THE LATISSIMUS DORSI-GROIN-LYMPH NODE COMPOUND FLAP: A COMPREHENSIVE TECHNIQUE WITH THREE FEATURES INCLUDING SKIN COVERAGE, RESTORATION OF MOTOR FUNCTION, AND PREVENTION OF UPPER LIMB LYMPHEDEMA

FABIO NICOLI, M.D.,[1,2,3] GEORGIOS ORFANIOTIS, M.D.,[1,4] DAVIDE LAZZERI, M.D.,[3] SEONG YOON LIM, M.D.,[1] KIDAKORN KIRANANTAWAT, M.D.,[1,5] PEI-YU CHEN, M.D.,[6] PEDRO CIUDAD, M.D.,[1] RAM M. CHILGAR, M.D.,[1] STAMATIS SAPOUNTZIS, M.D.,[1] BULENT SACAK, M.D.,[1,7] and HUNG-CHI CHEN, M.D., Ph.D.[1]*

Reconstruction of complex upper extremity defects requires a need for multiple tissue components. The supercharged latissimus dorsi (LD)-groin compound flap is an option that can provide a large skin paddle with simultaneous functional muscle transfer. It is necessary to supercharge the flap with the superficial circumflex iliac pedicle to ensure the viability of its groin extension. In this report, we present a case of a supercharged LD-groin flap in combination with vascularized inguinal lymph nodes, which was used for upper limb reconstruction in a young male patient, following excision of high-grade liposarcoma. Resection resulted in a 28 cm × 15 cm skin defect extending from the upper arm to the proximal forearm, also involving the triceps muscle, a segment of the ulnar nerve and the axillary lymph nodes. Restoration of triceps function was achieved with transfer of the innervated LD muscle. Part of the ulnar nerve was resected and repaired with sural nerve grafts. Post-operatively, the flap survived fully with no partial necrosis, and no complications at both the recipient and donor sites. At 1-year follow up, the patient had a well-healed wound with good elbow extension (against resistance), no tumor recurrence, and no signs of lymphedema. We believe this comprehensive approach may represent a valuable technique, for not only the oncological reconstruction of upper extremity, but also for the prevention of lymphedema. © 2015 Wiley Periodicals, Inc. Microsurgery 00:000–000, 2015.

Complex upper extremity defects may arise after trauma, infection, radiation injury, and tumor resection.[1,2] The latter is often associated with regional lymphadenectomy,[3] which further increases the morbidity of the procedure.[4] A variety of reconstructive options are available including skin grafts, pedicled, and free flaps, or their combination.[1,5] For major defects of the elbow and shoulder, the pedicled latissimus dorsi (LD) flap remains a favorable option offering ample, well-vascularized soft tissue for limb coverage, with and acceptable donor site morbidity.[5,6]

The pedicled LD myocutaneous flap can be designed to reach up to the level of the proximal forearm, however this carries a risk of distal flap necrosis.[6] To avoid such problem a variety of free flap options are available depending on the needs of the recipient wound.[1,7] Single conventional flaps may not be however sufficient for reconstruction of extensive complex upper limb defects. Here, the concept of the compound flap implies an "all-in-one" use of different tissue components, to allow not only immediate skin coverage but also restoration of function and correction of volume deficit.[8]

In this report, we present a case of a supercharged LD-groin flap in combination with vascularized inguinal lymph node transfer (LD-GLN compound flap). This technique was used for reconstruction of an extensive upper limb defect following excision of a high-grade liposarcoma and axillary clearance in a young male patient. The groin component of the flap was supercharged by the superficial circumflex iliac pedicle to maximize flap survival and allow vascularized inguinal nodes to be transferred safely for the prevention of lymphedema.

