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CLINICAL TIP

Murphy's Slap

I wish to describe a clinical sign, which I call 'Murphy's Slap' for assessing the healing of split skin graft donor sites.

Over 15 years of clinical practice in plastic surgery nursing, I have used the following method to determine whether or not split skin graft donor sites have healed. At the time at which a donor site should have healed, usually day 10 to day 14, I ask the patient to slap their own thigh on top of the dressing over the donor site. If the patient reports pain, the wound is judged not to have healed and the dressing is left intact. When the test is negative, that is, the slap does not cause any pain, the wound is judged to be healed and the dressing is removed. The test is particularly applicable to thigh donor sites, but can be used on any split skin graft donor site. I have used this test for 15 years and have never uncovered an unhealed wound as a result of it nor have there been any problems applying the test. Exceptions to the rule are when the dressing has been on for longer than 14 days, or if the patient complains of pain judged to be out of proportion to an uncomplicated healing donor site wound. In both these cases I would remove the dressing to inspect the wound.

I have not seen this described before and have found it to be invaluable. This test obviates the need to remove the dressing in order to assess for signs of healing, a move which may cause unnecessary pain and be detrimental to the healing process of the donor site.

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HEMODYNAMIC ALTERATIONS IN THE TRANSFERRED TISSUE TO LOWER EXTREMITIES

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A higher incidence of failure has been reported for free flaps transplanted to the lower extremities. However, the physiological background of this phenomenon has not been elucidated. We reviewed the 3-day postoperative hemodynamic data for 103 free flaps, including the in situ venous pressure (N = 103), arterial pressure (N = 53), and surface blood flow (N = 42). The cases were divided into two groups based on the recipient site, i.e., lower extremity (the LE group: N = 29) and the other (non-LE group: N = 74). The venous pressure was significantly higher in the LE group (26.6 ± 2.2 vs. 14.8 ± 1.2 mmHg), whereas the arterial pressure immediately after surgery was lower than the non-LE group. The hemodynamic data within the transferred tissues demonstrated significant differences between groups, especially in the early postoperative period. There is a possibility that the high venous pressure may aggravate the poor perfusion in tissues transferred to the lower extremities. ©2008 Wiley-Liss, Inc. Microsurgery 29:000–000, 2009.

Lower extremity reconstruction has enjoyed renewed interest with the development of free tissue transfers.[1–3] However, thrombosis and flap failure remain major complications of this method. Despite improved overall success rates approaching 99% in several retrospective analyses of free flaps,[4–6] transfers to the lower extremities still show failure rates of more than 10%, especially under posttraumatic conditions.[2,7,8] Although a multitude of factors determine the success or failure of a microvascular free tissue transfer,[9] the actual reason for the higher risk of flap failure in lower extremity reconstruction has not been elucidated. Infection has been suggested as a predominant cause of morbidity in free flaps transferred to the lower legs.[10] However, other factors must be considered in the majority of cases of failure in which aggressive wound care and antisepsis were properly undertaken. Hypercoagulability associated with thrombocytosis may be related to the higher incidence of vascular thrombosis in lower leg reconstructions,[11] although this scenario also is applicable only to limited cases in limited situations.

The vascular system in the legs is unique because it has a high hydrostatic pressure during orthostasis,[12,13] and it is easily affected by several disorders on both the arterial and venous sides. We hypothesized that tissues transferred to the lower extremities may present different hemodynamics compared with other parts of the body in the early postoperative period. Currently, we have developed a novel method for monitoring the flap circulation with regard to the intraparenchymatous vascular pressure.[14] This study is based upon data collected in patients who underwent microvascular free tissue transfer with this novel monitoring system. The patient profiles such as sex, etiology, and preferred tissue for reconstruction and recipient vessels were totally different among patient groups. In spite of these inherent differences, we decided that it would be informative to determine the hemodynamic characteristics in tissues transferred to different recipient sites.

PATIENTS AND METHODS

Patients

This study included 103 consecutive patients who underwent free tissue transfer with venous pressure monitoring between 2003 and 2007. This monitoring system, approved by the ethical committee of Tokyo Women's Medical University, included a continuous data acquisition system,[14] therefore, we retrospectively reviewed hemodynamic data in the transferred flap. The patients with a history of cardiopulmonary disorder or hypertension were excluded in the study. All patients underwent surgery under general anesthesia. There were 38 female and 65 male patients. The patients ranged in age from 9 to 82 years, with a mean age of 54 years. The patients were divided into two groups depending on the recipient site, lower extremity (LE group; N = 29), and other sites (non-LE group; N = 74). The specific donor sites employed in the two groups are shown in the Table 1. In the LE group, we preferentially used the deep venous system rather than the superficial venous system as the recipient vein (Table 2). We included four cases of stasis ulcer because of superficial venous insufficiency, for which superficial venous stripping was performed prior to the free tissue transfer.

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Venous Pressure Measurements

The patients were fully informed concerning the reasons, the technique of catheter placement, the details of the monitoring procedure, and the consequences as well as possible complications associated with catheter placement.

After completion of vascular anastomoses, an intravenous catheter (3 Fr, 1.0-mm OD, Atom Medical, Tokyo, Japan) was inserted into a side branch of the anastomosed vein. The catheter was then connected to a fluid pressure transducer (P23ID, Statham Gould, Oxnard, CA) and to a physiological recorder (BSS-9800, Nihon Kohden, Tokyo, Japan). The line solution of the venous catheter contained heparin at 10 U/ml in 0.9% sodium chloride, and the flow rate of the flush solution was ~3 ml/hr, resulting in continuous infusion of the heparin at 720 U/day. Zero calibrations were taken at the level of the right atrium.

Three days after the operation, the catheter was locked and disconnected from the transducer, but left in position for a further 4 days. Thereafter, the catheter was gently tugged at and withdrawn from the flap.

Table 1. Patient Profiles: Gender, Age, and Donor Site

	LE group (N = 29)	Non-LE group (N = 74)
Male/female	24/5	41/33
Age (year)	49 ± 4	52 ± 2
Type of tissues		
Anterolateral thigh flap	15	16
Groin flap	5	9
LD musculocutaneous flap	3	11
Omentum	2	
Fibula osteocutaneous flap	2	4
Rectus abdominis MC flap		12
Jejunum		7
Forearm flap		6
DIEP flap		3
DP		3
Others	2	3

