A Surgical Approach to the Harvest of the Vascularized Submandibular and Submental Lymph Node Flap

The "Through-the-Gland" Dissection Technique

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Background: Extremity lymphedema is a pathological condition resulting from absence of lymph nodes and disease of lymphatic vessels, often due to oncologic clearance of lymph nodes. In recent years, vascularized lymph node transfer has become a rapidly emerging method of lymphatic reconstruction shown to lead to lymphatic regeneration. In particular, lymphatic flaps based on the submental artery have shown good results with its favorable donor site and available nodes. The lymph nodes here are in close relation to the submandibular gland and require careful dissection around and through the gland for safe harvest. We studied this region of the neck and describe the blood supply to the lymph nodes, their variable positions in relation to the gland, and our technique of dissecting through the submandibular gland while keeping the lymph nodes' hilar blood supply intact.

Methods: We dissected 2 cadaver heads (4 sides of the neck) to study the submandibular and submental lymph nodes, where to locate them in relation to the submandibular gland and how best to dissect through the submandibular gland for access while keeping the hilar supply intact. We applied this knowledge in 6 clinical cases and provide a brief description of our "through-the-gland" dissection technique.

Results: The submandibular lymph nodes may lie (1) superficial and posterior to the gland, (2) between the superficial and deep parts of the submandibular gland, or (3) anteriorly and submental. They are classified as superficial, deep, and submental, respectively. The through-the-gland dissection technique gave the surgeon improved access and exposure to the lymph nodes. It also facilitated safer dissection because their hilar blood supply is well visualized.

Conclusions: The through-the-gland technique of harvesting vascularized submandibular lymph node flaps is a safe technique that allows the surgeon to clearly identify and preserve blood supply of lymph nodes.

Key Words: vascularized lymph node transfer, lymphedema, submandibular lymph node, through-the-gland dissection, microsurgery

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Extremity lymphedema is a pathological condition resulting from absence of lymph nodes and disease of lymphatic vessels, often due to clearance of lymph nodes in cancer resection. Treatment is aimed at controlling swelling and infection, which ultimately improves the quality of life through weight reduction and added mobility. Early diagnosis and therapy offer the best control before irreversible damage of lymphatic channels occurs. The International Society of Lymphology grades lymphedema into stages 0, I, II, and III, which denote latent lymphedema, spontaneously reversible lymphedema, spontaneously irreversible lymphedema, and lymphostatic elephantiasis, respectively. In early stage lymphedema, decongestive therapies including manual lymphatic drainage, compression bandaging, and pneumatic pumps are effective although results vary depending on patient compliance. Surgical therapies are indicated for stage I onwards, with the modalities being broadly classified into lymphatic reconstructive procedures and excisional procedures.[1] Excisional procedures can produce spectacular reductions in limb girth but may be complicated by unstable scars and poor aesthetic appearance. Lymphatic reconstructive procedures such as lymphovenous bypass and lymphatico-lymphatic anastomosis are useful acute surgical decongestive therapies and may be accomplished stage-wise under local anaesthesia. However, their long-term patency cannot be monitored.[2]

In recent years, vascularized lymph node transfer has become a rapidly emerging method of lymphatic reconstruction shown to lead to lymphatic regeneration. In particular, lymphatic flaps based on the facial/submental artery have shown good results with its favorable donor site and available nodes.[2,3] However, a potential pitfall is the failure to incorporate sufficient lymph nodes.[2] The lymph nodes here are in close relation to the submandibular gland and require careful dissection around and through the gland for a safe harvest. We studied this region of the neck and herein describe the blood supply to the lymph nodes, their variable positions in relation to the submandibular gland, and our technique of dissection.

