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Supermicrosurgery for oncologic reconstructions

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Abstract: With advancement of microsurgical techniques, supermicrosurgery has been developed. Supermicrosurgery allows manipulation (dissection and anastomosis) of vessels and nerves with an external diameter of 0.5 mm or smaller. Because quality of life of cancer survivors is becoming a major issue, less invasive and functionally-better oncological reconstruction using supermicrosurgical techniques attracts attention. Conventional free flap reconstruction usually sacrifices major vessels and muscle functions, whereas supermicrosurgical free flaps can be transferred from anywhere using innominate vessels without sacrifice of major vessel/muscle. Since a 0.1-0.5 mm vessel can be anastomosed, patient-oriented least invasive reconstruction can be accomplished with supermicrosurgery. Another important technique is lymphatic anastomosis. Only with supermicrosurgery, lymph vessels can be securely anastomosed, because lymph vessel diameter is usually smaller than 0.5 mm. With clinical application of lymphatic supermicrosurgery, various least invasive lymphatic reconstruction has become possible. Lymphatic reconstruction plays an important role in prevention and treatment of lymphatic diseases following oncologic surgery such as lymphedema, lymphorrhea, and lymphocyst. With supermicrosurgery, various tissues such as skin/fat, fascia, bone, tendon, ligament, muscle, and nerves can be used in combination to reconstruct complicated defects; including 3-dimensional inset with multi-component tissue transfer.

***Keywords*:** microsurgery, supermicrosurgery, reconstruction, cancer, lymphedema

Introduction

Reconstructive microsurgery has developed to allow various tissue reconstructions after tissue defect or functional deficit after oncologic surgeries (*1-3*). Locoregional flaps are used to reconstruct soft tissue defects. Pectoralis major myocutaneous flap and deltopectoral flap were mostly used for head and neck reconstructions, and various local flaps were developed to reconstruct soft tissue defects in any body part (*2-4*). With development of microvascular anastomosis, free tissue transfer or free flap transfer became a choice for reconstruction (*5-7*). Myocutaneous flap, consisting of major vessel and muscle/fat/skin such as latissimus dorsi myocutaneous flap and rectus abdominis myocutaneous flap, played a major role in free flap extremity and breast reconstructions. Free flap transfer from a donor site distant from tumor ablation site allows simultaneous flap elevation during tumor resection, which results in shorter operation time. Unlike local flap, free flap is useful for a microsurgeon to inset a flap with more ease and safety. Although myocutaneous free flaps enable immediate reconstruction of wide defects, these flaps are associated with significant morbidities in donor sites because of sacrificing major vessels and muscle. Since myocutaneous flaps have large volume due to muscle, esthetic reconstruction with natural contouring is difficult in face/head/neck and extremity reconstructions (*4-8*).

With advancement of microsurgical techniques and anatomical knowledge, perforator flaps were developed, in which the muscle can be preserved (*8-12*). Rectus abdominis myocutaneous flap was replaced with deep inferior epigastric artery perforator (DIEP) flap for breast reconstruction. Anterolateral thigh (ALT) perforator flap has become a choice of flap for head and neck reconstructions. Various perforator flaps were developed, allowing less invasive and more esthetically pleasing reconstruction. However, optimal functional and esthetic reconstruction is yet to be established even with perforator flaps requiring major vessels for flap pedicle and recipient vessels; recipient site and donor site cannot be freely selected, because major vessels are required in both donor and recipient sites (*9-13*).

With further advancement of microsurgical techniques, more sophisticated micro-vessels' manipulation becomes possible. Half-millimeter vessels can be anastomosed, and the technique is named supermicrosurgery (*14-19*).

Supermicrosugery

Definition of supermicrosurgery has been changing over time (*14,20-22*). It is considered feasible for supermicrosurgery to be defined as microsurgical techniques dealing with vessels with external diameter of 0.5 mm or smaller, because surgical techniques and clinical applications are significantly different.

Technically, microsurgery deals with 1-2 mm vessels and its techniques are basically the same as in conventional vascular surgery (*22,23*). Left hand's forceps are inserted into a vessel lumen to assist suturing by right hand; the left hand's forceps keeps the lumen open, and prevent back wall catching by the right hand's needle. On the other hand, in supermicrosurgery, even micro-forceps cannot be inserted into a supermicro-vessel, and a surgeon has to perform suturing only based on a needle tip's sensation without left hand assistance. Since supermicrosurgery requires very meticulous manipulations with the sensation of tip of a 50 micron needle, rigorous training is necessary to master this technique (*22-25*).

