Vascularized Groin Lymph Node Transfer Using the Wrist as a Recipient Site for Management of Postmastectomy Upper Extremity Lymphedema

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Background: Restoring the continuity of lymphatic drainage by lymphaticovenous or lymphaticolymphatic anastomosis was observed in the short term to be patent but eventually occluded because the elevated interstitial pressure will cause obliteration of these tiny, thin-walled, low-pressure lumens. The purpose of this study was to evaluate the outcome of vascularized groin lymph node transfer using the wrist as a recipient site in patients with postmastectomy upper extremity lymphedema.
Methods: Between January of 1997 and June of 2005, 13 consecutive patients with a mean age of 50.69 ± 11.25 years underwent vascularized groin lymph node transfer for postmastectomy upper extremity lymphedema. A vascularized groin lymph node nourished by the superficial circumflex iliac vessels was harvested and transferred to the dorsal wrist of the lymphedematous limb. The superficial radial artery and the cephalic vein were used as the recipient vessels. Outcome was assessed by upper limb girth, incidence of cellulitis, and lymphoscintigraphy.
Results: All flaps survived, and one flap required reexploration, with successful salvage. No donor-site morbidity was encountered. At a mean follow-up of 56.31 ± 27.12 months, the mean reduction rate (50.55 ± 19.26 percent) of the lymphedematous limb was statistically significant between the preoperative and postoperative groups ($p < 0.01$). The incidence of cellulitis was decreased in 11 patients. Postoperative lymphoscintigraphy indicated improved lymph drainage of the affected arm, revealing decreased lymph stasis and rapid lymphatic clearance. A hypothesis was proposed that the vascularized groin lymph node transfer might act as an internal pump and suction pathway for lymphatic clearance of lymphedematous limb.
Conclusion: Vascularized groin lymph node transfer using the wrist as a recipient site is a novel and reliable procedure that significantly improves postmastectomy upper extremity lymphedema. (*Plast. Reconstr. Surg.* 123: 1265, 2009.)

Postmastectomy upper extremity lymphedema, one of most significant postmastectomy sequelae, is estimated to occur in 16 to 39 percent of breast cancer patients.[1–4] Lymphedema is especially prevalent in patients subjected to radiotherapy and axillary lymph node dissection. The majority of patients exhibit lymphedema within 3 years of surgery or irradiation; late-onset symptoms affiliated with infection, injury, or weight gain appear at a rate of 1 percent per year. The use of sentinel lymph node biopsy can reportedly reduce postmastectomy upper extremity lymphedema.[5] Postmastectomy upper extremity lymphedema is usually managed conservatively with complex decongestive physiotherapy, which involves the use of external compression, manual lymphatic drainage, exercise, and skin care. Stabilization or modest improvement can be achieved through daily adherence to a strict regimen. Medical

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management focuses mainly on treatment of up to 50 percent of dermatolymphangioadenitis, including bacterial or viral infections, erysipelas, cellulitis, and lymphangitis.

Few surgical options for obstructive lymphedema affecting the extremities have achieved satisfactory long-term results. O'Brien first described microlymphaticovenous anastomoses in 1977, and explored the potential application of microsurgery for obstructive lymphedema.[6] Lymphaticovenous anastomoses have achieved long-term improvements in 42 to 83 percent of selected patients.[7–10] However, the efficacy of this treatment modality is proportional to the number of lymphatics that can be identified and anastomosed.[7] Distal lymphatics suitable for anastomosis are difficult to locate in the fibrotic tissue of a severely edematous upper extremity. The lymphatic vessels are minute, thin-walled, and technically challenging to anastomose. Furthermore, anastomotic patency cannot be monitored using traditional methods applicable to other free flaps. Puckett reported a 100 percent patency rate 1 week after lymphaticovenous anastomosis, but all had occluded in 3 weeks.[11]

Clinical and experimental studies have demonstrated that lymphatic continuity can be restored spontaneously by lymphaticolymphatic or lymphaticovenous shunts.[12–18] An alternative for the management of lymphedema is microvascular transfer of perinodal soft tissue with nodes inside to reestablish lymphatic drainage. Chen et al. reported new lymphatic continuity by using vascularized lymph node transfer, resulting in significantly reduced limb size in a canine model.[19] The groin skin flap, including superficial inguinal lymph nodes, is the preferred donor site because of its familiar anatomy and inconspicuous scar. The purpose of this study was to investigate the outcome and efficacy of vascularized groin lymph node transfer for the reconstruction of postmastectomy upper extremity lymphedema.