CASE REPORT

A 33-year-old male was referred to our unit with a rapidly growing mass on his right upper limb and a suspected diagnosis of a recurrent liposarcoma. He was previously treated in a different institute where he underwent wide local excision and direct closure. Tissue biopsy and PET-CT scan confirmed the diagnosis of a high-grade liposarcoma. Following discussion at the

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[1]Department of Plastic and Reconstructive Surgery, China Medical University Hospital, Taichung, Taiwan

[2]Department of Plastic and Reconstructive Surgery, University of Rome "Tor Vergata", Rome, Italy

[3]Plastic Reconstructive and Aesthetic Surgery, Villa Salaria Clinic, Rome, Italy

[4]Department of Plastic and Reconstructive Surgery, St. Thomas' Hospital, London, UK

[5]Department of Plastic and Maxillofacial Surgery, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

[6]Department of Pathology, China Medical University Hospital, Taichung, Taiwan

[7]Department of Plastic and Reconstructive Surgery, Marmara University School of Medicine, Istanbul, Turkey

*Correspondence to: Hung-Chi Chen, Department of Plastic and Reconstructive Surgery, China Medical University Hospital, 2 Yuh-Der Road, Taichung, 40447, R.O.C, Taiwan. Tel: +(886)-4-2205-2121 (1538), E-mail: D19722@mail.cmuh.org.tw

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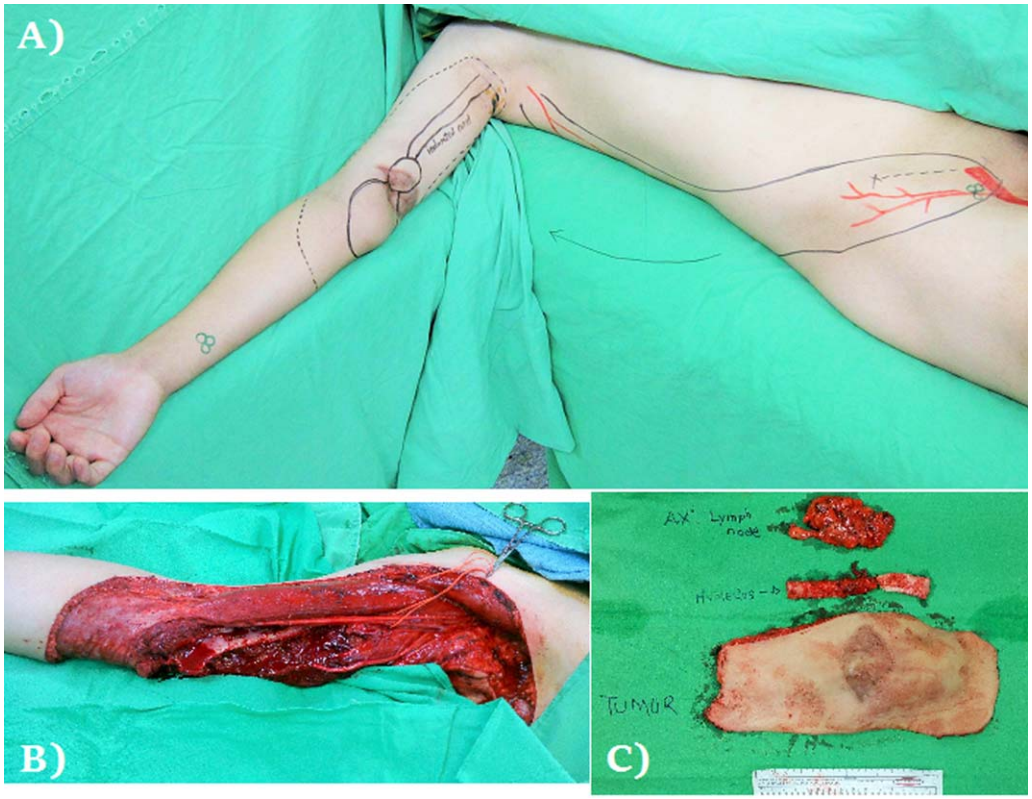

Figure 1. ***A****: Preoperative plan of LD-groin-lymph Node combined flap.* ***B****,****C****: Resection of the liposarcoma and final defect.*

