

Soft Tissue Reconstruction of the Foot Using the Distally Based Island Pedicle Flap after Resection of Malignant Melanoma

Hyun Guy Kang, MD, June Hyuk Kim, MD, Hwan Seong Cho, MD*, Ilkyu Han, MD[†],
Joo Han Oh, MD[†], Han-Soo Kim, MD[†]

Orthopaedic Oncology Clinic, National Cancer Center, Goyang,

**Department of Orthopaedic Surgery, Kyungpook National University School of Medicine, Daegu,*

†Department of Orthopaedic Surgery, Seoul National University College of Medicine, Seoul, Korea

Background: We report on our experience with using a distally based island flap for soft tissue reconstruction of the foot in limb salvage surgery for malignant melanoma patients.

Methods: A distally based sural flap was used for 10 cases for the hindfoot reconstruction, and a lateral supramalleolar flap was used for 3 cases for the lateral arch reconstruction of the mid- and forefoot after wide excision of malignant melanomas.

Results: The length of the flap varied from 7.5 cm to 12 cm (mean, 9.6 cm) and the width varied from 6.5 cm to 12 cm (mean, 8.8 cm). Superficial necrosis developed in four flaps, but this was successfully treated by debridement and suture or a skin graft. All thirteen flaps survived completely and they provided good contour, stable and durable coverage for normal weight bearing.

Conclusions: The distally based sural flap is considered to be useful for reconstructing the hindfoot, and the lateral supramalleolar flap is good for reconstructing the lateral arches of the mid- and forefoot after resection of malignant melanoma of the foot.

Keywords: *Malignant melanoma, Distally based sural flap, Lateral supramalleolar flap*

Despite the recent advances in operative technique, reconstructing large soft-tissue defects of the foot poses substantial challenges to surgeons. When malignant melanomas involve the foot, large soft tissue defects created after excision of tumor with wide margin. A variety of techniques, ranging from a skin grafting to free-tissue transfer, have been used to reconstruct this defect although few have yielded entirely satisfactory results.¹⁾

The goal of reconstruction of the foot is to provide durable tissue which can withstand the stress of the body weight. In addition, these reconstructions also have to be able to withstand adjuvant chemotherapy by prompt

primary wound healing especially in melanoma patients. A safe, easy and reliable reconstructive option must be available to reconstruct the foot region no matter how and where a defect develops.

The distally based island sural flap^{2,3)} is raised on the posterior aspect of the calf, and the anatomical structures that constitute the pedicle are the superficial and deep fascias, the sural nerve, the lesser saphenous vein and the superficial sural artery. This flap is especially indicated for coverage of the hindfoot and the region of the lateral malleolus. The lateral supramalleolar flap^{4,5)} is raised on the lateral aspect of the lower leg and it is vascularized by branches of a perforating branch of the dorsal peroneal artery. The lateral supramalleolar flap is usually employed as a distally-based pedicle flap and it has a wide range of coverage that includes the whole dorsum of the foot, the medial and the lateral arches and all the regions of the heel.

Received August 31, 2009; Accepted November 11, 2009

Correspondence to: June Hyuk Kim, MD

Orthopaedic Oncology Clinic, National Cancer Center, 809 Madu 1-dong, Ilsan-gu, Goyang 411-764, Korea

Tel: +82-31-920-1732, Fax: +82-31-920-1244

E-mail: docjune@ncc.re.kr

Copyright © 2010 by The Korean Orthopaedic Association

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Clinics in Orthopedic Surgery • pISSN 2005-291X eISSN 2005-4408

Previous reports of foot reconstruction have focused chiefly on patients suffering from trauma or ischemic wounds.⁶⁻⁸⁾ However, very little literature deals with the results of limb salvage surgery by microvascular reconstruction in the melanoma patient. Herein, we present our experience with thirteen malignant melanoma patients who were treated successfully using the distally-based island pedicle flap for covering large soft-tissue defects in the foot.

