Vascularized Groin Lymph Node Flap Transfer for Postmastectomy Upper Limb Lymphedema: Flap Anatomy, Recipient Sites, and Outcomes

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Background: Vascularized groin lymph node flap transfer is an emerging approach to the treatment of postmastectomy upper limb lymphedema. The authors describe the pertinent flap anatomy, surgical technique including different recipient sites, and outcome of this technique.
Methods: Ten cadaveric dissections were performed to clarify the vascular supply of the superficial groin lymph nodes. Ten patients underwent vascularized groin lymph node flap transfer for postmastectomy upper limb lymphedema using the wrist ($n = 8$) or elbow ($n = 2$) as a recipient site. Ten patients who chose to undergo physical therapy were used as controls. Intraoperatively, indocyanine green was injected subcutaneously on the flap margin to observe the lymph drainage. Outcomes were assessed using improvement of circumferential differentiation, reduction rate, and decreased number of episodes of cellulitis.
Results: A mean 6.2 ± 1.3 groin lymph nodes with consistent pedicles were identified in the cadaveric dissections. After indocyanine injection, the fluorescence was drained from the flap edge into the donor vein, followed by the recipient vein. At a mean follow-up of 39.1 ± 15.7 months, the mean improvement of circumferential differentiation was 7.3 ± 2.7 percent and the reduction rate was 40.4 ± 16.1 percent in the vascularized groin lymph node group, which were statistically greater than those of the physical therapy group (1.7 ± 4.6 percent and 8.3 ± 34.7 percent, respectively; $p < 0.01$ and $p = 0.02$, respectively).
Conclusions: The superficial groin lymph nodes were confirmed as vascularized with reliable arterial perfusion. Vascularized groin lymph node flap transfer using the wrist or elbow as a recipient site is an efficacious approach to treating postmastectomy upper limb lymphedema. (*Plast. Reconstr. Surg.* 131: 1286, 2013.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

Postmastectomy upper limb lymphedema is a relatively uncommon but potentially devastating complication of axillary lymph node dissection and irradiation.[1–3] Nonsurgical treatments, such as exercise and elevation, lymphatic massage, static compression garments,

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intermittent pneumatic compression, and multilayer lymphedema banding can be helpful in International Society of Lymphedema stage 1 to 2 lymphedema, but can be uncomfortable, restrictive, cumbersome, and time-consuming.[4–23] The risk of lymphedema can be significantly decreased by sentinel lymph node biopsy (22.2 percent) instead of axillary lymph node dissection (43.3 percent).[24,25]

Surgical interventions have been attempted with variable success, including (1) lymphaticovenous anastomoses[26–36]; (2) methods to decrease lymph loading such as liposuction,[5,37,38] wedge excision, and ablative surgery[39–42]; (3) pedicle latissimus dorsi myocutaneous flap to the axilla[43–45]; (4) omental flap or free autologous flap with or without lymph nodes to the axilla[41,45–48]; and (5) vascularized lymph node transfer.[49–52]

Liposuction can be used for nonpitting lymphedema International Society of Lymphedema stage 1 to 2 with removal of fibrotic adipose tissue. The reduction results can be maintained with continued use of compression garments.[4] In 1977, O'Brien et al. reported improvements in 42 to 83 percent of selected patients who underwent lymphaticovenous anastomoses.[35] However, Puckett reported that lymphaticovenous anastomoses may be occluded at 3 weeks despite a 100 percent patency rate 1 week after anastomoses.[36] Koshima et al. reported an average decrease in circumference of 4.1 to 4.7 cm (41 to 55 percent) in lower limb lymphedema after intervention with 10 or more lymphaticovenous anastomoses,[29–32,34] and an average decrease of 4.1 cm (47.3 percent) in the circumference of upper limb lymphedema.[29] Slavin et al. reported the possible restoration of lymphatic drainage after free-tissue transfer in extremity wounds.[53,54] Chang and Kim reported that nine of 38 cases (24 percent) experienced improved lymphedema symptoms after delayed breast reconstructions with autologous tissue transfer.[45]

Vascularized lymph node transfer was introduced by O'Brien et al. and Chen et al. to treat obstructive lymphedema in the canine model.[55,56] Becker et al. reported a series of 17 vascularized groin lymph node flaps to the axilla and seven to the elbow.[49] Forty-two percent of the cases returned to normal and 50 percent improved, but only five of 16 cases (31 percent) demonstrated activity of the transplanted nodes under isotopic lymphoscintigraphy.[49] Continuous postoperative compression and upper limb elevation were required in 37.5 percent of the patients. Since 1997, we have transferred vascularized groin lymph node flaps to the wrist to treat postmastectomy upper limb lymphedema, with a mean reduction rate of 50.55 ± 19.26 percent at a mean follow-up of 56.31 ± 27.12 months.[52] Using a sheep model, Tobbia et al. reported that lymphedema was improved by transferring a vascularized lymph node.[57] Recently, the free transverse rectus abdominis myocutaneous or deep inferior epigastric perforator flap was transferred with the inferior epigastric lymph nodes to the axilla and was shown to improve lymphedema.[48] In this case control study, we describe the pertinent flap anatomy, surgical technique of different recipient sites, and the outcome of this technique.

MATERIALS AND METHODS

Anatomical Investigation

Ten groin dissections were performed on five embalmed cadavers at Singapore General Hospital to clarify the vascular supply of the superficial inguinal lymph nodes and characterize the vessels that could be used as vascular pedicles. The iliac arteries were accessed through a lower abdominal incision remote from the groin and were injected with latex dye. A 5 × 10-cm elliptical skin paddle was incised in the groin; its long axis was parallel and 4 cm inferior to the inguinal ligament, and its medial corner was directly superficial to the common femoral vessels. The dissection proceeded with the intent of identifying vessels emanating from the femoral vessels and supplying the adipolymphatic tissue associated with the skin paddle. The depth of the dissection remained just superficial to the plane of the femoral vessels. The length and caliber of the supplying vessels were recorded. After the flap was completely dissected, the number of lymph nodes contained within the flap and their association with the supplying vessels were assessed (Figs. 1 and 2).