PATIENTS AND METHODS

Between January of 1997 and June of 2005, 13 consecutive patients with a mean age of 50.69 ± 11.25 years (range, 36 to 69 years) with postmastectomy upper extremity lymphedema and lymphoscintigraphically confirmed proximal lymphatic obstruction were included in the study. All patients had undergone axillary lymph node dissection following a modified radical mastectomy in 11 patients and breast conservation therapy in two patients. One patient received adjuvant chemotherapy and 12 received adjuvant chemoradiotherapy. All patients had predominant swelling of the forearm and arm. Nonoperative treatments for lymphedema, such as weight reduction, antibiotics for cellulitis, arm elevation, and complex decongestive physiotherapy, were all undertaken before proceeding to vascularized groin lymph node transfer.

Preoperative assessments included photography, measurements of arm circumference for both the normal and lymphedematous arm at the level 10 cm proximal to the elbow joint, and technetium-labeled lymphoscintigraphy. Skin discolorations, vesicles, keratotic changes, pitting on digital pressure, and assessments of limb function (with emphasis on fine hand movements and flexibility of large joints) were documented for each patient. Serial measurements of arm circumference and photography were used for objective clinical assessment. Lymphoscintigraphy was performed at 3 to 6 months postoperatively for all patients. The patient satisfaction at follow-up was classified as poor, fair, good, or excellent.

Surgical Technique

The common femoral artery position was located by palpation of the pulse, and then a skin paddle was designed below and parallel to the inguinal ligament and lateral to the femoral artery in the groin area, which is different from that of traditional groin flap design (Fig. 1). Quiescent lymph nodes in the groin were usually impalpable. A skin incision was placed at the upper margin of the flap, and the superficial circumflex iliac vessels were explored from distal to proximal. The superficial circumflex iliac vein incorporated within the flap was usually separate from the artery (Fig. 2), and anatomical variations may be observed.

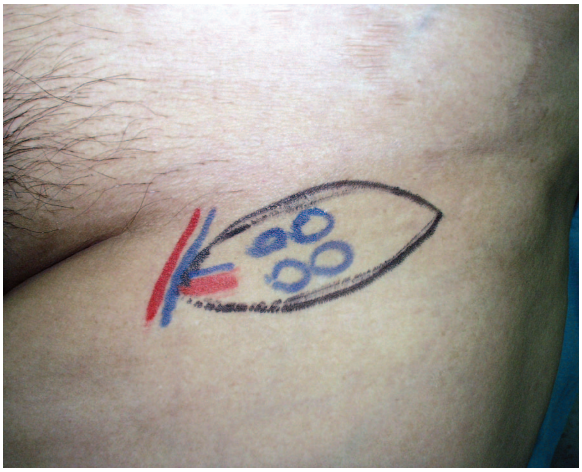

Fig. 1. The vascularized groin lymph node flap is designed with inclusion of the pedicle of the superficial circumflex iliac vessels.

Fig. 2. Meticulous preservation of lymphatic tissues around the vessels.

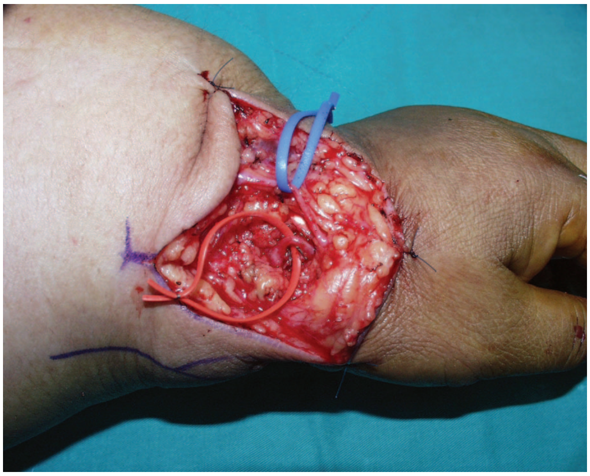

Fig. 4. Recipient vessels at the wrist (*above*, cephalic vein; *below*, branch of the radial artery).

