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Lymphatic Flow Restoration Following Soft Tissue Reconstruction of Extremities Using Fasciocutaneous Free Flaps

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Abstract

Background: Post-traumatic lymphedema is minimally researched; only a few articles are talking about post-traumatic lymphedema at the extremities, and few incidence data are available, but up to 20% of patients with major trauma of the limbs have persistent edema after the injury.

Aim and objectives: To evaluate the impact of using free flaps based on lymph axially on lymph flow restoration (LFR).

Subjects and methods: This interventional study was conducted on thirty post-traumatic patients undergoing soft tissue reconstruction surgeries at an extremity at the plastic and reconstructive surgery unit of Azhar University Hospitals.

Results: There was a statistically significant difference between the positivity and negativity of Lymph Flow Restoration regarding the presence of a missed gap (M gap) between lymphatic vessel stumps, and there was a highly statistically significant difference between the LFR Positive and LFR negative regarding lymph axially.

Conclusion: Restoration of lymph flow can be achieved with free flap transfer surgery to an extremity without transferring lymph node (LN) surgery or super-microsurgical lymphatic procedures; lymph axially (LA) without any missed gap between donor and recipient lymph vessels stump is the key for lymph flow restoration.

Keywords: Post Traumatic Lymphedema; Indocyanine Green Lymphography; Fasciocutaneous Free Flap

1. Introduction

The Lymphatic system has a great share in the regulation of fluids and absorption of lipids from the intestine.¹

The deep and superficial lymphatic systems at the extremities work independently. The superficial system is more valuable because it has more vessels and delivers the majority of lymph fluid in the limb.²

Traumatic damage to specific regions of the limbs, such as major lymph vessels alongside large subcutaneous veins, can result in the interruption of lymph flow, ultimately leading to the development of chronic progressive lymphedema.³

Traumatic injuries frequently contribute to the incidence of lymphedema in extremities; nonetheless, posttraumatic lymphedema remains inadequately comprehended, and its prevalence remains uncertain.⁴

Conventional reconstruction prioritizes addressing defects coverage, restoring function, and enhancing aesthetics; by comprehending the lymphatic system anatomy and physiology, surgeons will proactively anticipate and manage any potential complications related to the lymphatic system.⁵

This study aimed to evaluate the effect of using fasciocutaneous free flaps, considering lymphatic axially during flap inset, on lymph flow restoration (LFR) in post-traumatic patients.

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2. Patients and methods

Study Design: Between March 2022 and November 2023, thirty patients with soft tissue loss at an extremity due to trauma were selected from those who sought treatment at the outpatient clinic and emergency room (E.R.) in both plastic surgery department, Al-Hussien & Bab Elsheria Hospital, Faculty of Medicine, Al-Azhar university (Cairo).

All of them gave informed written consent for participation. The study was performed according to the World Medical Association Declaration of Helsinki. Nineteen patients were male, and eleven were female, and their ages ranged from 19 to 52 (mean 36.6 years).

All patients were assessed by plastic surgeons who recommended fasciocutaneous free flap coverage of the defects.

The defect size ranged from 50 to 200 mm²; patients presented with soft tissue defects: eight patients due to recent trauma, twenty-two patients were due to old trauma and unstable scar, all were reconstructed using free flaps, twenty-four with SCIP flap, ten with ALT flap, six with DIEP flap.

All patients were assessed preoperatively and 3: 6 months postoperatively using indocyanine green (ICG) lymphography using an infrared camera system.

Inclusion Criteria

All Patients included in the study fulfilled the following criteria: Age: 18 - 60 years old, Sex: male and female and Cause: trauma either recent or old, Site: extremity.

Exclusion Criteria: Patients with malignancy, a history of radiotherapy related to the target limb, an ischemic limb, or a non-skin flap.

Ethical Considerations: Time was spent with patients and their families, explaining the procedures and ICG lymphography in detail utilizing photographs and video imaging, as well as discussions with other patients who have undergone the procedure. An explanation of the research project was given to the patients and/or their parents, and a consent form was signed by the patients and /or their parents involved in this study.

