



7-1-2024

Section: Plastic surgery

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How to Cite This Article

EL Banouby, Tarek Mahmoud; El Shamy, Mahmoud Ebrahim; Ouf, Mohamed Osama; and Kasem, Abdullah Mohamed (2024) "Lymphatic Mapping for Faciocutaneous Free Flap Selection Using Magnetic Resonance Lymphography with Contrast," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 6, Article 50. DOI: <https://doi.org/10.58675/2682-339X.2510>

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Lymphatic Mapping for Faciocutaneous Free Flap Selection Using Magnetic Resonance Lymphography with Contrast

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Abstract

Background: The evacuation of fluid and proteins from interstitial tissues and their subsequent return to the systemic circulation is one of the main tasks of the lymphatic system. In order to avoid edema, or swelling, this mechanism is essential for keeping the body's fluid levels stable and from tissues accumulating too much fluid.

Aim: To map and determine the lymphatic axiility using magnetic resonance lymphography with contrast in some fasciocutaneous free flaps: ALT free flap from the thigh, DIEP free flap from the anterior trunk, and para scapular free flap from the posterior trunk.

Patients and methods: This study conducted on 20 patients with ages ranged from 20 to 58 years underwent fasciocutaneous lymphatic mapping for the para scapular region from the posterior trunk, lower abdominal wall from the anterior trunk and anterolateral region of the thigh from lower limb selected from those seeking treatment in the outpatient clinic and emergency room at plastic surgery department at Al Hussien and Bab Elsheria Hospitals, Faculty of Medicine, Al Azhar University between February 2022 and June 2023 Regarding underlying etiology, there were 14 patients (70%) need flap due to trauma, four patients (20%) were due to post-burn loss skin and soft tissue and two patients (10%) were due to excision of unstable scar. Regarding flap types, 10 (50%) flaps were ALT, 6 (30%) flaps were DIEP, and 4 (20%) flaps were Para-scapular.

Results: The foremost sub-dermal lymphatic collectors of the ALT flap were oblique, the DIEP flap was vertical, and the collectors of the para-scapular flap were transverse via magnetic resonance lymphography with contrast.

Conclusion: Lymphatic mapping is essential for knowledge of normal lymphatic anatomy and excluding the diseased one. Magnetic resonance lymphography with contrast is an accurate method that visualizes the normal lymphatics and lymphatic axiility and detects abnormalities.

Keywords: Lymphatic Mapping, Magnetic resonance lymphography, Faciocutaneous free flap

1. Introduction

Lymphatic vessels are present in almost all organs and blood vessels, housing interstitial tissue and acting as a conduit to remove surplus fluid, large molecules, and cells that struggle to re-enter venules. These vessels are delicate and slender in structure, gradually increasing in thickness as they penetrate deeper into tissues.¹

The lymphatic system returns interstitial fluid and proteins to the systemic circulation, among its other principal activities. Edema, or

swelling, can develop when tissues accumulate too much fluid, therefore this process is essential for keeping the body's fluid balance in check.^{2,3}

Lymphedema is an enduring and advancing ailment that occurs when protein-rich fluid builds up in the interstitium, triggering cellular growth and inflammation. This process leads to the thickening and scarring of lymphatic vessels and the neighboring tissue. Consequently, swelling occurs, significantly impacting the overall quality of life.⁴

Accepted 21 June 2024.

Available online 31 June 2024

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<https://doi.org/10.58675/2682-339X.2510>

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Methods such as lymphatic venous anastomosis (LVA), vascular pedicle lymph node (LN) transplantation, and flap transfer focusing on the reconstruction of lymphatic stagnation have been documented. These techniques aim to address lymphatic stasis without the involvement of lymph nodes.⁵

The orientation of lymphatic flow may be a significant factor to consider when ensuring the successful integration and continuity of lymph flow between the transplanted flap and the recipient site during extremity reconstruction using flaps.⁶

Magnetic resonance (MR) lymphangiography with gadolinium chelates can visualize preclinical lymphatic alteration.⁷

MRI has dramatically enhanced the ability to visualize lymph nodes and the lymphatic vasculature, both centrally and peripherally. As a result, it has quickly become a viable alternative to conventional invasive imaging methods.⁸

This study aimed to map and determine the lymphatic axiality using magnetic resonance lymphography with contrast in some fasciocutaneous free flaps: the ALT free flap from the thigh, the DIEP free flap from the anterior trunk, and the para scapular free flap from the posterior trunk.

