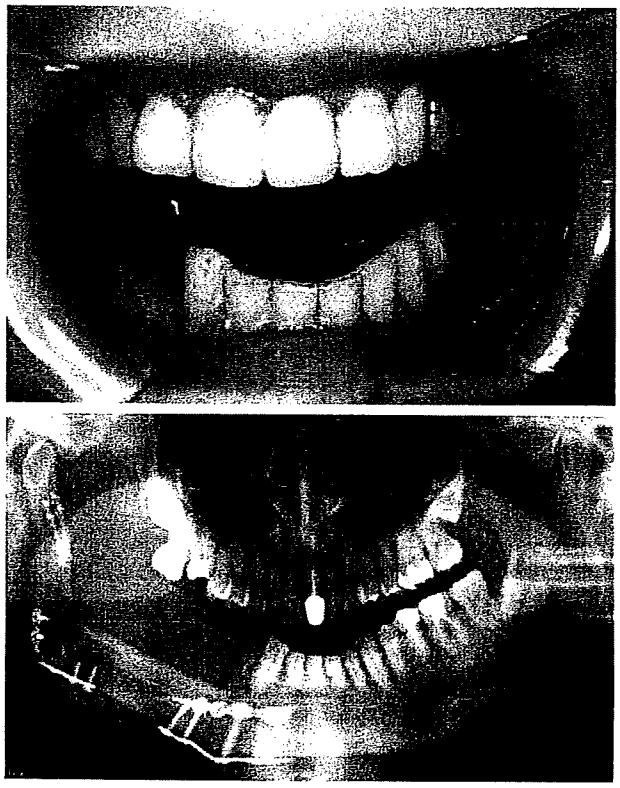

Fig. 7. Six months after reoperation. The transferred tissue survived completely.

The ability to detect problems intraoperatively is considered to decrease the incidence of reexploration after free tissue transfer.[9] Intraoperative monitoring of venous pressure rapidly detected venous insufficiency found in two of our present 52 cases, and also in other cases where we have noticed transiently elevated venous pressure as the wound was closed or a dressing was applied, which was then corrected immediately. In addition, this monitoring modality helped to facilitate postoperative care by avoiding critical elevations in venous pressure because of posturing and movement by the patient. Because the blood flow is derived from the pressure gradient between the arterial and venous sides, keeping the venous pressure at a lower level is important to ensure good perfusion in the transferred tissue. Despite the high-risk group indicated for venous pressure monitoring in our patient series, postoperative venous thrombosis occurred in only one of the 52 patients. The ability to detect critical venous pressure elevation during the intraoperative and/or postoperative period might lead to a lower incidence of venous thrombosis.

Reproducibility on an individual basis may be affected by potential artifacts, such as an unfavorable location of the catheter, motion, posturing, and obstruction of the line connected to the transducer. However, provided that one has a clear understanding of the technical background of this method, intraparenchymatous venous pressure monitoring can provide reproducible results in the assessment of venous compromise. This technique is not advocated for all cases of free-flap surgery because of potential complications in association with the pulling out of the catheter. Because we experienced only one case of postoperative venous thrombosis, further investigations were obviously required to discuss cost-effectiveness analysis of this technique. It would seem to be particularly indicated for high-risk patients, such as those demonstrated to have an abnormality in the venous anatomy, those undergoing reconstruction after lower leg trauma, and those requiring a vein graft.

CONCLUSIONS

Venous outflow abnormalities in instances of free composite tissue graft transfer can lead to devastating sequelae. Although various methods for monitoring the interstitial blood flow have been advocated, no single approach has been found to provide reliable information about incompetence of venous outflow. Monitoring the changes in the venous pressure is a method that is simple to implement, and the findings are, generally speaking, reliable and useful in helping the surgeon to decide when to reexplore the operative site. Although the venous pressure is in the range of 0 to 35 mmHg during the first 3 days after surgery, a subsequent trend to venous hypertension reaching a level of 50 mmHg clearly indicates venous outflow obstruction. Reexploration of the

wound is indicated if the "ailing" flap is to be rescued.