The vascularized groin lymph node flap was harvested meticulously without additional dissection of the lymph nodes, which may preserve the fine lymphatic channels and lymphatic integrity within the perinodal tissue (Fig. 3). The overlying skin paddle was included not only for flap monitoring but also to allow tension-free closure at the recipient site. The dorsal wrist in the lymphedematous limb was selected as a recipient site, and a transverse skin approach was used to create a pocket within which the flap could be partially inset. A superficial branch of the radial artery at the anatomical snuffbox was used as the arterial inflow vessel and one of the branches of cephalic vein was used as the drainage vessel (Fig. 4).

In severe cases, the dense fibrotic circumferential adventitia of the superficial radial artery was released to gain strong spurting before microvascular anastomosis. Arterial anastomosis was performed first to ensure adequate venous return. The skin of the vascularized groin lymph node flap was loosely approximated to the wrist to avoid compression. The average operation time was 5 hours 31 minutes.

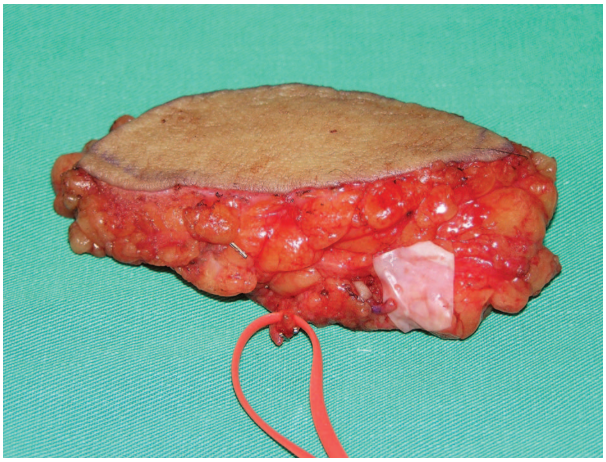

Fig. 3. Flap with short pedicle, superficial circumflex iliac vessels before inset.

All patients were monitored postoperatively for 5 days in a microsurgical intensive care unit and discharged between postoperative days 7 and 10. The upper limb was elevated postoperatively and the wrist was placed in a neutral position with splinting for 2 weeks. Finger flexion and extension were encouraged on postoperative day 3.

Lymphoscintigraphy Technique

For lymphoscintigraphy, 37 MBq of filtered technetium-labeled sulfur colloid (0.22 μm) in a volume of 0.5 ml was injected subcutaneously in the second webspace of the affected hand. The contralateral hand was not injected with radiotracer because of the limited field of view of the detector. Image recording began immediately after injection with both arms at the patient's side. Exercise was not performed. Anterior and posterior view dynamic images were acquired by a large-field-of-view computerized gamma camera (VariCam; Elscint, Haifa, Israel) over the arm and forearm. For each upper limb, the dynamic data were acquired as 1 minute/frame for 10 minutes in a 128 $\times$ 128 matrix. Acquisition of subsequent anterior and posterior static images of each upper limb was performed at 30, 60, and 120 minutes in continuous mode with a scan speed of 15 cm/minute. Postoperative lymphoscintigraphy was performed by subcutaneous injection of techne-

Table 1. Data for the 13 Consecutive Patients with a Mean Age of 50.69 ± 11.25 Years Who Underwent a Vascularized Groin Lymph Node Transfer for Postmastectomy Upper Limb Lymphedema*

Patient	Age (yr)	Site	Mastectomy Method	Duration of Symptoms (mo)	Preoperative Circumference (cm)		Postoperative Circumference (cm)		Circumference Reduction Rate¶ (%)	Morbidity	Follow-Up (mo)
					Lesion†	Healthy‡	Lesion§	Healthy‖			
1	36	R	MRM	4	28.5	22.1	25.5	22.4	51.6		96
2	47	R	MRM	8	30.3	23.3	26.4	23.6	60		96
3	34	L	MRM	7	28.4	21.2	23.6	21.4	69.4		84
4	57	L	MRM	12	35.3	22.7	28.3	22.6	54.8		72
5	39	R	MRM	4	36.1	25.3	30.8	25.6	51.9		72
6	69	R	MRM	21	40	26.5	36	27	33.3		60
7	51	L	BCS	12	32.5	28	30	28.5	66.7		48
8#	40	R	MRM	84	30	25	25	23	No reduction	WI	48
9	65	R	MRM	30	38.5	28.5	31	27	60		48
10	49	R	MRM	60	42	31.5	43	32	60		42
11#	52	L	MRM	72	32.7	21.5	27.7	21.2	71		36
12	68	R	MRM	78	23	19.58	26	21.5	42	VC	24
13**	52	R	BCS	39	35.5	30	32.5	29	36.4		6
Mean ± SD	50.69 ± 11.25				33.3 ± 5.3††	25 ± 3.7	29.7 ± 5.3††	25 ± 3.5	50.55 ± 19.26		56.31 ± 27.12
Range	34–69				23–42	19.5–31.5	23.6–43	21.2–32	0–71		6–96