METHODS

We retrospectively reviewed our series of patients with malignant melanoma involving the foot. We enrolled 13 consecutive patients between March 2005 and March 2009 and who met the following inclusion criteria: 1) they were diagnosed with acral lentiginous melanoma by punch biopsy; 2) their skin lesion confined to the foot; 3) there was no skin or soft tissue disease on the ipsilateral lower leg. We routinely checked the preoperative ultrasonography for popliteal and inguinal lymph node metastasis, and we performed computed tomography of the chest and positron emission tomography to assess for distant metastasis.

A distally-based island sural flap was used in 10 cases for hindfoot reconstruction, and the lateral supra-malleolar fasciocutaneous flap was used in 3 cases for lateral arch reconstruction of the mid- and forefoot after wide excision of malignant melanomas (Table 1). Eight patients were women and 5 were men with mean age of 60.3 years (range, 35 to 73 years). The mean duration of follow-up was 23.3 months (range, 6 to 48 months). One patient had ipsilateral inguinal and popliteal lymph node metastasis, and one patient had ipsilateral inguinal lymph node metastasis at the time of diagnosis.

Surgical Technique

We performed wide excision of the malignant melanoma with a 2 cm margin in all the patients. After wide excision, we confirmed that the margin of resection was free of tumor by frozen section, and then we measured the exact size of the defect.

The distally based island sural flap was outlined at the junction of the two heads of the gastrocnemius muscle. A line of incision was traced over the presumed course of the sural nerve and the lesser saphenous vein. The pivotal point of the pedicle was three fingers breadth proximal to the tip of the lateral malleolus. The flap and

Table 1. Demographics of Patients

Patient No.	Age (yr)/sex	Location	Size of melanoma (cm), depth (mm)	Lymph node metastasis, distant metastasis	Type of flap	Size of flap (cm, length × width)	Complication	Follow-up (mo)	Patient status
1	59/F	Hindfoot	1.5 × 1.5, 1	Yes, No	DBSF	9.0 × 8.0	No	42	AWD
2	56/F	Hindfoot	1.5 × 1.5, 1	Yes, No	DBSF	7.5 × 6.5	No	15	DOD
3	58/F	Hindfoot	4.5 × 2.5, 4	No, No	DBSF	8.0 × 8.0	Partial necrosis	39	NED
4	70/F	Hindfoot	4.5 × 4.5, 8	No, No	DBSF	10.0 × 10.0	No	45	NED
5	35/M	Lateral arch of forefoot	2.0 × 2.0, 4	No, No	LSMF	12.0 × 9.0	Partial necrosis	48	NED
6	59/M	Hindfoot	7.5 × 6.0, 5	No, No	DBSF	11.0 × 12.0	No	7	DOD
7	64/F	Lateral arch of forefoot	2.5 × 1.5, 1	No, No	LSMF	10.0 × 7.5	No	13	DOD
8	53/M	Lateral arch of forefoot	3.0 × 1.5, 4	No, No	LSMF	10.5 × 9.0	Partial necrosis	10	DOD
9	67/M	Hindfoot	3.0 × 4.0, 1	No, No	DBSF	8.0 × 10.0	No	24	NED
10	63/F	Hindfoot	6.0 × 5.5, 1	No, No	DBSF	12.0 × 11.5	No	21	NED
11	73/F	Hindfoot	2.0 × 2.0, 3	No, No	DBSF	8.0 × 7.0	Partial necrosis	20	AWD
12	73/F	Hindfoot	4.5 × 4.5, 3	No, No	DBSF	9.0 × 8.0	No	13	NED
13	47/M	Hindfoot	5.5 × 6.0, 3	No, No	DBSF	10.0 × 9.0	No	6	NED

DBSF: Distally based sural flap, LSMF: Lateral supra-malleolar flap, AWD: Alive with disease, NED: No evidence of disease, DOD: Die of disease.

the pedicle were raised including the fascia (Fig. 1).