2. Patients and methods

This study was conducted on 20 patients of different ages ranging from 20 to 58 years (mean 36 years) who underwent fasciocutaneous lymphatic mapping for the para scapular region from the posterior trunk, the lower abdominal wall from the anterior trunk, and the anterolateral region of the thigh from the lower limb. From February 2022 to June 2023, they were chosen from patients who visited the plastic surgery emergency room and outpatient clinic at Al Hussien and Bab Elsheria Hospitals, which are part of the Faculty of Medicine at Al Azhar University in Cairo.

Inclusion Criteria: Age: 15 -60 years old, sex: male and female, and cause: the patient who needs fasciocutaneous free flap transfer, ALT free flap from the thigh, DIEP free flap from the anterior trunk and para scapular free flap from the posterior trunk.

Exclusion Criteria: Patients with a history of any vascular diseases, patients with renal or hepatic diseases, and patients with body mass index > 35

Ethical Considerations: Time was spent with patients and their families, explaining to them the meaning and significance of the procedure, its methods and tools, and the likely complications. They agreed to undergo the examination. Also,

informed consent was taken from all patients about every step of the procedure.

Funds and Grants: This study is self-funded with no grants.

Methods:

All patients were assessed by a Plastic surgeon, who recommended faciocutaneous free flap coverage, and also by a radiologist before they underwent the examination.

As preparation for the examination, all patients underwent history, labs, radiological, and local examination to search for any vascular, renal, or hepatic compromise.

Procedure technique:

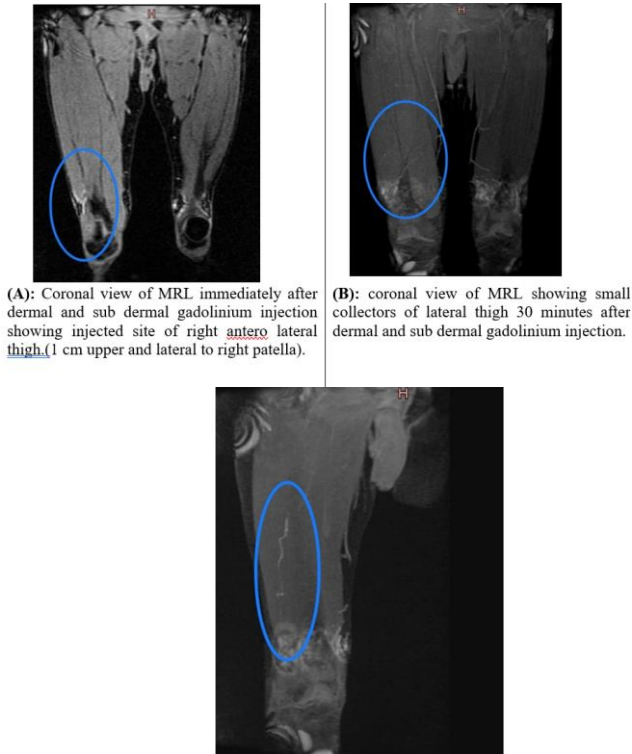
Identification of the region of the flap, directions of its lymphatic vessels, and the distal border of the flap where the lymphatic fluids migrate within the lymphatic vessel, these were: ALT flap: anterior, upper, and lateral skin of the patella, DIEP flap: 1, 2 cm lateral to the umbilicus and para scapular flap: 1 cm lateral to the first and third thoracic vertebrae. A local anesthetic gel was applied over the targeted site for injection for 15 minutes to reduce the injection pain. Under the complete aseptic conditions, sterilization of skin with alcohol-soaked gauze. Subdermal and intradermal injection of 2 cm of 0.5 mmol/ml Gadodiamide solution into the sterilized border of the selected flap with weak massage over the injected area. The patient was introduced to an MRI machine without any metal material to undergo the examination. The imaging protocol generally consists of a 3D fast spoiled gradient-echo T1-weighted sequence with a fat-saturation technique for lymphatic visualization. The axial and coronal cuts of magnetic resonance lymphography at the targeted areas were done immediately after injection, 15 minutes after, 30 minutes after, and after 1 hour. All cuts and results are to be analyzed and discussed through this research. The following is the mapping of lymphatic axiality by magnetic resonance lymphography with contrast.

