Microlymphatic Surgery for the Treatment of Iatrogenic Lymphedema

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KEYWORDS

- Lymphedema • Treatment • Autologous lymph node transplantation (ALNT)
- Microsurgical vascularized lymph node transfer • Iatrogenic • Secondary
- Brachial plexus neuropathy • Infection

KEY POINTS

- Autologous lymph node transplant or microsurgical vascularized lymph node transfer (ALNT) is a surgical treatment option for lymphedema, which brings vascularized, VEGF-C producing tissue into the previously operated field to promote lymphangiogenesis and bridge the distal obstructed lymphatic system with the proximal lymphatic system. Additionally, lymph nodes with important immunologic function are brought into the fibrotic and damaged tissue.
- ALNT can cure lymphedema, reduce the risk of infection and cellulitis, and improve brachial plexus neuropathies.
- ALNT can also be combined with breast reconstruction flaps to be an elegant treatment for a breast cancer patient.

OVERVIEW: NATURE OF THE PROBLEM

Lymphedema is a result of disruption to the lymphatic transport system, leading to accumulation of protein-rich lymph fluid in the interstitial space. The accumulation of edematous fluid manifests as soft and pitting edema seen in early lymphedema. Progression to nonpitting and irreversible enlargement of the extremity is thought to be the result of 2 mechanisms:

1. The accumulation of lymph fluid leads to an inflammatory response, which causes increased fibrocyte activation.
2. Fat deposition occurs when malfunctioning lymphatics are unable to transport fat molecules effectively.[1]

Clinically, patients develop firm subcutaneous tissue, progressing to overgrowth and fibrosis.

Lymphedema is a common chronic and progressive condition that can occur after cancer treatment. The reported incidence of lymphedema varies because of varying methods of assessment,[1–3] the long follow-up required for diagnosing lymphedema, and the lack of patient education regarding lymphedema.[4] In one 20-year follow-up of patients with breast cancer treated with mastectomy and axillary node dissection, 49% reported the sensation of arm lymphedema.[5] Of the patients who developed lymphedema, 77% were diagnosed within the 3-year period following breast cancer treatment, and the remaining patients developed arm lymphedema at a rate of about

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1% per year after the 3 years. Therefore, about a quarter of patients will develop lymphedema years after breast cancer treatment, and a long follow-up is required.

The incidence of lymphedema after breast cancer treatment ranges from 24% to 49% after mastectomy and 4% to 28% after lumpectomy.[1] Patients requiring more extensive breast cancer treatment with axillary node dissection and radiation have the greatest risk for the development of lymphedema. However, even the less extensive lymph dissection in sentinel node biopsy is associated with a 5% to 7% incidence of upper-extremity lymphedema.[6]

The incidence of lymphedema after treatment of other malignancies is reported as follows: 16% with melanoma, 20% with gynecologic cancers, 10% with genitourinary cancers, 4% with head and neck cancers, and 30% with sarcoma. Patients requiring pelvic dissection and radiation therapy for the treatment of non–breast cancer malignancies have a reported lymphedema rate of 22% and 31%, respectively.[3] Risk factors for developing lymphedema after cancer treatment are obesity, infection, and trauma.[1,5]

In addition to the decreased amount of lymph tissue critical to a normal immune response, tissue changes and lymphostasis result in increased susceptibility to infection in the lymphedematous extremity. Clinically, patients may develop cellulitis from minor trauma that would otherwise be insignificant in a normal extremity (**Fig. 1**). Each episode of infection further damages lymphatic channels and perpetuates a vicious cycle. Patients may require lifelong antibiotic prophylaxis.

Lymphedema can also lead to erysipelas, lymphangitis, and even lymphangiosarcoma. Erysipelas is a streptococcal infection of the dermis. Lymphangitis is inflammation of the lymphatic channels as a result of infection at a site distal to the channel, such as a paronychia, an insect bite, or an intradigital web space infection. Lymphangiosarcoma is a rare malignant tumor that occurs in long-standing cases of lymphedema (**Fig. 2**). Stewart-Treves syndrome is angiosarcoma arising from postmastectomy lymphedema and has an extremely poor prognosis, with a median survival of 19 months.[1]

THERAPEUTIC OPTIONS FOR IATROGENIC LYMPHEDEMA
Conservative Treatment

Conservative lymphedema therapy is the backbone for providing symptomatic improvement of lymphedema and may slow the progression of disease. Multiple layers of short-elastic bandages are wrapped circumferentially around the lymphedematous

Fig. 1. Leg cellulitis in a patient with congenital lymphedema.

extremity to squeeze edema fluid out of the tissue and push the edema fluid proximally. Customized compression garments are subsequently placed on the extremity to maintain the decreased extremity size. Decongestive lymphatic therapy usually begins with intensive (daily for several weeks) lymphatic massage and bandaging. This therapy is followed by less-frequent maintenance

Fig. 2. Lymphangiosarcoma.

lymphatic massage and daily placement of compression garments for the rest of patients' lives. Flare-ups of lymphedema may require repeating the initial intensive daily lymphatic massage with bandaging. Patients with severe lymphedema may require bandaging every night and wearing compression garments everyday.

The major limitation of conservative therapy is that reduction in extremity size is short lived without continual compression; the maintenance of compression (conservative therapy) is difficult to achieve long term because it is time consuming, labor intensive, requires specialized therapists, and requires commitment of patients and patients' support network. Frequently, it is difficult for patients to self-apply bandages. In addition, insurance companies may inadequately cover therapists for bandaging and massage therapy, requiring patients to parcel out therapy sessions. A second major limitation of conservative therapy is that it cannot affect change in extremity girth because of subcutaneous fat deposition and fibrosis. Thus, surgical options for treatment have an important role in the treatment of lymphedema, and a *combination* of treatment modalities may achieve the most improvement.

Surgical Treatment

Surgical options for lymphedema treatment fall into 2 categories: debulking and physiologic.

Debulking procedures may involve elliptical wedge excision of excess skin and subcutaneous tissue from an extremity or liposuction. Wedge excision of tissue can provide immediate symptomatic relief to patients with severe lymphedema. Removal of heavy or hanging bulky tissue from an extremity can improve the function of the extremity[7] and can also improve the application of bandages and compression garments.