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ACKNOWLEDGMENT

The authors thank Dr. Ted Huang for help in preparing the manuscript.

DISCLOSURE

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this article.

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Breast Cancer
Vol. 14 No. 4 October 2007

Original Article

Options for Immediate Breast Reconstruction Following Skin-Sparing Mastectomy

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Background: Skin-sparing mastectomy (SSM) is a type of breast cancer surgery presupposed as breast reconstruction surgery. Cosmetically, it is an extremely effective breast cancer operation because the greater part of the breast's native skin and infra-mammary fold are conserved. All cases of SSM and immediate breast reconstruction performed by the senior author during the last five years were reviewed.

Methods: There are three implant options for breast reconstruction, namely, deep inferior epigastric perforator (DIEP) flap, latissimus dorsi myocutaneous (LDM) flap, and breast implant, and one of these was used for reconstruction after comprehensive evaluation.

Results: From 2001 to 2005, immediate reconstructions following SSM were performed on 124 cases (128 breasts) by the same surgeon. Partial necrosis of the breast skin occurred in 4 cases of SSM. The mean follow-up was 33.6 months. During the follow-up, there was local recurrence following surgery in 3 cases. The overall aesthetic results of immediate breast reconstruction after SSM are better than those after non-SSM.

Conclusion: SSM preserves the native breast skin and infra-mammary fold, and is an extremely useful breast cancer surgery for breast reconstruction. SSM is an excellent breast cancer surgical technique. We think this procedure should be considered in more facilities conducting breast reconstruction in Japan.

Breast Cancer 14:406-413, 2007.

Key words: Skin-sparing mastectomy, Immediate breast reconstruction, Deep inferior epigastric perforator (DIEP) flap, Latissimus dorsi myocutaneous (LDM) flap, Breast implant

Introduction

Reconstructive surgery following cancer resection is an important procedure for plastic surgeons, and breast reconstruction is a surgery in which aesthetics are of utmost importance. Cooperation of the breast surgeon is essential in the pursuit of good appearance, and surgical procedures that allow easy reconstruction of good breast form without affecting the completeness of cure are desirable.

Skin-sparing mastectomy (SSM) is mastectomy with minimum necessary skin removal only the areola, nipple, and skin directly over the tumor or skin at the biopsy site is removed as necessary[1]. Cosmetically, it is an extremely effective breast cancer operation because the greater part of the breast's native skin and inframammary fold are conserved. That is, an implant that corresponds in size to the amount of removed tissue is simply placed into the subcutaneous pocket formed after tumor excision. Regarding the implant, we have three options, namely, deep inferior epigastric perforator (DIEP) flap, latissimus dorsi myocutaneous (LDM) flap, and breast implant, and one is selected for the reconstruction after comprehensive evaluation.

We examined the cases that underwent breast-reconstructive surgery following SSM at our institution during the last five years, and report the details.

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Received September 9, 2006; accepted June 25, 2007

Table 1. Mean Operation Time and Blood Loss for Each Reconstructive Techniques and SSM

	LDM flaps (n: 66)	free DIEP flaps (n: 45)	Tissue Expander (n: 10)	TRAM flap (n: 6)	VRAM flap (n: 1)
Operation time, (h)	4.68 ± 1.38	8.73 ± 2.83	2.65 ± 1.30	7.85 ± 1.89	7
Blood loss, (ml)	304 ± 179	541 ± 276	218 ± 179	595 ± 295	340

Patients and Methods

Indications

The indications for SSM are determined after a comprehensive evaluation including the breast surgeon's examination, cytodiagnosis, biopsy, and diagnostic imaging. Fundamentally, it is limited to cases having extensible breast skin with low probability of infiltration, regardless of the extent of intraductal progression. Even if breast preservation is possible, discussion with the patient often leads to SSM being selected due to its excellent local control.