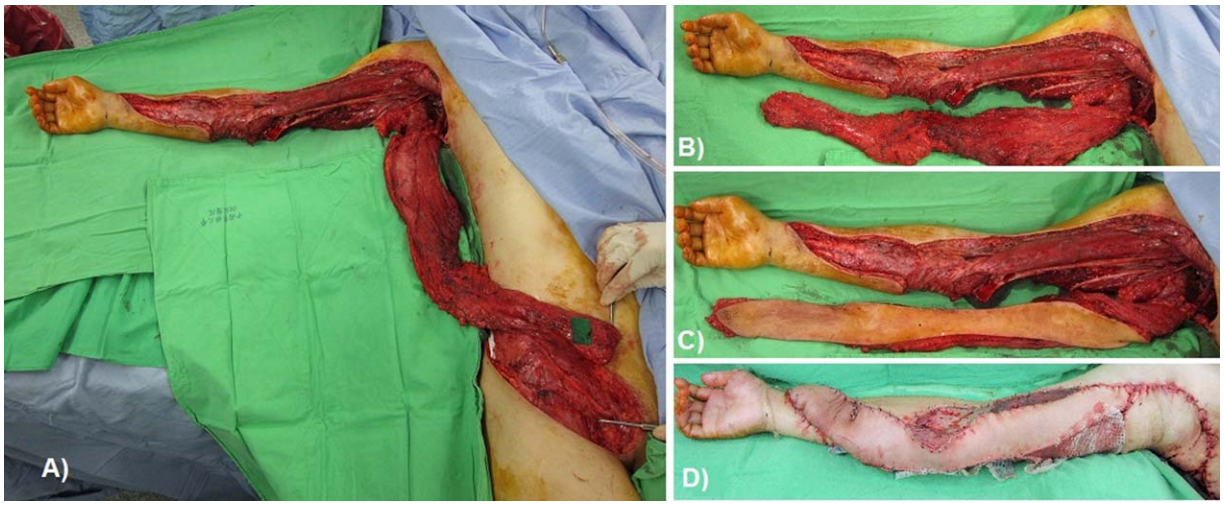

Figure 2. ***A–D****: Transposition of the compound flap to cover the defect.*

sarcoma multi-disciplinary team meeting, we carried out wide resection of the tumor with 5 cm and completion axillary lymphadenectomy. In view of the anticipated size and complexity of the resulting defect, we planned reconstruction using a large LD-GLN combined flap (Fig. 1A).

The defect extended from the inferior border of the axilla to the proximal forearm and measured approximately 28 cm × 15 cm (Fig. 1B). In the forearm, the excision included partial removal of the flexor muscles origin. In the arm, resection included the short head of biceps brachii, and the medial and long heads of triceps