Table 2. Patient Profiles of the LE Group

No.	Sex	Age	Ethiology	Flap	Recipient vessel: Artery	Recipient vessel: Vein	Measurement: VP	Measurement: AP	Measurement: LDP	Comment
1	M	29	Tibial bone open fracture	FOCF	PTA	PTV	+			
2	M	64	Intractable ulcer on the lower leg	ALT	ATA	ATV	+			
3	M	74	Intractable ulcer on the lower leg	Omentum	ATA	ATV	+	+		
4	M	71	Tibial bone open fracture	FOCF	ATA	ATV	+			
5	M	35	Traumatized lower leg	ALT	ATA	ATV	+	+		Arterial thrombosis
6	M	59	Intractable stasis ulcer on the lower leg	Omentum	ATA	ATV	+	+		
7	M	17	Scar contracture of the dorsal foot	Groin flap	DPA	GSV	+			
8	M	68	Chronic osteomyelitis of tibial bone	ALT	ATA	ATV	+	+	+	
9	M	71	MM at the heel	ALT	PTA	PTV	+		+	
10	M	46	Intractable stasis ulcer on the lower leg	ALT	PTA	PTV	+		+	
11	M	43	SCAR contracture around knee joint	Groin flap	DGA	GSV, DGV	+	+	+	
12	M	80	SCC at the medial foot	ALT	PTA	PTV	+	+	+	
13	F	63	Intractable stasis ulcer on the lower leg	ALT	PTA	PTV	+	+	+	
14	M	55	Chronic osteomyelitis of the femur	ALT	DGA	GSV	+	+	+	
15	M	9	Degloving injury of the foot	LD	ATA	ATV	+	+	+	
16	M	28	Mangled lower extremity	Fillet flap	FA	FV	+			
17	M	33	Intractable ulcer on the foot	ALT	ATA	ATV	+	+		Hematoma
18	F	64	Intractable ulcer on the lower leg	LD	ATA	ATV	+			
19	F	13	Postburn contracture on the thigh	Groin flap	SIEA	GSV	+		+	
20	M	68	SCC on the lower leg	ALT	ATA	ATV	+	+	+	
21	F	58	AVM on the foot	Groin flap	LTA	SSV	+	+	+	
22	M	49	Postburn contracture on the lower leg	Scapular flap	DGA	SSV	+		+	
23	M	49	Diabetic ganglene	ALT	ATA	ATV	+	+		
24	M	59	Intractable ulcer on the lower leg	LD	FA	ATV	+	+		
25	M	64	Traumatized foot	Groin flap	DPA	GSV	+	+	+	
26	M	20	Traumatized foot	ALT	PTA	PTV	+	+	+	
27	F	68	Intractable stasis ulcer on the lower leg	ALT	PTA	PTV	+	+	+	Venous thrombosis
28	M	48	Intractable ulcer on the foot	ALT	ATA	ATV	+	+	+	
29	M	17	Intractable ulcer on the foot	ALT	PTA	PTV	+	+	+	

M, male; F, female; FOCF, fibula osteocutaneous flap; ALT, anterolateral thigh flap; LD, latissimus dorsi MC flap; PTA (V), posterior tibial artery (vein); ATA (V), anterior tibial artery (vein); DPA, dorsalis pedis artery; DGA(V), descending genicular artery (vein); LTA, lateral tarsal artery; GSV, great saphenous vein; SSV, small saphenous vein.

Arterial Pressure Monitoring

Fifty-three of the patients (LE group: 19, non-LE group: 34) also underwent in situ arterial catheterization for further hemodynamic analysis. The method was essentially the same as that for the venous catheterization. However, the line solution of the arterial catheter did not contain hèparin, avoiding the risk of bleeding tendency in the transferred tissue. In some case, the arterial catheterization was impossible because of the small size of the diameter. In those cases, we used Doppler auscultation for the monitoring of arterial thrombosis.

Laser Doppler Flowmetry

In addition, the surface blood flow was continuously monitored in 42 patients (LE group: 17, non-LE group: 25) using a laser Doppler flowmeter (Laserflo BPM 403, TSI, St. Paul, MN) with a standard right angle probe having a head diameter of 19 mm (Model P-430). This probe is applicable only to the exteriorized skin island. This apparatus provided flow rates in millimeters per minute per 100 g of tissue.

Data Acquisition

All parameters were continuously recorded for 3 days at a sampling frequency of 250 Hz via a commercial data acquisition system (PowerLab®, AD Instruments Pty., Australia). During this postoperative period, all patients were confined to bed rest. Because all parameters were influenced by the patient's positioning, posture, and movements, analysis was performed of sections showing stable hemodynamics for more than 30 minutes while the patients were at rest and in the supine position (immediately after surgery and 12 and 72 hours after surgery). The mean values of the venous pressure, arterial pressure, and blood flow were obtained using the customized program included in the data acquisition system (PowerLab).

Data Analysis and Statistics

Data are expressed as means ± SEM. The effects of different recipient sites (i.e., LE, non-LE groups) on the hemodynamic data were tested using ANOVA with repeated measures across time. Statistical significance was defined as a P value of 0.05 or less. All statistical analyses were performed with SAS statistical package version 8.2.

RESULTS

There were three cases with postoperative anastomotic failure (two cases of venous thrombosis and one case of arterial thrombosis) in the 103 cases. One of the cases with venous thrombosis received a mandibular reconstruction with free fibular osteocutaneous flap (in the non-LE group). In this case, cutaneous flap was located in the oral cavity, therefore, the flow probe of the LDF was not readily applicable. The other case who developed venous thrombosis presented with an intractable stasis ulcer. In this case, we applied both venous pressure monitoring and LDF monitoring. Both methods were quite sensitive responding the compromised venous outflow. The arterial thrombosis in another case was detected with the continuous arterial pressure monitoring. All three cases were successfully salvaged by the early detection with the monitoring system. There was no statistically significant difference in the incidence of the vascular thrombosis between two groups.

Free flaps transplanted to the lower extremities demonstrated a significantly higher venous pressure compared with the other sites (LE: 26.6 ± 2.2 mmHg, non-LE: 14.8 ± 1.2 mmHg) (see Fig. 1). The high venous pressure in the LE group declined gradually, whereas the venous pressure in the non-LE group remained virtually unchanged during the 3-day postoperative period.

The arterial pressure in the LE group was significantly lower than that in the non-LE group (see Fig. 2). Therefore, the arteriovenous pressure gradients, defined as the driving pressure for perfusion of transferred tissues, showed significant differences between groups (see Fig. 3). The driving pressure in the LE group was 52.6 ± 3.7 mmHg immediately after surgery, whereas those in the non-LE group was 75.0 ± 2.4 mmHg. Thereafter, the lower driving pressure in the LE group gradually increased to 59.8 ± 3.6 mmHg at 72 hours after surgery; however, it was still significantly lower than the non-LE group.

The surface blood flow measured by the laser Doppler flowmeter in the LE group was 2.2 ± 0.6 ml/min/100 g immediately after surgery, whereas that in the non-LE group was 3.7 ± 0.5 ml/min/100 g (see Fig. 4). There was no statistically significant difference between groups. As the driving pressure increased during the 3-day postoperative period, the blood flow increased significantly in the LE group (4.1 ± 0.9 ml/min/100 g on the 3rd postoperative day). On the other hand, the blood flow in the non-LE group was relatively constant during the 3-day postoperative period.

DISCUSSION

Free tissue transfer using a microvascular technique has been firmly established since its introduction more than three decades ago. However, little is known about the physiological aspects within the transferred tissue. The monitoring technique currently developed in our institution,[14] in which the in situ vascular pressure can be continuously measured, provides us a great opportunity to elucidate the hemodynamic changes after free tissue transfer. Although this method required catheterization of

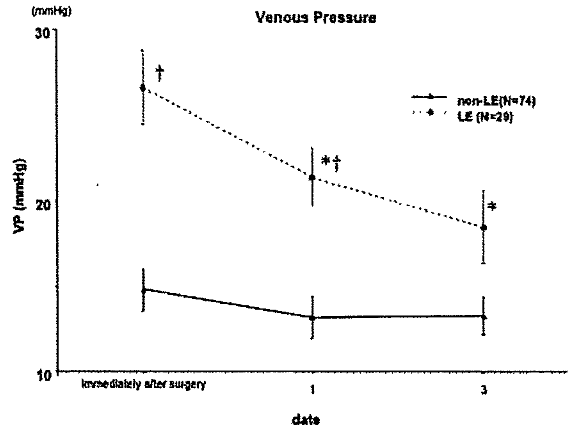

Figure 1. Changes in venous pressure within the tissues transferred to the lower extremity (LE group) and the other sites (non-LE group). Values are given as the mean ± SEM. *: Significant difference ($P < 0.05$) from the value immediately after surgery. †: Significant difference ($P < 0.05$) between groups.