Operative Procedure

SSM: Essentially, the entire mammary gland is removed through a lateral breast incision, but the thickness of the fat attached to the skin flap depends on the surgeon's judgement. The skin directly above the tumor is also excised according to its proximity to the tumor, but even when it is not excised, the fat that is preserved should be 5 mm or less in thickness, and it is necessary to take care not to damage the vascular network beneath the dermis. In particular, care must be exercised because the risk of necrosis increases if the electric scalpel is excessively used for hemostasis on the underside of the skin. Whether to excise the areola and nipple is determined by a quick perioperative pathological examination of the tissue under the nipple. If biopsy was performed before surgery, fusiform resection including the skin of the biopsy site is conducted.

We have three options for reconstruction, a DIEP flap, LDM flap, or breast implant. Fundamentally, the DIEP flap is chosen if the breast volume is at least moderate and the abdominal fat is sufficient[9]. The LDM flap is chosen for a small breast. Reconstruction using a breast implant is performed for moderate or larger breasts when the subcutaneous abdominal fat is insufficient, or when the patient does not desire reconstruction with autologous tissue.

1) DIEP flap: The perforators in the navel area are found by preoperative color Doppler flowmetry, and the largest perforator is selected. Usually one perforator is used to elevate a flap, but sometimes we use two if they are relatively narrow. The skin flap is selected from the side contralateral to the lesion, centered on zones I and III, and the inclusion of zone II is determined by whether the perforator is a lateral division or a medial one. The perforator is traced to the bifurcation of the external iliac vessels, and a long vascular pedicle is taken and anastomosed to the thoracodorsal vessels. However, if it is judged during the procedure that the perforator is very narrow and that a perforator flap cannot be used, a pedicled transverse rectus abdominis myocutaneous (TRAM) flap is used instead.

2) LDM flap: Usually a transverse, fusiform incision is designed so that the scar will be hidden in the bra line on the back. The LDM flap has adipose tissue beneath the superficial fascia attached to it. The insertion of the latissimus dorsi muscle is severed with an electric scalpel, sparing the entry site of the thoracodorsal vessels so that the flap is an island myocutaneous flap with thoracodorsal vessels as a pedicle. The myocutaneous flap is subcutaneously tunneled through the axillary region to the precordial region to create a breast mound. It is made slightly bigger than the unaffected side in consideration of postoperative atrophy.

3) Breast implant: The skin and subcutaneous tissue detached in SSM are thin and there is risk of capsular contracture or exposure of artificial materials if the breast implant is simply placed in the subcutaneous pocket, and therefore it is inserted under the pectoralis major muscle. The pectoralis major muscle is cut at its origin, a sufficiently large pocket is created, and a tissue expander (TE) is inserted. The TE is gradually enlarged and the breast volume is determined by comparison with the contralateral breast. Then, the TE is injected with physiological saline to 20% more than the volume of the breast implant. The

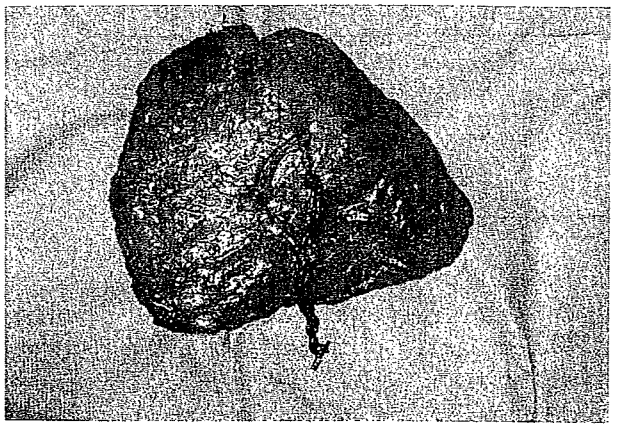

Fig 1. Case 1: A 13 × 30 cm DIEP flap was elevated with two perforators.