Clinically, various reconstructions can be performed only with supermicrosurgery. First, any small tissue can be re-vascularized (*14,26-28*). After oncologic resection of some body part, the distal tissue can be replanted with supermicrosurgical anastomosis if needed. Second, single fascicle of a nerve can be coaptated with supermicrosurgery (*14,19-29*). Supermicrosurgical neurorapy allows less invasive and fascicle-oriented nerve reconstruction. Third, any innominate vessels can be used as flap pedicle and recipient vessels (*14,18,20,30*). Supermicrosurgery does not require major vessels for donor or recipient sites, and allows free tissue transfer from anywhere to anywhere; true perforator flap transfer with perforator-to-perforator anastomosis (*17,30,31*). Three-dimensional multi-component tissues can be harvested and transferred with supermicrosurgery (*32,33*). Capillary-like supermicro-vessels nourishing various tissues can be dissected separately; chimeric flap transfer. Thickness-controlled flap transfer is possible with supermicrosurgical distal dissection of a perforator, allowing esthetic contouring reconstruction (*34*). Lastly, lymph vessels can be anastomosed (*14,17,35-45*). As collecting lymphatic vessels are usually smaller than 0.5 mm, supermicrosurgery is necessary for lymphatic reconstruction. Immediate or secondary lymphatic reconstruction becomes possible to prevent or treat lymphedema, lymphorrhea, and lymphocyst.

One of the most important clinical applications of supermicrosurgery in reconstructive surgery is versatile usage of superficial circumflex iliac artery (SCIA) perforator (SCIP) flap (*22,23,34,46,47*). SCIP flap is based on the superficial branch and/or the deep branch of the SCIA, and is a minimally invasive flap with a most esthetically pleasing donor site; and donor scar remains along the inguinal crease, which is concealable with underwear (Figure 1) (*22,23).* Since a SCIA branch is around 0.5 mm, supermicrosurgery is required for secure transfer of the SCIP flap. With supermicrosurgery, this optimal flap can be applied to various reconstructions in any body part as described below.

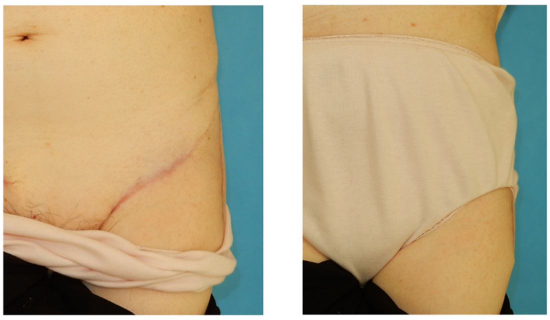

Figure 1. Superficial circumflex iliac artery perforator flap donor site scar is concealable.

Nerve and lymphatic reconstruction

In any body part, nerves and lymphatics exist, and may require reconstruction after cancer treatment. Reconstructive surgeons should consider these reconstructions for better functional outcomes.

Sensory and/or motor nerve injury can occur after oncologic ablation. Nerve defect should be reconstructed with vascularized nerve flap, because nerve flap has better postoperative nerve regeneration than non-vascularized nerve graft (*19,29,48*). Especially for motor nerve reconstruction, vascularized nerve flap is recommended due to 3 times faster regeneration (*48*). SCIP-based vascularized lateral femoral cutaneous nerve is a useful option for nerve flap transfer. Nerve flap can be used combined with skin flap for soft tissue defects. When a nerve defect is short, fascicular turnover flap based on the sacrificed nerve itself can be used for reconstruction, allowing autologous nerve reconstruction without donor site morbidity (*19,29*).

Lymphatic reconstruction is important for management or prevention of intractable lymphedema, lymphorrhea, and lymphocyst (*17,18,22,33,40*). Lymphedema is an obstructive lymphatic disease, and lymphorrhea/-cysts are a leakage disease. For lymphatic leakage diseases, precise localization of ruptured lymph vessels with near-infrared fluorescent lymphography and secure reconstruction is important (*17,40,41,49,50*). Since simple ligation may cause lymph flow obstruction and subsequent lymphedema development, lymphatic reconstruction should be performed for the leakage diseases as for obstructive disease (*17*).