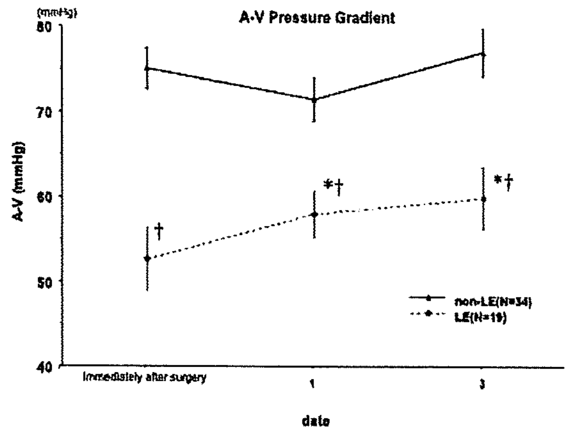

Figure 3. Changes in arteriovenous pressure gradient within the tissues transferred to the lower extremity (LE group) and the other sites (non-LE group). Values are given as the mean ± SEM. *: Significant difference ($P < 0.05$) from the value immediately after surgery. †: Significant difference ($P < 0.05$) between groups.

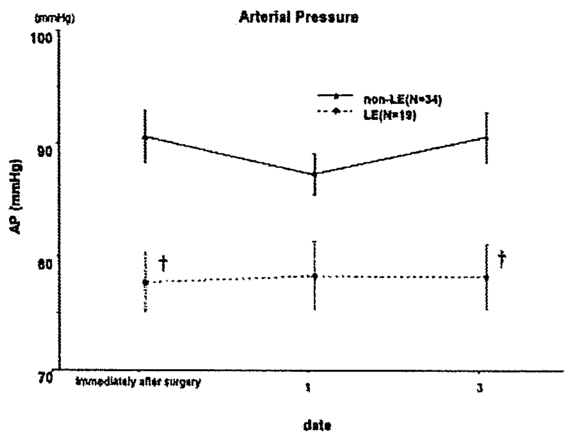

Figure 2. Changes in arterial pressure within the tissues transferred to the lower extremity (LE group) and the other sites (non-LE group). Values are given as the mean ± SEM. †: Significant difference ($P < 0.05$) between groups.

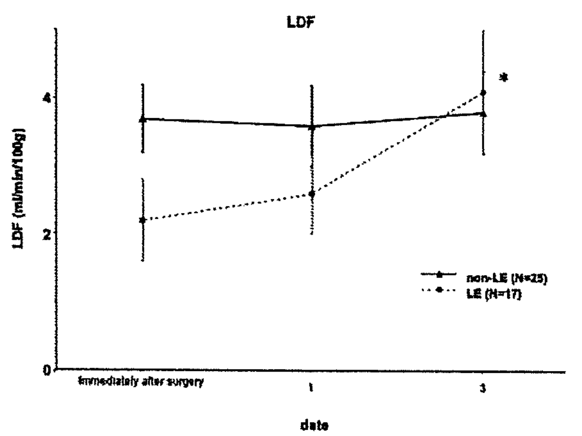

Figure 4. Changes in the value of LDF after free tissue transfer. Values are given as the mean ± SEM. *Significant difference ($P < 0.05$) from the value immediately after surgery.

the vessels within the transferred flap, the safety and efficacy of such catheterization has been well documented in previous reports in which anticoagulant agents were continuously infused through a catheter.[15–17]

In this study, the hemodynamic data within the transferred tissue were strongly influenced by the recipient site. The venous pressure in the LE group was significantly higher compared with the values in the non-LE group. It is conceivable that the positioning of the lower extremities may affect the venous pressure. Because we analyzed the venous pressure during the initial 3 days after surgery while the patients rested in bed the whole day, the gravitational effects on the venous pressure were considered to be at a minimum. Additionally, the site of the arterial catheterization was identical to the venous catheterization; therefore, the effect of the position of the recipient sites on the hemodynamic data was negligible when one looked at the pressure gradient between the arterial and venous sides. Because the arterial pressure in the LE group was significantly lower than that in the non-LE group, the arteriovenous pressure gradient showed clear differences between the groups. According to the concept of Burton,[18] a decreased driving pressure results in reduced blood flow. Although we could not detect significant difference in the incidence of anastomotic failure between the two groups, there is a possibility that the hemodynamic differences might be related to the reported high failure rates in lower leg reconstruction using free-tissue transfer.[2,7,8]

Lower limb hemodynamic impairment associated with surgery and general anesthesia has been well documented. Foate et al.[19] reported that the mean arterial leg blood flow in patients under general anesthesia was only 28% of the control at 1 hour after surgery. This compromised arterial inflow has been linked to a higher rate of early postoperative graft failure in infrainguinal arterial bypass surgery, whereas epidural anesthesia did not cause this adverse effect of general anesthesia.[20] Knaggs et al.[21] reported that the maximal venous flow attenuation was seen during the early recovery period. By disrupting the laminar flow of the venous circulation, stasis brings platelets into contact with the endothelium, leads to the build-up of thrombi and promotes the activation of endothelial cells, setting off a vicious circle of hypercoagulability. Although the mechanisms involved in the susceptibility of the lower leg hemodynamics to general anesthesia and surgical interventions are not fully understood, the early postoperative period is the most critical for vascular compromise even after free tissue transfer.

Despite the lower driving pressure in the LE group, we could not detect significant differences in the LDF data. This inability to detect differences may be attributed to the method we used for assessment of the blood flow. It is well known that the flow values with LDF vary greatly depending on the patient and the type of tissue.[22–24] Therefore, one must not rely on absolute values, and recent reports emphasize the importance of observing the trend of the perfusion rather than the absolute value.[22,23] It is of interest that the decrease in the venous pressure during a 3-day postoperative period was associated with an increased blood flow in the LE group.

When the venous pressure in a limb is elevated to more than 25 mmHg, the cutaneous, subcutaneous, and muscle vascular resistances increase within that region, resulting in a reduction in blood flow of about 40%.[13] This reflex has been termed the venoarteriolar response, because stretch receptors located in small veins induce changes in the arteriolar vascular tone "upstream" of the veins.[12] A local mechanism, not the central neurogenic response, seems to mediate the venoarteriolar response. Therefore, the high venous pressure may aggravate the poor perfusion in the transferred tissue through this response, leading to the high incidence of failure in lower limb reconstruction.

This study is limited by its small number of patients. Further investigations are warranted to determine the effects of injury-related variables, the type of transferred tissue, the selection of the recipient vessels, local heparinization, and epidural anesthesia. Nonetheless, monitoring the vascular pressure through in situ catheterization provided us further insight into the pathophysiology after free tissue transfer.

CONCLUSIONS

In summary, tissues transferred to the lower extremities demonstrated a higher venous pressure and poorer perfusion immediately after surgery compared with tissues transferred to other parts of the body. Thereafter, the venous pressure gradually decreased in association with an increase in the blood perfusion of the flap. There is a possibility that the impaired hemodynamics in tissues transferred to the lower extremities might be a contributing factor to the higher incidence of flap failure during the early postoperative period.