The lateral supramalleolar fasciocutaneous flap need an essential landmark, which is the perforating branch of the peroneal artery as it pierces the interosseous membrane at the distal tibiofibular angle about 5 cm proximal to the tip of the lateral malleolus. The fasciocutaneous flap contained the superficial peroneal nerve, the perforating branch from the peroneal artery and the venae comitantes (Fig. 2). We attempted neuroorrhaphy between the proximally cut superficial peroneal nerve and the distally cut lateral plantar nerve in the two lateral supramalleolar flaps.

At a mean time of 21 days after the first operation, the skin graft on the flap donor site and opening the pedicle tunnel was carried out with full thickness skin, which was obtained from the ipsilateral inguinal area. Inguinal lymph node dissection was concomitantly performed, after harvesting the full thickness skin graft, in 10 patients who had “thick melanomas” (> 1.0 mm in thickness by Breslow microstaging) and who had lymph node metastasis seen on the preoperative ultrasonography. Three patients with “thin melanoma” (\leq 1.0 mm in thickness by Breslow microstaging) had a split thickness skin graft that was harvested from the thigh without inguinal lymph node dissection.⁹⁾

Postoperative Care

Low molecular weight Dextran was routinely used for 5 days postoperatively. Partial and full weight bearing ambulation could be started after 6 weeks and 12 weeks after the first operation without concern for wound healing. All the patients underwent postoperative adjuvant immunotherapy with interferon- α .

RESULTS

One patient, who had a split thickness skin graft without lymph node dissection, was revealed to have pulmonary and inguinal lymph node metastasis at 4 months postoperatively, and the patient died of disease at 13 months. Among those who underwent elective inguinal lymph node dissection, 2 patients were revealed to be alive with disease and 3 patients died of disease at 7, 10, 13, 15 months later after operation respectively. Meanwhile, there was no local recurrence in all the patients. The length of the flap varied from 7.5 to 12 cm (mean length, 9.6 cm) and the width varied from 6.5 to 12 cm (mean width, 8.8 cm). In 4 cases, superficial necrosis developed, but this was successfully treated by debridement and suture or skin graft (Table 1). All 13 flaps survived completely and they provided stable defect coverage, good contour and normal weight bearing ambulation. As for the patients who had

