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Open-book Splitting of a Distally Based Peroneus Brevis Muscle Flap to Cover Large Leg and Ankle Defects

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Background: Large soft-tissue defects in the lower leg and ankle are a major problem for plastic surgeons. Many local flaps that are either proximally or distally based have been previously described to cover small defects. Larger defects may require a distant flap that is either pedicled or free. The peroneus brevis muscle flap is a well-known distally based safe flap that is used to cover a small defect.
Methods: Ten distally based peroneus brevis muscle flaps were elevated in 10 patients (8 males and 2 females) with major lower third leg and ankle defects that were 6–12 cm in length and 6–10 cm in width, with open-book splitting of the proximal portion of the muscle to cover these large defects.
Results: Flap survival was excellent, and partial skin graft loss in two cases healed with dressing. The average flap length was 10 cm, ranging between 6 and 12 cm. The average flap width was 8 cm, ranging between 6 and 10 cm. The donor site also healed uneventful.
Conclusions: Open-book splitting of the distally based peroneus brevis muscle flap is ideally suited for moderate to large defects in the distal third of the lower leg and ankle. This modification of the distally based peroneus brevis muscle flap offers a convincing alternative for covering large defects of up to 12×10 cm in the distal leg and ankle region. *(Plast Reconstr Surg Glob Open 2015;3:e572; doi: 10.1097/GOX.0000000000000560; Published online 8 December 2015.)*

Large defects in the lower leg and ankle are challenging for a plastic and reconstructive surgeon. A variety of useful methods for lower leg reconstruction are now available, including the use of local cutaneous flaps, fascial or fasciocutaneous flaps, muscle flaps and free flaps, the distally based sural island flap,[1] lateral supramalleolar island flap,[2] reverse adipofascial flap,[3] and free tissue transfer.[4]

Reconstruction of the distal third of the leg is associated with the highest complication rate for local procedures because of the paucity of reliable local flaps, which is because of the limited amount of available local tissue. In addition, local flaps are not always suitable for covering defects in the lower leg because of the small radius of extension in the distal direction.[5] Thus, free tissue transfer is often recommended as the treatment of choice for large defects. However, microvascular flaps require microsurgical expertise, which is a relatively complex and time-consuming procedure.[6] Moreover, not all patients are willing or healthy enough to undergo free tissue transplantations.

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The peroneus brevis muscle flap has been proven to be a sufficient local flap for small defects.[7, 8] These muscles were first described by Pers and Medgyesi,[9] and this flap has become an established workhorse in reconstructive procedures of the lower leg. This flap was originally described as a proximally based flap for pretibial defects.[10] Barr[11] and Saydam[12] reported on the reliability of distally based peroneus brevis muscle flaps.

Anatomical Consideration

The peroneus brevis muscle is located deep to the peroneus longus in the lateral compartment of the leg. The extensor digitorum longus is found anterior to the peroneus brevis in the anterior compartment, and the flexor hallucis longus is posterior to it in the deep posterior compartment. The peroneus brevis muscle originates from the mid shaft of the lateral fibula, passing posterior to the lateral malleolus and inserting at the tuberosity of the fifth metatarsal bone. It remains muscular distal to the lateral malleolus, beyond which it is entirely tendinous. Motor supply to the peroneus muscles is from the superficial peroneal nerve, which is located superficially in the lateral compartment.[13] Originally, the peroneus brevis was a type II muscle flap, but it was reclassified by Mathes and Nahai[14] as type IV with a dominant pedicle or pedicles from the peroneal artery, located proximally, entering the muscle from its deep surface, and distal minor pedicles from the peroneal or anterior tibial vessels. When the flap is based distally, it is recommended that 3 fingerbreadths be left intact from the distal tip of the lateral malleolus.[15]

Yang et al[16] described the vascular pattern of the peroneus muscle. Six cadaveric specimens were dissected to determine the location of the distal pedicles and flap type. This flap was identified as a type IV flap, and the location of the distal pedicle was found within 6 cm of the fibula tip.