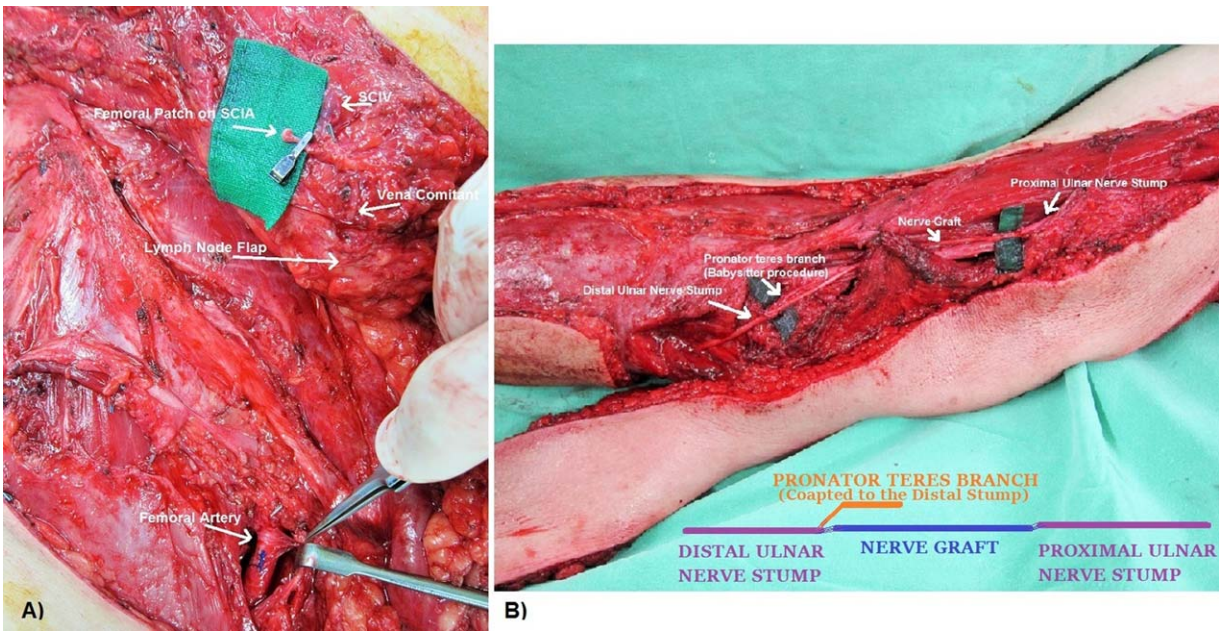

Figure 3. ***A****: Vascularization of the groin-lymph node flap with a patch of femoral artery and two venae comitantes.* ***B****: Nerve graft and "babysitter" procedure: transposition of a pronator teres branch to the distal stump of the ulnar nerve.*

brachii. A 10 cm segment of the ulnar nerve was involved and therefore resected. Marginal resection of the humeral bone was also undertaken for a 14 cm long segment. A level 3 axillary completion lymphadenectomy was carried out at the same time (Fig. 1C).

Planning and execution of the LD-groin flap was performed in a similar fashion, as previously described by Harii et al. and Katsaros et al.[9,10] With the patient in lateral decubitus position, the flap was marked from the posterior axillary line, along the anterior edge of the LD muscle, to the posterior superior iliac spine, with a fasciocutaneous extension from the groin region (Figs. 2A–2D). The elevation of the proximal part of the flap included the LD muscle with the overlying skin, based on the thoracodorsal vascular pedicle and nerve.[11] At the level of the iliac crest, dissection proceeded distally toward the groin area with harvesting of the skin and deep fascia as described by McGregor and Jackson for the groin flap.[12] The lateral lymph node groups (superior and inferior) were finally dissected and included within the flap, as reported for cases of groin lymph node transfer.[13–15]

The groin component of the LD-GLN flap was based on the superficial circumflex iliac artery (SCIA) pedicle, which was dissected up to its origin. A patch of femoral artery was also harvested to increase the caliber of the SCIA (Fig. 3A).[16] Subsequently, the patient was turned in a supine position and preparation of the recipient vessels took place. The radial artery and vein were selected and prepared. The 10 cm ulnar nerve gap was bridged with sural nerve grafts. A motor branch of the pronator teres was coapted end-to-side to the distal stump of the ulnar nerve as a permanent "babysitter" procedure (Fig. 3B).[17]

To restore the triceps function, the innervated LD muscle and its deep fascia were sutured proximally to the insertion of the pectoralis major, and distally to the periosteum of the olecranon process. The lymph nodes were positioned on the volar aspect of the distal forearm. Revascularization took place with end-to-side anastomosis of the SCIA to the radial artery, along with end-to-end anastomosis of two venae comitantes. The ischemia time was 2 h. Small areas of exposed muscle were resurfaced with split thickness skin graft. The donor site area was closed primarily over three suction drains. The patient stood the operation well (Fig. 2D).

Histological analysis with the support of immunohistochemistry showed a high-grade dedifferentiated liposarcoma associated with rhabdomyosarcomatous differentiation (Figs. 4A–4F). Postoperatively, the compound LD-GLN flap survived fully with no complications and the patient was discharged after ten days hospital stay. Post-operative radiotherapy was also carried out uneventfully. At one year follow-up the patient was assessed with the manual muscle strength testing method according to the Medical Research Council, showing good elbow extension with grade 4 muscle strength (against resistance). Sensory and motor recovery of the ulnar nerve was also satisfactory (grade 3) (Figs. 5A–5C and Supporting Information Video).