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Case reports

Prefabricated flap for multiple facial units reconstruction using a jejunal seromuscular patch as a vascular carrier

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1. Introduction

Prefabricated flap is a versatile reconstructive option especially in patients with severe burns, because it can create new donor sites without limitation of natural vascular territories. In this method, a vascular carrier is implanted to a new skin territory. Following a period of maturation and neovascularization, the prefabricated flap can be transferred, based on the implanted pedicle. The very first attempt of prefabricated flap was reported by Washio [1] in a canine model using an intestinal seromuscular patch as the vascular carrier. However, the development of various types of tissue transfer, such as muscle [2], fascia [3], and vascular pedicle alone, has precluded the usage of intestine in this clinical setting.

For reconstruction of the facial skin, the concept of the aesthetic units [4] has been well accepted since its introduction more than five decades ago. Prefabricated flaps have been utilized for reconstruction of individual aesthetic unit such as nose, ear, cheek, lip and neck [5–7]. However, in a case of composite units defect, a single vascular carrier may not be sufficient to perfuse all units to be reconstructed. In these cases, separated vascular carriers that can nourish each unit independently are desirable. We experienced a case in which the units of nose, upper lip, and lower lip were simultaneously reconstructed with a prefabricated flap. In this case, we used jejunal seromuscular patches as "vascular carriers", because the jejunum could be divided in multiple segments owing to the arcade structure of the vessels. Description of the technical details and the experience gained with the patient form the basis of this report.

2. Case Repot

A 72-year-old man sustained a 37.5 percent body surface area burn, including the whole face, neck, upper and lower extremities. Association of severe inhalation injury resulted in complete laryngeal obstruction necessitating tracheotomy. Sequential debridement and skin grafting were required to primarily close the burn wound. After complete wound closure, the patient presented with severe facial deformities including partial loss of the nose and bilateral ears (Fig. 1). The lower lip was severely pulled down, resulting in poor oral hygiene and interference with the oral sphincter function. The left anterior chest was left intact for the facial reconstruction, and we initiated a plan to develop a prefabricated flap in this area for the simultaneous reconstruction of the composite aesthetic units including nose, upper lip and lower lip.

The jejunal segment was followed to approximately 40 cm below the ligament of Treitz, where the vascular arcades were evaluated by transillumination. Approximately 25 cm of jejunum was harvested to obtain the long pedicle. The

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Fig. 1 – Preoperative findings.

methods to elongate the vascular pedicle were described elsewhere [8,9]. Briefly, the oral side of the mesentery was dissected transversely leaving the most distal arcade, vasa recta, while the anal side of the arcade was connected to the mesenteric artery and vein. After completion of the revascularization with microvascular anastomoses of jejunal vessels to the left facial artery and vein, the jejunal flap was divided into three segments. After the conduits of the jejunum were opened, the mucosa was hydrodissected with an epinephrine solution in order to decrease cumbersome oozing and to facilitate dissection [10]. The mucosa was sharply dissected away leaving a thin seromuscular layers (Fig. 2). These three seromuscular flaps were implanted to the subcutaneous layer of the anterior chest through the incision of the suppositional oral orifice, for prefabrication of nose, upper lip, and lower lip, independently. At the same time, costal cartridge was transplanted to the nasal portion sandwiched between skin and transferred seromuscular layer. (Fig. 3)

Fig. 2 – Jejunal seromuscular flaps after dissection of the mucosal layer.

Five weeks after surgery, the prefabricated flap was elevated. The vascular pedicle and implanted jejunal segment were easily dissected with minimum adhesion to the underlining tissue (Fig. 4). Even after fenestration for the mouth and nostrils, three segments of the prefabricated flap demonstrated stable perfusion. After transplantation of the prefabricated flap, the donor site was closed with mesh skin grafting (Fig. 5). The Postoperative course was uneventful, and free from complications. Three years after surgery, the shape of the nose was well maintained without any shrinkage of the prefabricated flap (Fig. 6).

3. Discussion

Severe post-burn scarring of the face presents a formidable challenge to the reconstructive surgeon. Skin grafts are generally used during acute burn management, but they almost invariably contract over time. Because full supplementation of dermis and soft tissue is required to correct a fundamental problem, various types of flaps have been used to reconstruct the facial skin [11,12]. In addition to functional considerations, this area needs to be reconstructed with the concept of aesthetic unit [4,11].

The clinical applications of flap prefabrication have increased reconstructive capabilities and overcome problems not solved satisfactorily by the available classical free flaps. Because this method can also modify the shape of skin flaps, reconstruction of individual units such as nose, ear, cheek, lip and neck have been previously reported [5–7]. The prerequisites for an ideal vascular carrier for prefabricated flap are high

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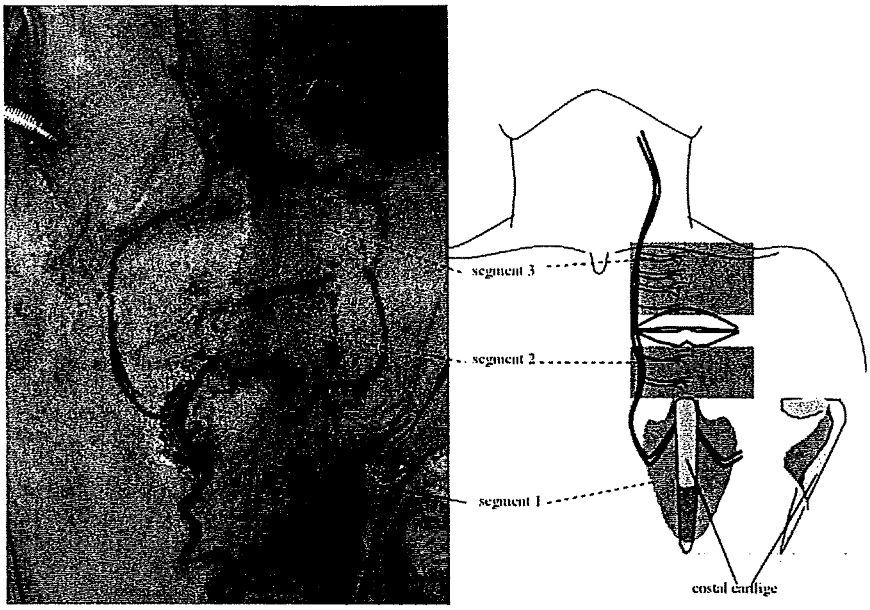

Fig. 3 – Prefabricated flap created in the left anterior chest. Segment 1: prefabrication for nsasal reconstruction. The costal cartridge was transplanted between skin and transferred seromuscular layer. Segment 2: prefabrication for upper lip reconstruction. Segment 3: prefabrication for lower lip reconstruction.

Fig. 4 – Dissection of the prefabricated flap. The vascular pedicle and implanted jejunal segments were easily dissected with minimum adhesion to the underlining tissue.

intrinsic vascularity, a vascular pedicle of adequate length and caliber, limited bulk, acceptable donor site morbidity, and predictable ability to form new vascular connections. In the previous study, Tark et al. [13] demonstrated that the musculovascular pedicle surpasses the other carriers in revascularization of new tissues, with its abundant vascular beds and a vascular pedicle of adequate length and caliber. However, the bulkiness and donor site morbidity may limit the use of muscles as carriers. On the other hand, a fasciovascular pedicle is a thin pliable tissue that allows wider attachments to the area of prefabrication, although it is lagging in quantitative skin-surface perfusion because of less intrinsic vascularity [13]. In this regard, the jejunal seromuscular patch met all properties expected for the ideal vascular carrier.