There are mainly 2 lymphatic reconstructive methods; lymphatic anastomosis and lymphatic transfer. Lymphatic anastomosis includes lymphaticolymphatic anastomosis (LLA) and lymphaticovenular anastomosis (LVA) (*17,22,35-45*). In LLA, an affected lymph vessel is anastomosed to a nearby intact lymph vessel, whereas it is anastomosed to a vein in LVA (Figure 2). In both LLA and LVA, anastomosis should be done in an intima-

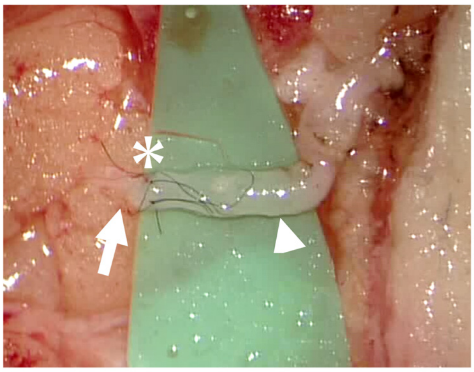

Figure 2. Lymphaticovenular anastomosis (asterisk) for the treatment of lymphedema, lymphorrhea, or lymphocyst. A lymph vessel (arrow) is supermicrosurgically anastomosed to a nearby venule or a vein (arrowhead) in an intima-to-intima coaptation manner. The vein looks like a lymph vessel, as lymph flows inside the vein making the vein translucent.

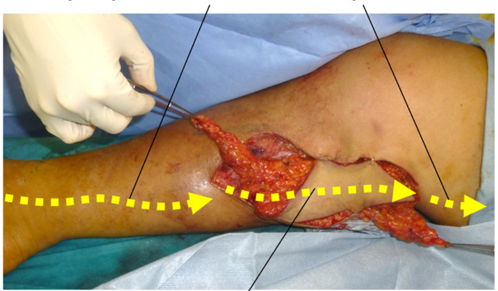

Figure 3. Lymph-interpositional-flap transfer (LIFT). LIFT bridges a gap of lymph vessel in a recipient site for lymphatic reconstruction.

to-intima coaptation manner with supermicrosurgery. Lymphatic transfer includes lymph node transfer (LNT), lymph vessel transfer (LVT), and lymph-interpositional-flap transfer (LIFT) (*14,18,22,49*). In LNT/LVT, vascularized lymph node/vessel is transferred to absorb lymph in a recipient site. In LIFT, a perforator flap including lymph vessels is transferred in a recipient site to bridge a gap between distal and proximal lymph vessel stumps caused by cancer ablation (*22,49*). SCIP flap can be used either as LNT, LVT, or LIFT (Figure 3).

Trunk reconstruction

Although conventional flaps are considered for reconstruction of a large defect requiring hard tissue reconstruction such as abdominal/chest wall or pelvic floor, true perforator flap or chimeric flap can be applied with less donor site morbidity (*1,22*). SCIP fascia flap can be used as a pedicled flap for abdominal wall and pelvic floor reconstruction, and as a free flap for chest wall reconstruction with or without a skin paddle (*22*). The deep branch of the SCIA should be used to transfer a vascularized fascia flap.

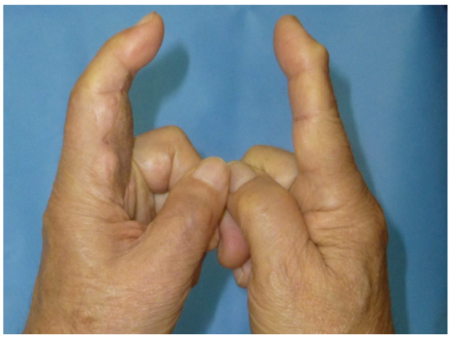

Figure 4. Super-thin flap for reconstruction of the finger.