Cadaver Study

The submandibular lymph nodes were studied in 2 formalin-fixed adult cadaver head and necks (4 sides). These nodes correspond to levels 1A and 1B nodes according to the American Head and Neck Society classification.[4] The specimens were obtained from Science Care and stored in the freezer upon arrival according to standard protocol. Vascular injections were carried out in steps. We started with irrigation of normal saline followed by formalin to prime the vessels. We then infused diluted colored latex into the arterial system to fill the fine vessels, followed by a thicker latex-tapioca flour mixture for the larger vessels. Red latex was used for the arteries and blue for veins. Dissection was carried out under magnification.

RESULTS

In relation to the submandibular gland, 2 to 3 lymph nodes were consistently found (1) superficial and posterior to the gland (33%), (2) deep, that is, between the superficial and deep parts of the gland (50%), and (3) anterior (17%). The lymph nodes were supplied by hilar vessels emanating from the facial artery system. We classified the nodes as (1) superficial, (2) deep, and (3) submental, respectively, according to their location. The superficial nodes were found closely applied to the posterior border of the gland, near the origin of the facial artery, and in close proximity to the confluence of facial veins before they empty into the internal jugular vein (IJV) (Figs. 1A, 2).The deep nodes were located deep to the superficial part of the submandibular gland, being supplied by the glandular branches of the facial artery and drained by

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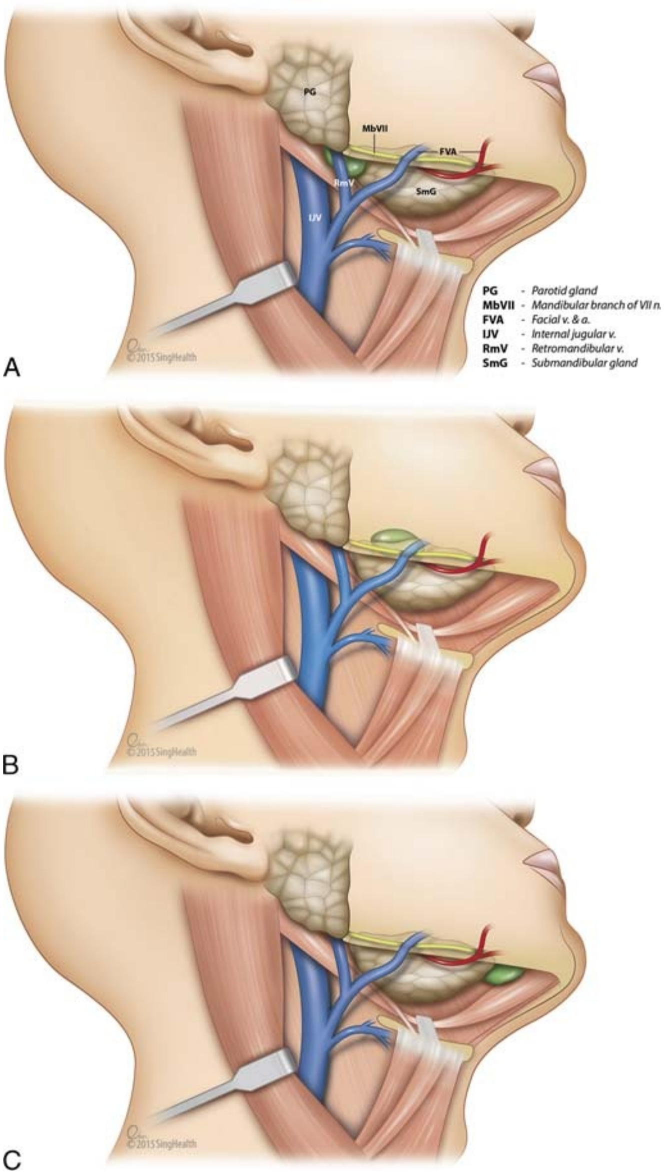

FIGURE 1. Illustration of the right submandibular triangle showing the classification based on the location of the lymph nodes. A, Superficial: the superficial nodes were found closely applied to the posterior border of the gland. B, Deep: the deep nodes were located deep to the superficial part of the submandibular gland. C, Submental: the submental nodes were located anterior to the gland.

the facial veins (Figs. 1B, 2). The submental nodes were located anterior to the gland and perfused by the terminal branch of the facial artery, that is, the submental artery (Figs. 1C, 2). For this reason, we call them the *submental lymph nodes*.