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

For each patient, the following records were taken:

Preoperative and postoperative photographs, Defect size (cm²) after debridement and release of any contracture, ICG lymphography of donor flap and recipient site preoperatively and three to six months postoperatively to evaluate lymph flow restoration (LFR), Missed gap between lymphatic vessels stumps during flap inset.

Surgical technique: A local anesthetic gel is applied over the targeted site for injection for 15

minutes to reduce the injection pain; under complete aseptic condition, 0.2-0.4 ml of (ICG) (Diagnogreen 0.25%; Daiichi Pharmaceutical, Tokyo, Japan) was injected intradermal and subcutaneous 15 cm distally to donor and recipient sites, circumferential images of the superficial lymphatic system were taken using a near-infrared camera system (Photodynamic Eye; Hamamatsu et al., Japan), these photos were captured promptly following the injection of indocyanine green (ICG) to mark the linear pattern.

Case 1:- As shown in figure 1 (a,b,c,d,e,f & g), a male patient 25 years old, suffered from a contracted scar with a history of degloving injury skin grafting three years ago; he was reconstructed using SCIP free flap.



Figure 1. (a,b,c,d,e,f & g) male patient 25 years

old suffered from contracted scar with history of degloving injury & skin grafting 3 years ago, he was reconstructed using SCIP free flap.

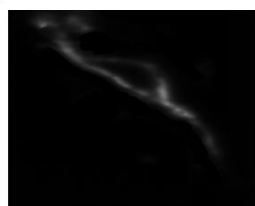
Case 2:- As shown in figure 2 (a,b,c,d & e) A female patient, 20 years old suffered from contracted scar at lt forearm with history of trauma 2 years ago, she was reconstructed with SCIP free flap.



a) Contracted scar at lt forearm



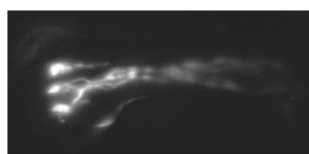
b) SCIP flap elevation



c) Linear pattern at preoperative ICG lymphography of donor flap



d) 6 months post operative



e) 6 month post operative ICG lymphography showing passage of the dye through the flap.

Figure 2. (a,b,c,d & e) A female patient, 20 years old suffered from contracted scar at lt forearm with history of trauma 2 years ago, she was reconstructed with SCIP free flap.

3. Results

The main results of this study were as follows:

The current study enrolled 30 patients with mean age of 36.6 ± 9.5 years and ranged from 19 - 52 years, (63.3%) of patients were males and (36.67%) were females with mean BMI was 26.31 kg/m².

Regarding underlying etiology, we found that twenty-two patients (73.3%) underwent free flap surgery due to unstable scar of an old trauma, eight patients (26.6%) were due to recent trauma.

Regarding site, the most frequent site was Lower leg (26.66%) followed by elbow (16.66%) then upper arm, ankle, and knee (13.33%).

Regarding the used flap of the studied

patients, it was found that 10(33.3%) patients used ALT flap, 6(20%) patients used DIEP flap and 14(46.7%) patients used SCIP flap. Regarding intraoperative (ICG) lymphography findings there was missed gap between lymphatic vessels stump (M gap) at 2 (6.67%) patients and 28 (93.33%) patients were negative regarding to M gap, 26 (86.67%) patients were positive regarding lymphatic axially (LA) during flap inset, and 4 (13.33%) patients were negative, on postoperative (ICG) lymphography, lymph flow restoration (LFR) was observed in 24(63%) cases (linear pattern)

According to demographic data, site, cause of trauma or the used flap there was no statistically significant difference regarding restoration of lymph flow, a statistically significant difference was observed between (LFR) positive and (LFR) negative regarding presence of missed gap between lymphatic vessels stumps and there was highly statistically significant difference between (LFR) positive and (LFR) negative regarding lymph axially.

As shown in Table 1 and Figure 3 according to Cause, this table shows that unstable scar was found in 73.33% and recent trauma was found in 26.66%, the most frequent site was lower leg (26.66%) followed by elbow (16.66%) then upper arm, ankle, and knee (13.33%).