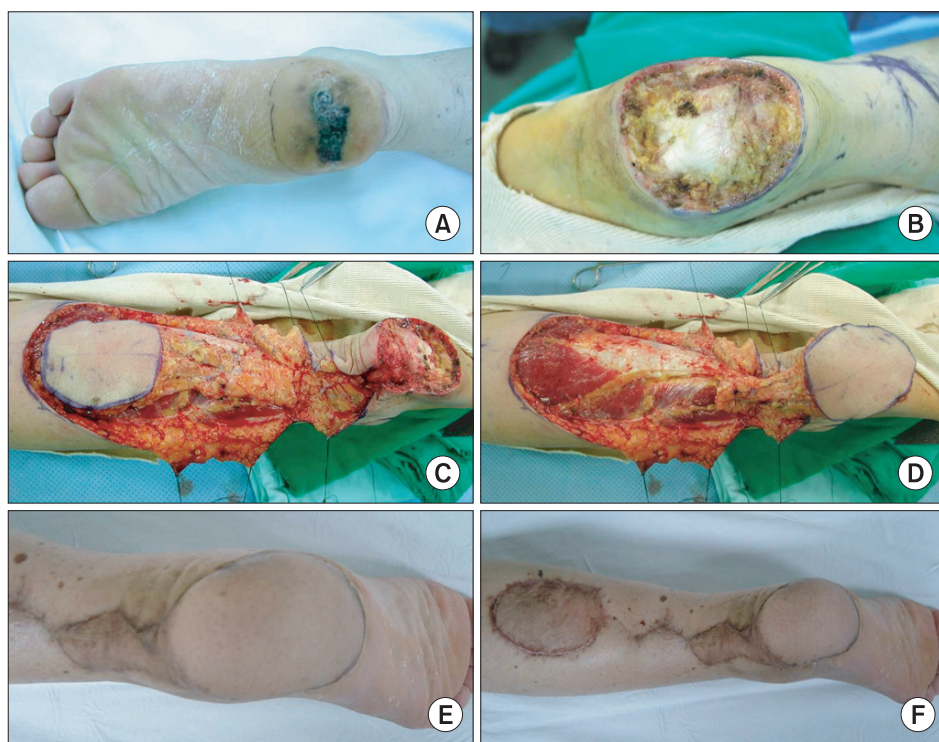


Fig. 1. Case 3. (A) The patient was referred from a regional hospital with a pathologic report of malignant melanoma on the heel. (B) After wide excision, an 8 × 8 cm defect was present. (C) The sural flap pedicle contains the sural artery and nerve and lesser saphenous vein. (D) The pivotal point of the pedicle is three fingers breadth proximal to the tip of the lateral malleolus. (E, F) A delayed full thickness skin graft on the flap donor site and an opened pedicle tunnel were performed with concomitant ipsilateral inguinal lymph node dissection at the time of skin harvest at 15 days postoperatively.