Small intestinal submucosa (SIS) is a type I collagen-based biomaterial extracted from the porcine intestine in a manner that removes all cells. This material can attract host cell migration [14,15], therefore, it has been clinically used as a scaffold for tissue engineering in a variety of systems such as the bladder [16], urethra [17], blood vessels [18], tendon [19], and the abdominal wall [20]. In addition, the SIS has been reported to induce the proliferation of human dermal microvascular endothelial cells, producing several angiogenic cytokines [21,22] such as fibroblast growth factor (FGF-2), transforming growth factor-β(TGF-β), and vascular endothelial growth factor (VEGF). These favorable properties of the SIS in tissue engineering supported the superiority of the jejunal seromuscular patch as the vascular carrier of prefabricated flaps.

The unique architecture of the mesenteric vessels was the major reason why the jejunal seromuscular patch was used in this particular patient who required composite facial units reconstruction. After fenestration for the mouth and nostril, a single vascular carrier may not be sufficient to perfuse all units. The jejunal patch could be easily divided into three

Fig. 5 – Simultaneous reconstruction of the composite facial units. (Left) elevated prefabricated flap. (Right) immediately after operation.

Fig. 6 – Three years after reconstruction.

segments, facilitating simultaneous reconstruction of three different facial units.

To the best of our knowledge, this is the first report of clinical application using intestinal seromuscular patch as a vascular carrier for prefabrication. Although necessity of a laparotomy is a drawback of this method, it is worthy to be considered especially when the composite facial units need to be restored with limited donor site.

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◆特集／四肢のリンパ浮腫の治療

Untied Stay Suture 法によるリンパ管静脈吻合とリンパ管静脈吻合術の有効性

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Key Words：リンパ浮腫(lymphedema)，リンパ管静脈吻合術(lymphaticovenous anastomosis)，マイクロサージャリー(microsurgery)，超微小血管吻合術(supermicrosurgery)，蛍光リンパ管造影法(fluorescence lymphography)

Abstract　当科では2006年4月よりICG蛍光リンパ管造影法を用いたリンパ管静脈吻合術を行っている．手術手技では，我々の考案した1st stay sutureをuntied sutureとし，2nd stay sutureの糸が通ってから両方の糸を結紮するUntied Stay Suture法を，特に0.3～0.5 mm以下のリンパ管静脈吻合に応用している．現在までの手術症例数は上肢13例，下肢63例，合計76症例である．今回術後5か月以上経過観察できた上肢12例・下肢37例を対象に評価した．上肢・下肢症例を合わせた54肢の結果はexcellent 17肢(31%)，good 21肢(39%)，fair 9肢(17%)，poor 7肢(13%)であり，70%に効果を示した．

はじめに

従来，我々は四肢リンパ浮腫に対して，光嶋ら[1)]が報告したスーパーマイクロサージャリーテクニックを用いたリンパ管静脈吻合術(LVA：lymphaticovenous anastomosis)を行ってきた．2006年4月にICG蛍光リンパ管造影法(FL-ICG：fluorescence lymphography using ICG)を導入することにより，リンパ管の同定が容易となり，また吻合直後にリンパ管から静脈内にリンパ液が入っていることを確認できるためLVAがより確実になってきた．さらに我々の考案したUntied Stay Suture(USS)法は0.5 mm以下のリンパ管や微小血管の吻合には有用であり，LVAの有効性と併せて報告する．

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Untied Stay Suture 法によるリンパ管静脈吻合

まずICG蛍光リンパ管造影法を用いリンパ管を観察する．手背や足背などの任意の場所にICGを皮内注射し，特殊な赤外線カメラ(Photo Dynamic Eye：PDE．浜松ホトニクス社製)で観察すると，リンパ管はICGの線状の流れとして造影される(図1)．

リンパの流れに沿ってボールペンで直上の皮膚にマーキングをいれ，同部を切開し顕微鏡下にリンパ管を探して確認し，同時に皮静脈も確保しておく．静脈にはsingle clampを付けるが，リンパ管はリンパ液を流したままのほうが開口部を確認しやすいのでclampを付けない．静脈はできるだけ尾側で，リンパ管は頭側で切離し，縫合部に緊張がかからないようにする(図2)．

口径が0.5 mm以上のリンパ管の吻合は11-0ナイロン糸で4～6針を目安に従来の微細血管吻合法を用いる．0.3～0.5 mm以下のリンパ管の吻合には12-0ナイロン糸で我々の考案したUntied Stay Suture法を用いている．