Expected Local Complications: Pain, edema, Echymosis, and irritation

Expected General Complications: Headache, nausea, discomfort and annoyance

CASE PRESENTATION:

Case (1): A male patient 46 y came to the outpatient clinic at AL HUSSIEN hospital suffering from post-traumatic raw area at the medial aspect of left ankle with exposed bone and tendons recommended for covering by free tissue transfer mostly fasciocutaneous ALT free flap from Rt thigh

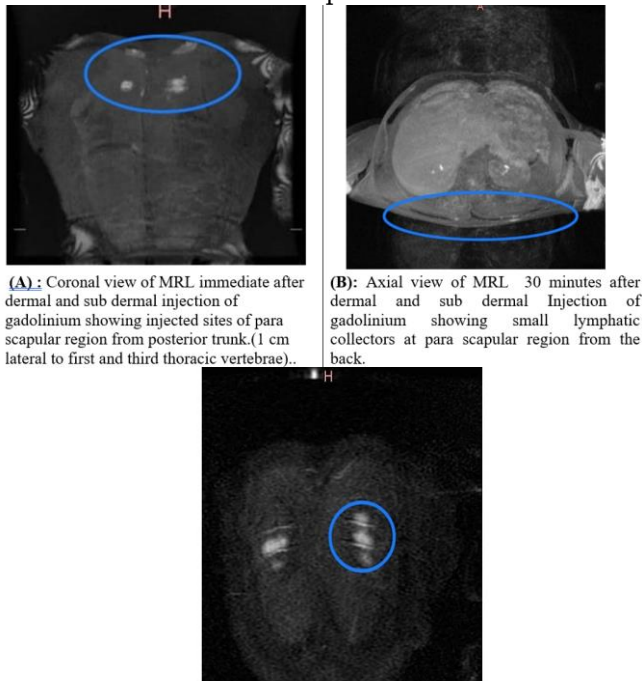


(A): Coronal view of MRL immediately after dermal and sub dermal gadolinium injection showing injected site of right antero lateral thigh (1 cm upper and lateral to right patella). (B): coronal view of MRL showing small lymphatic collectors of lateral thigh 30 minutes after dermal and sub dermal gadolinium injection.

(C): Coronal view of MRL one hour after gadolinium injection showing main lymphatic collector of right anterolateral thigh.

Figure 1. Photos of case 1

Case (2): Male patient 30 years old presented to AL HUSSIEEN hospital outpatient clinic with post-burn raw area on right forearm anteriorly with exposed tendons indicated for para scapular fasciocutaneous free flap from back.



(A): Coronal view of MRL immediate after dermal and sub dermal injection of gadolinium showing injected sites of para scapular region from posterior trunk (1 cm lateral to first and third thoracic vertebrae). (B): Axial view of MRL 30 minutes after dermal and sub dermal injection of gadolinium showing small lymphatic collectors at para scapular region from the back.

(C): Coronal view of MRL one hour after dermal and sub dermal injection of gadolinium showing large lymphatic collectors at para scapular region from the back.

Figure 2. Photos of case 2

3. Results

Table 1 showed that number of males were 13 and number of females were 7, their ages ranged from 20 to 58 years (mean 36.85± 11.36 years).

Table 1. Distribution of studied cases according to Age and Sex

		No. = 20
Age	Mean ± SD	36.85 ± 11.36
	Range	20 – 58
Sex	Male	13 (65.0%)
	Female	7 (35.0%)

Regarding underlying etiology, we found that 14 patients (70%) need flap due to trauma, 4 patients (20%) were due to post burn loss skin and soft tissue and 2 patients (10%) were due to excision of unstable scar (Table 2).

Table 2. Distribution of the studied cases according to Cause of skin and soft tissue loss

Cause	No.	%
Trauma	14	70%
Post burn	4	20%
Unstable scar	2	10%

Regarding flap types, 10 (50%) flaps were ALT, 6 (30%) flaps were DIEP and 4 (20%) flaps were Para-scapular. (Table 3)

Table 3. Distribution of the studied cases according to the type of mapped flaps

Mapped Flap	No.	%
ALT	10	50%
DIEP	6	30%
Parascapular	4	20%

4. Discussion

Completely agree with the findings of Chavhan,⁹. The lymphatic system is a vital part of the circulatory system, serving critical physiological functions such as providing nutrition, maintaining fluid balance, supporting immunity, and eliminating waste products. It helps return excess fluid and protein from the interstitial tissue to the systemic circulation. Additionally, the lymphatic system, including lymph nodes and the spleen, plays a crucial role in immune function and the removal of cellular debris, including bacteria and proteins. Lymph is the surplus tissue fluid derived from blood plasma and is transported through the lymphatic system, containing nutrients, hormones, fatty acids, toxins, and cellular waste products.