Liposuction is another effective modality for removing excess fat deposition as a result of abnormal lymphatic transport. It is helpful as an adjunct to other surgical treatments and can be performed in a second stage of treatment after a first-stage physiologic surgical treatment. Complications of debulking procedures may be chronic wounds, infection, widened scars, hematoma, skin necrosis, potential damage to remaining lymphatics, and worsening of the lymphedema.[3] Compression garments are necessary *lifelong* after debulking methods of treatment.[7,8]

Physiologic procedures seek to reconstruct the lymphatic transport system. Lympholymphatic graft[9] is a procedure that connects an obstructed lymphatic to a healthy lymphatic using a vein or a lymphatic as an interposition graft.[10] The procedure is technically demanding and time consuming because lymphatic channel walls are thin, transparent, and very fragile. In addition, there may be significant donor site morbidity. Lymphovenous anastomosis (LVA) connects an obstructed lymphatic to a vein to shunt the lymph fluid into the venous system and seem to be effective, especially in early stages of lymphedema.[11,12] The LVA remains patent if the lymphatic pressure is higher than the venous pressure. Currently, a subdermal vein is used because it has lower venous pressure. The caliber of subdermal veins is less than a 1 mm, requiring supermicrosurgery with extrafine microsurgical instruments and sutures. Usually, multiple LVAs (3–5)[12,13] are created to a lymphedematous extremity. Although in other centers, an average of 9 LVAs (range of 5–18) are routinely created by teams of surgeons operating with multiple microscopes simultaneously.[14]

Autologous lymph node transplantation (ALNT),[15–17] also called microsurgical vascularized lymph node transfer, is another reconstructive surgical treatment of lymphedema. This article focuses on ALNT and its use in patients with secondary iatrogenic lymphedema. In ALNT, a recipient bed in the lymphedematous extremity is prepared by releasing scar tissue until healthy soft tissue is encountered. Then a small flap containing superficial lymph nodes are harvested from a donor site with an artery and vein and microsurgically anastomosed to an artery and vein at the recipient site.

The ALNT procedure is considered to be physiologic for several reasons. First, scar tissue, which may be blocking lymphatic flow, is released. Second, healthy vascularized tissue in the form of a flap is brought into the previously operated site, which may bridge lymphatic pathways through the scar tissue. Third, the flap contains healthy lymph nodes, which produce vascular endothelial growth factor C (VEGF-C).[18] VEGF-C promotes lymphangiogenesis[19] and is hypothesized to stimulate reconnections in the distal obstructed lymphatic system with the proximal lymphatic system.[20] Fourth, lymph nodes have important immunologic functions, and adding healthy lymph nodes may provide benefit to a lymphedematous extremity predisposed to development of infection.[21] Fifth, lymph nodes themselves are an interface between the lymphatic and venous systems for drainage of lymph into the venous system[22] without surgically created lymphovenous anastomoses distally on the extremity.

INDICATIONS FOR ALNT IN IATROGENIC LYMPHEDEMA

Iatrogenic lymphedema is most commonly associated with the treatment of cancer, such as lymph

node dissection and radiation therapy. Alternatively, lymphedema may also be caused by nononcologic procedures, such as saphenous vein removal,[23] hernia repair, liposuction,[24] and thigh lift.[25] When lymphedema is caused by previous surgery, a lymph node flap may be indicated to reconstruct the deficit.

A complete blockage of lymph drainage pathways from removal and/or damage to lymph nodes is an absolute indication for ALNT to replace the missing or damaged lymphatic tissue. This condition can be diagnosed on lymphoscintigraphy as a lack of uptake of a radioactive particle (technetium-99 m) in the inguinal or axillary lymph nodes after distal injection of the particle in the extremity. More recently, magnetic resonance lymphography (MRL) with T2-weighted images,[26] also called lymphatic magnetic resonance imaging (MRI), is being used to visualize the lymphatic system anatomy with greater sensitivity.[27] An absence of lymph nodes and/or lymph channels traversing the surgical site may appear as a black area on MRL (**Fig. 3**).

Other indications for ALNT procedures are lymphedema resistant to conservative treatment, pain or signs of brachial plexus neuropathy,[28] and chronic infections in the lymphedematous extremity. If conservative treatment fails to bring satisfactory long-lasting results and if lymphatic MRI or lymphoscintigraphy demonstrate decreased lymphatic drainage, ALNT is indicated to reconstruct the damaged or missing lymphatic tissue. Release of scar tissue and placement of vascularized, nonirradiated tissue can treat neuromas and stop the progression of brachial plexus neuropathies (**Fig. 4**). Chronic infections are also a main indication for ALNT because of the immunologic function of lymph nodes.

In breast reconstruction patients with lymphedema, it is possible to use a deep inferior epigastric perforator (DIEP) flap or transverse rectus abdominis musculocutaneous flap in continuity with a lymph node flap. This combined flap allows for breast reconstruction with axillary lymphatic reconstruction. However, it is only indicated for breast reconstruction patients with established lymphedema or history of upper-extremity cellulitis. Lymph node transfer is not indicated in breast reconstruction patients without lymphedema because of the risk of inducing an iatrogenic lymphedema by dissecting in a previously operated axilla.

## OPERATIVE TECHNIQUE
ALNT for Arm Lymphedema

The dissection always begins at the recipient site, usually the axilla. The scarred fibrotic tissue is incised and, if possible, excised until healthy tissue is reached. During the dissection, thoracodorsal branches are identified and isolated with vessel loops. If a neuroma is encountered or patients have chronic pain or weakness, then external neurolysis of the brachial plexus is done. The release of scar tissue can be challenging, and great care must be taken to avoid injury to the vital structures within the axilla. It is best to work from known to unknown and start dissection from where the anatomy is more normal. When the dissection is complete, the extent of the flap needed can be estimated.