Fig. 1. Two lymph nodes were nourished by the superficial circumflex iliac artery in a cadaveric groin dissection.

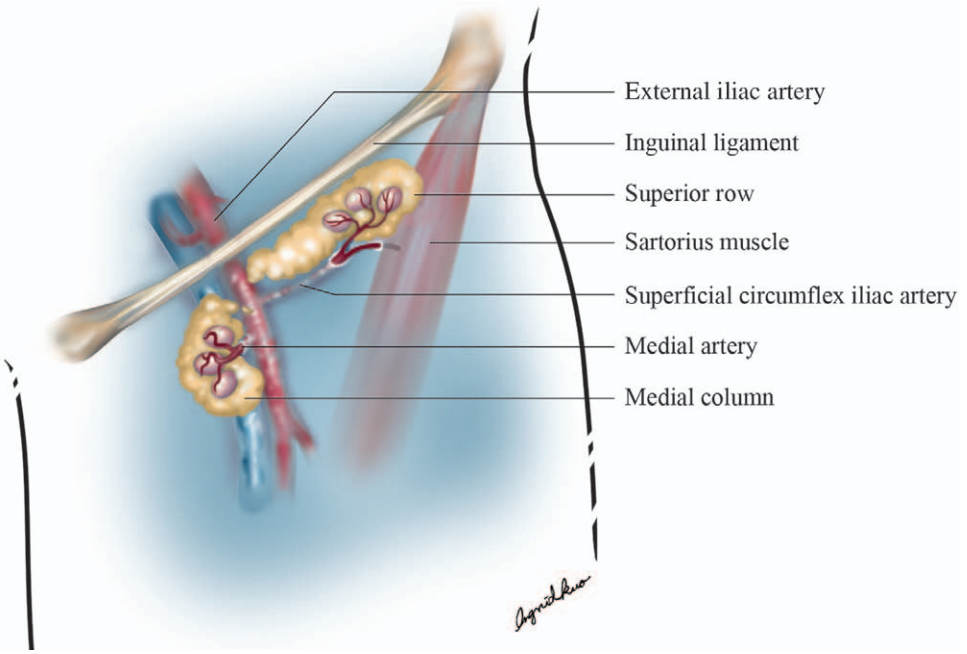


Fig. 2. A summary of the anatomical study, with a mean 6.2 ± 1.3 superficial groin lymph nodes. The medial column, with a mean 2.8 ± 1.5 nodes, was nourished by the medial artery and the other superior row, with a mean 3.4 ± 0.3 nodes, was nourished by the superficial circumflex iliac artery.

Clinical Applications

Following approval by the Institutional Review Board of Chang Gung Memorial Hospital (project no. 3282A), this study prospectively evaluated 20 consecutive postmastectomy upper limb lymphedema patients who met the following inclusion criteria for vascularized groin lymph node flap transfer: (1) total occlusion on lymphoscintigraphy, (2) International Society of Lymphedema stage 2 (15 percent greater circumference than the normal limb) with repeated episodes of cellulitis, (3) no acute cellulitis, and (4) more than 12 months of follow-up. Exclusion criteria for vascularized groin lymph node flap transfer were (1) regional recurrence of the breast cancer, (2) distant metastasis, or (3) brachial plexus neuritis. The hard charts, electronic charts, and pathology records of all patients were completely reviewed. Between April of 2009 and April of 2011, 20 patients were offered vascularized groin lymph node transfer and given the choice of the wrist or elbow as a recipient site. Ten patients (Fig. 3) accepted and became the vascularized groin lymph node group (Figs. 4 and 5), whereas 10 patients declined surgery and instead chose to be treated with physical therapy (physical therapy group). The vascularized groin lymph node group was subdivided according to recipient sites (wrist and elbow groups) (Tables 1 and 2).

Surgical Technique

Donor Flap Harvest

The patient was placed in the supine position with the affected extremity on an arm table. (**See Video, Supplemental Digital Content 1,** which shows the design and harvest of a vascularized groin lymph node flap, ***http://links.lww.com/PRS/A728***.) The vascularized groin lymph node flap was marked below the inguinal ligament and medial to the sartorius (Fig. 4). An elliptical skin paddle, 5 × 10 cm, was designed with its long axis parallel and inferior to the inguinal ligament. The skin was incised superiorly, and the dissection proceeded from lateral to medial, just above the sartorius fascial plane. The flap was supplied by either the superficial circumflex iliac artery or a small medial branch of the femoral artery; the medial artery was usually selected for better perfusion of the soft tissue and a natural lymphaticovenous connection around the common femoral vessels. No attempt was made to actively identify the inguinal lymph nodes (Fig. 5).

Recipient-Site Preparation

The patients who chose to have the vascularized groin lymph node flap transferred to the medial elbow were very concerned about the cosmesis of the wrist as the recipient site. [**See Video, Supplemental Digital Content 2,** which shows the elbow used as a recipient site and the ulnar artery

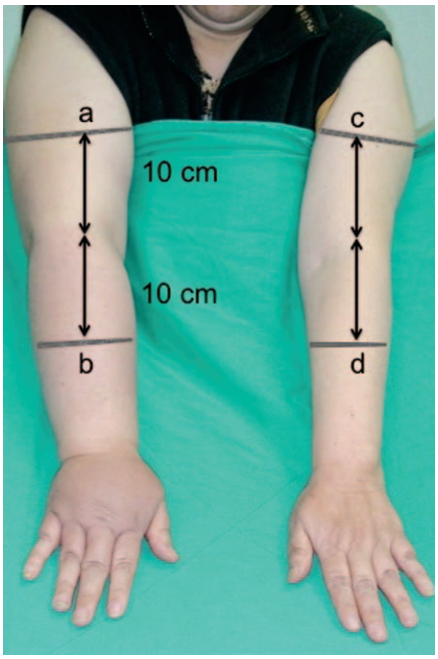


Fig. 3. A 67-year-old woman suffered from right upper limb lymphedema with five episodes of cellulitis over a 5-year period after her mastectomy, axillary lymph node dissection, and irradiation 9 years previously. She received aggressive physical therapy for 7 months, with no improvement. The circumference was measured for both lesion (*right*) and healthy (*left*) limbs at 10 cm above the elbow and 10 cm below the elbow. The circumferential differentiation in the above-elbow area before the operation was defined as the circumference of the lesion limb (*a*) minus the circumference of the healthy limb (*c*) divided by the circumference of the healthy limb (*c*) in the above-elbow preoperatively (preoperative above elbow = $(a - c)/c$).