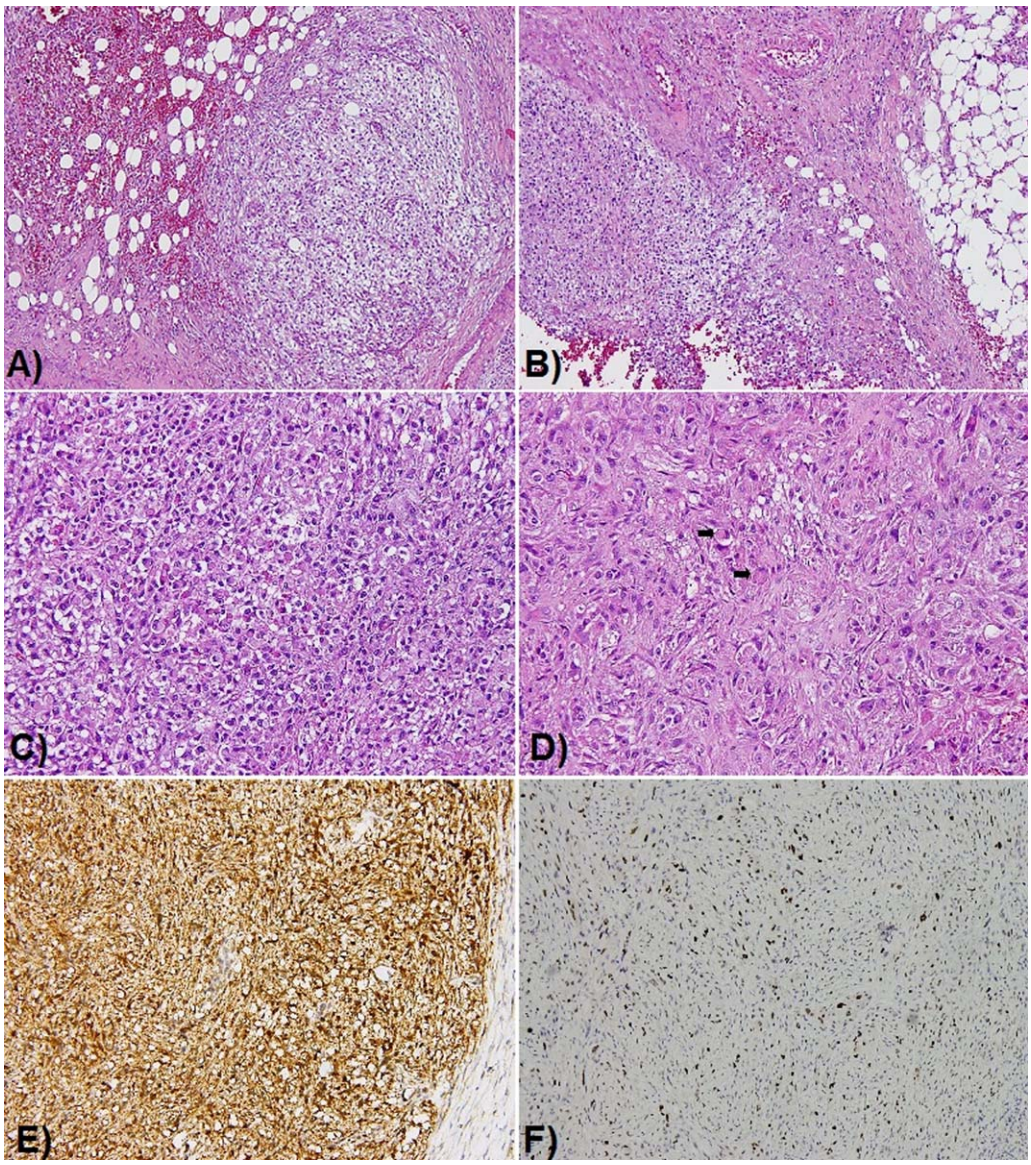

Figure 4. ***A,B****: Abrupt transition between well-differentiated liposarcoma and a high-grade dedifferentiated component is shown.* ***C,D****: Heterologous rhabdomyosarcomatous differentiation is also observed.* ***E****: Intense nuclear immunoreactivity for CDK4 helps to detect the 12q14-15 genetic abnormalities at the protein level.* ***F****: Positive MDM2 nuclear immunoreactivity represents a useful clue favoring the diagnosis of dedifferentiated liposarcoma.*

DISCUSSION

The compound flap concept was introduced by Harii et al. in 1981 for extensive, complex wound cases of the upper extremity.[9] To date, a limited number of compound flap cases have been reported in the literature and their classification has been defined by Hallock and Koshima.[8,18] According to this nomenclature, we performed a combined siamese flap based on the thoracodorsal and SCIA pedicles. This allowed the LD myocutaneous flap and groin-lymphnode flap to remain connected, and practically form a bipedicled flap.