Breast reconstruction

DIEP flap is the most popular flap for autologous tissue breast reconstruction, which is less invasive than rectus abdominis myocutaneous flap (*7-9*). Although preserving the rectus abdominis muscle DIEP flap requires dissection of the muscle and the intercostal nerves. The muscle dissection causes postoperative abdominal bulging and significant pain. Other perforator flaps allow even less invasive breast reconstruction without muscle dissection, which include superior/inferior gluteal artery true perforator flap, profunda femoris artery true perforator flap, lumbar artery true perforator flap, and SCIP flap (*22*). Flaps other than SCIP flap have relatively shorter pedicle unless proximal muscle dissection is not dissected. Both the deep branch and the superficial branch of the SCIA should be included to elevate an extended SCIP with enough bulk for breast reconstruction.

Hand and upper extremity reconstruction

Various pedicled perforator flaps can be used for relatively small defects, but requires additional skin grafting for donor site closure to reconstruct larger defects (*1,8,22*). True perforator free flap is functionally and esthetically better for reconstruction of medium to large soft tissue defects. SCIP flap plays an important role in upper extremity reconstruction, which allows thin and pliable skin reconstruction of the dorsum of the hand as super-thin or pure skin perforator flap, and simultaneous lymphatic reconstruction for prevention of lymphedema as LIFT (Figure 4) (*14,33,34,49*). Toe flaps are used to reconstruct digits, and domino free flap transfer is recommended for reconstruction of the toe donor sites (*16,26,31*). Chimeric SCIP flap with vascularized iliac bone is useful for complex reconstruction including the toe phalanx to preserve toe function and shape.

Lower extremity reconstruction

With supermicrosurgery, true perforator flap transfer with perforator-to-perforator anastomosis is a choice

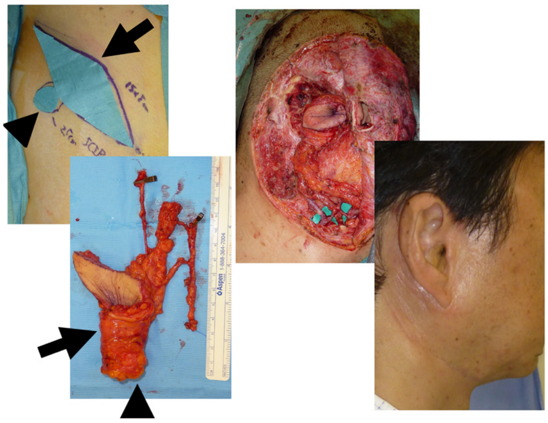

Figure 5. Superficial circumflex iliac artery perforator flap for reconstruction of the external auditory canal (arrow) and the tympanic membrane (arrowhead).

of reconstruction for distal lower leg and foot defects (*14,20,22*). Since any innominate vessels can be used as recipient vessels, supermicrosurgical true perforator flap transfer is applicable even for critical limb ischemia with no patent major vessels. For complex reconstruction of the ankle or the foot, chimeric SCIP flap is recommended, as it can transfer various tissues (the iliac bone, the deep fascia, the sartorius muscle, the inguinal lymph node, and the lateral femoral cutaneous nerve) without the need for a large recipient vessel (*22,33*). Since the lower extremities are likely to suffer from edema, lymphatic reconstruction plays an important role in improvement of postoperative quality of life. Therefore, LNT, LVT, or LIFT is recommended for reconstruction when a defect includes major lymphatic pathways as shown in Figure 3 (*22,33,49*).

Face, head, and neck reconstruction

Various true perforator flaps can be used for face, head, and neck reconstruction. For facial reconstruction, thoraco-acromial artery perforator flap is useful for color-matched re-surfacing (*14,22*). When a recipient vessel is not applicable in the ipsilateral side, contralateral vessels can be used as a recipient with a long pedicle flap. Deep branch-based SCIP flap can include a vascular pedicle as long as 22 cm, which is enough to reach the contralateral vessels (*22,46*). SCIP flap is useful also for reconstruction of the external auditory canal including the tympanic membrane (Figure 5). Facial nerve reconstruction has a significant impact on quality of life, and should be reconstructed simultaneously with soft tissue reconstruction as possible. Chimeric flap including vascularized nerve is a choice method for simultaneous facial nerve reconstruction rather than non-vascularized nerve grafting (*22,32,33,46*).