Surgical Technique

The patient is placed supine, with neck extended and turned to the opposite side. A rolled blanket placed between the shoulders facilitates exposure of the submandibular triangle. We routinely use the upper neck crease incision, which affords exposure to both the submandibular and upper jugular nodes.[5] The incision is carried through the subcutaneous tissue to the level of the platysma. When the platysma is incised, the lobulated surface of the submandibular gland comes into view. Balloting the gland with the surgeon's fingers confirms its position. The deep cervical fascia is incised, and dissection is directed towards the inferior border of the submandibular gland to avoid the marginal mandibular branch of the facial nerve. It courses deep to the cervical fascia, passing superficial to the facial vein and artery. The cervical fascia and capsule of the gland are reflected superiorly as a composite layer to safeguard the nerve. A monopolar cautery set at low energy (7 W) is used to dissect tissue, and any twitching in the vicinity indicates the facial nerve is near.

We then proceed to locate the lymph nodes with the aid of an operating microscope. If the lymph nodes are found in a superficial location (Fig. 1A), harvest is straightforward. The superficial lobe of the submandibular gland is displaced anteriorly to expose the vasculature surrounding the lymph nodes, and these are selectively ligated, keeping the ends *long* for multiple vascular anastomoses. After isolating the lymph nodes on their pedicle, they must appear pink and not be congested. They should perfuse well on indocyanine green angiography (HyperEye, Mizuho, Japan).

If no superficial nodes are seen, the superficial part of the gland is mobilized and reflected down to look for deep nodes (Fig. 1B). The facial artery and vein crossing the mandibular border have to be divided for access. The deep nodes are nestled between the superficial and deep parts of the gland. During dissection of the submandibular gland, glandular branches supplying the lymph nodes are carefully preserved. Piece meal removal of the gland may be necessary to avoid damaging these branches, and since the gland will be devitalized in this process, it is usually excised. The duct is ligated flush with the remaining deep part of the gland. Rarely, no deep nodes are seen, and in this instance, the facial artery is traced distally to look for submental nodes. To do so, the neck crease incision is extended to afford more exposure.

Proximally, further dissection is carried out towards the origin of the facial artery and the pedicle ligated close to its origin at the external carotid artery for maximal length. Along the way, excising the submandibular gland piecemeal will expose the hilar vessels and nodes. This aids the surgeon in tracing the pedicle while preserving the hilar vessels and draining veins. Note that the draining vein/s often run separate from the facial artery. They drain into the IJV and are harvested with maximal length. The node is raised with a cuff of fatty tissue to avoid damaging it. Care is taken to preserve the hypoglossal nerve and its branches.

Once sufficient pedicle length is achieved, 2 or 3 lymph nodes directly perfused by the main pedicle are selected for transfer. The proximal and distal ends of the pedicle are clamped with redundancy. Potentially, 4 anastomoses (at both ends of pedicle as a flow through flap) may be performed.

At the recipient site, multiple anastomoses are done for this "miniflap" to optimize circulation. Supplementary venous anastomoses will augment drainage and prevent congestion. Sometimes, we connect the distal arterial run-off to another recipient vessel to dissipate pressure in the flap. The donor site is closed primarily, and a suction drain is placed.

