Perforator Flaps and Supermicrosurgery

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KEYWORDS

- Supermicrosurgery • Perforator flaps
- Reconstructive surgery • Supramicrosurgery

WHAT IS SUPERMICROSURGERY OR SUPRAMICROSURGERY?

Supermicrosurgery, or *supramicrosurgery*, is a technique of microneurovascular anastomosis for smaller vessels and single nerve fascicle, and also microneurovascular dissection for these small vessels less than 0.3 to 0.8 mm. This technique needs ultradelicate microsurgical instruments (Emi Company, Swa City, Nagano, Japan) and fain suture materials (Crown Jun Company, Tokyo, Japan) with a needle less than 30 to 80 μm. With this technique, new reconstructive microsurgery using true perforator flaps and nerve flaps has been recently developed.

HISTORY OF SUPERMICROSURGERY

The concept and naming of supermicrosurgery was established in Japan in the 1980s and introduced internationally in 1997.[1] This technique developed a high success rate after replantations above the distal phalanx of the fingers,[2,3] vascularized toenail for finger nail losses,[4] vascularized distal interphalangeal joints, and toe-tip transfers for fingertip reconstructions.[5] In addition, many new free tissue transfers have been developed, including appendix transfer for urethral reconstruction,[6] partial auricular transfer for upper eyelid[7–12] and tracheal loss,[13] toe-web transfers for oral commissure loss,[14] vascularized nerve flaps with perforator vessel,[15] fascicular turnover flaps for nerve gaps,[16] supermicrosurgical lymphaticovenular anastomosis for obstructive lymphedema in the extremities,[17–19] mini-bone flap, and periosteal flaps.

With this technique, new short T pedicle or true perforator flaps have been developed.[20] These flaps have advantages of short time elevation anywhere in the body. Free perforator-to-perforator flaps are now topic (ie, true perforator flaps with anastomosing small perforators of flap and recipient site <0.8 mm of diameter). Such flaps have been reported as paraumbilical perforator (PUP) adiposal flap or deep inferior epigastric perforator (DIEP) flap for breast reconstruction and facial augmentation,[21–24] thoracodorsal artery perforator (TAP) flap for extremities, anterolateral thigh perforator (ALT) flap for extremities,[20] tensor fasciae lata (TFL) perforator flap for hand, medial thigh perforator flap for foot, gluteal artery perforator flap for facial augmentation,[25] posterior tibial flap for hand coverage, and medial plantar perforator flap for finger pulp coverage.[26–29] Also, vascularized adiposal flaps with these perforators are now useful for facial and breast augmentation.[30]

NEW CLASSIFICATION OF PERFORATOR FLAPS

Based on the authors' previous reports, perforator flaps can be classified as long vascular pedicle perforator flaps (DIEP flaps, ALT and anteromedial thigh [AMT] flaps, TAP flaps); short T pedicle perforator flaps, including a short T-shape segment of large vessels (DIEP or PUP flaps, ALT and AMT

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flaps, TFL flaps, TAP flaps, superficial circumflex iliac artery perforator flaps [SCIP], radial artery perforator flaps, snuff box flaps, medial plantar flaps); and true perforator flaps (**Fig. 1**). The T perforator flaps are usually used as a flow-through perforator flap. The true perforator flap has only perforators and no main trunk vessels.

CASE REPORTS

Representative cases with supermicrosurgical technique are as follows:

Case 1: Distal Phalangeal Replantation

A 47-year-old man amputated the distal phalanx of the left middle finger. Under digital block, the proximal arteriole of digital artery was anastomosed to the distal volar cutaneous venule, and the distal ulnar venule was anastomosed to the proximal cutaneous vein with arteriolar graft as the drainage system. The distal subdermal venule (0.3 mm) was joined to the proximal subdermal venule postoperatively. The finger survived completely without congestion (**Fig. 2**).

Case 2: Fascicular Turnover Flap for Facial Nerve Defect

A 68-year-old woman had a larger left parotid tumor, pleomorphic adenoma, for 20 years. After an extirpation of the tumor, buccal branches of the facial nerve were resected. The nerve defect (3 cm) was repaired with a fascicular turnover flap from one of the distal buccal branch. Fascicular nerve anastomosis was performed with a 50 μm needle (12-0 Crown Jun suture material). This nerve flap had reverse-flow from the distal buccal branch, and all Schwann cells within the flap could survive to accept rapid nerve regeneration from the proximal nerve. The postoperative recovery of her facial nerve function was excellent. A few months after surgery, functional recovery occurred and the patient gained normal function at 1 year, postoperatively (**Fig. 3**).