Large LD myocutaneous flaps with extended skin paddles may be susceptible to ischemia and distal necrosis. Choudry et al.[6] reported that pedicled LD myocutaneous flaps had a 38% complication rates when used for upper extremity reconstruction. Harii et al.[9] in their first series of LD-groin flap reported one case of arterial thrombosis and distal necrosis. In our report, a femoral artery patch was utilized to increase the SCIA caliber and avoid turbulence through the anastomosis.[16] Moreover decompression of the forearm skin was performed distally to accommodate the transplanted lymph nodes and avoid excessive pressure to the pedicle.

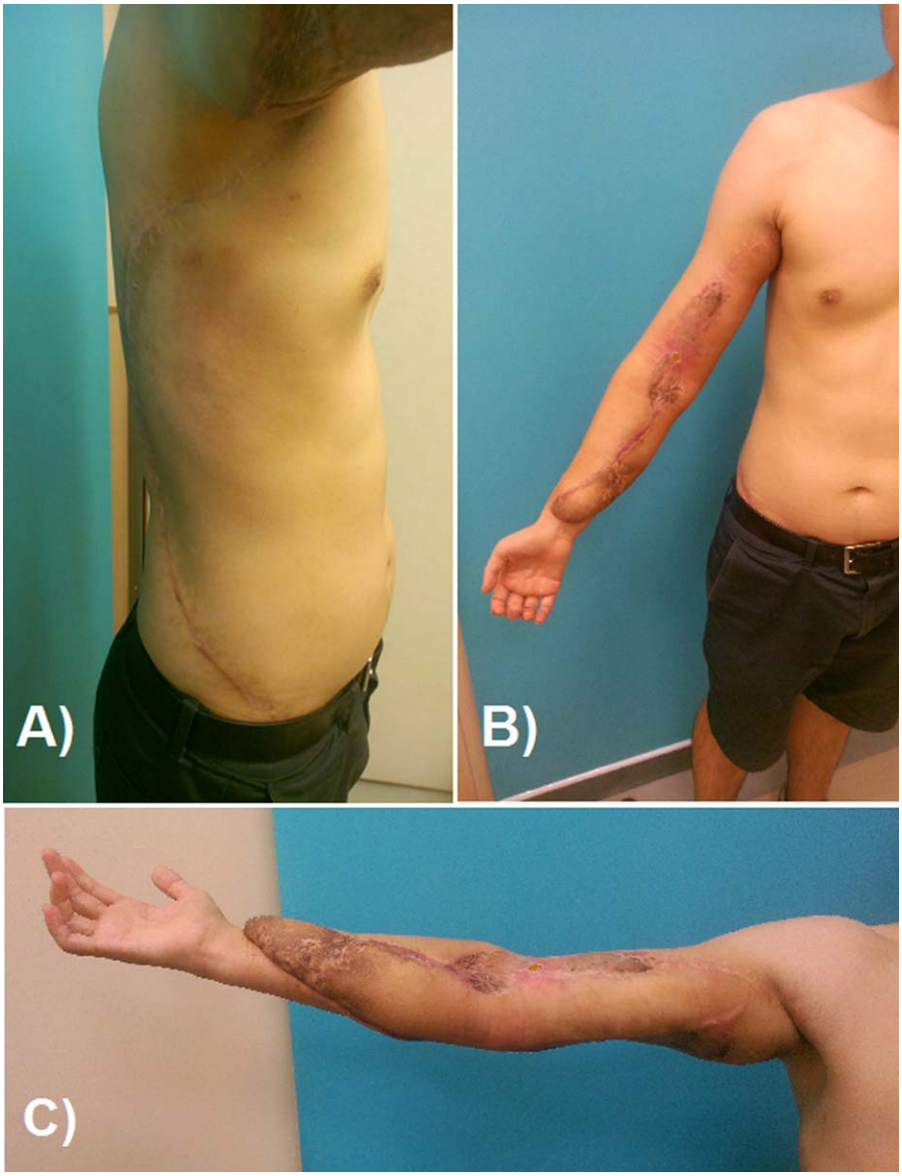

Figure 5. ***A****: Follow-up at 1 year: primarily closure of the donor site area.* ***B,C****: Completely wound healing and restoration of motor function.*