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References

1. Toth BA, Elliott LF. Aesthetic refinements in reconstructive microsurgery. Ann Plast Surg. 1989; 22:117-125.
2. Ariyan S. The pectoralis major myocutaneous flap. A versatile flap for reconstruction in the head and neck. Plast Reconstr Surg. 1979; 63:73-81.
3. Robinson DW. The deltopectoral flap in chest wall reconstruction. Br J Plast Surg. 1976; 29:22-26.
4. Schneider WJ, Hill HL Jr, Brown RG. Latissimus dorsi myocutaneous flap for breast reconstruction. Br J Plast Surg. 1977; 30:277-281.
5. Daniel RK, Taylor GI. Distant transfer of an island flap by microvascular anastomoses. A clinical technique. Plast Reconstr Surg. 1973; 52:111-117.
6. Harii K, Omori K, Torii S, Murakami F, Kasai Y. Free groin skin flaps. Br J Plast Surg. 1975; 28:225-237.
7. Drever JM. The lower abdominal transverse rectus abdominis myocutaneous flap for breast reconstruction. Ann Plast Surg. 1983; 10:179-185.
8. Blondeel PN, Van Landuyt KH, Monstrey SJ, Hamdi M, Matton GE, Allen RJ, Dupin C, Feller AM, Koshima I, Kostakoglu N, Wei FC. The "Gent" consensus on perforator flap terminology: preliminary definitions. Plast Reconstr Surg. 2003; 112:1378-1383.
9. Koshima I, Soeda S. Inferior epigastric artery skin flaps without rectus abdominis muscle. Br J Plast Surg. 1989; 42:645-648.
10. Yamamoto T, Matsuda N, Doi K, Oshima A, Yoshimatsu H, Todokoro T, Ogata F, Mihara M, Narushima M, Iida T, Koshima I. The earliest finding of indocyanine green lymphography in asymptomatic limbs of lower extremity lymphedema patients secondary to cancer treatment: the modified dermal backflow stage and concept of subclinical lymphedema. Plast Reconstr Surg. 2011; 128:314e-321e.
11. Koshima I. Free anterolateral thigh flap for reconstruction of head and neck defects following cancer ablation. Plast Reconstr Surg. 2000; 105:2358-2360.
12. Angrigiani C, Grilli D, Siebert J. Latissimus dorsi musculocutaneous flap without muscle. Plast Reconstr Surg. 1995; 96:1608-1614.
13. Allen RJ, Tucker C Jr. Superior gluteal artery perforator free flap for breast reconstruction. Plast Reconstr Surg. 1995; 95:1207-1212.
14. Koshima I, Yamamoto T, Narushima M, Mihara M, Iida T. Perforator flaps and supermicrosurgery. Clin Plast Surg. 2010; 37:683-689.
15. Yamamoto T, Narushima M, Yoshimatsu H, Seki Y, Yamamoto N, Oka A, Hara H, Koshima I. Minimally invasive lymphatic supermicrosurgery (MILS): indocyanine green lymphography-guided simultaneous multisite lymphaticovenular anastomoses *via* millimeter skin incisions. Ann Plast Surg. 2014; 72:67-70.
16. Yamamoto T, Yoshimatsu H, Kikuchi K, Taji M, Uchida G, Koshima I. Use of non-enhanced angiography to assist the second toetip flap transfer for reconstruction of the fingertip defect. Microsurgery. 2014; 34:481-483.
17. Yamamoto T, Yoshimatsu H, Koshima I. Navigation lymphatic supermicrosurgery for iatrogenic lymphorrhea: supermicrosurgical lymphaticolymphatic anastomosis and