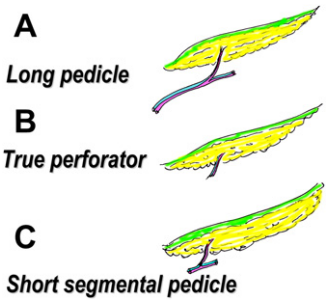

Fig. 1. The classification of free perforator flaps. (*A*) A long pedicle perforator flap. (*B*) Short T-segmental pedicle flap, which is useful as a flow-through flap. (*C*) A true perforator flap.

Case 3: Lymphaticovenular Anastomosis for Obstructive Lymphedema

A 64-year-old woman had secondary lymphedema and complete brachial nerve palsy of the left upper arm for 11 years. Sixteen years ago, she received a mastectomy and radiation. Two lymphaticovenular anastomoses were performed at the forearm. There was remarkable improvement of the affected arm after surgery and the patient did not need postoperative compression and physiotherapy. It is thought that degenerated smooth muscle cells within the anastomosed lymphatics were regenerate because of surgical bypass effect and the arm regained the lymph-drainage function (**Fig. 4**).

Case 4: Silicon Mastitis with Deep Inferior Epigastric Perforator Adiposal Perforator-to-Perforator Flap

The major perforators from the deep inferior epigastric artery anatomically locate around the umbilicus. The size of these perforators is usually 0.5 to 0.8 mm, which can be anastomosed to the same size recipient vessels. The flap can be thinned with removal of fatty tissue in one stage (**Fig. 5**).

A 53-year-old woman with painful silicon mastitis was repaired by silicon removal and simultaneous DIEP adiposal flap transfer with a short pedicle. The pedicle perforators with or without T segment of the deep inferior epigastric artery were joined to the distal level of the lateral thoracic vessel. Postoperatively, the patient had regained normal shape and softness of breast and had no pain (**Fig. 6**).

DISCUSSION

Supermicrosurgical innovative technology developed new free tissue transfers, including distal phalangeal replantation, toe-tip or vascularized toenail transfers, partial auricular flap or concha flap for eyelid and tracheal loss, lymphaticovenular anastomosis for lymphedema, and vascularized appendix transfer for penile urethral loss. Also, the pedicle perforator or short pedicle of perforator flaps can be anastomosed to small (<1 mm) or large recipient vessels with this technique.

Supermicrosurgical lymphaticovenular anastomosis is a new topic for treatment of lymphedema. Based on the authors' more than 500 cases, the surgery with more than 10 anastomoses can be