PATIENTS

This technique was performed in 6 patients for stage II lymphedema according to the International Society of Lymphology (Table 1). The average volume reduction was 21% after an average follow-up of 40 months. Ancillary procedures included suction-assisted lipectomy and lymphaticovenous anastomosis (LVA). The lymph node flaps were placed proximally either in the medial arm or groin. The recipient arteries for the lower extremity included the

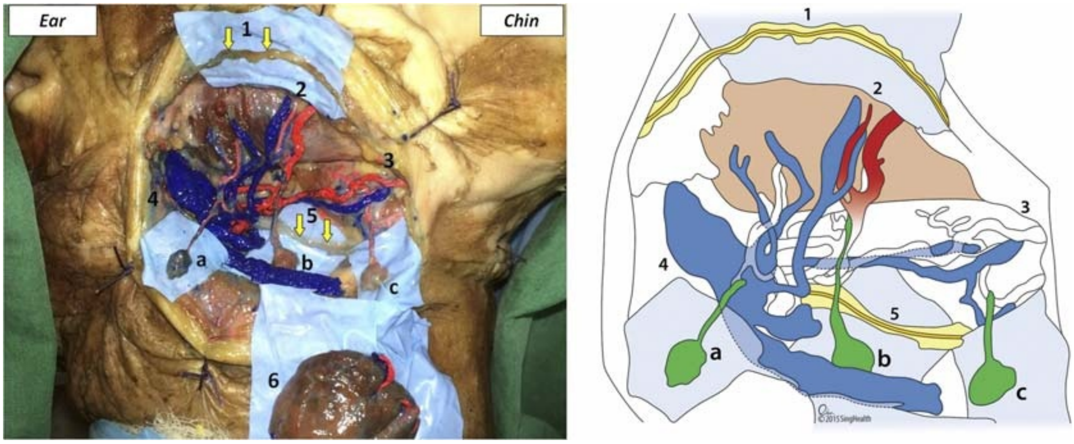

FIGURE 2. Cadaveric dissection of the right submandibular triangle. 1, Marginal mandibular branch of the facial nerve; 2, facial vein and artery; 3, submental artery and vein; 4, IJV; 5, hypoglossal nerve; 6, submandibular gland (excised). A, Superficial lymph node, (B) deep lymph node, and (C) submental lymph node.

superficial circumflex iliac artery, branches of the profunda femoris artery, and branches of the femoral artery. These vessels were exposed using a curvilinear incision placed 2 cm inferior and parallel to the groin crease, incorporating a medial extension along the course of the great saphenous vein. In the upper extremity, the branches of the brachial artery were used. The brachial artery branches were exposed using an 8-cm linear incision entering the septum between the biceps and brachialis muscles. As for the recipient veins, in the upper extremity, we used the basilic vein, vena comitantes of the brachial artery branches, and superficial veins. In the lower extremity, tributaries of the great saphenous vein were used. We used the largest caliber vein to drain the hilar vein of the lymph node flap. A second venous outflow was created when the extra veins on the lymph node remained tumescent and had copious flow upon clamp release. Monitoring of the flaps was performed with ultrasonography because they were buried flaps without a skin paddle. No major complications were encountered. One patient had 2 episodes of mild cellulitis over the 60 months of follow-up. It was successfully treated with intravenous antibiotics. All patients are on life-long compression garment therapy.

Case Illustration (Case Number 2)