A lymph node flap can be prepared from 3 donor sites: inguinal, thoracic, and cervical. The inguinal lymph node flap harvests superficial lymph nodes based on branches from the superficial circumflex iliac or superficial inferior epigastric vessels. An incision is made along a line between the iliac crest and the pubis bone. The length of the incision depends
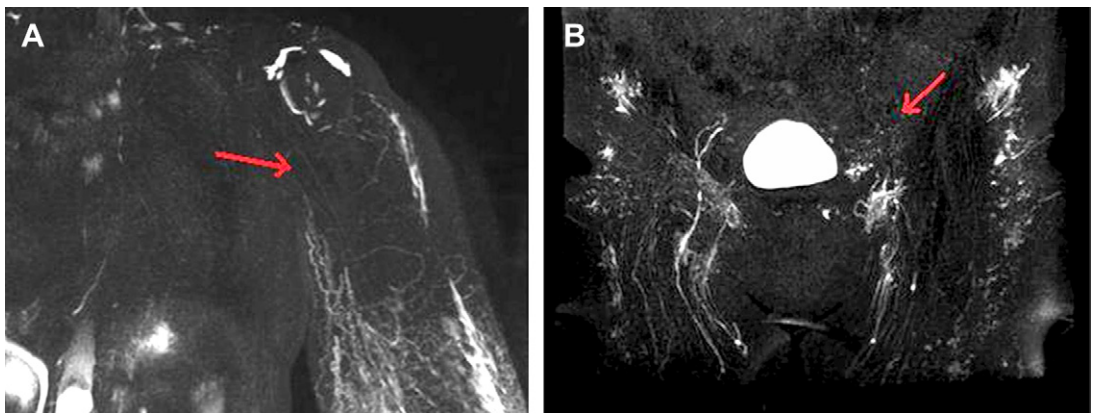
Fig. 3. (*A*) MRL after modified radical mastectomy, axillary node dissection, and radiation treatment. Red arrow points to dark area showing absence of lymph drainage. (*B*) MRL after radical hysterectomy. Red arrow points to dark area showing absence of lymph drainage.
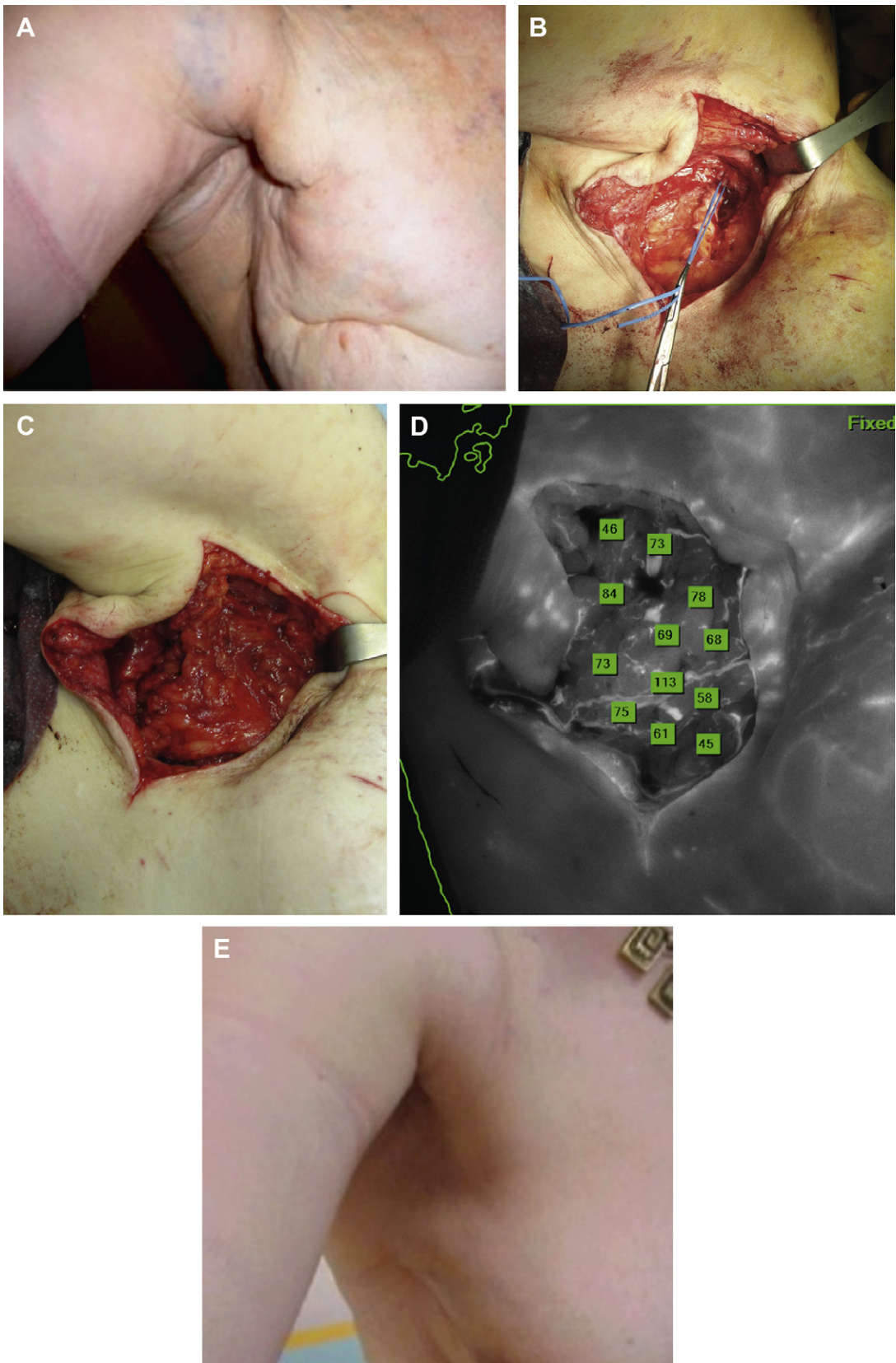
Fig. 4. (*A*) Axillary contraction in a patient with lymphedema and progressive numbness of fingers after mastectomy, axillary node dissection, and radiation. (*B*) Brachial plexus with scar removed. (*C*) Lymph node flap placed in axilla over brachial plexus. (*D*) SPY imaging showing perfusion of lymph node flap. (*E*) Postoperative axillary contraction. Improved sensibility in middle 3 fingers.

on the flap size needed for the defect. Subcutaneous fat is incised to the depth of the cribriform fascia, at the level where superficial veins are seen. At times, there is an unnamed superficial vein diagonally traversing the operative field. This diagonal superficial vein helps to identify the plane and to localize the lymph nodes in the fat between the muscular aponeurosis and the superficial fascia. The superficial circumflex iliac vessels are identified, dissected, and isolated with vessel loops (**Fig. 5**). The lateral part of the flap is elevated to the isolated superficial circumflex iliac vessels. The superficial inferior epigastric vessels are identified and isolated with vessel loops and may alternatively be used for anastomosis. The borders of the dissection are the following: inguinal ligament (caudal), muscular aponeurosis (deep), and cribriform fascia (superficial). It is of paramount importance to not dissect lymph nodes beyond these first two borders to avoid removing the deeper lymph nodes that drain the leg.