This study showed that the number of males was 13 and the number of females was 7; their ages ranged from 20 to 58 years (mean 36.85± 11.36 years). Regarding underlying etiology, we found that 14 patients (70%) needed flaps due to trauma, four patients (20%) were due to post-burn loss of skin and soft tissue, and 2 patients (10%) were due to excision of the unstable scar. Regarding flap types, 10 (50%) flaps were ALT, 6

(30%) flaps were DIEP, and 4 (20%) flaps were Parascapular.

As Forte,¹⁰ There are a number of reasons why MRL should be considered for the purpose of evaluating lymphatic pathways prior to surgery. Its superior resolution compared to conventional lymphoscintigraphy makes it possible to visualize even the tiniest lymphatic vessels. This precisely delineates areas of dermal backflow, gives information on the number, depth, and trajectory of lymphatic channels, and permits a more comprehensive evaluation of lymphatic channel anatomy.

Confirmation on Sedbon,¹¹ When planning the preoperative reconstruction of skin and soft tissue using a free flap, it is essential to consider the lymphatic axiarity. This is because it can restore lymph flow between the flap and the recipient site without needing lymphatic anastomosis or lymph node transfer. However, to validate this hypothesis, additional studies are required. Specifically, further studies with extended follow-up are necessary to investigate the lymphatic connections between the flap and the recipient area.

According to Pan,¹² The number of lymph collecting vessels in the thigh ranged from 27 to 31, with an average of 29. In terms of diameter, these arteries averaged 0.8 mm (ranging from 0.3 to 1.7 mm). Within the superficial tissue of the thigh, three clusters of veins and arteries were located. The anterior group was the first to form, and it began on the outside of the thigh. Before reaching the lateral cluster of superficial inguinal lymph nodes, these arteries meandered obliquely across the subcutaneous tissue.

Based on the findings of this study that strongly agree with Felmerer's¹³ investigation, it was determined that the superficial fat layer and its accompanying arteries of the front abdominal wall are vital for draining the DIEP flap. The abdominal fascia muscles and other deep tissues are drained by lymphatic systems that are situated close to the veins and arteries. The study also found that small, horizontally-oriented pre-collectors may be filled by injecting dye into the fascia and rectus abdominis muscle. Near the perforating arteries, these pre-collectors eventually fused to create bigger lymphatic channels. Also, two lymphatic vessels were discovered to be associated with the inferior epigastric artery, and they were linked by lymphatic channels that resembled ladders. The iliac lymph nodes receive drainage from the deeply situated tissues of the abdominal wall. The lymph vessels of the DIEP flap were aligned with those at the recipient site during the intraoperative process of patients who were enrolled in the study. All patients were required to undergo lymphography as per the study

protocol in order to ascertain the lymphatic drainage of the intended DIEP flap from the lower abdomen. For this investigation, five locations were chosen at random from the middle of the indicated flap boundary to inject contrast material. As a result, the lymphatic drainage routes could be seen. Images taken using a lymphography machine showed that the right inguinal lymph nodes were the primary sites of lymphatic drainage from the flap. These results point to the DIEP flap's ideal lymphatic drainage route.

I strongly agree with Sakai,¹⁴ Understanding the lymphatic anatomy is crucial when planning a flap procedure. For instance, when designing an ALT flap, it is essential to inject contrast at the mid-lateral thigh. This allows visualization of the lymphatic pathways as lymph flows from the mid-lateral thigh toward the inguinal lymph nodes. On the other hand, when designing a DIEP flap from the lower abdomen, the contrast should be injected at the level of the umbilicus. This is because the lower abdominal lymph flows from the level of the umbilicus towards the inguinal lymph nodes.

4. Conclusion

Lymphatic mapping is essential for knowledge of normal lymphatic anatomy and excluding the diseased one. Magnetic resonance lymphography with contrast has an accurate 3D visualization of the lymphatics, lymphatic axiarity, and surrounding structures. It can also image lymphatics in deeper plans >2 cm without invasive complications. Popular fasciocutaneous free flaps containing patent lymphatic vessels like ALT, DIEP, and periscapular free flap can achieve soft tissue reconstruction with lymphatic regeneration and restoration without needing LVA or lymph node transfer.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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