A 33-year-old man presented with recurrent cellulitis of the left lower extremity secondary to postsurgical lymphoedema (Table 1). He underwent resection of a diffuse lipomatosis of the left thigh at age 18 years and developed leg swelling soon after. He had failed repeated trials of conservative therapy, and despite 2 limb volume reduction procedures by general surgeons, there was no improvement. At the initial consultation, his left lower extremity was in stage II according to the International Society of Lymphology. The patient underwent vascularized lymph node flap transfer, harvested with the above technique from the right neck (Figs. 3, 4). In this dissection, the superficial part of the submandibular gland was sacrificed because the lymph nodes were deep to the gland. The lymph node flap was supplied by the facial artery and vein of calibers 3 mm and 5 mm, respectively. An additional 2-mm venous tributary of the flap was preserved. Concurrently, a curvilinear incision was made in the left groin by a second team exposing the femoral triangle to look for recipient vessels. Revascularization of the flap was accomplished as follows. End-to-end anastomosis was first performed between the facial artery and a branch of the femoral artery. The arterial clamp was then released to determine the dominant draining vein, which was the facial vein. It was anastomosed end-to-end with a matching tributary of the great saphenous vein. Compression therapy was started on postoperative day 2, and the patient was ambulant with partial weight bearing on postoperative day 9. There was no donor site morbidity, and the scar healed nicely along the neck crease. Outpatient review 3 months postoperatively showed 18.0 (50–41 cm), 20.8 (48–38 cm), and 23.7 (38–29 cm) percent reductions in limb circumference at the midthigh, proximal, and distal leg, respectively (Fig. 5). There were no new episodes of cellulitis in the left leg after surgery. Technitium (Tc) 99-m scans showed functioning left inguinal nodes with new lymphatic connections (Fig. 6).

DISCUSSION

Vascularized lymph node transfer is a technique that is gaining momentum in the treatment of extremity lymphoedema.[2,6–9] Chen and O'Brien had demonstrated the efficacy of lymph node transfer in a canine model in 1990,[6] but it has taken more than 10 years for lymphatic surgery to become well-established because of evolving supermicrosurgery techniques. A recent meta-analysis on operative treatment of peripheral lymphoedema by Basta et al[3] reported reductions in circumference and volume from 49% to 57%, with 92.7% of patients reporting subjective improvement postintervention. Vascularized lymph node transfer was found to afford a 20% greater prospect of discontinuing conservative treatment compared with lymphaticovenular anastomosis. It has a low complication rate and high flap survival rates.[3]

In 2012, Cheng et al[2] described the vascularized submental lymph node flap for vascularized lymph node transfer. The main advantages of this flap are sparing the groin of donor morbidity and an inconspicuous donor site under the lower border of the mandible. We believe that our "through-the-gland" technique affords the advantages of the originally described technique and further improves on lymph node visualization and vascularity. Raising the lymph node flap without a skin paddle simplifies the dissection and allows the surgeon to focus on capturing the hilar blood supply of the lymph nodes. The lymph nodes are directly visualized and not merely a component of a composite flap. A skin paddle can still be included based on the skin perforator if the recipient site is tight and cannot be closed primarily.

The submandibular gland is supplied by the facial and submental artery, with contributions from the lingual, deep lingual, or directly from the external carotid artery.[7,10] Originating from the external

TABLE 1. Patients

No	Gender	Age, y	Diagnosis	Grade	Region Affected	Site of Lymph Node Flap	Perimeter Measurements: Preop Volume, mL	Perimeter Measurements: Postop Volume, mL	Perimeter Measurements: Improvement, %	Revascularization	Adjunctive Treatments	Follow-up, mo
1	F	56	Breast cancer	2	Upper extremity	Medial arm	2737	2335	15	1 Artery, 1 vein	Suction-assisted lipectomy of forearm	49
2	M	36	Lipomatosis	2	Lower extremity	Groin	10195	7138	30	1 Artery, 1 vein	Nil	33
3	F	68	Cervical cancer	2	Lower extremity	Groin	8231	7102	14	1 Artery, 1 vein	LVA (ankle)	53
4	F	54	Cervical cancer	2	Lower extremity	Groin	8826	6203	30	1 Artery, 1 vein	Suction-assisted lipectomy of leg and thigh	22
5	F	57	Endometrial cancer	2	Lower extremity	Groin	10,028	7722	23	1 Artery, 2 veins	Suction-assisted lipectomy of leg and thigh	60
6	F	58	Cervical cancer	2	Lower extremity	Groin	9172	7796	15	1 Artery, 2 veins	Suction-assisted lipectomy of leg and thigh and LVA	20

Table shows the qualitative and quantitative data of lymph node transfer procedure for 6 patients with stage II lymphedema.