The majority of cases of upper limb reconstruction with the LD-groin flap reported to date have been performed either for traumatic defects or for benign conditions. In this report, the compound LD-GLN flap was utilized following wide resection of a high-grade liposarcoma, with concomitant completion axillary lymphadenectomy. In general, the treatment of high-grade soft tissue sarcomas consists of wide resection with the addition of radiation or chemotherapy when indicated.[19] Additionally, radical lymphadenectomy has demonstrated to provide a better long-term prognosis.[3] In fact, according to current literature, upper extremity soft tissue sarcomas progress to regional lymph node metastases in 10% to 15% of cases.[3,4] Moreover, some histologic subtypes, such as epithelioid sarcoma, rhabdomyosarcoma, clear cell sarcoma, and angiosarcoma, have been shown to have a stronger predilection for lymph node metastasis up to 45% of patients.[3,4,20]

The incidence of lymphedema following radical node dissection still remains significant despite the recent development of minimal access dissection techniques.[21] Although recent advances in lymphatic reconstruction have showed encouraging results in the management of lymphedema, however emphasis has been currently placed on its prevention.[22] A number of microsurgical techniques have been proposed toward this direction with encouraging results,[23,24] specifically in the prevention of post-mastectomy upper limb lymphedema.[22,25,26] In our

case, the groin lymph nodes were included in the flap and transferred to the forearm, in order to induce regrowth of lymphatic network and prevent the development of this condition.[27,28] At one-year follow-up, the patient did not show any signs of lymphedema.

One year post-operatively, the patient showed also a good functional outcome with the transfer of the innervated LD muscle, achieving elbow extension against resistance and good control of the arm. For reconstruction of the ulnar nerve, in addition to sural nerve grafting, we also performed an end-to-side coaptation of the distal stump to a pronator teres motor branch. This was a similar method to the "babysitter" procedure described by Terzis and Tzafetta,[17] however in our case there was no need for a secondary procedure. This technique has contributed in preventing the degeneration of the distal stump of the ulnar nerve and avoids wasting of the muscles, while waiting for regeneration through the sural nerve grafts.

In summary, here we introduce a modification of the compound LD/groin flap, including vascularized groin lymph node transfer. We believe that the combined LD-GLN flap may be a favorable option in these circumstances as it could not only provide skin coverage and functional muscle transfer, but also offers the opportunity for simultaneous lymphatic reconstruction for the prevention of lymphedema.