(end to side) and the basilic vein used as the recipient vessels, ***http://links.lww.com/PRS/A729***.] In these cases, a longitudinal, S-shaped incision was made on the medial volar elbow area at the epicondyle level (Fig. 6). The recipient vessels were the anterior recurrent ulnar artery and the basilic vein (Fig. 7). The flap was then transferred to the recipient site, with one arterial anastomosis and one venous anastomosis (Fig. 7).

Most patients chose to have the vascularized groin lymph node flap transferred to the wrist with the hope of greater functional recovery (as explained in the Discussion section). In these cases, a transverse S-incision was made on the dorsal wrist (Fig. 8). The superficial radial nerves were carefully preserved. The branch of the radial artery in the snuffbox was identified, divided distally, and rerouted around the extensor pollicis longus and abductor pollicis longus to avoid compression when the thumb moved (Fig. 8). The radial artery itself was sometimes prepared for

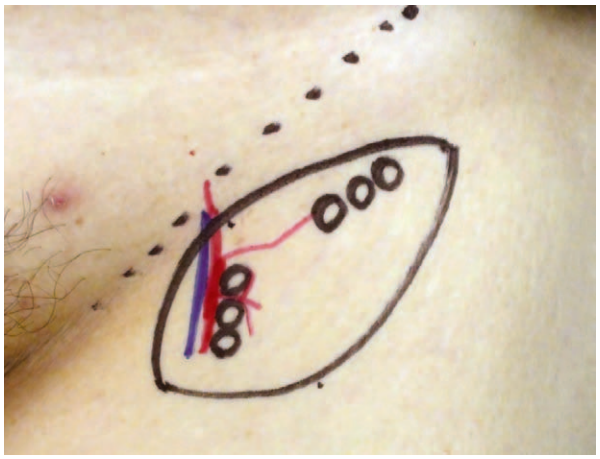


Fig. 4. A 10 × 5-cm vascularized groin lymph node flap was marked parallel to and 1 cm below the inguinal ligament.

end-to-side anastomosis. The cephalic vein or a tributary thereof was prepared.

In the majority of cases, the skin paddle could not be completely inset into the dorsal wrist pocket because of the disparity between the thickness of the flap and the thin and fibrotic subcutaneous fat of the dorsal wrist. Rather, the skin was closed along one side of the flap, and the exposed fat of the other side was covered with a thin split-thickness skin graft. This strategy was felt to minimize the risk of compression of the pedicle, as might be the case if the flap were taken with a larger skin paddle and folded aggressively over the relatively small recipient area. Furthermore, the graft was felt to be advantageous in that it contracted as it healed, reducing the skin redundancy at the dorsal wrist. The flap's donor site was closed primarily.

Postoperatively, all patients were admitted to the Microvascular Intensive Care Unit for

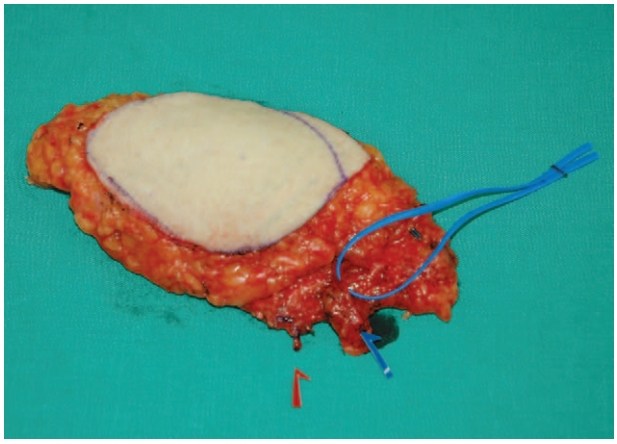


Fig. 5. The left vascularized groin lymph node flap was elevated based on the medial artery. *Red arrow*, medial artery; *blue loop*, a medial branch of the femoral vein.

Table 1. Comparisons of Patient Demographics between Patients Who Underwent Vascularized Groin Lymph Node Flap Transfer and Those Who Underwent Physical Therapy Instead

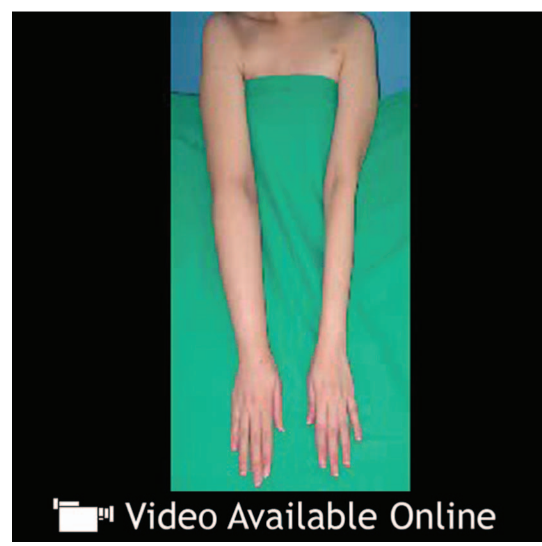
Group	No.	Age, yr (range)	Body Mass Index (range)	Lymph Node Excised (range)	Tobacco (%)	Diabetes (%)	Irradiation (%)	Durations of Symptom, mo (range)
VGLN	10	53.3 ± 10.3 (39–68)	26.5 ± 4.1 (21.1–33.6)	28.3 ± 10.5 (18–51)	0 (0)	2 (20)	9 (90)	33.2 ± 22.7 (12–84)
PT	10	50.1 ± 9.6 (38–68)	22.2 ± 3.4 (18.5–27.2)	19.5 ± 5.7 (10–24)	0 (0)	1 (10)	5 (50)	33.8 ± 26.7 (12–80)
Mean ± SD		51.7 ± 9.8 (38–68)	24.4 ± 4.2 (18.5–33.6)	24.5 ± 9.6 (10–51)				33.5 ± 24.1 (12–84)
Total (%)	20				0 (0)	3 (15)	14 (70)	
p		0.5	0.02*	0.09	—	1	0.1	1