Table 1. Distribution of cause and site of trauma in the studied group.

STUDIED PATIENTS. (N=30)	
CAUSE	
SCAR	22 (73.33%)
RECENT TRAUMA	8 (26.66%)
SITE	
LOWER LEG	8 (26.66%)
UPPER ARM	4 (13.33%)
ANKLE	4 (13.33%)
FOREARM	3 (10%)
FOOT	2 (6.67%)
KNEE	4 (13.33%)
ELBOW	5 (16.66%)

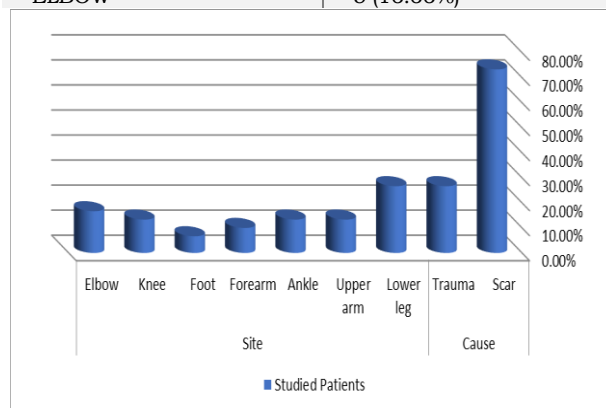


Figure 3. shows distribution of cause and site in the studied group.

According to the used flap, Table 2 and Figure 4 shows that 10 (33.3%) patients used ALT flap, 6 (20%) patients used DIEP flap and 14 (46.7%) patients used SCIP flap.

Table 2. Distribution of the used flap in the studied group.

THE USED FLAP	STUDIED PATIENTS. (N=30)
ALT	10(33.3%)
DIEP	6(20%)
SCIP	14(46.7%)

SCIP: superficial circumflex iliac artery perforator flap , DIEP: deep inferior epigastric artery perforator flap, ALT: anterolateral thigh.

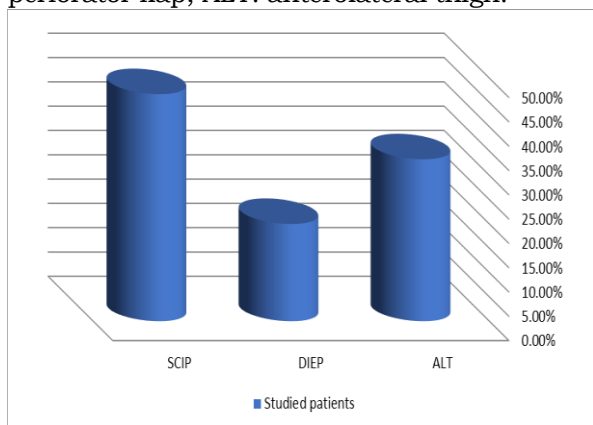


Figure 4. shows distribution of the used flap in the studied group.

According to indocyanine green findings, Table 3 and Figure 5 shows 2 (6.67%) patients were positive and 28 (93.33%) patients were negative regarding to M gap, 26 (86.67%) patients were positive, and 4 (13.33%) patients were negative regarding to LA.

Table (3): Distribution of the intraoperative indocyanine green findings (ICG) in the studied group.

	STUDIED PATIENTS. (N=30)
M GAP	
POSITIVE	2 (6.67%)
NEGATIVE	28 (93.33%)
LA	
POSITIVE	26 (86.67%)
NEGATIVE	4 (13.33%)

ICG: indocyanine green, M gap: missed gap at lymph axiality, LA: lymph axiality.