TE is removed, and the breast implant is inserted 3 to 6 months after surgery.

Results

From 2001 to 2005, immediate reconstructions following SSM were performed by the same surgeon on 124 cases (128 breasts). The SSM group consisted of 68 cases with excision of the nipple and 56 cases with preservation of the nipple. The SSM reconstruction techniques were 66 LDM flaps, 45 free DIEP flaps, 10 TE + bag, 6 TRAM flaps, and one VRAM flap. The time for the operation was 4.68 ± 1.38 hours in the LDM flap group, 8.73 ± 2.83 hours in the free DIEP flap group, and 2.65 ± 1.30 hours in the TE + bag group (Table 1). The volume of blood loss was 304 ± 179 ml in the LDM flap group, 541 ± 276 ml in the free DIEP flap group, and 218 ± 179 ml in the TE + bag group. Reconstruction of the areola and nipple was done in 32 cases. Partial necrosis of the breast skin occurred in 4 cases of SSM. In two cases, it healed with scar formation by conservative treatment, one case was reconstructed with an LDM flap because of extensive necrosis in all layers, and the other case was excised and sutured because the area was small. The mean follow-up period was 33.6 months. During the follow-up, postoperative local recurrence occurred in three cases; in two cases mastectomy including the reconstructed tissue was done, and in one case partial mastectomy including the skin at the site of local recurrence was done.

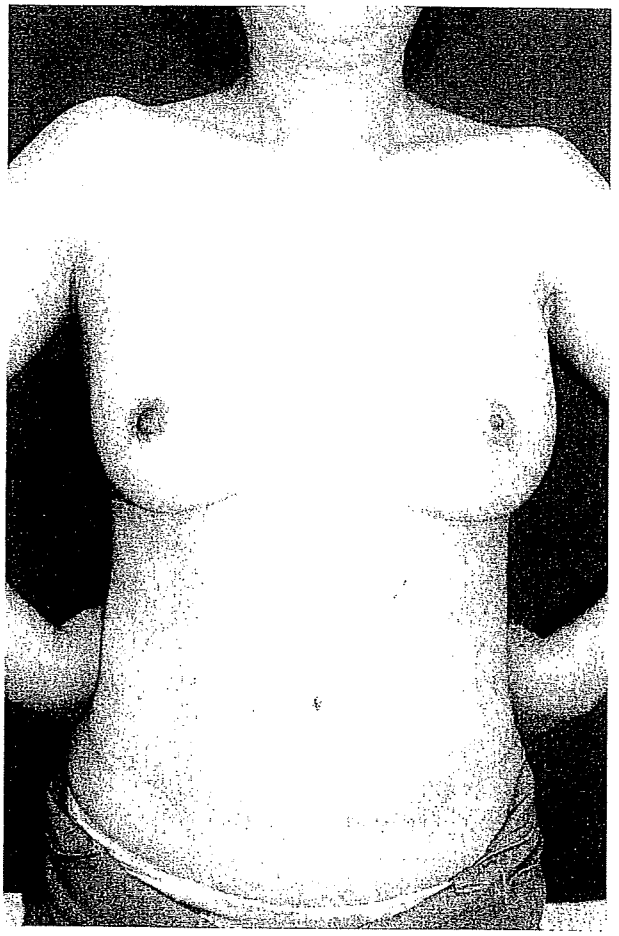

Fig 2. Case 1: The breasts have left/right symmetry, and the patient is satisfied 3 years after surgery. The rectus abdominis muscle function was preserved, there is no abdominal bulge, and the scars are not prominent.