VGLN, vascularized groin lymph node; PT, physical therapy.
*Analysis of differences between VGLN and PT groups was performed by means of the Mann-Whitney U test ($p < 0.02$).

Table 2. Comparisons of Patient Demographics between Patients Who Underwent Vascularized Groin Lymph Node Flap Transfer Using Either the Wrist or Elbow as the Recipient Site

Group	No.	Age, yr (range)	Body Mass Index (range)	Lymph Nodes Excised, No. (range)	Tobacco (%)	Diabetes (%)	Irradiation (%)	Durations of Symptom, mo (range)
Wrist	8	53.8 ± 9.5 (42–68)	26.7 ± 3.9 (22.1–33.6)	30.7 ± 11.1 (18–51)	0 (0)	2 (25)	7 (87.5)	37 ± 23.9 (12–84)
Elbow	2	50 ± 12.8 (39–64)	24.7 ± 4.8 (21.1–30.2)	19 ± 4.6 (15–24)	0 (0)	0 (0)	2 (100)	18 ± 8.5 (12–24)
Mean ± SD		53.3 ± 10.3 (39–68)	26.5 ± 4.1 (21.1–33.6)	28.3 ± 10.5 (18–51)				33.2 ± 22.7 (12–84)
Total (%)	10				0 (0)	2 (20)	9 (90)	
p		0.8	0.8	0.3	—	1	1	0.3

Video 1. Supplemental Digital Content 1 shows the design and harvest of a vascularized groin lymph node flap, ***http://links.lww.com/PRS/A728***.



Video 2. Supplemental Digital Content 2 shows the elbow used as a recipient site and the ulnar artery (end to side) and the basilic vein used as the recipient vessels, ***http://links.lww.com/PRS/A729***.

flap monitoring (i.e., color, temperature, and capillary refill), pencil Doppler examination, and remote smartphone photography.[58] Wedge resections of transferred skin and subcutaneous fat were also performed electively for improved cosmesis in patients who developed significant skin redundancy after 1 year.

Evaluation of Lymph Drainage

Immediately after the completion of microsurgical anastomoses of the artery and vein, 1 ml

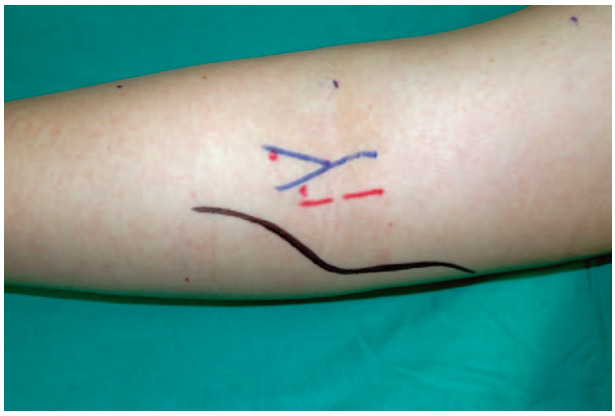


Fig. 6. The right elbow was selected as the recipient site using the anterior recurrent ulnar artery and the basilic vein as the recipient vessels.

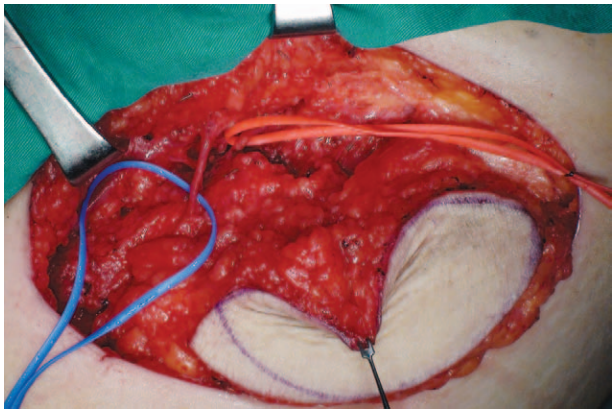


Fig. 7. The vascularized groin lymph node flap was transferred to the elbow, and the flap was temporarily inset. The donor vessels were anastomosed to the recipient vessels, the anterior recurrent ulnar artery (*red loop*) and the basilic vein (*blue loops*), in end-to-end fashion.

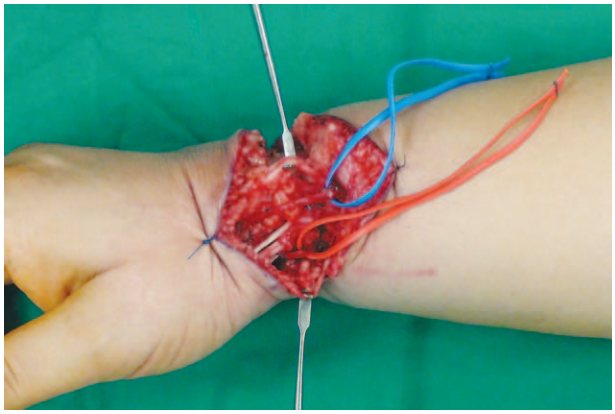


Fig. 8. The wrist was selected as the recipient site. The radial artery dorsal branch (*red loop*) was pulled from beneath the abductor pollicis longus and extensor pollicis longus to above these two tendons to avoid compression.