まず静脈側より針を入れる．鑷子の先が血管内

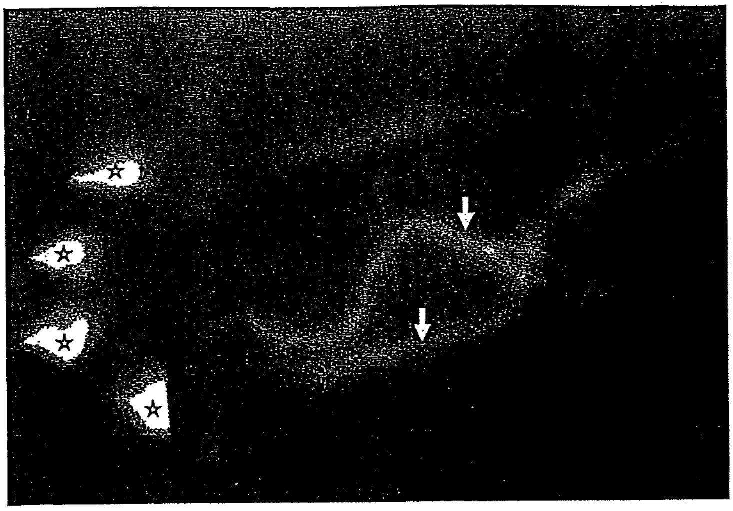

図 1. PDE を使った FL-ICG によるリンパ管の観察
星印：ICG を趾間部に皮内注射
黄色矢印：造影された足背部のリンパ管

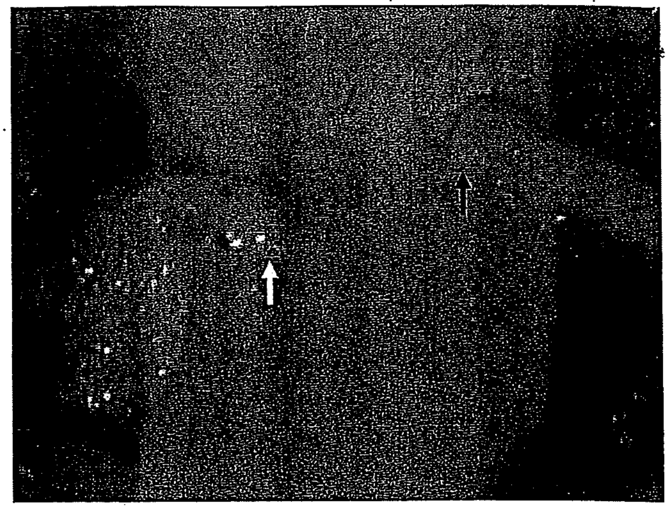

図 2. 吻合直前のリンパ管と皮静脈
青色矢印：皮静脈断端
黄色矢印：リンパ管断端

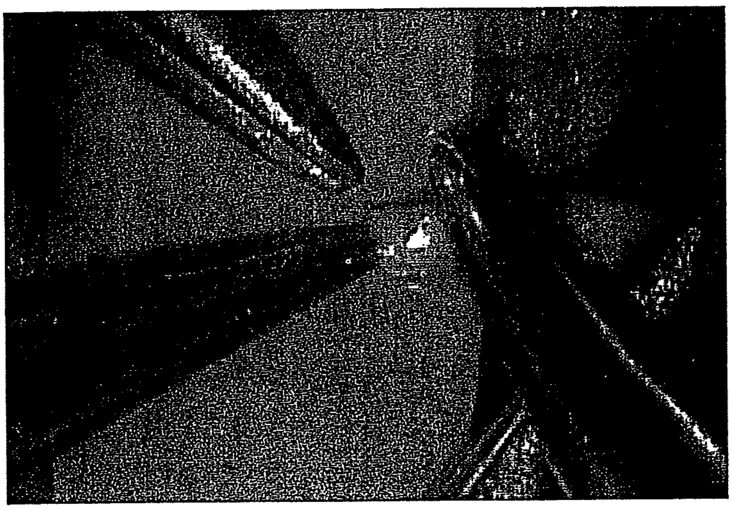

図 3. 第 1 針目の静脈への刺入

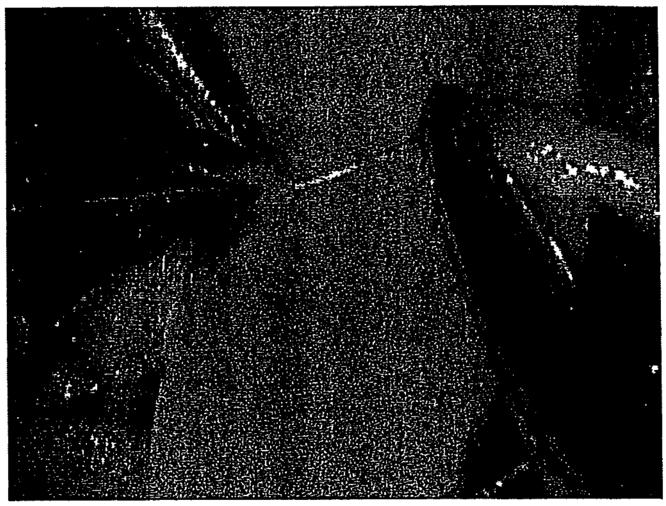

図 4. 第 1 針目のリンパ管への刺入

図 5. untie にされた 1st stay suture

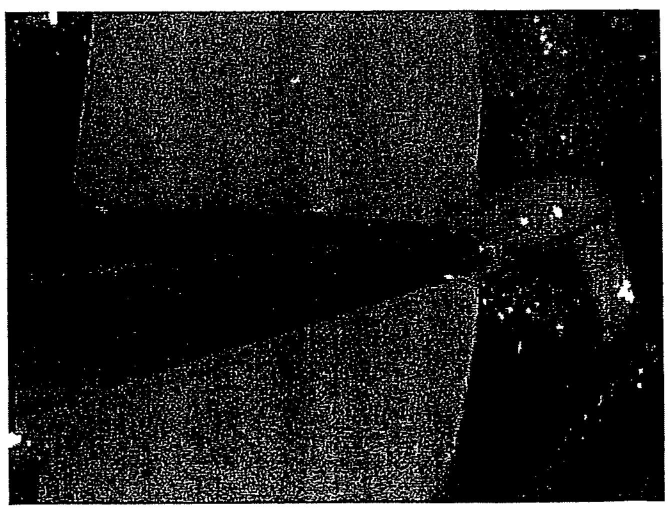

図 6. 第 2 針目の静脈への刺入

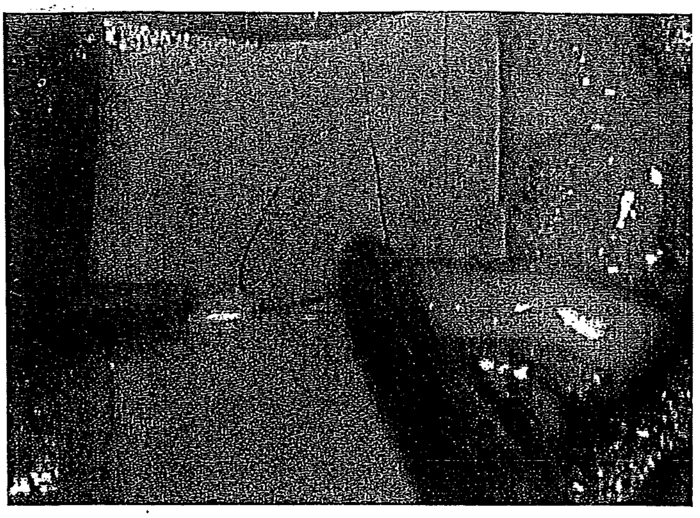

図 7. 第2針目のリンパ管への刺入

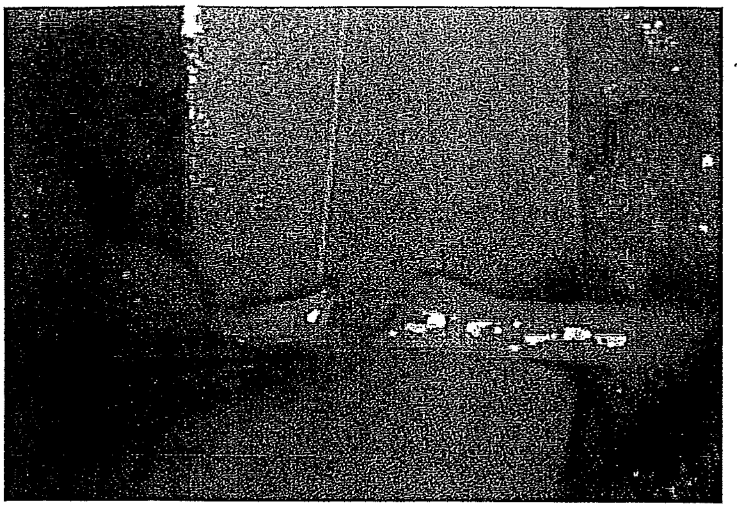

図 8. リンパ管・静脈内に通った 1st・2nd stay suture

図 9. 第3針目の静脈・リンパ管への刺入

図 10. 第3針目の縫合後

図 11. LVA 終了時
青色矢印：皮静脈
黄色矢印：リンパ管

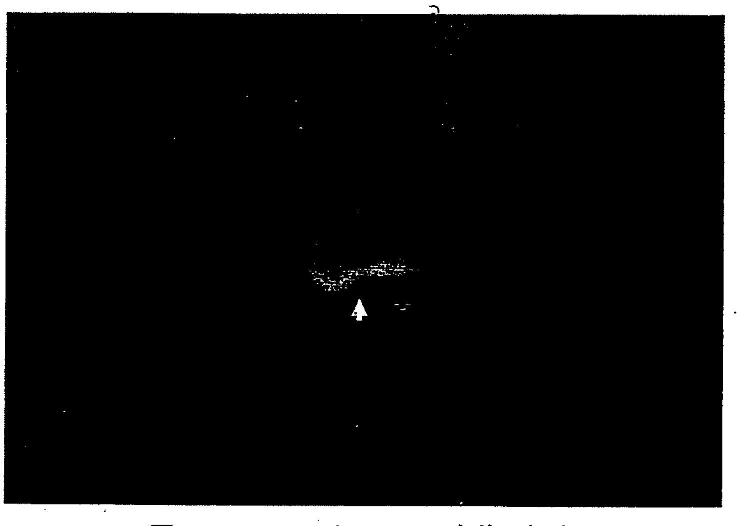

図 12. PDE による LVA 直後の観察
青色矢印：造影された皮静脈
黄色矢印：造影されたリンパ管

に入らない場合には軽くそえるようにして刺入する．針が入ったら必ず入ったことを確認する(図3；本症例は静脈の径が約 0.7 mm と大きく，鑷子が入っている)．

次にリンパ側に針を入れる．注意深く 12-0 の針先を内膜の下に滑り込ませる(図 4)．リンパ管の壁は弱いので，針を抜く時も注意が必要である．

1 針目の stay suture は untie にし(図 5)，糸が抜けないように糸の両端を血管クリップで留め，助手がリンパ管と静脈の断端に適度な緊張がかかるように調節する(図 6～8)．一般的には微細血管吻合の際には 1 針目は stay suture として結紮するが，極端に小さなリンパ管の吻合の際には，結紮時に生じる捻れの問題と 2 針目が入れやすいということより 1 針目を untie にして 2 針目を入れている．1 針目の縫合糸を結紮せずにリンパ管—静脈内に残すことにより intravascular stenting(IVaS)法[2]と類似の効果が得られる(図 7)．