McHenry[17] reported that the peroneus brevis muscle had an average of 3.5 vascular pedicles (range, 2–6). The average distance of the distal pedicle from the tip of the lateral malleolus was 6.7 cm (range, 3.5–12.0 cm). Villarreal et al[18] described 2 principal source arteries: the anterior tibial artery and peroneal artery, which supply the muscles. The anterior tibial artery is the dominant artery and supplies the proximal and middle thirds of these muscles. The peroneal artery is considered to be a supplementary vascular source and supplies the distal third of these muscles.

On the basis of these surgical anatomies, this muscle is circumpennate, with an internal axial blood supply from 2 arteries corresponding to nearly its total length, and the blood supply enters through its deep surface. The muscle splitting through its superficial surface described here allows for the coverage of larger defects than has been previously described in the literature.

Surgical Technique

Under tourniquet control, refreshment of the edge of the defect was performed first, followed by flap elevation. An incision was made over the peroneus muscle bellies, from below the neck of the fibula to the proximal edge of the defect. Using loupe magnification, the peroneus brevis muscle was separated from the peroneus longus muscle. The origin of the brevis muscle was detached from the fibula, keeping the periosteum attached to this muscle, and care was taken not to injure the epimysium of the muscle. Dissection proceeded distally with ligation of the proximal branches of the peroneal and anterior tibial arteries to the muscle and cutting the motor branch to the peroneus brevis from the superficial peroneal nerve. Dissection proceeded up to 6 cm above the lateral malleolus, preserving the most distal segmental branches of the peroneal and anterior tibial arteries, which feed the distal portion of the peroneus brevis. The tourniquet was then released, and hemostasis was achieved. The proximal portion of the muscle belly was then split from the outer external surface, leaving the deep part of the muscle intact with its attached epimysium and periosteum (Figs. 1, 2, and 4B and C). The muscle was then turned over and gently sutured into the defect using fine 4/0 absorbable sutures (Figs. 3C and D). The split thickness skin graft was immediately applied (Fig. 4E), suction drainage was inserted, the donor site was closed, and the leg was dressed and secured using a posterior splint.

PATIENTS AND METHODS

Ten distally based peroneus brevis muscle flaps were elevated in 10 patients (8 males and 2 females) with major leg and ankle defects that were 6–12 cm in length and 6–10 cm in width, at the Department of Plastic and Reconstructive Surgery, Al-Husain University Hospitals, Al-Azhar Faculty of Medicine.

Seven patients sustained a posttraumatic chronic ulcer on the lower leg and ankle. Three patients sustained a postburn unstable scar and ulcer on the Achilles tendon area and lower leg. Many previous surgical procedures were performed, for some of these cases, in the forms of skin graft but with recurrence of the ulcer. One case was previously treated with a distally based sural flap, which was complicated by congestion and failure (Fig. 4). The demographic data of the patient, defect site and size, and muscle width before and after splitting are illustrated in Table 1.