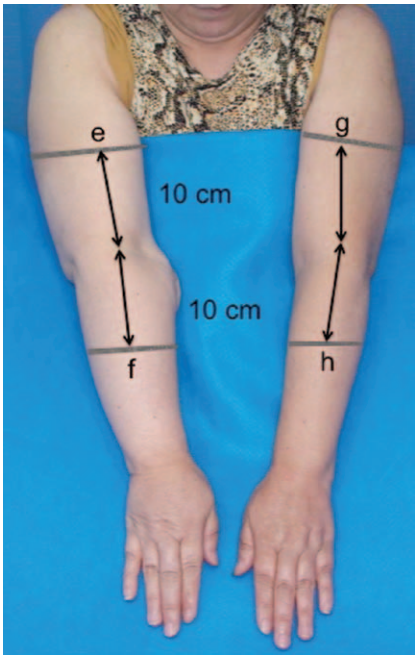


Fig. 9. At 33-month follow-up, reduction rates of 50 percent above the elbow and 40 percent below the elbow were observed. The donor site was much less conspicuous after one skin revision. The postoperative circumferential differentiation above the elbow was defined as the circumference of the lesion limb (*e*) minus the circumference of the healthy limb (*g*) divided by the circumference of the healthy limb (*g*) above the elbow postoperatively (postoperatively above elbow = $(e - g)/g$). The reduction rate in the above-elbow circumference measurement was defined as the preoperative difference ($a - c$) between the circumferences of the lesion (*a*) and healthy limbs (*c*) minus the postoperative difference ($e - g$) divided by the preoperative difference ($a - c$) [postoperative above-elbow reduction rate = $(a - c) - (e - g)/(a - c)$]. A similar formula was applied for the below-elbow circumferential differentiations of preoperative below elbow [$(b - d)/d$] and postoperative below elbow [$(f - h)/h$]; and reduction rate of postoperative below elbow [$(b - d) - (f - h)/(b - d)$].

of 0.5% indocyanine green was injected subcutaneously on the vascularized groin lymph node flap margin in selected patients to elucidate the mechanism of action of the vascularized groin lymph node flap. The fluorescence was observed with the assistance of a custom-made near-infrared (emission wavelength, 780 nm) camcorder (Sony HD Handycam CM05; Sony Corp., Tokyo, Japan) covered with a filter of 835 nm. Postoperatively, lymphoscintigraphy was performed with subdermal injection of technetium-99 through the second web space of the lesion hand in selective cases to demonstrate the activity of lymph clearance.

Fig. 10. A 52-year-old woman sustained right upper limb lymphedema after ablation surgery for breast cancer, axillary lymph node dissection, and postoperative radiotherapy for 4 years. The preoperative circumferential differentiations were 12.9 percent above the elbow and 11.2 percent below the elbow, respectively.

Fig. 11. At 20-month follow-up, the circumferential differentiations were 3.2 percent above the elbow and 0.8 percent below the elbow; the reduction rates were 50 percent above the elbow and 80 percent below the elbow.

Outcome Measurement

Although the Archimedes principle of water displacement is the most accurate measurement of true volume, it is not convenient for the patient to have water displacement measurements every month, especially in the winter. The limb circumference was measured at 10 cm above the elbow and 10 cm below the elbow (Figs. 3 and 9) on both limbs preoperatively and every month postoperatively.[9,52] The circumferential differentiation was defined as the circumference of the lesion limb minus the healthy limb, divided by that of the healthy limb (Figs. 3 and 9). The circumferential reduction rate was defined as the preoperative difference between the circumferences of the lesion and healthy limbs minus the postoperative difference, divided by the preoperative difference (Figs. 3 and 9). All clinical measurements were performed by the same research assistant (M.C.Y.L.), who worked independently of the operating surgeon. The lymphoscintigrams were interpreted by two physicians in the Department of Nuclear Medicine using lymphoscintigraphy criteria.[59]

Statistical Analysis

SPSS 17.0 software (SPSS, Inc., Chicago, Ill.) was used to analyze the data. Chi-square test or Fisher's exact test was used to assess categorical variables, and the Mann-Whitney U test was used to assess continuous variables. A value of $p < 0.05$ was considered statistically significant.

RESULTS

Anatomical Investigation

In the cadaveric dissections, there were 6.2 ± 1.3 (mean ± SD) nodes, including two separate clusters of sizable nodes with distinct and consistent pedicles: (1) a superior row with a mean 3.4 ± 0.3 nodes, supplied by the superficial circumflex iliac vessel; and (2) a medial column with 2.8 ± 1.5 nodes, supplied by a small medial branch of the common femoral vessels (Fig. 2). To our knowledge, this medial branch is unnamed, but it was consistently present and appeared to be of sufficient caliber for microvascular anastomosis in our specimens. The length and diameter of the arterial pedicles were 2.5 cm and 1.5 mm for the superior row and 1.9 cm and 1 mm for the medial column, respectively.