The thoracic lymph node flap harvests lymph nodes at the lower axilla based on branches from the thoracodorsal or lateral thoracic vessels. An incision is made on a longitudinal line anterior to the latissimus dorsi muscle and lateral to the breast. The superficial fascia is opened, and thoracodorsal branches are dissected around the main vessel supplying the latissimus muscle, and isolated with vessel loops. A freestyle flap is designed in this region by dissecting vessels and a few nodes. Branches of the lateral thoracic vessels are also identified and isolated with vessel loops (**Fig. 6**). In approximately 60% of cases, branches from the lateral thoracic vessels supply the nodes in the superior portion of the flap. If the caliber of the blood vessels is adequate for microanastomosis, the flap will be based on the branches of the lateral thoracic vessels so that the thoracodorsal branches are left intact. In the remaining 40% of cases, the flap is dissected based on the distal branches of the thoracodorsal

vessels. It is very important that the lymph nodes surrounding the axillary vein are not dissected to avoid damaging lymphatic drainage of the arm. Therefore, harvest is limited to level I lymph nodes only (inferior to the lateral border of pectoralis minor muscle), avoiding the level II nodes (posterior to pectoralis muscle) and level III nodes (superior to medial border of pectoralis minor muscle).

The cervical lymph node flap harvests lymph nodes based on branches from the transverse cervical artery. An incision is made over the medial clavicle, and the sternocleidomastoid muscle is retracted. Branches of the transverse cervical artery are identified and isolated with vessel loops. Lymph nodes are then chosen based on branches of the transverse cervical artery. The venous outflow is from branches of the external jugular vein, which are identified and isolated with vessel loops (**Fig. 7**). A freestyle flap containing a few nodes based on the transverse cervical artery is then dissected.

The lymph node flap is harvested and brought to the axilla for microsurgical anastomosis. It should be placed over the axillary vein, where lymphatic tissue was originally removed for cancer treatment. An absorbable suture may be used to anchor the flap so that it does not shift and kink the vascular pedicle. SPY imaging (Novadaq Technologies, Inc, Mississauga, Ontario) with indocyanine green is then performed to confirm perfusion of the flap. The incisions at the donor site and recipient site are closed over a small drain.

ALNT for Leg Lymphedema

As with arm lymphedema, dissection begins at the recipient site, usually the inguinal region. The scar tissue is released until healthy nonfibrotic tissue is reached. Cephalad to the inguinal ligament, the superficial circumflex iliac vessels are identified and isolated with vessel loops. Just caudal to the inguinal ligament, a space is created for the lymph
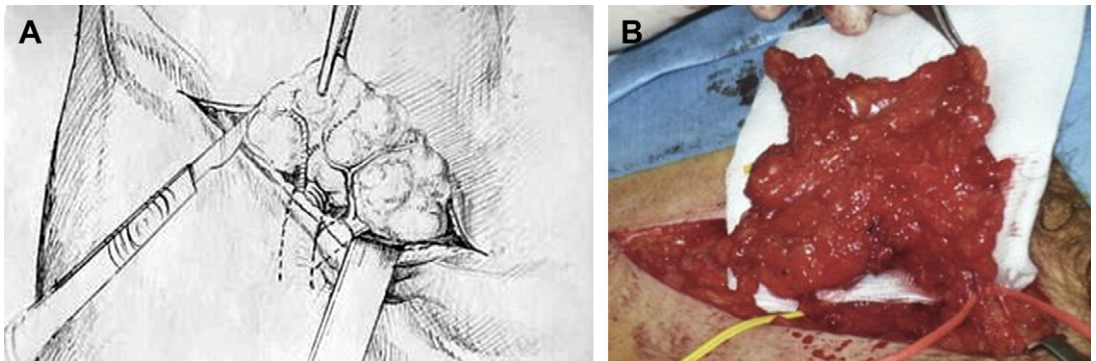
Fig. 5. (*A*) Inguinal lymph node flap. (*B*) Inguinal lymph node flap. Red vessel loop is around superficial circumflex iliac vessel and yellow vessel loop is around superficial inferior epigastric vessel.
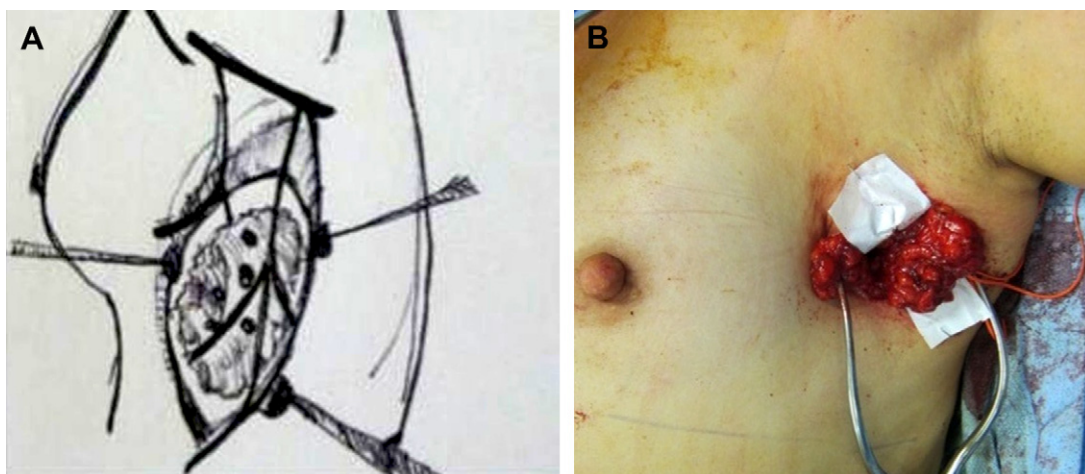
Fig. 6. (*A*) Thoracic lymph node flap. (*B*) Thoracic lymph node flap. Vessel loops are around thoracodorsal and lateral thoracic branches.

node flap. If the flap will be placed at the knee, then a medial incision is made just above the knee. Medial genicular branches or saphenous vessel branches are isolated with vessel loops. Harvest of the donor site (inguinal, thoracic, or cervical lymph node flap) and microsurgical anastomosis proceed in an identical fashion to ALNT for the arm.