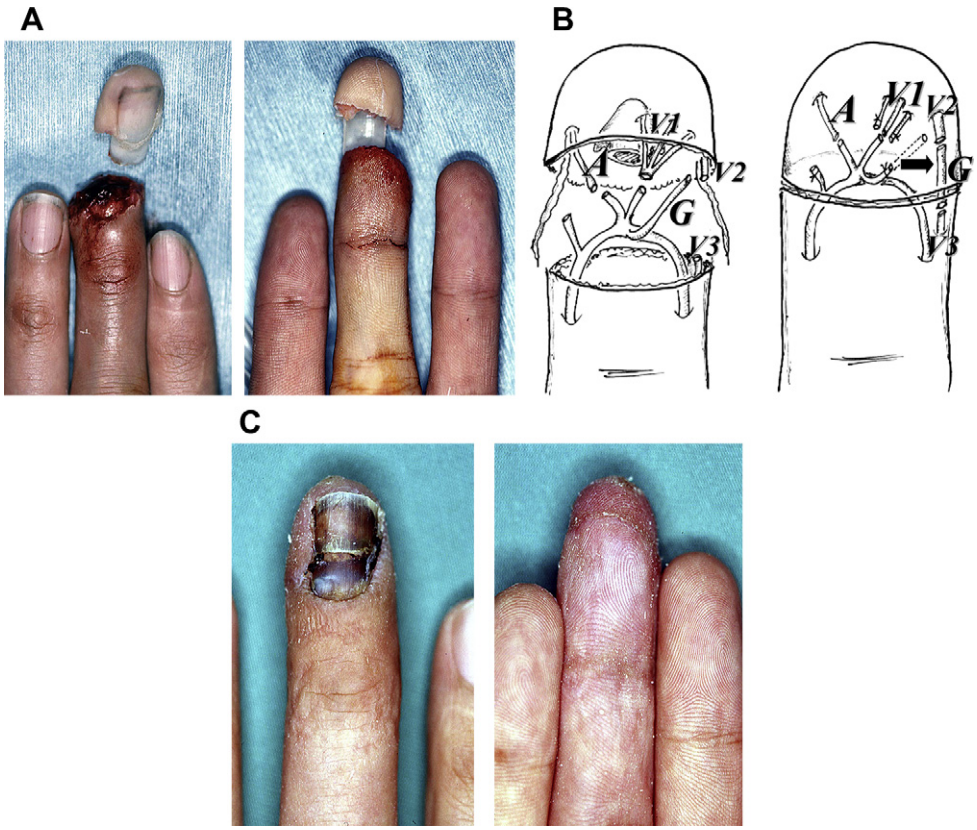

Fig. 2. (*A*) A 47-year-old man had an amputation of the left middle finger. (*B*) Under digital block, the proximal arteriole of digital artery (A) was anastomosed to the distal volar cutaneous venule (V1), and the distal ulnar venule (V2) was anastomosed to the proximal cutaneous vein (V3) with arteriolar graft (G) as drainage system. (*C*) At 2 months after surgery.

possible within 3 hours under local anesthesia. The result is dependent upon the number of anastomoses (more than 5 anastomoses in 1 limb is desirable), and stage of edema (early stage is the best). For severe edema cases resistant to left ventricle (LV) anastomosis, the authors confirm the effect of a free vascularized lymphoadipose flap with a smaller perforating vessel and lymphovenous anastomoses for establishment of the lymph drainage function. The authors are also trying prophylactic LV anastomosis simultaneous with cancer removal. The concept of this surgery is to preserve the normal drainage function of lymph smooth muscle cells, which seems to be the best method to prevent lymphedema. The next topic in lymphedema may be supermicrosurgical vascularized lymphoadipose flap and prophylactic LV anastomosis.

Another topic of supermicrosurgery is the introduction of nerve reconstructions. Peripheral nerves have rich vascular systems and all of those come from perforating vessels of perforator flaps. Vascularized nerve flaps, such as the deep peroneal nerve flap and the lateral femoral cutaneous nerves, are now used for longer nerve gap and showing excellent motor and sensory recovery. Vascularization of nerve is always essential even in nerve transfer because survival of Schwann cells within a nerve flap is an important factor for nerve recovery. Vascularized cross-face nerve flap using an intraoral transfer of lateral femoral cutaneous nerve was proved to be a useful method for total removal of facial nerve. This method is indicated in the early stage of palsy. In addition, excellent functional recovery using fascicular turnover flap was reported for short nerve gap of facial and digital nerve reconstruction because this fascicular flap has reverse-flow blood circulation. Although supermicrosurgical anastomosis of single fascicle is difficult and needs some training, this concept and technique will be essential in the next phase of nerve reconstruction.

Regarding the recipient vessels for perforator-to-perforator flaps, many branches of temporal