Clinical Applications

There were no statistical differences in age, axillary lymph nodes removed, tobacco use, diabetes, irradiation, or duration of symptoms between the vascularized groin lymph node and

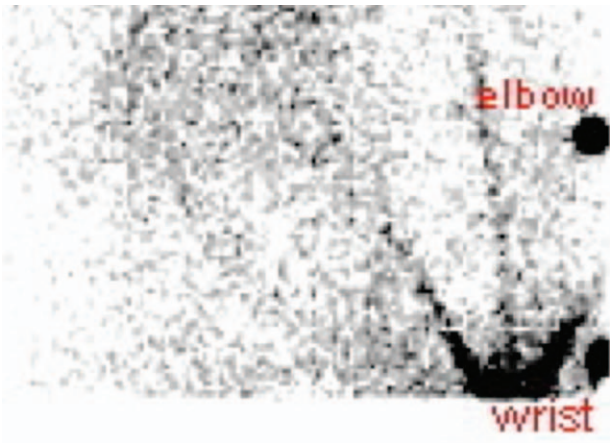
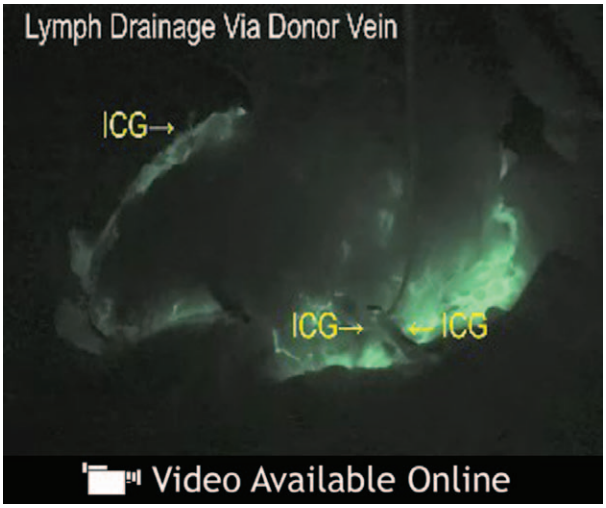


Fig. 12. One cubic centimeter of technetium-99 was injected subdermally into the second web space of the lesion hand, and the contrast was observed in the cephalic vein within 60 seconds. This served as indirect evidence that the technetium-99 was absorbed by the transferred lymph node and drained into the venous system.



Video 3. Supplemental Digital Content 3 shows how fluorescence is directly observed first in the recipient vein and then in the donor vein after the injection of 1 ml of 0.5% indocyanine green to the transferred flap edge, ***http://links.lww.com/PRS/A730***. The contrast was absorbed by the transferred lymph nodes and was drained into the donor vein through its native lymphaticovenous connection.

physical therapy groups or between the wrist and elbow groups (Tables 1 and 2) (chi-square test or Fisher's exact test and Mann-Whitney *U* test). All vascularized groin lymph node flaps survived (Figs. 9 through 11). No long-term donor-site morbidity was encountered. One patient developed transient edema of the donor extremity, but this resolved spontaneously after 12 weeks. Split-thickness skin graft was required in eight cases in the wrist group and no cases in the elbow group.

Postoperative lymphoscintigraphy was performed in only three cases because the subdermal injection of technetium-99 through the second web space was very painful. The contrast was observed at the cephalic vein within 60 seconds, and clearance of lymph drainage was improved (Fig. 12). For direct evidence, indocyanine green was injected subcutaneously at the flap margin in four cases; fluorescence was observed draining from the flap edge into the donor vein followed by the recipient vein. (**See Video, Supplemental Digital Content 3,** in which fluorescence is directly observed first in the recipient vein and then in the donor vein after the injection of 1 ml of 0.5% indocyanine green to the transferred flap edge, ***http://links.lww.com/PRS/A730***. The contrast was absorbed by the transferred lymph nodes and was drained into the donor vein through its native lymphaticovenous connection.)

At a mean follow-up of 39.1 ± 15.7 months, the mean improvement of circumferential differentiation of the vascularized groin lymph node group was statistically greater than that of the physical therapy group (7.3 ± 2.7 percent versus 1.7 ± 4.6 percent; $p < 0.01$) (Table 3). The mean circumferential reduction rate was 40.4 ± 16.1 percent in the vascularized groin lymph node group, which was statistically greater than 8.3 ± 34.7 percent in the physical therapy group ($p = 0.02$) (Table 3). The decrease in the number of episodes of cellulitis was not statistically different between the vascularized groin lymph node and physical therapy groups ($p = 0.5$) (Table 3).

Comparing the two recipient sites, at a mean follow-up of 36.6 ± 17.8 months, there were no statistical differences in mean improvement of circumferential differentiation (8 ± 2.5 percent versus 4.5 ± 2.3 percent), circumferential reduction rate (44.4 ± 15.2 percent versus 24.4 ± 7.9 percent), or decrease of episodes of cellulitis (1.3 ± 1.1 percent versus 1.3 ± 0.4 percent) between the wrist and elbow groups ($p = 0.1$, $p = 0.07$, and $p = 1$, respectively). The improvement of circumferential differentiation at the below-elbow measurement point in the wrist group was statistically significantly greater than in the elbow group (7 ± 3.8 percent and 1.8 ± 0.3 percent, $p < 0.01$). The circumferential reduction rate at the below-elbow measurement in the wrist group was significantly greater than that in the elbow group (41.3 ± 28.7 percent versus 9.6 ± 0.6 percent; $p = 0.02$) (Table 4).

All patients who underwent vascularized groin lymph node flap transfer were satisfied with the functional outcome (Figs. 3 and 9 through 11).

Table 3. Comparisons of the Outcomes between Patients Who Underwent Vascularized Groin Lymph Node Flap Transfer and Those Who Underwent Physical Therapy Instead

		Improvement of Circumferential Differentiation (%)			Circumferential Reduction Rate (%)			Episodes of Cellulitis			
Group	No.	Above-Elbow 10 cm	Below-Elbow 10 cm	Mean	Above-Elbow 10 cm	Below-Elbow 10 cm (%)	Mean	Before	After	Mean Decrease	Follow-Up, mo (range)
VGLN	10	8.5 ± 3.8	6 ± 4	7.3 ± 2.7	45.9 ± 13.8	34.9 ± 28.7	40.4 ± 16.1	2.2 ± 1.8	0.3 ± 0.5	1.3 ± 1	36.6 ± 17.8 (12–54.3)
PT	10	2.2 ± 4.3	1.3 ± 8.3	1.7± 4.6	19.5 ± 35.4	−2.9 ± 54.5	8.3 ± 34.7	1.1 ± 0.7	0.4 ± 0.5	0.9 ± 0.4	41.7 ± 13.6 (19.8–63.6)
Mean ± SD		4.7 ± 4.3	4.6 ± 7.2	4.7 ± 4.6	32.7 ± 29.4	16 ± 46.6	24.4 ± 31.1	1.8 ± 1.5	0.3 ± 0.5	1.1 ± 0.8	39.1 ± 15.7 (12–63.6)
p		<0.01*	0.1	<0.01*	0.05*	0.07	0.02*	0.2	0.3	0.5	0.5

VGLN, vascularized groin lymph node; PT, physical therapy.
*Analysis of differences between VGLN and PT groups was performed by means of the Mann-Whitney *U* test.