2 針目はできるだけ 1 針目から 180° の位置に入れるようにする(図 6～8)．2 針目の刺入方法は 1 針目と同じであるが，助手が untie にした 1st stay suture の糸を上手くコントロールし緊張をかけることにより特にリンパ管への刺入が易しくなる(図 7)．

2 針目が入ったら stay suture を結紮する．内腔を確認したい場合や鑷子の先を内腔に入れて縫合したい場合には 1st・2nd stay suture を untie とし，先に 3・4 針目を結紮した後に 2 本の stay suture を結紮することもあるが，LVA の場合には内腔が正しく合っていれば，stay suture を結紮することによりリンパ管からリンパ液が静脈内に流れ込み，しばらく待機するとリンパ管・静脈が次第に膨らんでくる(図 9)．吻合部が膨らむと，次の 3・4 針目は比較的容易に入れることができる．

3 針目つまり表側の縫合であるが，stay suture を結紮した場合，鑷子が内腔に入らないので注意して針を入れる必要がある(図 9，10)．

最後に血管クリップを反転し表側と同様に裏側の縫合を施行する．吻合が終了し血管クリップを外し顕微鏡下に確認すると，リンパ流量が十分な場合には静脈血の逆流はなく，静脈がリンパ液で十分に膨らんでいるのが確認できる(図 11；本症例では一部逆流した静脈血が吻合部を越えてリンパ管の中にまだ少し残っている)．

吻合後 PDE で観察すると，黒く写っているバックグランドシートの上で，リンパ管から静脈内にリンパ液が入り，静脈がリンパ管と同様に造影されていることを確認できる(図 12)．

リンパ管静脈吻合術の有効性

2006 年 4 月に ICG 蛍光リンパ管造影法を導入した後に，LVA を施行し，術後 5 か月以上の経過観察が可能であった上肢リンパ浮腫 12 症例 12 肢，下肢リンパ浮腫 37 症例 42 肢を対象に評価し，有効性について検討した．

上肢症例は全例女性で，乳癌術後に発症していた．年齢は 54～87 歳で，左上肢 7 肢，右上肢 5 肢であった．発症より手術までの期間は 1 年 6 か月～29 年であった．下肢症例は男性 6 例，女性 31 例で，特発性が 9 症例，2 次性が 28 症例であった．女性は全て女性性器腫瘍術後に発症していた．年齢は 35～81 歳で，左下肢 29 肢，右下肢 13 肢であった．発症から手術までの期間は 6 か月～30 年であった．

評価は図 13 のごとく，上肢または下肢で，5 か所の周囲径を測定し，術前の周囲径に対する術後の周囲径の割合(改善率)をもとめ，いずれかの部位で 89% 以下に改善したものを excellent(図 14-a)，90～95% の改善を good(図 14-b)とした．96～104% の変化は測定誤差を考慮し不変と考え fair(図 14-c)とした．そしていずれの部位にも改善を認めず，105% 以上の悪化を認めた場合を poor(図 14-d)と評価した．

上肢，下肢症例を合わせた 54 肢の結果は excellent 17 肢(31%)，good 21 肢(39%)，fair 9 肢(17%)，poor 7 肢(13%)であった．Excellent と good を有効とし fair と poor を無効と考えると，