lymphaticovenular anastomosis under indocyanine green lymphography navigation. J Plast Reconstr Aesthet Surg. 2014; 67:1573-1579.
18. Yamamoto T, Yoshimatsu H, Yamamoto N. Complete lymph flow reconstruction: a free vascularized lymph node true perforator flap transfer with efferent lymphaticolymphatic anastomosis. J Plast Reconstr Aesthet Surg. 2016; 69:1227-1233.
19. Yamamoto T, Yoshimatsu H, Narushima M, Yamamoto N, Hayashi A, Koshima I. Indocyanine green lymphography findings in primary leg lymphedema. Eur J Vasc Endovasc Surg. 2015; 49:95-102.
20. Choi DH, Goh T, Cho JY, Hong JP. Thin superficial circumflex iliac artery perforator flap and supermicrosurgery technique for face reconstruction. J Craniofac Surg. 2014; 25:2130-1233.
21. Masia J, Olivares L, Koshima I, Teo TC, Suominen S, Van Landuyt K, Demirtas Y, Becker C, Pons G, Garusi C, Mitsunaga N. Barcelona consensus on supermicrosurgery. J Reconstr Microsurg. 2014; 30:53-58.
22. Yamamoto T. Onco-reconstructive supermicrosurgery. Eur J Surg Oncol. 2019; 45:1146-1151.
23. Narushima M, Mihara M, Koshima I, Gonda K, Takuya I, Kato H, Nakanishi K, Yamamoto Y, Araki J, Abe H, Mundinger GS, Kikuchi K, Uehara E. Intravascular stenting (IVaS) method for fingertip replantation. Ann Plast Surg. 2009; 62:38-41.
24. Yamamoto T, Yamamoto N, Yamashita M, Furuya M, Hayashi A, Koshima I. Establishment of supermicrosurgical lymphaticovenular anastomosis model in rat. Microsurgery. 2017; 37:57-60.
25. Yamamoto T, Yamamoto N, Doi K, Oshima A, Yoshimatsu H, Todokoro T, Ogata F, Mihara M, Narushima M, Iida T, Koshima I. Indocyanine green-enhanced lymphography for upper extremity lymphedema: a novel severity staging system using dermal backflow patterns. Plast Reconstr Surg 2011; 128:941-947.
26. Koshima I. Atypical arteriole anastomoses for fingertip replantations under digital block. J Plast Reconstr Aesthet Surg. 2008; 61:84-87.
27. Zhang YX, Yongjie H, Messmer C, Ong YS, Li Z, Zhou X, Spinelli G, Agostini T, Levin LS, Lazzeri D. Thoracoacromial artery perforator flap: anatomical basis and clinical applications. Plast Reconstr Surg. 2013; 131:759e-770e.
28. Yamamoto T, Narushima M, Yoshimatsu H, Yamamoto N, Oka A, Seki Y, Todokoro T, Iida T, Koshima I. Indocyanine green velocity: lymph transportation capacity deterioration with progression of lymphedema. Ann Plast Surg. 2013; 71:591-594.
29. Yamamoto T, Narushima M, Yoshimatsu H, Yamamoto N, Mihara M, Koshima I. Free anterolateral thigh flap with vascularized lateral femoral cutaneous nerve for treatment of neuroma-in-continuity and recurrent carpal tunnel syndrome after carpal tunnel release. Microsurgery. 2014; 34:145-148.
30. Yamamoto T, Yoshimatsu H, Kikuchi K. Free prepuce perforator flap: ultra-thin superficial artery perforator flap for a dorsal finger defect. Microsurgery. 2017; 37:252-255.
31. Yamamoto T, Hayashi A, Tsukuura R, Goto A, Yoshimatsu H, Koshima I. Transversely-inset great toe hemi-pulp flap transfer for the reconstruction of a thumb-tip defect. Microsurgery. 2015; 35:235-238.
32. Koshima I, Yamamoto H, Hosoda M, Moriguchi T, Orita Y, Nagayama H. Free combined composite flaps using the lateral circumflex femoral system for repair of massive defects of the head and neck regions: an introduction to the chimeric flap principle. Plast Reconstr Surg. 1993; 92:411-420.
33. Yamamoto T, Saito T, Ishiura R, Iida T. Quadruple-component superficial circumflex iliac artery perforator (SCIP) flap: a chimeric SCIP flap for complex ankle reconstruction of an exposed artificial joint after total ankle arthroplasty. J Plast Reconstr Aesthet Surg. 2016; 69:1260-1265.
34. Narushima M, Yamasoba T, Iida T, Matsumoto Y, Yamamoto T, Yoshimatsu H, Timothy S, Pafitanis G, Yamashita S, Koshima I. Pure Skin Perforator Flaps: The Anatomical Vascularity of the Superthin Flap. Plast Reconstr Surg. 2018; 142:351e-360e.
35. Yamamoto T, Narushima M, Kikuchi K, Yoshimatsu H, Todokoro T, Mihara M, Koshima I. Lambda-shaped anastomosis with intravascular stenting method for safe and effective lymphaticovenular anastomosis. Plast Reconstr Surg. 2011; 127:1987-1992.
36. Yamamoto T, Yoshimatsu H, Narushima M, Yamamoto N, Shim TW, Seki Y, Kikuchi K, Karibe J, Azuma S, Koshima I. Sequential anastomosis for lymphatic supermicrosurgery: multiple lymphaticovenular anastomoses on one venule. Ann Plast Surg. 2014; 73:46-49.
37. Yamamoto T, Yoshimatsu H, Narushima M, Yamamoto N, Koshima I. Split intravascular stents for side-to-end lymphaticovenular anastomosis. Ann Plast Surg 2013; 71:538-540.
38. Yamamoto T, Yoshimatsu H, Yamamoto N, Narushima M, Iida T, Koshima I. Side-to-end lymphaticovenular anastomosis through temporary lymphatic expansion. PLoS One. 2013; 8:e59523.
39. Yamamoto T, Yoshimatsu H, Narushima M, Seki Y, Yamamoto N, Shim TW, Koshima I. A modified side-to-end lymphaticovenular anastomosis. Microsurgery. 2013; 33:130-133.
40. Yamamoto T, Yamamoto N, Azuma S, Yoshimatsu H, Seki Y, Narushima M, Koshima I. Near-infrared illumination system-integrated microscope for supermicrosurgical lymphaticovenular anastomosis. Microsurgery. 2014; 34:23-27.
41. Yamamoto T, Yamamoto N, Numahata T, Yokoyama A, Tashiro K, Yoshimatsu H, Narushima M, Koshima I. Navigation lymphatic supermicrosurgery for the treatment of cancer-related peripheral lymphedema. Vasc Endovasc Surg. 2014; 48:139-143.
42. Yamamoto T, Koshima I. Supermicrosugical anastomosis of superficial lymphatic vessel to deep lymphatic vessel for a patient with cellulitis-induced chronic localized leg lymphedema. Microsurgery. 2015; 35:68-71.
43. Yamamoto T, Yamamoto N, Hayashi A, Koshima I. Supermicrosurgical deep lymphatic vessel-to-venous anastomosis for a breast cancer-related arm lymphedema with severe sclerosis of superficial lymphatic vessels. Microsurgery. 2017; 37:156-159.
44. Yamamoto T, Kikuchi K, Yoshimatsu H, Koshima I. Ladder-shaped lymphaticovenular anastomosis using multiple side-to-side lymphatic anastomoses for a leg lymphedema patient. Microsurgery. 2014; 34:404-408.
45. Yamamoto T, Koshima I, Yoshimatsu H, Narushima M, Miahara M, Iida T. Simultaneous multi-site lymphaticovenular anastomoses for primary lower