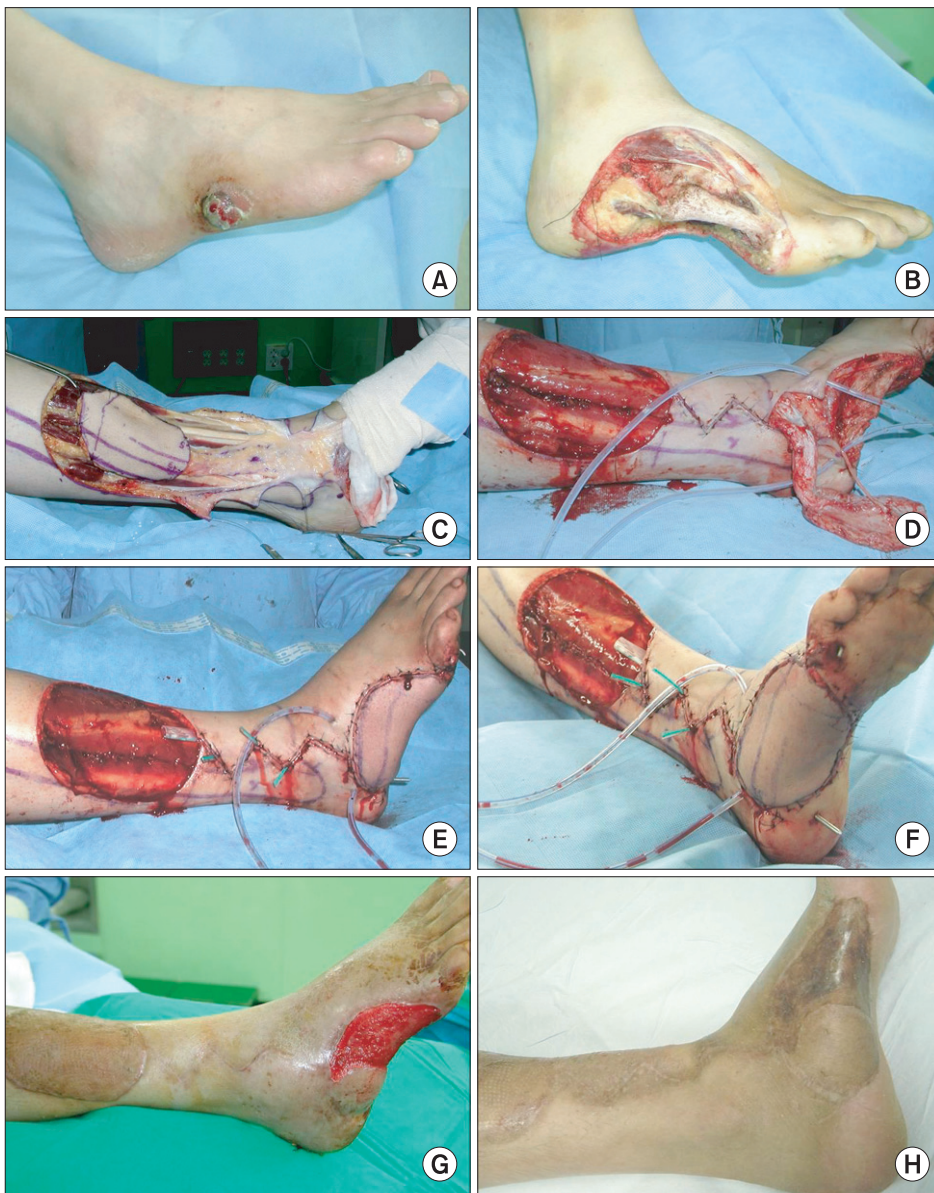


Fig. 2. Case 5. (A) Malignant melanoma with ulceration was confirmed through biopsy at a regional hospital. (B) Wide excision resulted in a 12×9 cm defect on the lateral arch of the mid and lateral foot. (C) The skin paddle is designed according to the arterial anastomotic arcade of the ankle. (D) The lateral supramalleolar flap pedicle contains the superficial peroneal nerve and the perforating branch of the peroneal artery that anastomoses with the anterior lateral malleolar artery, and it continues into the foot and then it anastomoses with the lateral tarsal artery. (E) Flap transposition and suture of the pedicle tunnel were performed after placing indwelling drains. (F) Temporary trans-ankle joint pinning is shown. (G) Superficial necrosis of the flap developed, which may have been caused by the initial pedicle tunnel closure, but this was successfully treated by debridement and a full thickness skin graft. (H) The photograph was taken at 10 months postoperatively, and the lateral contour of the foot has been well restored.

neurorrhaphy, the recovery of sensation was not observed.

DISCUSSION

Distally based fasciocutaneous flaps on the leg were first introduced in 1983.¹⁰ The main advantages of these flaps are a well-defined surface that is independent of a length-width ratio and the preservation of the main vascular axis. In most cases, the sural nerve descends in between the two heads of the gastrocnemius muscle and it penetrates the deep fascia at the median point of the leg. The superficial sural artery originates from the popliteal or sural arteries, and it reaches the sural nerve at 2 cm to 3 cm after its emergence, then subdivides into the medial, median and

lateral superficial sural arteries. The median superficial sural artery follows the course of the sural nerve, and then it emits numerous branches toward the skin at the lower half of the leg, along its superficial path. The peroneal artery, in turn, makes other anastomoses, notably through its descending branch, and especially with the anterior tibial artery. Several authors have stated that the principal anastomosis occurs at above to 5 centimeters from the lateral malleolus.^{2,11-13} Although there are some reports of a preoperative lesser saphenous vein mapping method that used Doppler ultrasound⁴ or using a simple rubber tourniquet for making the superficial vessels prominent,² we did not use these techniques. However, the incision was initiated in the proximal extreme of the flap, we identified

the lesser saphenous vein, sural artery and nerve, and then we made further incision with centralizing on the presumed vessel course as much as possible.