R, right; L, left; MRM, modified radical mastectomy; BCS, breast conservative surgery; WI, wound infection; VC, venous congestion.
*Parametric tests were applied for statistical analysis. A paired *t* test was performed to determine the significance of differences in hand circumference between preoperatively and postoperatively. Values of $p < 0.05$ were considered statistically significant. All patients had axillary lymphadenectomy. All except patient 12 had radiation.
†Preoperative, lesion of the arm (*a*).
‡Preoperative, healthy arm (*b*).
§Postoperative, lesion of the arm (*c*).
‖Postoperative, healthy arm (*d*).

¶The reduction rate of the circumference of the lymphedematous arm is: $= \frac{(a-b)-(c-d)}{(a-b)}$.

#Patients 8 and 11 with prolonged preoperative symptoms of upper limb lymphedema for more than 6 years required additional wedge excision or suction lipectomy of the subcutaneous tissue of the lesion limb to decrease the loading of clearance of lymph.
**Patient 13 is presented in Figures 7 through 10.
††$p < 0.01$.

tium-labeled sulfur colloid into the dorsal forearm proximal to the vascularized groin lymph node transfer site because the lymph may be accumulated by the vascularized groin lymph node. The imaging technique delineates the lymphatic vasculature and indicates changes in rate of lymph drainage by visual interpretation of changes in clearance of the technetium-99m sulfur colloid.

RESULTS

All flaps survived. Clinical details for each patient are summarized in Table 1. One patient (pa-

Fig. 5. (*Left*) Dorsal view of a 52-year-old woman (patient 11) who underwent successful vascularized groin lymph node transfer to the left wrist, with significantly decreased left forearm postmastectomy lymphedema. At the 4-month follow-up, the vascularized groin lymph node on the wrist significantly decreased the lymphedematous limb. (*Right*) Lateral view.

Fig. 6. (*Left*) At the 4-year follow-up, the skin of the vascularized groin lymph node flap on the wrist was deepithelialized, resulting in a linear scar (dorsal view). (*Right*) Volar view.

Fig. 7. Preoperative dorsal view of a 52-year-old woman (patient 13) who underwent a vascularized groin lymph node transfer to the right wrist for postmastectomy right upper limb lymphedema.

tient 12) required reexploration for venous congestion, with successful salvage. Postoperative wound infection occurred in one patient (patient 8) but was amenable to intravenous antibiotics. No donor-site morbidity was encountered. At a mean 56. 31 ± 27.12 months (range, 6 to 96 months) of follow-up, reductions in arm circumference were found in 12 of 13 patients (92.3 percent), with a mean reduction rate of 50.55 ± 19.26 percent (range, 0 to 71 percent) (Figs. 5 and 6). The mean reduction rate of the lymphedematous limb was statistically significant between the preoperative and postoperative groups ($p < 0.01$). Two patients (patients 8 and 11) with prolonged preoperative symptoms of lymphedema required additional procedures, including wedge excision or suction-assisted lipectomy of the subcutaneous tissue of the forearm and arm to decrease the loading of clearance of lymph (Fig. 5, *right*). The results were good in four patients and excellent in nine patients. Lymphoscintigraphy demonstrated radiolabeled tracer clearance through deep lymphatic channels or collateral channels, decreased stasis, and more rapid movement of tracer, indicating improved lymphatic clearance.

CASE REPORT

A 52-year-old woman (case 13) underwent right partial mastectomy, axillary lymph node dissection, and adjuvant chemoradiotherapy for stage II infiltrating ducal carcinoma of 4 years 3 months' duration. She sustained swelling of the upper limb 6 months postoperatively that was aggravated 2 years later. Initially, the patient was treated under complex decongestive physiotherapy, with minimal improvement. She suffered two episodes of cellulitis during this period (Fig. 7). Preoperative lymphoscintigraphy demonstrated residual deep lymphatic drainage in the dynamic flow study and faint uptake in an axillary lymph node at 10 minutes after injection (Figs. 8, *left* and 9, *above*). In addition, there was dermal lymphatic backflow with an intense diffuse superficial accumulation of radioactivity in the skin from the forearm to the elbow on 30-minute, 1-hour, and 2-hour static images, suggestive of partial lymphatic obstruction of the right upper extremity. The patient underwent