ABDOMINAL FLAP IN CONTINUITY WITH LYMPH NODE FLAP

An inguinal lymph node flap may be harvested with an abdominal-based breast reconstruction, such
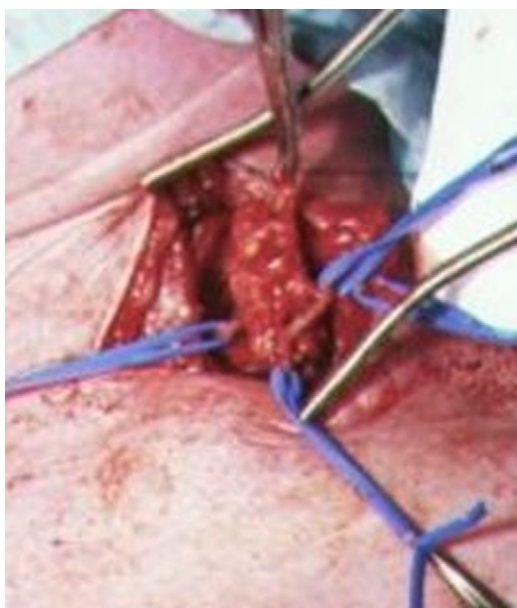
Fig. 7. Cervical lymph node flap. Vessel loops are around transverse cervical arterial and external jugular venous branches.

as the DIEP flap. Because the superficial inguinal lymph nodes used for ALNT are immediately adjacent to the DIEP flap, it is possible to harvest the lymph nodes using the same incision as used in a DIEP flap. Only a few lymph nodes are harvested to minimize any risk of causing iatrogenic leg lymphedema. Superficial lymph nodes may be identified with MRI or computed tomography before surgery.

The DIEP flap dissection proceeds in a standard fashion, except the flap is extended caudally to include 3 to 4 superficial inguinal lymph nodes. The superficial circumflex iliac vessels are identified and isolated with vessel loops. The DIEP flap is completely dissected and its perfusion is isolated to the deep inferior epigastric vessels by temporarily clamping the superficial circumflex iliac vessels. SPY imaging is used to evaluate the perfusion of the lymph node flap. If perfusion of the lymph nodes seems adequate, the DIEP flap pedicle is microsurgically anastomosed to the internal mammary vessels and the lymph node portion of the flap is placed in the prepared axilla. A suture may be used to anchor the lymph node–containing portion of the flap into the axilla. If lymph node perfusion with SPY does not seem adequate, the superficial circumflex iliac vessels may be anastomosed to branches of the lateral thoracic or thoracodorsal vessels (**Fig. 8**). A superficial inferior epigastric artery (SIEA) flap may also be combined with ALNT to reconstruct patients with partial mastectomy or brachial plexus neuropathies.

NONABDOMINAL FLAP WITH LYMPH NODE FLAP

In nonabdominal microsurgical breast reconstruction, the ALNT is always a separate free tissue
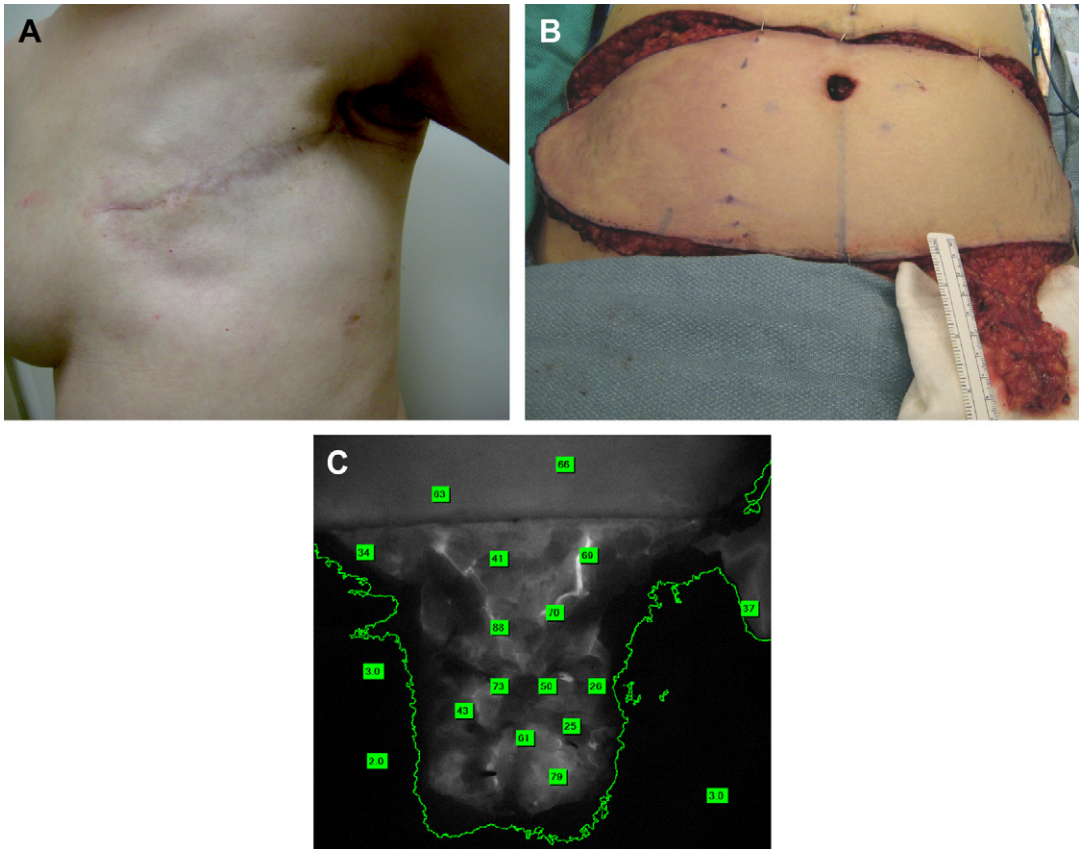
Fig. 8. (*A*) Axillary contraction in a patient with lymphedema after mastectomy and axillary node dissection without radiation therapy. (*B*) DIEP flap with superficial inguinal lymph node flap. The superficial circumflex iliac vessels have been clamped and flap perfusion is isolated to the DIEP pedicle. (*C*) SPY image showing perfusion to the lymph nodes is adequate without superficial circumflex iliac vessels.

transfer. Executing these procedures simultaneously can be complicated, and a team approach is recommended to maximize efficiency. For thoracodorsal artery perforator (TDAP) flap with a lymph node flap, dissection of the pedicled TDAP flap proceeds simultaneously with the dissection of the lymph node flap. To facilitate simultaneous harvest, patients are placed in a lateral decubitus position on a beanbag with the arm prepped in the field, and the ipsilateral inguinal lymph node flap is used. Scar tissue is released at the axilla, and recipient vessels are identified and isolated with vessel loops. Branches off the thoracodorsal vessels may be used for anastomosis with the lymph node flap. The TDAP flap is rotated and secured in position for reconstruction of the breast. Then, the inguinal lymph node flap is harvested, microsurgically anastomosed, and placed in the prepared axilla. SPY imaging is done to confirm perfusion of the lymph node flap (**Fig. 9**).