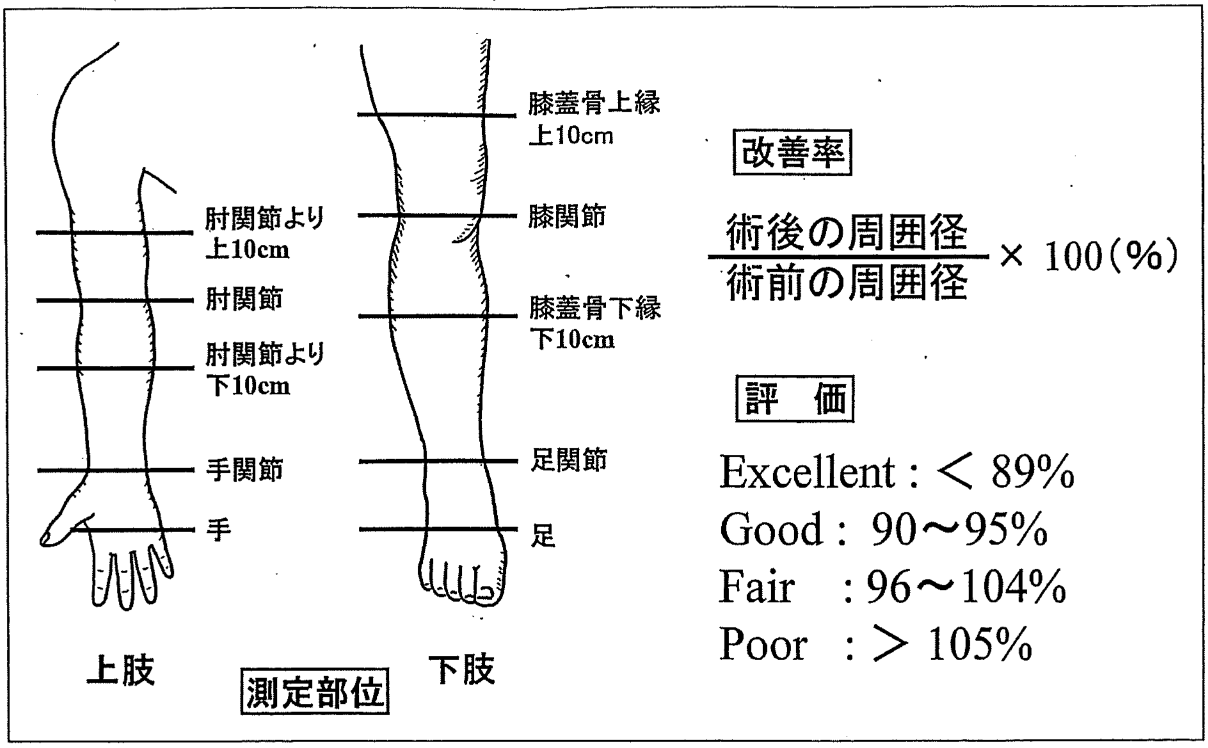

図 13. 評価方法

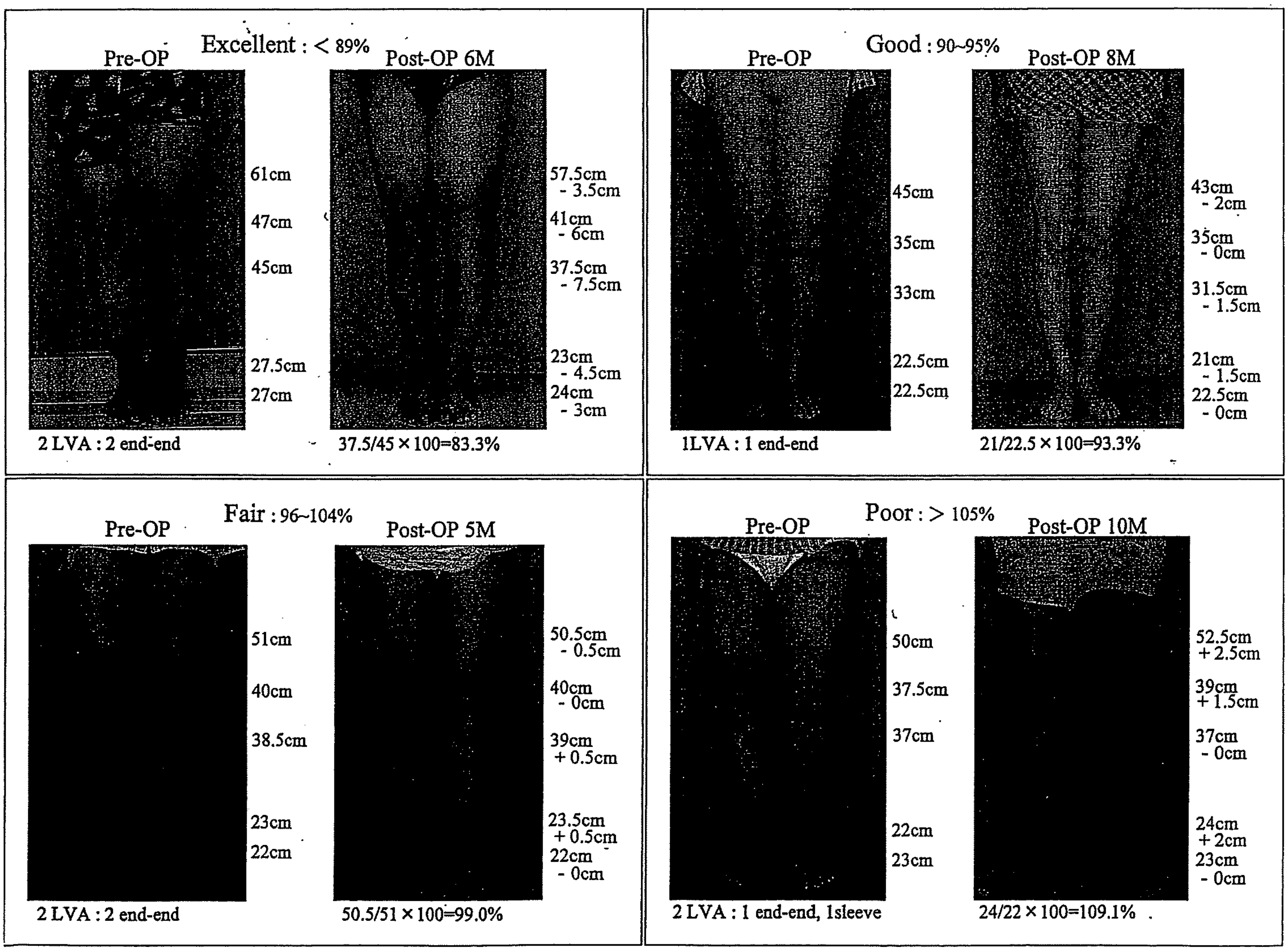

図 14. 評価に基づく代表症例
a：excellent, b：good, c：fair, d：poor

a	b
c	d

表 1. 四肢リンパ浮腫に対する FL-ICG を用いた LVA の術後成績

評価	上肢	下肢	合計(%)
excellent	5	12	17(31)
good	4	17	21(39)
fair	1	8	9(17)
poor	2	5	7(13)
	12	42	54(100)

表 2. 下肢リンパ浮腫に対する FL-ICG を用いた LVA の術後成績

評価	特発性	2次性	合計(%)
excellent	1	11	12(29)
good	6	11	17(40)
fair	3	5	8(19)
poor	0	5	5(12)
	10	32	42(100)

70%が有効で 30%が無効であった. 上肢症例と下肢症例間には有意差を認めなかった(表 1). 下肢症例を特発性と 2 次性に分けて同様に検討を加えたが両者間にも有意差は認めなかった(表 2).

考察

1st stay suture を untied suture とし 2nd stay suture の糸が通ってから両方の糸を結紮する Untied Stay Suture 法は, 壁が薄く透明なリンパ液の流れ込んでくる, 特に 0.3～0.5 mm 以下の LVA に有効な手技だと考えられる. また指尖部切断再接着術のような 0.3～0.5 mm 以下の微細血管吻合の場合には, 1st・2nd stay suture を untied suture とし先に 3・4 針目を結紮した後に 2 本の stay suture を結紮するほうが縫合しやすい. しかし 0.5 mm 以上のリンパ管や微細血管吻合の場合には従来法を用いた方が簡便である.

ICG 蛍光リンパ管造影法が導入される以前の光嶋らのリンパ浮腫に対するスーパーマイクロサージャリーテクニックを用いたリンパ管静脈吻合術の報告によると, 上肢リンパ浮腫に対する結果では, 12 症例を対象に経過観察期間 1 か月～6 年(平均 2.2 年)で, 前腕(肘から 10 cm 遠位)において, 0～8 cm(平均 4.1 cm)の減少が得られ, 4 cm 以上の減少がみられたのは 7 例(58.3%)であった[1]. また, 下肢リンパ浮腫に対する結果では, 13 症例に対して術後平均 4.6 年の経過観察で, 下腿(膝から 10 cm 遠位)において平均 4.7 cm の減少が得られ, 4 cm 以上の減少がみられたのは 8 例(61.5%)であった[3]. 局麻下の LVA の結果では, 52 症例を対象に術後平均 14.5 か月の経過観察で, 43 症例(82.5%)に効果が得られ, 4 cm 以上の減少がみられたのは 17 例(32.7%)であった[4]. これらの報告は評価法に違いがあり, 今回の結果と比較することは困難であるが, 我々の結果と同様にリンパ管静脈吻合術の有効性を示したものと考えられる.

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Abstract

Since April 2006, we have performed lymphaticovenous anastomosis (LVA) using indocyanine green fluorescence lymphography (FL-ICG). The use of FL-ICG in LVA allowed more precise identification of lymphatics and anastomosis to veins. We report the usefulness of this method for treatment of male lymphedema of the lower limbs.

Among the patients who underwent LVA since we introduced FL-ICG, 6 male patients (7 limbs) with lower-limb lymphedema who were followed postoperatively for 6 months or longer were included in the present study.

Indocyanine green (ICG) was injected intracutaneously at several points on the lower extremity, and the dye distribution was observed using a special infrared camera (Photo Dynamic Eye). ICG is taken up into the lymphatics and its spread along with the lymph flow can be monitored. When a lymphatic vessel was visualized by linear flow of ICG, an incision was made at the site and the lymphatic was searched and identified using an operating microscope, and then anatomosed to the cutaneous vein.

Among a total of 7 limbs, 4 were evaluated as excellent, 3 as good, 0 as fair and

Key words：Lymphedema (リンパ浮腫), Lymphaticovenous Anastomosis (リンパ管静脈吻合術), Microsurgery (マイクロサージャリー), Supermicrosurgery (超微小血管吻合術), Fluorescence Lymphography (蛍光リンパ管造影法)