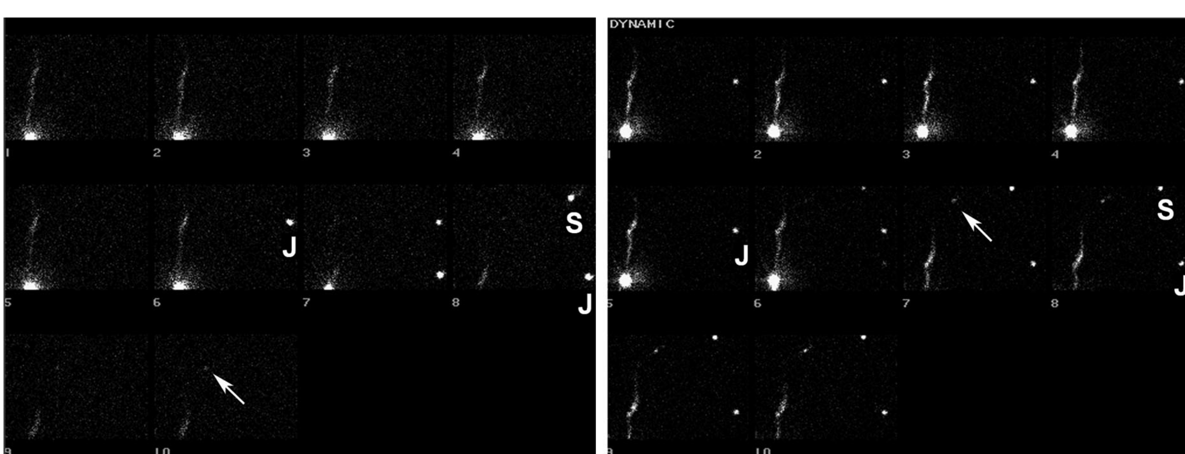

Fig. 8. Anterior views of dynamic flow images of an edematous right upper limb preoperatively (*left*) and postoperatively (*right*). Right axillary lymph node (*L*), left shoulder (*S*), and left elbow (*J*) are marked. Deep lymphatic drainage from the injection site was demonstrated immediately after subcutaneous injection of radiolabeled tracer and monitored as it flowed toward the axilla. One right axillary lymph node (*arrow*) was visualized faintly at 10 minutes after injection preoperatively (*left*). Postoperatively, the same lymph node became more rapidly (7 minutes) and intensely visible (*right*).