For a lymph node flap with a nonabdominal free flap, such as a profunda artery perforator flap or gluteal flap, 2 microsurgical anastomoses are required. The nonabdominal flap is dissected simultaneously with the dissection of an inguinal lymph node flap. The scarred axilla is prepared and recipient vessels are identified and isolated. Recipient vessels for the nonabdominal free flap, usually the internal mammary vessels, are also prepared. The inguinal lymph node flap anastomosis is performed first because of the increased difficulty with microsurgical anastomosis when a bulky breast flap reconstruction is present. After anastomosis, the inguinal lymph node flap is placed in the prepared axilla and SPY imaging is done to confirm perfusion. A suture may be used to anchor the lymph node flap in position. Then, the nonabdominal flap is microsurgically anastomosed to the internal mammary vessels. Great care must be taken with the placement of the nonabdominal flap under the breast skin to avoid vascular compromise of the lymph node flap by compression and shifting of the lymph node flap. Perfusion of the lymph node flap is confirmed again after the placement of the nonabdominal flap with SPY imaging.
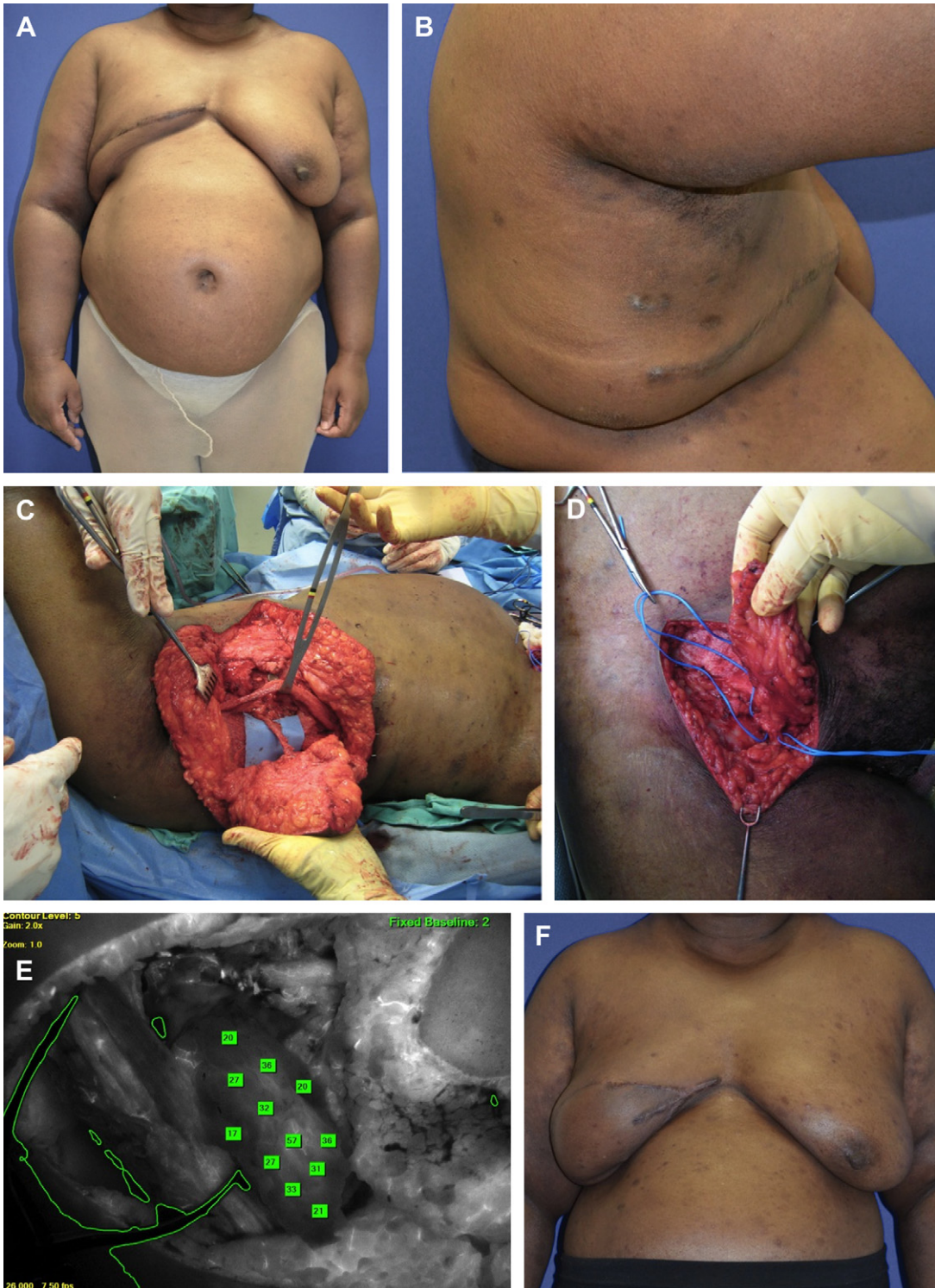
Fig. 9. (*A*) Severely obese (body mass index of 39.6) woman with hypertension and failed implant breast reconstruction with lymphedema after mastectomy and axillary node dissection. (*B*) Lateral thorax, demonstrating ample excess fat. (*C*) TDAP flap isolated on its pedicle. (*D*) Inguinal lymph node flap. Blue vessel loops around superficial circumflex iliac vessels. (*E*) Spy imaging showing adequate perfusion of lymph node flap. (*F*) Postoperative.

ALNT may be combined with other surgical treatments for optimal results. For example, wedge excision may be performed at the same time as ALNT procedures in patients with severe lymphedema. Liposuction is an effective adjunct to ALNT in patients with all stages of lymphedema. After excessive edema fluid is drained from the extremity, excess subcutaneous tissue is still present (lipedema) from long-standing lymphedema and contributes to increased extremity girth. Liposuction may be used in selective regions of the extremity to remove the extra fat. It should be performed carefully by surgeons familiar with lymphedema to avoid further damaging lymphatic channels. Selective liposuction to remove the excess fat deposition may be done parallel to the extremity and in a second stage.