Preop, preoperative; postop, postoperative.

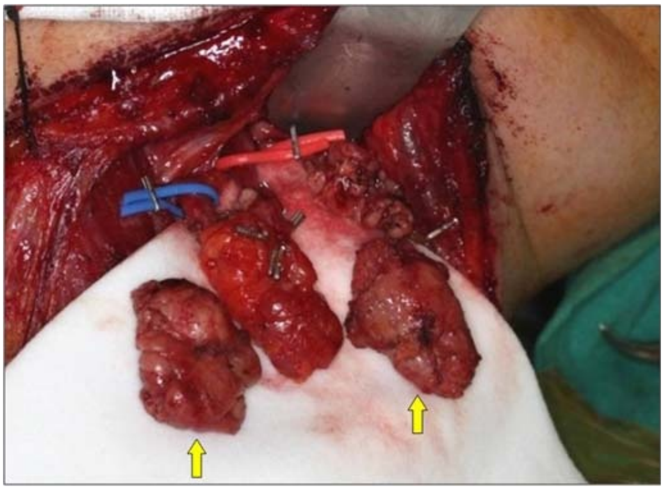

FIGURE 3. Vascularized submandibular lymph node flap in a 33-year-old man with lower extremity lymphedema. The flap was supplied by the facial artery (right vascular loop) and facial vein (left vascular loop) flanked by the excised portions of the submandibular gland (arrows).

carotid artery, the facial artery runs superiorly and then deep to the posterior belly of the digastric and stylohyoid muscles. It crosses over them and descends on the medial surface of the mandible, grooving or passing through the submandibular salivary gland.[11] The submandibular lymph nodes are supplied by hilar vessels, which are branches from the facial and submental arteries that course through and on the surface of the submandibular gland. This observation is clearly supported by our cadaver dissections.[7] The facial vein parallels the course of the artery above the inferior mandibular border but runs more superficially on the surface of the submandibular gland to terminate in the IJV.[7] Dissecting with the aid of the operating microscope ensures that the hilar vessels were visualized and preserved while trying to make sense of the network of arteries and veins supplying the flap.

FIGURE 4. Close-up view of the lymph node flap showing its pedicle. Big arrow points to the facial artery and small arrow to the facial vein. The vascularized lymph node flap was transferred to the left groin with donor vessels anastomosed to the branches of the femoral artery and tributaries of the long saphenous vein.

FIGURE 5. Left: Preoperative. Right: 3 months postoperatively. The postoperative percentage reductions in limb circumference at the midthigh, proximal, and distal leg were 18.0%, 20.8% and 23.7%, respectively.

The venous network of the submandibular gland is more complicated and variable than the arterial (Fig. 2). In an anatomical study of 60 submandibular glands by Li et al,[10] the venous drainage of submandibular gland drained mainly into the anterior facial vein (54/60), hilum vein of the gland (60/60), and venae comitantes (56/60) of facial artery. In addition, the gland was drained by the mental vein, deep lingual vein, external jugular vein, and anterior jugular vein.[10] From Figure 2, the retromandibular and the anterior facial veins join as the common facial vein(s), which drains into the IJV. Either veins were used for venous anastomosis depending on their connection with the hilar veins.

In the harvest of the vascularized lymph node flap, we obtained 2 to 4 pedicles for anastomoses. The vascularized lymph node flap could be designed as a flow-through flap to alleviate congestion. Perforators to the skin can be identified to include skin with the flap in aid of a tension-free closure at the recipient site.