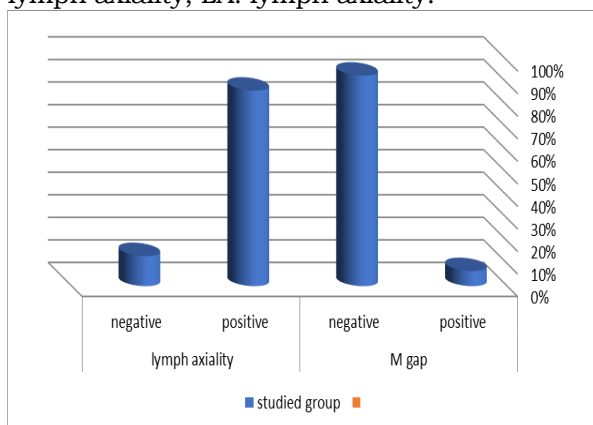


Figure 5. shows distribution of intraoperative indocyanine green findings in the studied group.

According to cause and site, Table 4 and

Figure 6 shows that no statistically significant difference was observed between LFR Positive and LFR negative.

Table 4. Distribution of cause and site of trauma associated with postoperative Lymph Circulation.

CAUSE	LFR POSITIVE (N=24)	LFR NEGATIVE (N=6)	P-VALUE
SCAR	17 (70.83%)	5 (83.33%)	0.53
RECENT TRAUMA	7 (29.16%)	1 (16.67%)	
SITE			
LOWER LEG	6 (25%)	2 (33.33%)	0.54
UPPER ARM	2 (8.33%)	2 (33.33%)	
ANKLE	3 (12.5%)	1 (16.67%)	
FOREARM	3 (12.5%)	0 (0%)	
FOOT	2 (8.33%)	0 (0%)	
KNEE	3 (12.5%)	1 (16.67%)	
ELBOW	5 (20.8%)	0 (0%)	

P value <0.05 is statistically significant

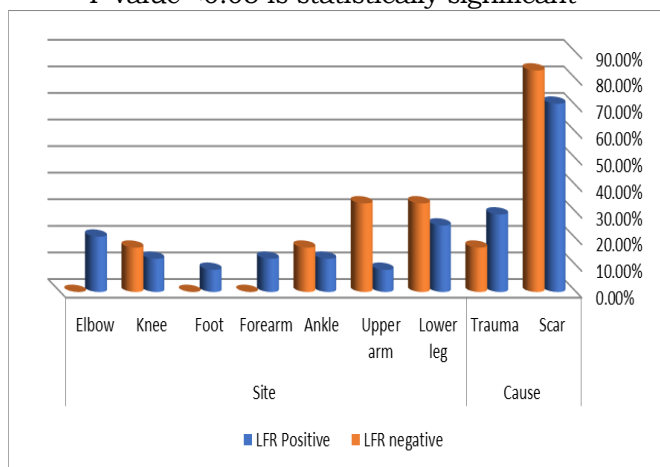


Figure 6. shows distribution of cause and site of trauma associated with postoperative Lymph Circulation.

According to intraoperative indocyanine green findings (ICG), Table 5 and Figure 7 shows that statistically significant difference was observed between LFR Positive and LFR negative as regard Missed gap between lymphatic vessels stump during flap inset (M gap), and there was highly statistically significant difference between LFR Positive and LFR negative regarding lymph axiality.

Table 5. Distribution of the intraoperative indocyanine green findings (ICG) associated with postoperative Lymph Circulation.

	LFR POSITIVE (N=24)	LFR NEGATIVE (N=6)	P-VALUE
M GAP			
POSITIVE	0	2(33.3%)	0.003
NEGATIVE	24(100%)	4(66.7%)	
LA			
POSITIVE	24(100%)	2(33.3%)	<0.0001*
NEGATIVE	0	4(66.7%)	

P value <0.05 is statistically significant, ICG: indocyanine green, M gap : missed gap in between lymphatic vessels stump, LA: lymph axiality.