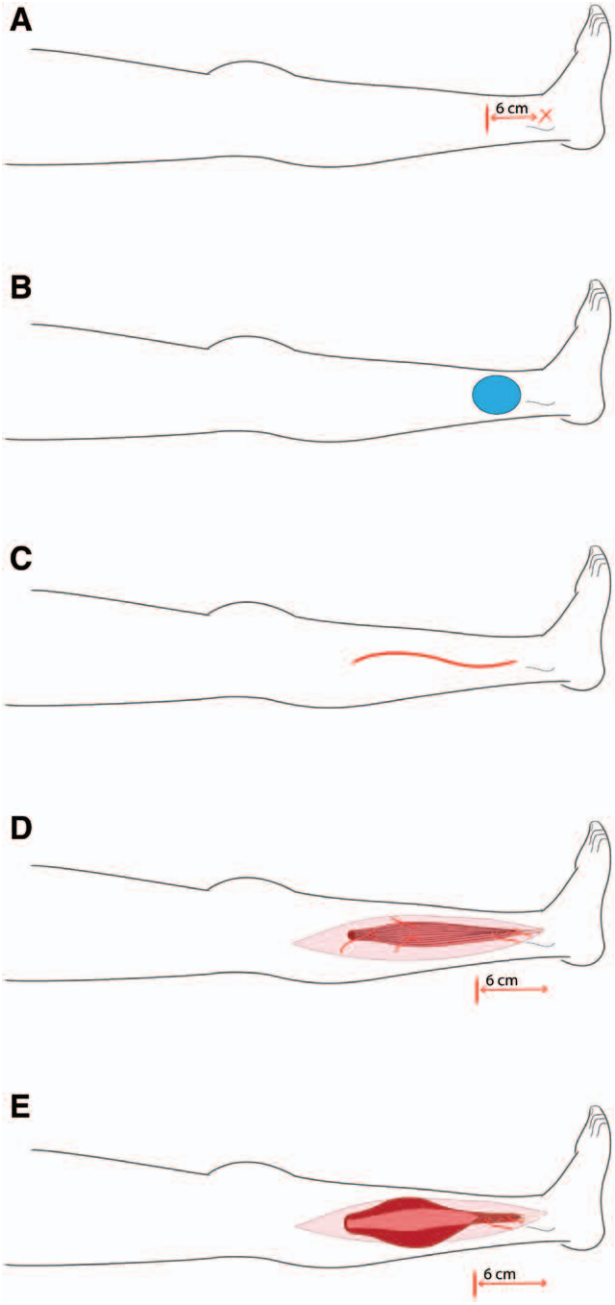

Fig. 1. Schematic diagram representing peroneus brevis before and after splitting. A, The lower limit of dissection of the muscle 6 cm above lateral malleolus; B, defect in the leg; C, incision for muscle approach; D, the muscle before splitting; E, the muscle after splitting.

Ethical Approval

This work was approved by the Ethical Committee at the Faculty of Medicine, Al-Azhar University, Cairo, Egypt.

RESULTS

Ten distally based peroneus brevis muscle flaps were performed to cover the large lower third leg and ankle defects in 10 patients (8 males and 2 females). The average patient age was 34.5 years (range, 6–50 years).

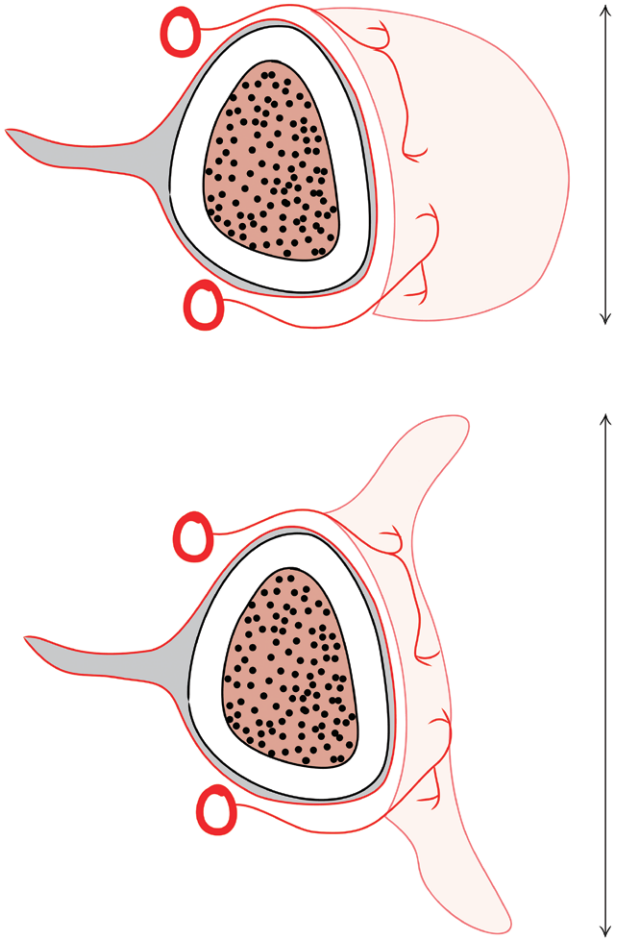

Fig. 2. Schematic diagram of transverse section of peroneus brevis before and after splitting.