The distally based sural flap had a tendency of having a short flap pedicle for coverage of a forefoot defect, as compared to that of the lateral supramalleolar flap. The lateral supramalleolar flap is a distally based fasciocutaneous flap that is vascularized by branches of a perforating branch of the dorsal peroneal artery. This branch is constant and it emerges 5 cm above the lateral malleolus, with 2 or 3 ascending cutaneous branches and a deep descending branch. The ascending branches are included in the intermuscular septum between the extensor digitorum longus and the peroneus brevis, and the ascending branches perforate the fascia and then they supply the skin over the lower lateral half of the leg. The descending branch runs distally below the deep fascia, and it anastomoses with the anterolateral malleolar branch of the tibialis anterior artery, and then it continues into the foot to form anastomoses with the tarsi arteries and dorsal arch. The point of emergence of the perforating branch of the dorsal peroneal artery could be detected "by palpating the groove just above and anterior to the lateral malleolus."¹⁴ This represents the pivot point. The axis of the flap is represented by a midline drawn from the anterior tibial crest to the posterior margin of the fibula. Voche et al.⁵ distinguished the type of arterial blood supply to the lateral supramalleolar flap depending on how far distally the flap is raised, and this can include a mixed antegrade and retrograde blood supply. So this flap can have a longer pedicle length due to the various possible vascular networks and the flap can reach to the forefoot.

Almeida et al.² reported on the complications in their 71 cases of a reverse-flow island sural flap, including partial (22.1%) or total (4.2%) flap necrosis, infection (8.5%) and venous congestion (4.1%). Voche et al.⁵ reported venous congestion and partial flap necrosis (5 to 30%) in their 41 cases of using the lateral supramalleolar flap. Kneser et al.³ suggested a technical modification to prevent partial flap necrosis. They presented the delayed neurofasciocutaneous sural flap, which is initially completely elevated and it is then fixed again at the donor site using running sutures for 7 to 15 days. After confirming the flap's survival, the flap was raised again and transposed into the defect. This delayed procedure could be an alternative to overcome these problems and to increase the reliability and viability of the flap. Tan et al.¹⁵ treated three patients with a supercharged reverse flow sural flap to reduce venous congestion and edema, and the venous drainage was achieved by end-to-end anastomosis between

the free end of the lesser saphenous vein and a superficial vein on the medial site of the ankle.

Among our 4 patients with partial necrosis, 2 occurred in the distally based sural artery flap. Partial necrosis developed on the lateral margin of the flap that was transposed medially on the plantar surface. The flap sizes of these patients were not too much larger than that of the other patients, but the routes of passage of the sural vascular pedicle were more laterally located from the flap center. Therefore, at the time of sural flap dissection, the skin island should be redrawn and shifted either medially or laterally as the dissection progresses, while trying to keep the pedicle centralized with regard to the flap. The other two cases of partial necrosis developed on the distal portion of the transposed lateral supramalleolar flap. These flaps were large size (12 × 9, 10.5 × 9 cm) with long pedicle lengths to reach the metatarso-phalangeal joint of the fifth toe. We confirmed well-blanching, transposed flap color to the lateral arch of the forefoot and then we completely sutured the pedicle tunnel. From these cases, we suggest that an opened pedicle tunnel can be beneficial for the long length pedicle and a large flap size.

When the defects are larger and more anterior, free tissue transfer is often required because it can provide a large amount of tissue.⁶ However, there are some disadvantages such as donor-site morbidity, an increased operation time, the use of a major vessel of the leg and the necessity of microsurgical expertise. Moreover, Langstein et al.¹⁶ reported the free tissue transfer for limb salvage of soft tissue malignancies on the foot. According to their results, over 50% of the patients with local recurrence and persistent disease required below knee amputation.

Voche et al.⁵ suggested the lateral supramalleolar flap is reliable and useful for coverage of the lower leg, ankle and foot skin defects, but coverage of the weight-bearing surface of the foot should be avoided. However, we had satisfactory results for a the large defect of the lateral half of the midfoot and forefoot, including a weight bearing area, so there seems to be no problem if the pedicle can be placed in a non-weight bearing portion or delayed weight bearing is performed.

One patient developed multiple inguinal lymph node and lung metastases after a late split thickness skin graft on the donor defect area and the patient had received a lateral supramalleolar flap. This all suggested the necessity of inguinal lymph node biopsy or dissection, and many articles have emphasized that sentinel lymph node biopsy needs to be done in a patient in the malignant melanoma.¹⁷ If this patient had received a full thickness skin graft instead of a split skin graft, then we would have

performed inguinal lymph node dissection. Our delayed full thickness skin graft had benefits with respect to confirming the flap's viability in a critical period, the one-time-approach for ipsilateral lymph node dissection after harvesting the full thickness skin and the safety for the pedicle tunnel that remained open rather than performing primary closure.