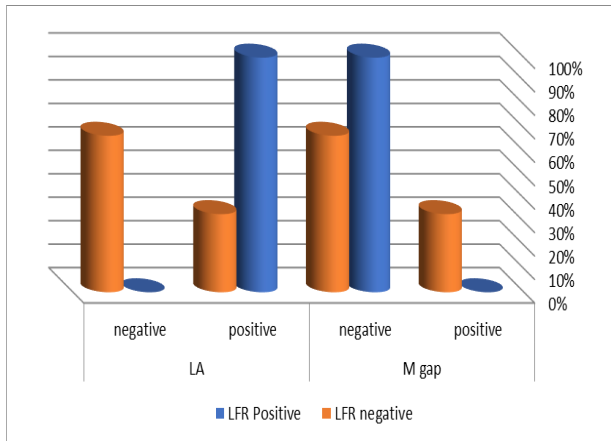


Figure 7. shows distribution of intraoperative indocyanine green findings (ICG) associated with postoperative Lymph Circulation.

4. Discussion

The lymphatic system has a crucial function in the regulation of tissue pressure, absorption of lipids from the intestine, lipid metabolism, immunity, and fluid balances; given that lymphedema can significantly impact patients' quality of life due to persistent inflammation and edema, it is better to consider lymphatic reconstruction at the same time with soft tissue coverage.⁵

prior studies proposed the potential for lymphatic restoration through the use of a free tissue that incorporates lymph vessels to connect through the defect at lymphatic vessels in a soft tissue defect, eliminating the need for lymph node involvement or super microsurgical lymphatic procedures.^{6,7}

Lymph axiality has been identified as the critical factor for restoring lymphatic flow through a flap that covers the lymphatic gap.^{8,9}

This study aimed to evaluate the effect of using fasciocutaneous free flaps, considering lymphatic axiality during flap inset, on lymph flow restoration (LFR) in post-traumatic patients.

Also, our results were in agreement with Yamamoto et al., who aimed to examine the factors that affect the restoration of lymphatic flow following tissue replantation and free tissue transfer by assessing superficial lymphatic system flow through (ICG) lymphography. They demonstrated that the age of their studied population ranged from 22 to 70 years with a median of 42 years; 23 (60%) patients were males, and 40% of patients were females.⁸

Similarly, our findings are in line with Yamamoto et al., who investigated the clinical impacts of lymph interposition flap transfer (LIFT) grounded in the principle of lymph axiality by comparing the rates of lymph flow restoration and lymphedema development (LED) between traditional flap reconstruction and the innovative lymphatic reconstruction method; they reported

that the age of LIFT patients ranged from 23 to 83 years with average 50.3 years, 36 (48.0%) patients were females, and 39 (52.0%) patients were males.³

Similarly, our study agreed with Seddon et al., who determined if lymph flow between the flap and recipient site could be achieved without performing lymphatic surgery; the findings indicated that all anterolateral thigh (ALT) flaps were fashioned in alignment with the limb axis, representing the lymphatic axiality, lymph flow restoration was observed in all seven ALT flaps, in contrast, eight deep inferior epigastric artery perforator (DIEP) flaps were designed upside down, and only one was configured in accordance with lymph axiality, with lymph flow restoration observed solely in the latter case.⁹

As regards intraoperative indocyanine green findings (ICG), the present study showed that 2 (6.67%) patients were positive, 28 (93.33%) patients were negative regarding the missed gap between lymphatic vessels stumps (M gap), 26 (86.67%) patients were positive, and 4 (13.33%) patients were negative regarding lymph axiality (LA).

As regards intraoperative indocyanine green findings (ICG), our results agreed with Yamamoto et al., who illustrated that raw surface between lymphatic vessels stump was seen in two cases (5%), and positive lymph axiality was seen in 25 cases (66%).⁹

The current study demonstrated that there was no statistically significant difference between LFR Positive and LFR negative regarding the type of flap used. According to intraoperative indocyanine green findings (ICG), the present study demonstrated that in LFR Positive, 24 (100%) patients were negative (M gap), and 24 (100%) patients were positive LA, while in LFR negative, there were 4 (66.7%) patients had negative (M gap) and positive LA, a statistically significant difference was observed between LFR Positive and LFR negative regarding the missed gap in lymph axiality. There was a highly statistically significant difference between LFR Positive and LFR Neg regarding lymph axiality during flap inset.