REFERENCES

1. Spyropoulou A, Jeng SF. Microsurgical coverage reconstruction in upper and lower extremities. Semin Plast Surg 2010;24:34–42.
2. Rogachefsky RA, Aly A, Brearley W. Latissimus dorsi pedicled flap for upper extremity soft-tissue reconstruction. Orthopedics 2002;25: 403–408.
3. Mazeron JJ, Suit HD. Lymph nodes as sites of metastases from sarcomas of soft tissue. Cancer 1987;60:1800–1808.
4. Fong Y, Coit DG, Woodruff JM, Brennan MF. Lymph node metastasis from soft tissue sarcoma in adults. Analysis of data from a prospective database of 1772 sarcoma patients. Ann Surg 1993;217: 72–77.
5. Behnam AB, Chen CM, Pusic AL, Mehrara BJ, Disa JJ, Athanasian EA, Cordeiro PG. The pedicled latissimus dorsi flap for shoulder reconstruction after sarcoma resection. Ann Surg Oncol 2007;14: 1591.
6. Choudry UH, Moran SL, Li S, Khan S. Soft-tissue coverage of the elbow: An outcome analysis and reconstructive algorithm. Plast Reconstr Surg 2007;119:1852–1857.
7. Pederson WC. Upper extremity microsurgery. Plast Reconstr Surg 2001;107:1524–1537.
8. Hallock GG. Simplified nomenclature for compound flaps. Plast Reconstr Surg 20001;5:1465.
9. Harii K, Iwaya T, Kawaguchi N. Combination myocutaneous flap and microvascular free flap. Plast Reconstr Surg 1981;68:700–711.
10. Katsaros J, Gilbert D, Russell R. The use of a combined latissimus dorsi-groin flap as a direct flap for reconstruction of the upper extremity. Br J Plast Surg 1983;36:67–71.
11. Silverton JS, Nahai F, Jurkiewicz MJ. The latissimus dorsi myocutaneous flap to replace a defect on the upper arm. Br J Plast Surg 1978;31:29–31.
12. McGregor IA, Jackson IT. The groin flap. Br J Plast Surg 1972;25: 3–16.
13. Clodius L, Smith PJ, Bruna J, Serafin D. The lymphatics of the groin flap. Ann Plast Surg 1982;9:447–458.
14. Lin CH, Ali R, Chen SC, Wallace C, Chang YC, Chen HC, Cheng MH. Vascularized groin lymph node transfer using the wrist as a recipient site for management of postmastectomy upper extremity lymphedema. Plast Reconstr Surg 2009;123:1265–1275.
15. Zhang H, Chen W, Mu L, Chen R, Luan J, Mu D, Liu C, Xin M. The distribution of lymph nodes and their nutrient vessels in the groin region: An anatomic study for design of the lymph node flap. Microsurgery 2014;34:558–561.
16. Lim SY, Yeo MS, Nicoli F, Ciudad P, Constantinides J, Kiranantawat K, Sapountzis S, Chung-Wai Ho A, Chen HC. End-to-patch anastomosis for microvascular transfer of free flaps with small pedicle. J Plast Reconstr Aesthet Surg 2015;68:559–564.
17. Terzis JK, Tzafetta K. "Babysitter" procedure with concomitant muscle transfer in facial paralysis. Plast Reconstr Surg 2009;124:1142–1156.
18. Koshima I. A new classification of free combined or connected tissue transfers: Introduction to the concept of bridge, siamese, chimeric, mosaic, and chain-circle flaps. Acta Med Okayama 2001;55:329–332.
19. Rosenberg SA, Tepper J, Glatstein E, Costa J, Young R, Baker A, Brennan MF, Demoss EV, Seipp C, Sindelar WF, Sugarbaker P, Wesley R. Prospective randomized evaluation of adjuvant chemotherapy in adults with soft tissue sarcomas of the extremities. Cancer 1983;52:424–434.
20. Riad S, Griffin AM, Liberman B, Blackstein ME, Catton CN, Kandel RA, O'Sullivan B, White LM, Bell RS, Ferguson PC, Wunder JS. Lymph node metastasis in soft tissue sarcoma in an extremity. Clin Orthop Relat Res 2004;426:129–134.
21. Karakousis CP. Surgical procedures and lymphedema of the upper and lower extremity. J Surg Oncol 2006;93:87–91.
22. Nguyen AT, Chang EI, Suami H, Chang DW. An algorithmic approach to simultaneous vascularized lymph node transfer with microvascular breast reconstruction. Ann Surg Oncol 2015;22:2919–2924.
23. Benoit L, Boichot C, Cheynel N, Arnould L, Chauffert B, Cuisenier J, Fraisse J. Preventing lymphedema and morbidity with an omentum flap after ilioinguinal lymph node dissection. Ann Surg Oncol 2005;12:793–799.
24. Sapountzis S, Ciudad P, Lim SY, Chilgar RM, Kiranantawat K, Nicoli F, Constantinides J, Wei MY, Sönmez TT, Singhal D, Chen HC. Modified Charles procedure and lymph node flap transfer for advanced lower extremity lymphedema. Microsurgery 2014;34:439–447.
25. Boccardo FM, Casabona F, Friedman D, Puglisi M, De Cian F, Ansaldi F, Campisi C. Surgical prevention of arm lymphedema after breast cancer treatment. Ann Surg Oncol 2011;18:2500–2505.
26. Campisi C, Davini D, Bellini C, Taddei G, Villa G, Fulcheri E, Zilli A, da Rin E, Eretta C, Boccardo F. Is there a role for microsurgery in the prevention of arm lymphedema secondary to breast cancer treatment? Microsurgery 2006;26:70–72.
27. Saaristo AM, Niemi TS, Viitanen TP, Tervala TV, Hartiala P, Suominen EA. Microvascular breast reconstruction and lymph node transfer for postmastectomy lymphedema patients. Ann Surg 2012; 255:468–473.
28. Nicoli F, Constantinides J, Ciudad P, Sapountzis S, Kiranantawat K, Lazzeri D, Lim SY, Nicoli M, Chen PY, Yeo MS, Chilgar RM, Chen HC. Free lymph node flap transfer and laser-assisted liposuction: A combined technique for the treatment of moderate upper limb lymphedema. Lasers Med Sci 2015;30:1377–1385.