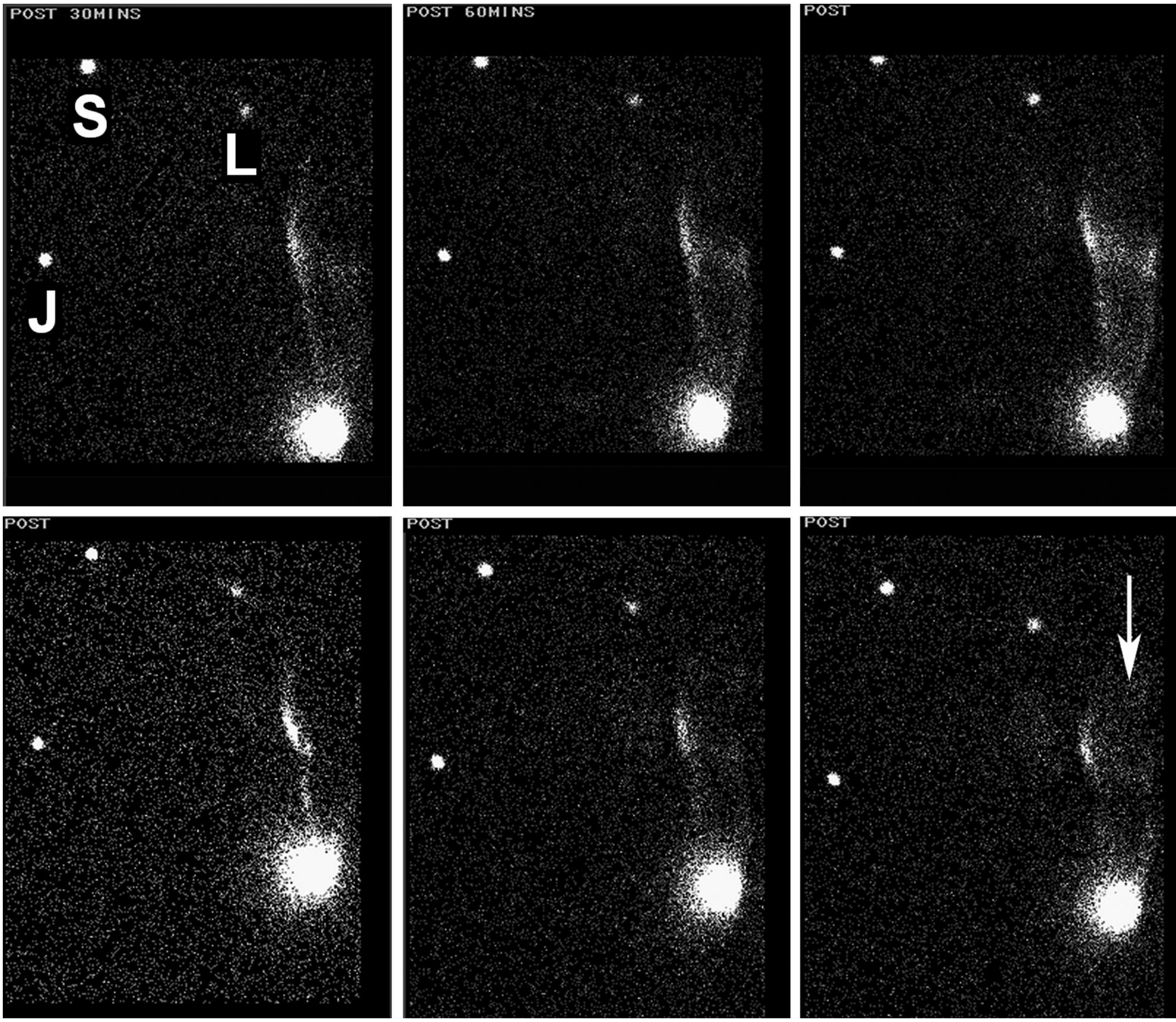

Fig. 9. Static posterior views of the same edematous upper limb. A series of three images of the hand and arm were taken at 30, 60, and 120 minutes after injection of radiolabeled tracer preoperatively (*above*) and postoperatively (*below*). The right axillary lymph node (*L*), left shoulder (*S*), and left elbow (*J*) are marked. Prominent diffuse accumulation of activity is shown in the skin of the affected forearm with time (*above*). Postoperatively, dermal backflow is less marked in the forearm, and radiolabeled tracer migrated more rapidly to the distal arm (*arrow* in *below*, *right*).

a successful vascularized groin lymph node transfer with a subjective "softening" of the tense skin of the upper limb and an increased range of motion of the digits within 2 weeks postoperatively. The circumference of the right upper extremity did not objectively reduce until 3 months later. Comparison of preoperative and 4-month postoperative lymphoscintigraphic images confirmed more rapid uptake of tracer in the right axillary lymph node that was visible by 7 minutes after injection, combined with less stasis in the skin of the arm. The deep lymphatic clearance was improved and the alternative lymphatic return pathway through the superficial dermal lymphatic collateral system following vascularized groin lymph node transfer was reduced (Figs. 8, *right* and 9, *below*). The patient was able to return to work at 1 month postoperatively. At 6-month follow-up, the limb girth had reduced 36.4 percent on the arm (Fig. 10, *left*). The patient had no further episodes of cellulitis postoperatively, with partial deepithelialization of the skin paddle of the vascularized groin lymph node flap (Fig. 10, *right*).

DISCUSSION

The possible complex pathophysiology of postmastectomy upper extremity lymphedema was the lower interstitial colloid osmotic pressure in edematous limbs compared with the contralateral normal limb.[20] The postmastectomy upper extremity lymphedema tends not to be uniform or sequential and is often localized to certain areas of the arm or forearm rather than globally, and the hand may be spared.[21] Any disturbances in the Starling

Fig. 10. (*Left*) At the 6-month follow-up, the vascularized groin lymph node transfer provided the circumference reduction rate of 36.4 percent compared with the right forearm. (*Right*) At the 37-month follow-up, the skin of the vascularized groin lymph node flap was partially deepithelialized to achieve better cosmesis without compromising the lymph drainage.

equilibrium that cause an increased net outward transcapillary force will push fluid out of the capillaries into the interstitium and result in edema formation if sustained. Derangements of arterial inflow, venous outflow, and/or osmotic forces acting within the tissues may contribute to lymphedema in the extremities.