Similarly, our results are consistent with Yamamoto et al who showed that in LFR Positive, 24 (100%) patients had negative RLA, and 24 (100%) patients had positive compatible lymph axiality (CLA), while in LFR negative, there were 12 (85.7%) patients had negative RLA and 13 (54%) patients had negative (CLA), statistically significant difference was observed between LFR Positive and LFR negative regarding compatible lymph axiality. While there was no statistically significant difference between LFR Positive and LFR negative as regard raw surface in lymph axiality, as regard to lymphatic axiality, the

condition in which negativity of raw surface between lymphatic vessels stump with positivity of lymph axially " was perfectly aligned with achieving lymph flow restoration, with a 100 percent accuracy rate in predicting postoperative restoration lymphatic flow.⁸

Similarly, our results line with those of Pereira et al. Who demonstrated that during undertaking soft tissue reconstruction following trauma in a critical area of lymphatic drainage, it is advisable to contemplate the utilization of flaps abundant in lymphatic vessels; the inset should be conducted in alignment with the axially of the drainage; this approach allows for the potential restoration of limb lymphatic drainage without the necessity for lymph node transfer surgery or super-microsurgical lymphatic procedures.¹⁰

4. Conclusion

Lymph flow restoration can occur following free flap transfer at an extremity without the need for lymph node involvement or super microsurgical lymphatic anastomosis; free flap transfer based on lymph axially, coupled with the absence of any missed gaps between lymphatic vessel stumps, is considered the key for lymph flow restoration at the extremities of post-traumatic patients.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

References

1. González-Loyola A, Petrova TV. Development and aging of the lymphatic vascular system. *Adv Drug Deliv Rev.* 2021;169:63-78
2. Quartuccio N, Agugliaro F, Alongi P, Sturiale L, Arnone G, Corrao S. A Systematic Review Comparing Lymphoscintigraphy and Magnetic Resonance Imaging Techniques in the Assessment of Peripheral Lymphedema. *Curr Med Imaging.* 2022;19(5):469-475
3. Yamamoto T, Yamamoto N, Kageyama T, Sakai H, Fuse Y, Tsukuura R. Lymph-interpositional-flap transfer (LIFT) based on lymph-axially concept: Simultaneous soft tissue and lymphatic reconstruction without lymph node transfer or lymphatic anastomosis. *J Plast Reconstr Aesthet Surg.* 2021;74(10):2604-2612
4. Pereira N, Cámbara Á, Kufeke M, Roa R. Post-traumatic lymphedema treatment with superficial circumflex iliac artery perforator lymphatic free flap: A case report. *Microsurgery.* 2019;39(4):354-359
5. Stritt S, Koltowska K, Mäkinen T. Homeostatic maintenance of the lymphatic vasculature. *Trends Mol Med.* 2021;27(10):955-970
6. Yamamoto T, Yamamoto N, Kageyama T, et al. Supermicrosurgery for oncologic reconstructions. *Glob Health Med.* 2020;2(1):18-23.
7. Kagami S, Akita S, Kubota Y, Mitsukawa N. Bridging Lymphatic Vessel Defects with a Perforator Flap that Contains Retrograde Axial Lymphatic Flow. *Plast Reconstr Surg Glob Open.* 2021;9(9):e3805
8. Yamamoto T, Iida T, Yoshimatsu H, Fuse Y, Hayashi A, Yamamoto N. Lymph Flow Restoration after Tissue Replantation and Transfer: Importance of Lymph Axiality and Possibility of Lymph Flow Reconstruction without Lymph Node Transfer or Lymphatic Anastomosis. *Plast Reconstr Surg.* 2018;142(3):796-804.
9. Sedbon T, Azuelos A, Bosc R, et al. Spontaneous Lymph Flow Restoration in Free Flaps: A Pilot Study. *J Clin Med.* 2022;12(1):229.
10. Pereira N, Oñate V, Roa R. A Comprehensive Approach to Posttraumatic Lymphedema Surgical Treatment. *Arch Plast Surg.* 2023;50(4):422-431