Case Reports

Case 1: DIEP Flap

The patient was 55-year-old woman. SSM was performed for breast cancer in the left C region (T1). From the lateral breast incision, SSM with nipple-areola complex resection was performed. Axillary lymph node dissection was not performed because biopsy of the sentinel lymph node was negative. A 13 × 30 cm DIEP flap was elevated with two perforators and anastomosed end-to-end to the thoracodorsal vessels (Fig 1). Since the perforator was a medial division, zones I and II were used to form the breast mound. The nipple-areola complex was later reconstructed. The patient's postoperative progress was favorable, and so far (3 year after surgery), neither local recurrence nor distant metastasis has occurred. The breasts have left/right symmetry, and the patient is satis-

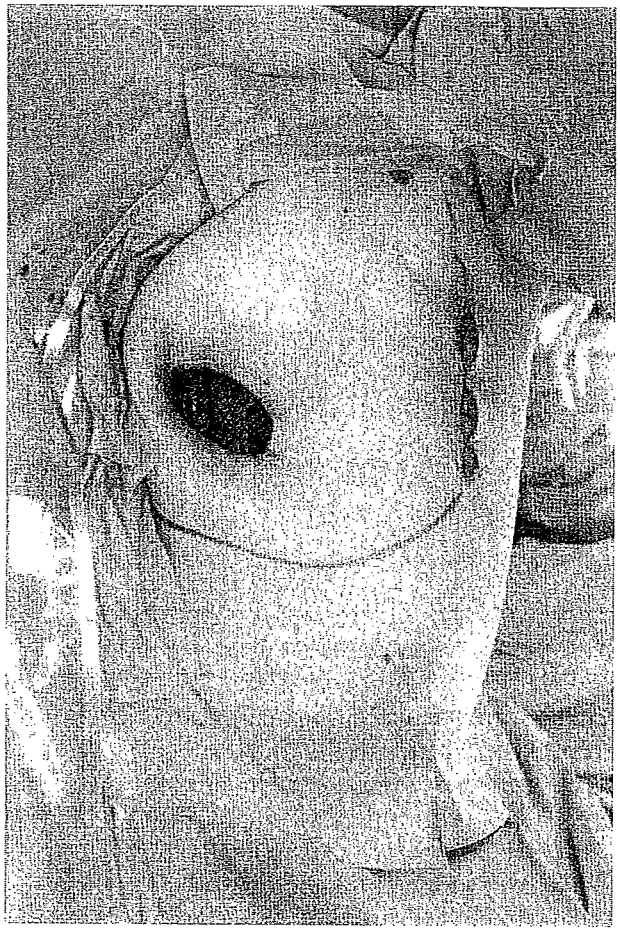

Fig 3. Case 2: SSM was conducted for breast cancer with involvement of the nipple-areola complex.