The negative subcutaneous pressure in normal legs and positive subcutaneous pressure in legs with primary lymphedema are consistent with tissue edema from impaired lymphatic fluid drainage.[22] These findings favor the proposition by Guyton and Barber that a lymphatic pump by "suction" causes the negative interstitial fluid pressure usually found in normal limbs.[23]

Lymphatic obstruction has been demonstrated to be associated with a significant rise in both subcutaneous and intramuscular compartment pressures in lower extremity lymphedema.[24] These elevated intramuscular and subcutaneous pressures act to decrease the rate of lymphatic drainage and capillary blood flow in the lymphedematous limb because the deep and superficial lymphatic channels become incrementally compressed.[25]

Raising thin skin flaps during axillary dissection may contribute to postmastectomy lymphedema because it causes disruption of dermal and subcutaneous lymphatic channels.[26] There is also evidence of the importance of cutaneous collateral lymphatic channels in rerouting lymph along a dermal pathway of low resistance and increased capacity in the swollen limb.[21,27] Current conservative treatment regimens such as exercise and complex decongestive physiotherapy act to raise interstitial fluid pressure in the subcutaneous compartment.[28] Although lymphatic clearance is initially enhanced by increased external compressive forces, eventually a critical closing pressure is reached and the vessels collapse and act to occlude lymph flow.[29]

The distribution of edema within a limb depends on fatigue and eventual pump failure of weaker vessels.[21] Restoring the continuity of lymphatic drainage channels by microsurgical lymphaticovenous or lymphaticolymphatic anastomoses was observed to be patent in the short term but eventually occluded because the elevated subcutaneous and/or intramuscular pressures will likely cause obliteration of these tiny, low-pressure anastomotic lumens.[11]

The vascularized groin lymph node has been successfully transferred to axilla for postmastectomy upper extremity lymphedema.[30] We hypothesized that the vascularized groin lymph node transfer may act by means of an internal pump and suction mechanism of pathways for lymphatic clearance of the lymphedematous limb (Fig. 11). The "pump" mechanism is driven by the high-

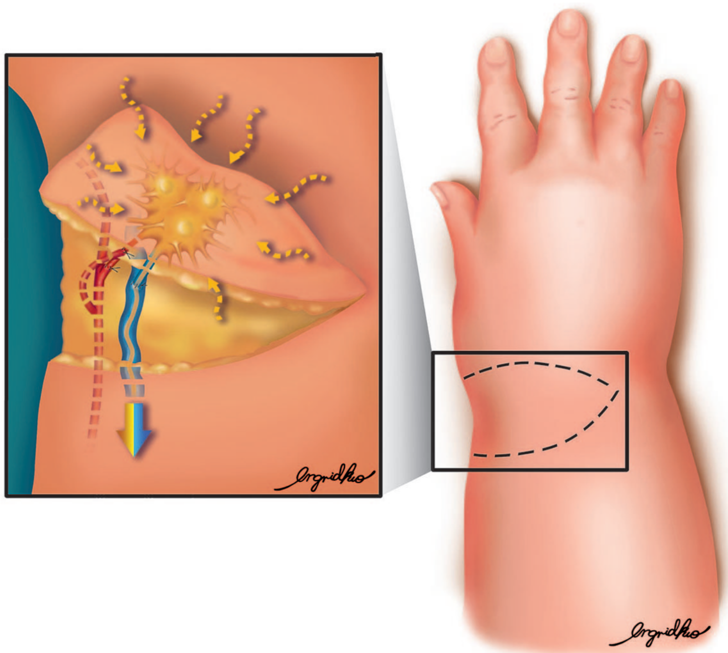

Fig. 11. A hypothesis was proposed that the vascularized groin lymph node transfer may act by means of internal pumping and suction of pathways for lymphatic clearance of the lymphedematous limb. The pump mechanism is driven by the high-pressure inflow of the arterial anastomosis from the radial artery, which provides a strong hydrostatic force into the vascularized groin lymph node flap. The suction is continued by the large-caliber, superficially located, low-pressure venous drainage provided by the cephalic vein. *L*, lymphatic duct; *yellow arrow*, lymph drainage direction.