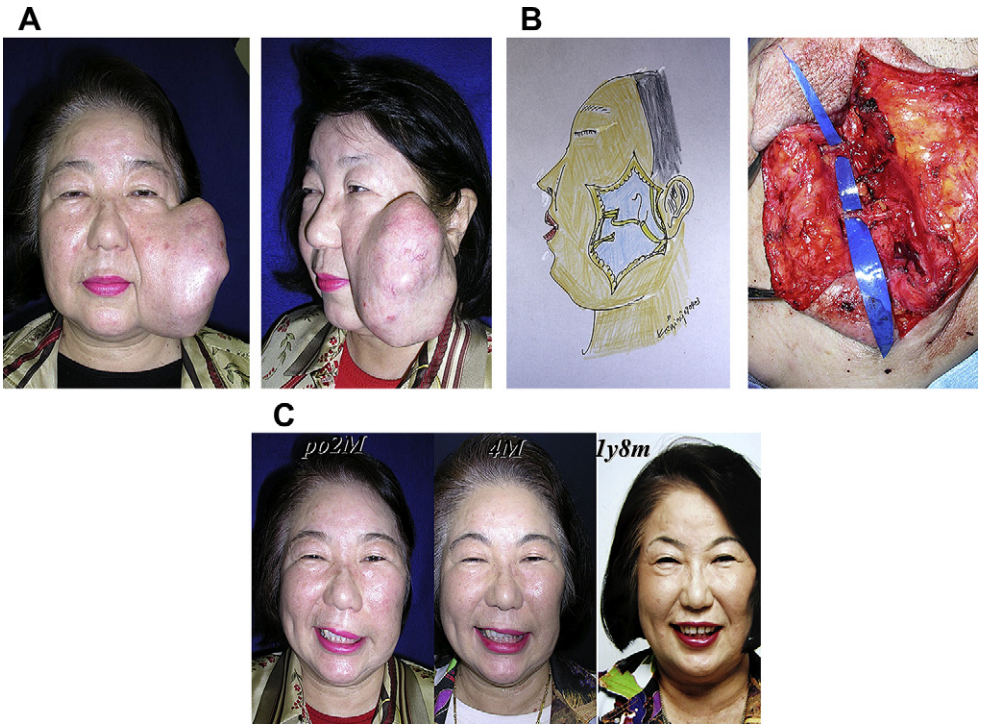

Fig. 3. (*A*) A larger pleomorphic adenoma for 20 years. (*B*) After an extirpation of the tumor, buccal branches of the facial nerve were resected. The nerve defect, of 3 cm, was repaired with fascicular turnover flap from the distal buccal branch. Fascicular nerve anastomosis was performed with 50 μm needle (12–0 Crown Jun suture material). (*C*) The postoperative recovery was excellent. At 2 months after surgery, functional recovery occurred and gained normal function within 1 year, postoperatively. Left, 2 months; middle, 4 months; right, 1 year and 8 months.

artery, facial artery, frontal artery, internal mammary artery, lateral thoracic artery, serratus muscle branch of the thoracodorsal system, radial artery, digital artery, anterior tibial artery, lateral and medial tarsal artery, and plantar digital artery were used. Vein grafts from the wrist volar aspect and foot dorsum are often used.

Free adiposal flap for facial and breast augmentation is the new topic in aesthetic supermicrosurgery. Based on the authors' more than 100 cases

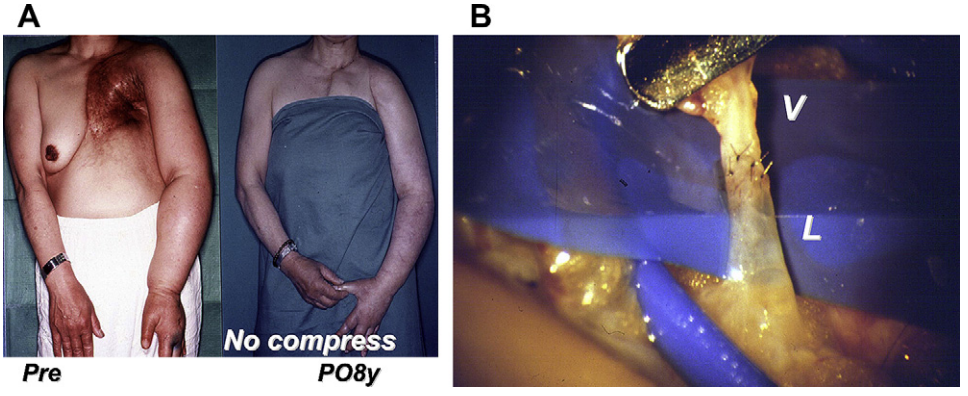

Fig. 4. (*A*) Left, 64-year-old woman with secondary lymphedema and complete brachial nerve palsy for 11 years. Sixteen years ago, she received mastectomy and radiation. Right, 8 years after surgery. Two lymphaticovenular anastomoses were performed at the forearm. There was remarkable improvement of the arm. The patient did not need postoperative compression and physiotherapy. The degenerated smooth muscle cells within anastomosed lymphatics might be regenerate because of bypass effect. (*B*) Lymphaticovenular anastomosis at the elbow fossa. L, lymphatic channel; V, venule.

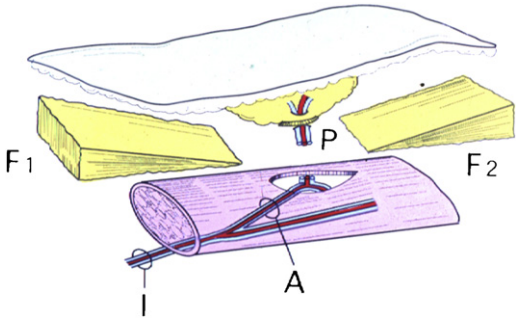

Fig. 5. Thin DIEP true perforator flap. The major perforators from the deep inferior epigastric artery are anatomically located around the umbilicus. The flap can be thinned with removal of fatty tissue in one stage. These perforators of DIEP flap can be anastomosed to the same size recipient vessels. (*From* Koshima I, et al. New microsurgical breast reconstruction using free PUP (paraumbilical perforator) adiposal flaps. Plast Reconstr Surg 2000;106:61–5; with permission.)

in 20 years, the potential of adiposal flap is greater than free fat injection and conventional dermal fat flap. This flap is indicated for any cases with a highly irradiated recipient, congenital hemifacial atrophy, and facial deformity after wide cancer removal. Adiposal flaps using DIEP, TAP, SCIP, and superficial inferior epigastric artery seem to be good donor candidates in young female patients. Also, intraoral transfer is the best approach for facial augmentation to avoid lateral bulkiness and postoperative drooping of the flap.