CLINICAL OUTCOMES OF ALNT

Changes in patient symptoms, level of function with activities of daily living, physical examination, and radiological imaging are recorded. After ALNT, most patients report a difference in their level of discomfort and may describe increased lightness of the extremity and improvement in throbbing or aching of the extremity are. Circumferential measurements of the lymphedematous and nonlymphedematous extremity are recorded at the dorsum of the hand or foot, the wrist or ankle, 10 cm above the wrist or ankle, 20 cm above the wrist or ankle, the elbow or knee, 10 cm above the elbow or knee, and 20 cm above the elbow or knee. Postoperative changes are calculated by comparing the difference between the lymphedematous and nonlymphedematous extremity before and after surgery. For example, preoperative measurements (lymphedematous right forearm 26.0 cm - normal left forearm 19.5 cm = 6.5 cm) are compared with postoperative measurements (lymphedematous right forearm 22.0 cm - normal left forearm 19.8 cm = 2.2 cm) to calculate a total relative reduction (6.5 cm − 2.2 cm = 4.3 cm relative reduction). This calculation provides a clinical
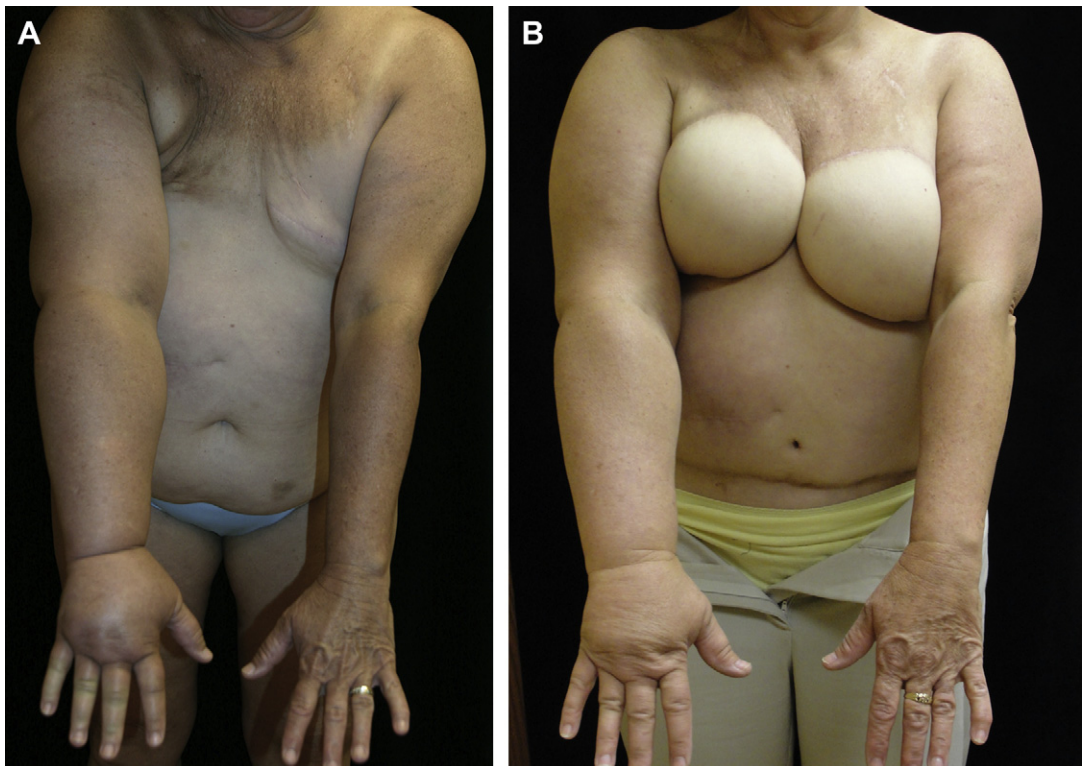
Fig. 10. (*A*) Patient with 14-year history of right arm lymphedema after mastectomy and radiation therapy, limited range of motion at the shoulder, chronic cellulitis with frequent hospital admissions for infection, taking prescribed daily oral antibiotics. Conservative therapy consisted of maintenance wrapping and compression garments. (*B*) Three years after ALNT with average circumferential reduction of 1.3 cm for the arm and 3.2 cm at the dorsum of the hand. Full range of motion at the shoulder regained. Continuous oral antibiotic therapy was discontinued, with patient now only having occasional small cellulitis treated with oral antibiotic. Conservative therapy discontinued by the patient (not the physician), and compression garment only used when patient is working outside. Compression garment had not been worn for more than a month at time of photograph.

snapshot of the improvement achieved by ALNT regardless of patient-specific habitus changes throughout time (eg, weight gain or loss, water retention) (**Fig. 10**). Patients with infections before surgery can be monitored for reduction in infection severity, frequency, and need for hospital admission.

In a series of 1500 patients operated over a period of 20 years by the senior author (CB), with stages 1, 2, and 3 of lymphedema (International Society of Lymphology), 98% of the patients had some degree of improvement. Forty percent of the patients with stages 1 or 2 lymphedema had complete normalization (**Fig. 11** and **12**) and did not require additional conservative therapy. In the patients with stage 3 lymphedema, 95% had some degree of improvement. Only 2% had

repeat infection. However, patients with stage 3 lymphedema still required conservative therapy. The minimum follow-up was 3 years. About 10% of the patients had brachial plexus neuropathies. Seventy-five percent of patients with brachial plexus neuropathies had improved symptoms after neurolysis of the nerves and coverage with nonirradiated, well-vascularized tissue (ALNT or other flap). The patients had decreased pain and stabilization of previously progressive symptoms of weakness. Although sensation can recover in the following 2 years after surgery, motor recovery is rare and can only be expected in young patients. Tendon transfers may benefit some of these patients later in their follow-up.

Patients with less severe lymphedema and lymphedema for shorter duration tend to respond better

Fig. 11. (*A*) Patient with left leg lymphedema for 8 years after radical hysterectomy 12 years before. (*B*) Two years after ALNT, with complete normalization.

Fig. 12. (*A*) Patient with 5-year history of right leg lymphedema after lymphadenectomy and radiation therapy for Hodgkin lymphoma. (*B*) One year after ALNT, with complete normalization.

to ALNT. In patients with stage 1 and 2 lymphedema, lymphoscintigraphy and MRL can illustrate objective changes with new lymphatic pathways draining the extremity (**Fig. 13** and **14**). Even patients with long-standing lymphedema (more than 15 years) can show improvement with ALNT.