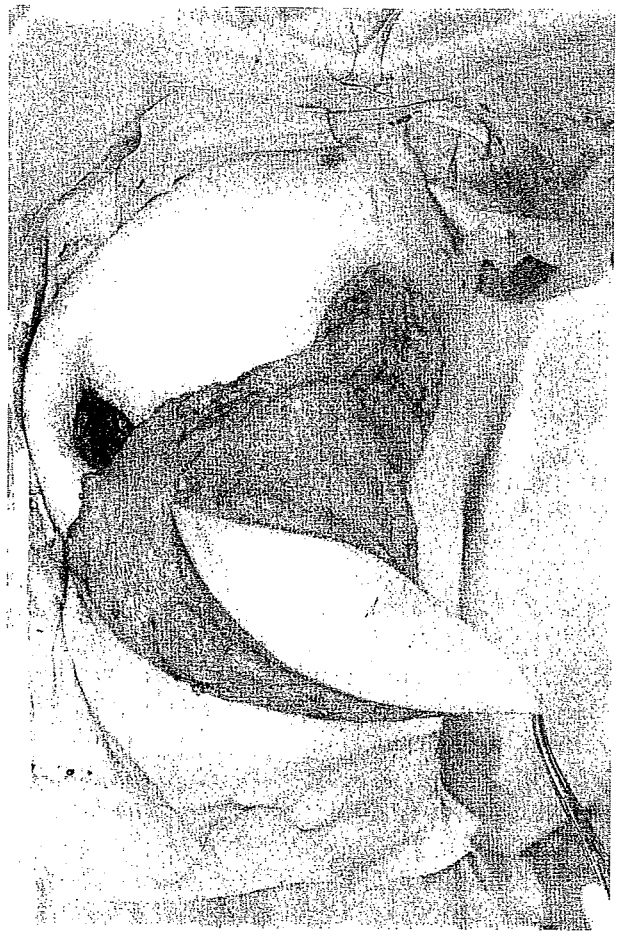

Fig 4. Case 3: The insertion of the latissimus dorsi muscle was severed and transferred to the precordial region as an island skin flap to form the breast mound.

fied. The rectus abdominis muscle function was preserved, there is no abdominal bulge, and the scars are not prominent (Fig 2).

Case 2: LDM Flap

The patient was 59-year-old woman. SSM was conducted for breast cancer in the left CE region (T1). The entire mammary gland with nipple-areola complex was removed via a lateral breast incision, and biopsy of the sentinel lymph node was negative (Fig 3). The skin island was designed to be hidden on the back by a bra. The insertion of the latissimus dorsi muscle was severed and transferred to the precordial region as an island musclocutaneous flap to form the breast mound (Fig 4). The LDM flap underwent deepithelialization except for the nipple-areolar region, and was placed under the mastectomy flap. The nipple-areola complex was later reconstructed. The patient's postoperative progress was favorable, and so far (2 years after surgery) neither local recurrence nor distant metastasis has occurred. The breasts have left/right symmetry, and the patient is satisfied (Fig 5). The scars on the back are not prominent.

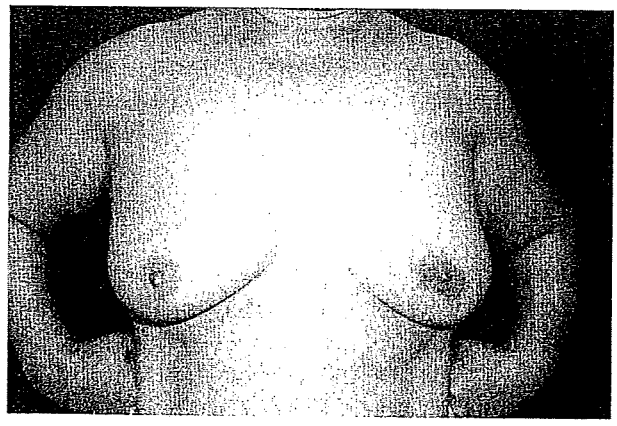

Fig 5. Case 3: The nipple-areola complex was later reconstructed. The patient's postoperative progress was favorable. The breasts have left/right symmetry, and the patient was satisfied 2 years after surgery. The scar on the back is not prominent.

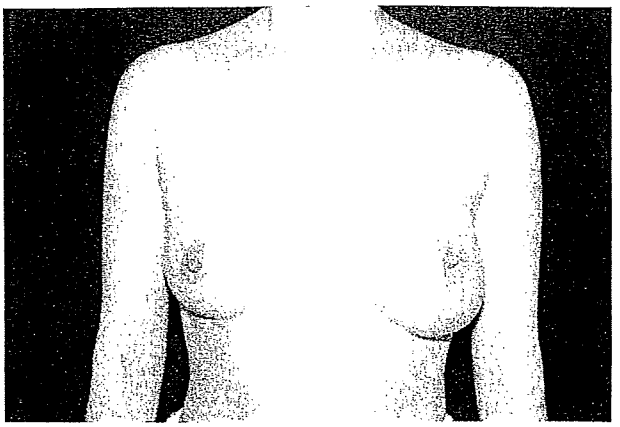

Fig 6. Case 3: The entire left mammary gland was removed via a lateral breast incision. The TE was filled with 300 cc of physiological saline.