extremity and genital lymphoedema complicated with severe lymphorrhea. J Plast Reconstr Aesthet Surg. 2011; 64:812-815.
46. Koshima I, Nanba Y, Tsutsui T, Takahashi Y, Urushibara K, Inagawa K, Hamasaki T, Moriguchi T. Superficial circumflex iliac artery perforator flap for reconstruction of limb defects. Plast Reconstr Surg. 2004; 113:233-240.
47. Hong JP, Sun SH, Ben-Nakhi M. Modified superficial circumflex iliac artery perforator flap and supermicrosurgery technique for lower extremity reconstruction: a new approach for moderate-sized defects. Ann Plast Surg. 2013; 71:380-383.
48. Koshima I, Harii K. Experimental study of vascularized nerve grafts: multifactorial analyses of axonal regeneration of nerves transplanted into an acute burn wound. J Hand Surg Am. 1985; 10:64-72.
49. Yamamoto T, Iida T, Yoshimatsu H, *et al*. Lymph flow restoration after tissue replantation and transfer: importance of lymph axiality and possibility of lymph flow reconstruction using free flap transfer without lymph node or supermicrosurgical lymphatic anastomosis. Plast Reconstr Surg. 2018; 142:796-804.
50. Yamamoto T, Narushima M, Doi K, Oshima A, Ogata F, Mihara M, Koshima I, Mundinger GS. Characteristic indocyanine green lymphography findings in lower extremity lymphedema: the generation of a novel lymphedema severity staging system using dermal backflow patterns. Plast Reconstr Surg. 2011; 127:1979-1986.

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