Table 4. Comparisons of the Outcomes between Patients Who Underwent Vascularized Groin Lymph Node Flap Transfer Using Wrist as a Recipient Site and Elbow Instead

		Improvement of Circumferential Differentiation (%)			Circumferential Reduction Rate (%)			Episodes of Cellulitis			
Group	No.	Above-Elbow 10 cm	Below-Elbow 10 cm	Mean	Above-Elbow 10 cm	Below-Elbow 10 cm	Mean	Before	After	Mean Decrease	Follow-Up, mo (range)
Wrist	8	8.9 ± 3.9	7 ± 3.8	8 ± 2.5	47.5 ± 14.1	41.3 ± 28.7	44.4 ± 15.2	2.1 ± 2	0.4 ± 0.5	1.3 ± 1.1	37.3 ± 19.5 (12–54.3)
Elbow	2	7.1 ± 4.3	1.8 ± 0.3	4.5 ± 2.3	39.3 ± 15.2	9.6 ± 0.6	24.4 ± 7.9	2.5 ± 0.7	0	1.3 ± 0.4	33.7 ± 13.2 (24.4–43)
Mean ± SD		8.5 ± 3.8	6 ± 4	7.3 ± 2.7	45.9 ± 13.8	34.9 ± 28.7	40.4 ± 16.1	2.2 ± 1.8	0.3 ± 0.5	1.3 ± 1	36.6 ± 17.8 (12–54.3)
p		0.6	<0.01*	0.1	0.5	0.02*	0.07	0.8	0.08	1	0.8

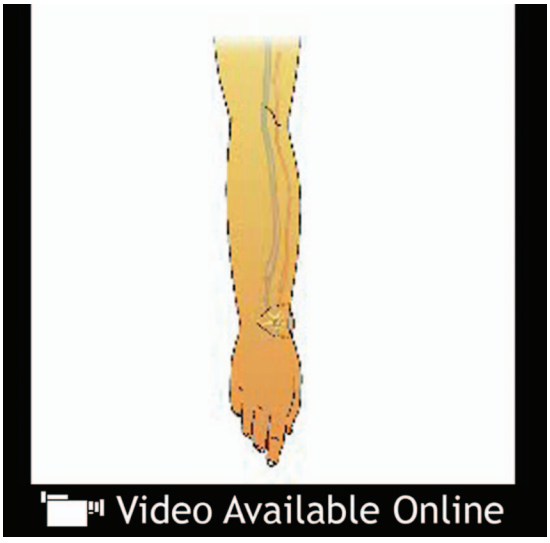
*Analysis of differences between Wrist and Elbow groups was performed by means of the Mann-Whitney *U* test.

None of the patients in the vascularized groin lymph node group required postoperative physiotherapy or compression garments. Four patients (40 percent) underwent deepithelialization 1 year postoperatively for better cosmesis.

DISCUSSION

The pathophysiology of postmastectomy upper limb lymphedema begins with the disruption of axillary lymphatic channels, which results in impaired lymphatic drainage and increased interstitial pressure of the entire upper limb. As this pressure continuously increases, the otherwise normal lymphatics become compressed, creating a vicious cycle. We hypothesize the mechanism of the vascularized groin lymph node flap transfer as follows (**see Video, Supplemental Digital Content 4,** which shows the hypothesized lymph drainage mechanism by means of the pump, catchment, and gravity effects of the vascularized groin lymph node flap transfer, ***http://links.lww.com/PRS/A731***):

1. The groin lymph nodes act as "lymph pumps," wherein the steep pressure gradient between the high-pressure arterial inflow and the low-pressure venous outflow draws fluid from the interstitial to the undamaged lymphatic tissue and into the venous system by means of lymphaticovenous channels around the nodes in the transferred flap.[52]
2. The "catchment effect" may recruit more lymph from the surrounding tissue into the transferred lymph nodes as the subcutaneous interstitial pressure in the lesion limb decreases.
3. A "gravity effect" may gradually drain from the upper arm to the forearm, and from the forearm to the wrist.
4. Further investigation is mandatory to support this hypothesis.



Video 4. Supplemental Digital Content 4 shows the hypothesized lymph drainage mechanism by means of the pump, catchment, and gravity effects of the vascularized groin lymph node flap transfer, ***http://links.lww.com/PRS/A731***.

How many lymph nodes should be transferred to adequately drain the lymph in postmastectomy upper limb lymphedema cases? Although the mean available superficial groin lymph nodes (6.2 ± 1.3) were much fewer than the axillary lymph nodes removed (26.8 ± 10.8), our experience shows that it is sufficient to gradually drain the lymph into the venous system. Preserving the lymph nodes and the soft tissue with the vascularized groin lymph node flap is, in our opinion, the key to the success of this technique.

Regarding the morbidity of the donor site, no long-term lower limb lymphedema developed after removal of the groin lymph nodes in this study. Becker et al. reported that the superior inguinal lymph nodes located along the superior circumflex iliac vein principally drain lymph from the abdominal wall.[50,51] Some patients who have abnormal lymph drainage or a borderline number of groin lymph nodes may be at risk of developing lower limb lymphedema when the superficial groin lymph nodes are harvested. This possible morbidity should be discussed with the patients preoperatively. Care should be taken to avoid harvesting the deep inguinal lymph nodes, which are located underneath the common femoral vessels.