The marginal mandibular branch of the facial nerve may be found up to 1.5 cm below the inferior border of the mandible.[12,13] In Ziarah and Atkinson's[13] dissections of 76 facial halves, it was found below the inferior border 53% of the time, whereas in a further 6%, the nerve continued for a farther distance of up to 1.5 cm before turning upward and crossing the mandible. In view of these findings, most surgeons recommend that the incision and deeper dissection be at least 1.5 cm below the inferior border of the mandible. Occasionally, the marginal mandibular branch may be found inferior to the mandible at the premasseteric notch, so care must be taken when dissecting at this anatomical landmark. In our practice, we avoided the nerve by starting with a low incision at the upper neck crease and approaching the submandibular gland in a caudal-to-cranial direction, thereby preserving the nerve in the cranially reflected fascia/capsule. After mobilizing the gland, dissection proceeded from superficial to deep towards the facial vein and artery in the hunt for nodes and the marginal mandibular nerve may encountered when approaching the area of the premasseteric notch of the mandible. The operating microscope was used to visualize the nerve and its branches.

The drawback of our technique was its tedious dissection leading to a lengthy operation and sacrifice of the superficial lobe of the gland.

From a clinical perspective, transferred lymph nodes have been postulated to improve local immunity through T and B cell traffic and activation. Foreign proteins are conveyed by migrating dendritic cells and presented to T cells. Subsequently, B cells are activated, enabling the production of the antibodies that are essential for combating infection. We postulate that transferred lymph nodes generate new lymphatic channels that connect with existing ones.[1] The postoperative Tc 99-m scans of our patient suggests that the transferred lymph node in the groin was able to induce new lymphatic connections and promote activity in existing popliteal nodes (Fig. 6). Techniques involving placing

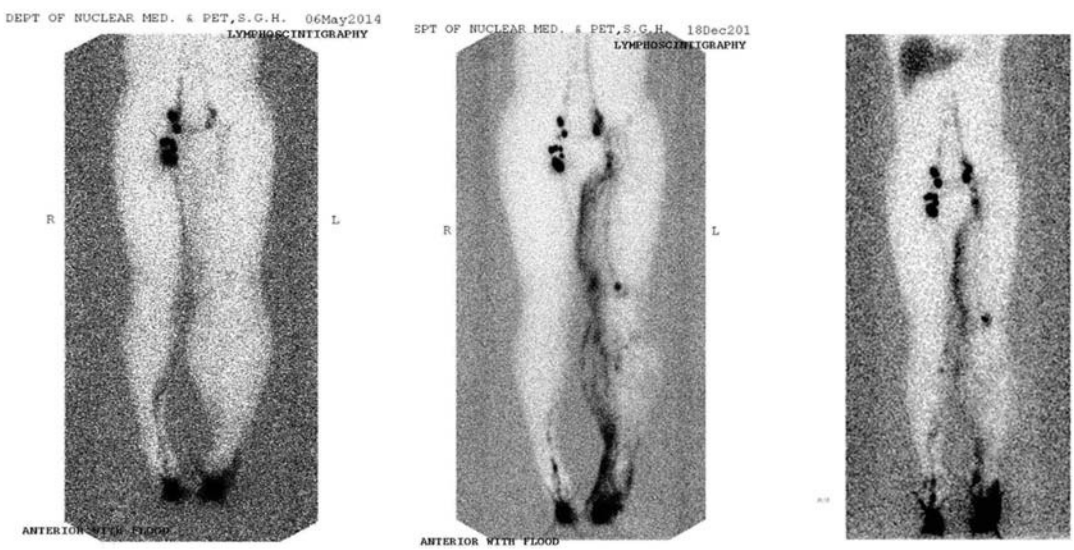

FIGURE 6. Tc 99-m scan: no visualization of lymphatic channels or inguinal lymph node in the left lower extremity after 4 hours (left). One year after vascularized lymph node transfer to the left inguinal region (center). Left inguinal nodes are seen 1.5 hours after injection. Lymphatics are seen over the medial aspect of the leg and thigh. A popliteal lymph node has appeared. Two years after lymph node transfer, left inguinal nodes and lymphatic corrections seen 30 minutes after injection (right). There is further reduction in the girth of the lower extremity.

lymph nodes at multiple levels, for example, ankle and calf, are now being studied.[8]

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