The advantages of these true perforator flaps include its simple operation, short time flap elevation, flaps can be obtained from anywhere in concealed areas, and it is a minimally invasive operation with less invasive donor-site morbidity. The disadvantages include their anatomic variation, the need for supermicrosurgical technique to dissect, and the technical difficulty for anastomosis with smaller vessels. These flaps are indicated for extremity reconstructions because

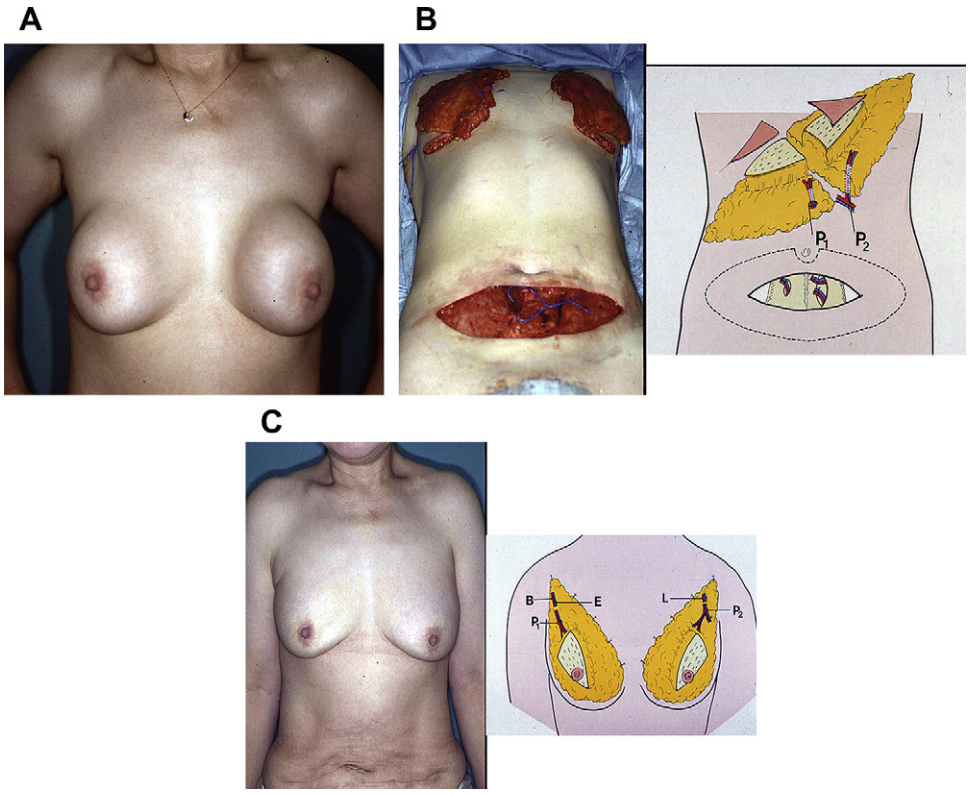

Fig. 6. (*A*) A 53-year-old woman with painful silicon mastitis. (*B*) Silicon prosthesis was removed and simultaneous DIEP adiposal flaps with short pedicle (P1, P2) were transferred. (*C*) Left, 2 years after surgery. The patient had regained normal shape and softness of breast and had no pain. Right, the pedicle perforators (P1, P2) were joined to the distal level of lateral thoracic vessel (B, right lateral thoracic artery; E, right lateral thoracic vein; L, left lateral thoracic vessel). (*From* Koshima I, et al. New microsurgical breast reconstruction using free PUP (paraumbilical perforator) adiposal flaps. Plast Reconstr Surg 2000;106:61–5; with permission.)

there are many recipient perforators of the same size as the flap perforators.

Technical tips for successful results include the use of duplicated vascular anastomoses using smaller recipient arteries and vein grafts; and flow-through vascular anastomosis using a T-shaped pedicle vessel, including perforator, assures double arterial inflow within a flap, and is indicated for ischemic extremities. The use of postoperative vasodilating drugs (prostaglandin E1) are recommended for successful results.

Finally, with supermicrosurgical techniques, many new flaps with a true perforator may be invented in the future. These flaps and vascularized tissues may be transferred without skin incision and sometimes flaps may be transferred under local anesthesia. New fields may be expected in all fields of surgery.

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