pressure inflow of the arterial anastomosis from the radial artery, which provides a strong hydrostatic force into the vascularized groin lymph node flap. The "suction" is continued by the large-caliber, superficially located, low-pressure venous drainage provided by the cephalic vein (Fig. 11). The vascularized groin lymph node also initially supplies an influx of new, nondamaged lymphatic capillaries to drain the lymph in the interstitium. Lymphatic fluid within the chronically lymphedematous tissues adjacent to the flap drains directly into the flap venous system through intraflap lymphaticovenous connections (Fig. 11). As the lymph in the area surrounding the flap reduces, the subcutaneous hydrostatic tissue pressure reduces and an expanded "catchment" area for lymph drainage from surrounding tissue is recruited. As time passes and the lymphedema resolves, compartment pressures may reduce sufficiently for old lymphatic channels to reopen or for the development of new lymph vessels to augment lymph clearance. In fact, because capillary angiogenesis has been demonstrated in lymphedema and lymphangiogenesis in postmastectomy lymphedema,[27] it can be speculated that vascularized groin lymph node transfer most likely promotes long-term lymphangiogenesis, in which improvement of lymphatic clearance in the deep lymphatic drainage system with less involvement of the superficial collateral dermal lymphatic system occurs. The long-term result will not be compromised, provided the arterial and venous anastomoses are patent.

Placement of the "lymphatic pump" has been seldom discussed before.[30] The proximal site of the lymphedematous limb was usually the recipient site for flap transfer to decrease lymphedema.[13,14,30] The wrist was chosen in this study as the recipient site because the wrist is the most dependent site in the lymphedematous upper limb. Advantages of selecting the wrist as the recipient site include a usually pristine bed, which promotes spontaneous restoration of lymphatic continuity, and the availability of the recipient vessels. The axilla in the postmastectomy upper extremity lymphedematous limb is usually severely scarred because of irradiation and surgery, so that it is difficult to find a pair of recipient vessels. Had the upper arm been the more affected region, placement of the lymphatic pump in the elbow would have needed further investigation.

The high-pressure arterial anastomosis of the vascularized groin lymph node serves to maintain inflation of the flap vasculature against the high surrounding hydrostatic tissue and compartmental pressures arising within the lymphedematous limb.[24,25] The lymph nodes themselves continue to act as functional lymphoid organs and therefore filter the lymph and provide a site for lymphocytes to interact with antigen and other cells of the immune system. The reduced incidence of postoperative cellulitis was one of the most significant benefits of the vascularized groin lymph node transfer and provided welcome respite to all the patients involved.

Groin lymph nodes are classified into deep and superficial groups. The superior external two to four lymph nodes, located along the superior circumflex iliac vein, principally drain lymph from the abdominal wall.[31] Lymphatic drainage of the lower extremity is not impaired by removal of these nodes.[32] The site of the groin lymph nodes therefore appears to be a suitable donor site.

The better results in this preliminary study were achieved in patients who had mild to moderate postmastectomy upper extremity lymphedema, characterized by some flexibility in the skin and moderate deposition of fibrous tissue. In severe cases, the lymphedematous and fibrotic soft tissues on the proximal arm may be reduced by wedge excision or suction lipectomy.

Two patients (patients 8 and 11) with advanced lymphedema in this series were mildly improved by vascularized groin lymph node transfer as assessed by objective lymphoscintigraphy. However, both still reported subjective improvements in hand function, quality of life, and decreasing episodes of cellulitis.

From an aesthetic perspective, the epidermis was deepithelialized, resulting in only a discrete transverse scar on the wrist. The dermis of the vascularized groin lymph node transfer was kept underneath the native wrist skin when the lymphedema gradually subsided and edematous skin of the lymphedematous limb became redundant. There was no lymphedema relapse after deepithelialization of vascularized groin lymph node transfer. The skin of the vascularized groin lymph node transfer is not necessary in the long-term follow-up but is important in wound closure when it is transferred to the wrist with tight and tense skin (Figs. 6 and 10, *right*). The wedge excision of soft tissue can decrease the load of excretion of lymph. This procedure cannot work well without the drainage of vascularized groin lymph nodes to the venous system. Thus, this procedure is not sufficient for solving the problem of lymphedema either before the vascularized groin lymph node transfer or alone.

CONCLUSION

Vascularized groin lymph node transfer using the wrist as a recipient site is a novel and reliable procedure that significantly improves postmastectomy upper extremity lymphedema.

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