In conclusion, the distally based sural flap and lateral supramalleolar flap provide effective coverage of variable sized soft tissue defects on the foot after wide excision of malignant melanoma. This is quick and safe

surgery without the necessity of microsurgical expertise, it preserves the major arteries of the leg and the donor-site morbidity is acceptable. The distally based sural flap is useful for the hindfoot, and the lateral supramalleolar flap is good for lateral arches of the mid- and forefoot.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

- Sommerlad BC, McGrouther DA. Resurfacing the sole: long-term follow-up and comparison of techniques. *Br J Plast Surg.* 1978;31(2):107-16.
- Almeida MF, da Costa PR, Okawa RY. Reverse-flow island sural flap. *Plast Reconstr Surg.* 2002;109(2):583-91.
- Kneser U, Bach AD, Polykandriotis E, Kopp J, Horch RE. Delayed reverse sural flap for staged reconstruction of the foot and lower leg. *Plast Reconstr Surg.* 2005;116(7):1910-7.
- Demiri E, Foroglou P, Dionysiou D, et al. Our experience with the lateral supramalleolar island flap for reconstruction of the distal leg and foot: a review of 20 cases. *Scand J Plast Reconstr Surg Hand Surg.* 2006;40(2):106-10.
- Voche P, Merle M, Stussi JD. The lateral supramalleolar flap: experience with 41 flaps. *Ann Plast Surg.* 2005;54(1):49-54.
- May JW, Jr., Rohrich RJ. Foot reconstruction using free microvascular muscle flaps with skin grafts. *Clin Plast Surg.* 1986;13(4):681-9.
- Clark N, Sherman R. Soft-tissue reconstruction of the foot and ankle. *Orthop Clin North Am.* 1993;24(3):489-503.
- Ferreira MC, Besteiro JM, Monteiro Junior AA, Zumiotti A. Reconstruction of the foot with microvascular free flaps. *Microsurgery.* 1994;15(1):33-6.
- Balch CM, Buzaid AC, Soong SJ, et al. Final version of the American Joint Committee on Cancer staging system for cutaneous melanoma. *J Clin Oncol.* 2001;19(16):3635-48.
- Donski PK, Fogdestam I. Distally based fasciocutaneous flap from the sural region: a preliminary report. *Scand J Plast Reconstr Surg.* 1983;17(3):191-6.
- Hasegawa M, Torii S, Katoh H, Esaki S. The distally based superficial sural artery flap. *Plast Reconstr Surg.* 1994; 93(5):1012-20.
- Masquelet AC, Romana MC, Wolf G. Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. *Plast Reconstr Surg.* 1992;89(6):1115-21.
- Torii S, Namiki Y, Mori R. Reverse-flow island flap: clinical report and venous drainage. *Plast Reconstr Surg.* 1987; 79(4):600-9.
- Masquelet AC, Beveridge J, Romana C, Gerber C. The lateral supramalleolar flap. *Plast Reconstr Surg.* 1988;81(1):74-81.
- Tan O, Atik B, Bekerecioglu M. Supercharged reverse-flow sural flap: a new modification increasing the reliability of the flap. *Microsurgery.* 2005;25(1):36-43.
- Langstein HN, Chang DW, Miller MJ, et al. Limb salvage for soft-tissue malignancies of the foot: an evaluation of free-tissue transfer. *Plast Reconstr Surg.* 2002;109(1):152-9.
- Dubois RW, Swetter SM, Atkins M, et al. Developing indications for the use of sentinel lymph node biopsy and adjuvant high-dose interferon alfa-2b in melanoma. *Arch Dermatol.* 2001;137(9):1217-24.