There are three recipient sites available for vascularized groin lymph node flap transfer. The axillary area is usually operated on and irradiated with fibrotic changes, which makes the dissection of recipient vessels more tedious. Venous grafts may be needed to bridge the pedicle to the recipient vessels, usually the thoracodorsal vessels. Most importantly, it is difficult for the vascularized lymph nodes to drain the lymph against gravity, especially from the forearm and hand. In this study, no cases used the axilla as the recipient site because most patients hoped to achieve the best possible outcome from the surgery given the limited donor sites available. Both the elbow and the wrist are healthy areas for recipient vessel dissection. The anterior recurrent ulnar artery is sometimes very small; the ulnar artery may be

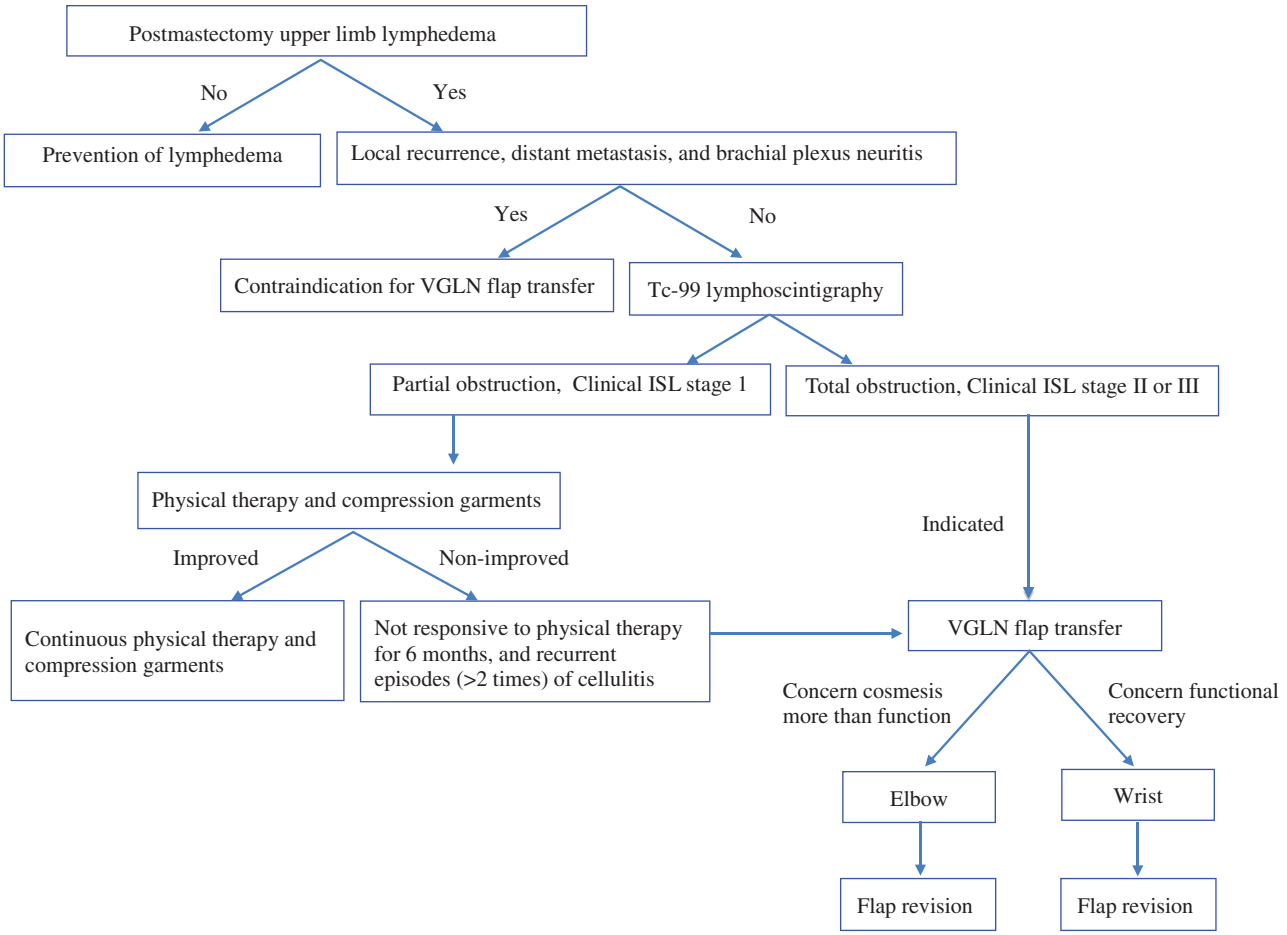


Fig. 13. The indications, contraindications, and algorithm for selection of recipient site for the vascularized groin lymph node flap transfer. *VGLN*, vascularized groin lymph node; *ISL*, International Society of Lymphedema; *Tc-99*, technetium-99.

used instead with an end-to-side technique. The recipient vessels of the radial artery's dorsal branch and the cephalic vein are more superficial and easily dissected. The effect of lymph drainage in the elbow group was not as good as in the wrist group, although the difference did not reach statistical significance in this study. The only difference between the elbow and wrist groups was the gravity effect. In our opinion, if the patient has prolonged and severe symptoms, the wrist is the preferred recipient site for better functional recovery. The cosmesis of the elbow group was much better than that of the wrist group. The cosmesis of both groups could be improved with deepithelialization after the lymphedema subsided and the skin became redundant. None of the patients with vascularized groin lymph node flap transfer required compression therapy or compression garments, which significantly improved their quality of life. The indications, contraindications, and selection of recipient sites for vascularized groin lymph node flap transfer are summarized in Figure 13.

CONCLUSIONS

The superficial groin lymph nodes were confirmed as vascularized with reliable arterial perfusion. Vascularized groin lymph node flap transfer using the wrist or elbow as a recipient site is an efficacious approach to treating postmastectomy upper limb lymphedema.

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