COMPLICATIONS AND CONCERNS ALNT

Lymphocele at the donor site can be avoided with use of a drain postoperatively for the first 24 to 48

hours and local compression. The use of surgical clips on lymphatics leading to the donor lymph nodes during dissection may also help. Deep lymph nodes beyond the inguinal ligament and axillary lymph nodes near the axillary vein should not be disturbed to avoid iatrogenic lymphedema of the extremity. Local infections, hematomas, and delayed wound healing may occur. Flap monitoring is difficult because the lymph node flap is a buried flap. In addition, the vessels are usually small, between 0.5 mm and 1.5 mm, which makes use
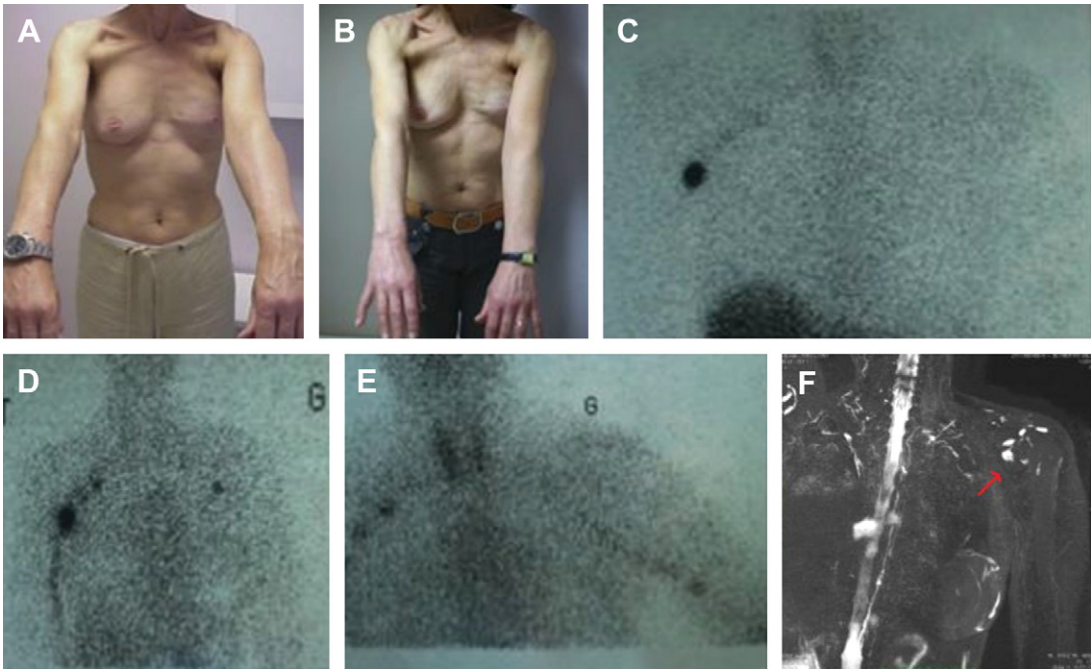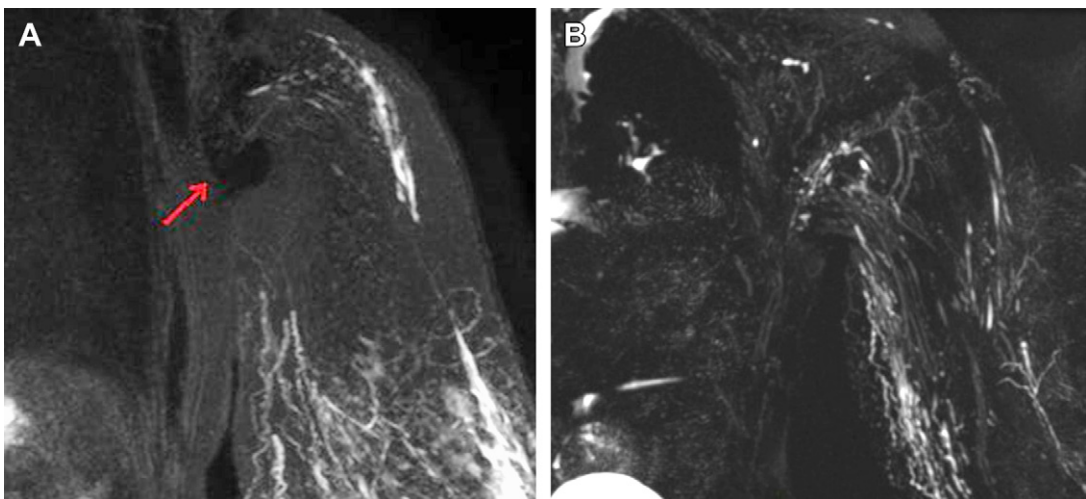
Fig. 13. (*A*) Patient with left arm lymphedema after modified radical mastectomy. (*B*) Patient 8 years after ALNT. (*C*) Preoperative lymphoscintigraphy. Absence of left axillary lymphatic drainage. (*D*) Postoperative lymphoscintigraphy, 1 year after ALNT. Left axillary lymphatic drainage now present. (*E*) Postoperative lymphoscintigraphy, 5 years after ALNT. Further improvement in left axillary lymphatic drainage. (*F*) Postoperative MRL. Red arrow showing lymphatic drainage.

of an internal Doppler probe challenging. Vascular thrombosis is thought to occur in 2% of patients, with no clinical improvement seen. When 2 sets of anastomoses are used in an abdominal flap in continuity with a lymph node flap, the ALNT part of the flap can remain viable if the abdominal flap pedicle thromboses.

SUMMARY ON ALNT

ALNT is an excellent alternative and complementary treatment of secondary iatrogenic lymphedema. It brings vascularized, VEGF-C–producing tissue into the previously operated field to promote lymphangiogenesis and bridge the distal

Fig. 14. (*A*) Preoperative MRL in patient with left arm lymphedema. Red arrow pointing to seroma of lymph fluid. (*B*) Postoperative MRL, 1 year after ALNT, showing new lymphatic channels.

obstructed lymphatic system with the proximal lymphatic system. Additionally, lymph nodes with important immunologic function are brought into the fibrotic and damaged tissue. ALNT can improve brachial plexus neuropathies and can be combined with breast reconstruction flaps to be an elegant solution for patients with breast cancer.

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