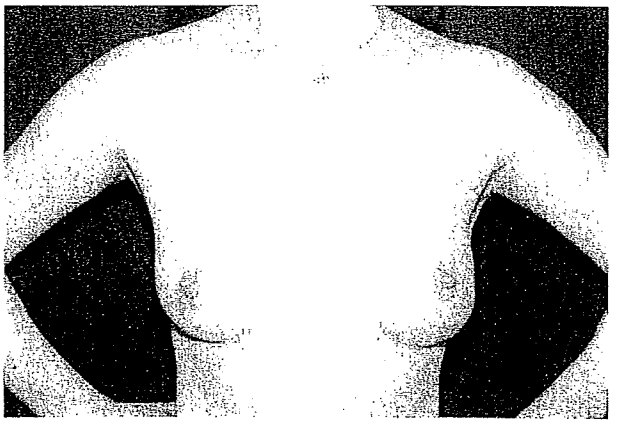

Fig 7. Case 3: After 4 months, a 220-cc cohesive silicone bag was implanted. The breasts have left/right symmetry, and the patient is satisfied 3 years after surgery.

Case 3: Breast Implant

The patient was 42-year-old woman. SSM was performed for breast cancer in the left C region (T1). The entire mammary gland was removed via a lateral breast incision. Biopsy of the sentinel lymph node was negative. The pectoralis major muscle was separated at its origin, and a 12.5 × 12.5 cm 600-cc TE was inserted in the pocket underneath the pectoralis major muscle. The TE was filled with 300 cc of physiological saline (Fig 6), and after 4 months a 220-cc cohesive silicone bag was implanted. The patient's postoperative progress was favorable, and so far (three years after surgery) neither local recurrence nor distant metastasis has occurred. The breasts have left/right symmetry, and the patient is satisfied (Fig 7). Capsular contracture was not recognized 3 years postoperatively.

Discussion

Surgery is still the main treatment for breast cancer, but the changes in the operative procedures have been dramatic. In the 1960s, mastectomy with excision of the pectoral muscles and extended surgery was predominant. In the 1980s, pectoral-preserving mastectomies gradually increased. Then in the 1990s, breast-preserving treatments appeared with a trend toward further scaling down. In a national survey conducted by the Japanese Breast Cancer Society in 2000, scaling down was prominently seen with pectoral-preserving mastectomies (52%), breast-preserving treatment (41%), and extended radical mastectomy with excision of the pectoral muscles (1%). In addition, cases of breast reconstruction are increasing, as awareness of the patient QOL increases. However, the breast skin is extensively removed in the pectoral-preserving surgery or excision of the pectoral muscles in the standard breast cancer surgery. Moreover, if reconstruction is done with an LDM flap or TRAM flap, a patchwork appearance is unavoidable because skin with different color and texture is exposed on the surface of the breast. In breast-preserving surgery, the partial tissue loss was sufficiently filled with the LDM flap, but considering the use of postoperative irradiation and the high rate of local recurrence in comparison with the other operations, it was not a reconstruction-oriented technique.

In contrast, the SSM reported by Toth & Lappert in 1991 is a breast cancer surgical technique in which the entire mammary gland is removed but the breast's native skin is preserved as far as possible on the assumption of reconstruction[1]. Because the native breast skin and the submammary sulcus are preserved by this method, it is extremely advantageous for breast reconstruction.

The indications for SSM were reportedly stage T1/T2, multiple tumors, DCIS and preventive mastectomy[3], but recently the range of operative indication has broadened to include stage T3 and T4[4-7]. The indications at our institution are not strictly related to the tumor diameter or stage, but are for cases in which breast-preserving treatment is not possible and in which no tumor invasion to the breast skin surface is observed. In the clinical practice, the indications include cases having