The etiology of the defect was a posttraumatic chronic ulcer in 7 cases, postburn ulcer and unstable scar in 3 cases. The average flap length was 10 cm, ranging between 6 and 12 cm. The average flap width was 8 cm, ranging between 6 and 10 cm. Flap survival was excellent, and partial graft loss in 2 cases healed with dressing. The donor-site scar area also healed nicely, except in 1 case of postburn scar, where it healed by secondary intention. These results were very satisfactory to both the patient and the surgeon, as the flap is thin and with durable coverage. In addition, the donor site was closed directly and placed in a hidden area in the posterolateral aspect of the leg (Figs. 3–4).

DISCUSSION

Defects around the ankle and distal lower leg often require flap coverage because the soft-tissue coverage over tendons, bones, and joints is thin.

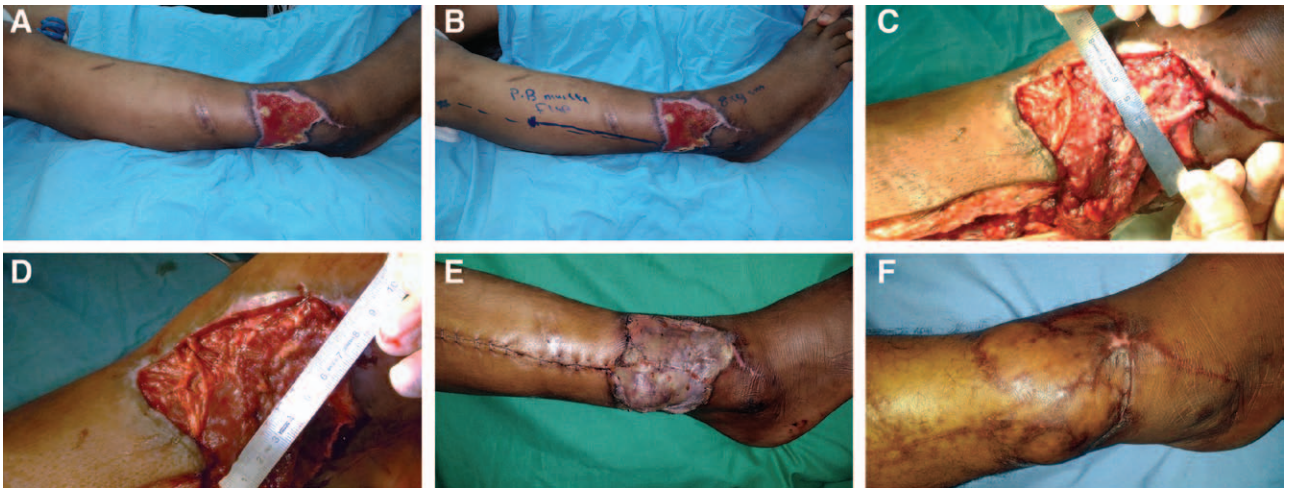

Fig. 3. A, Preoperative large ulcer on the lateral aspect of the leg; B, preoperative design of the flap and diameter of the defect before refreshment of the edge of approximately 8 × 9 cm; C, intraoperative after edge refreshment and split muscle sutured in the recipient site, showing the width of the defect; D, intraoperative after edge refreshment and split muscle sutured in the recipient site, showing the length of the defect; E, early postoperative; F, late postoperative after 6 months.

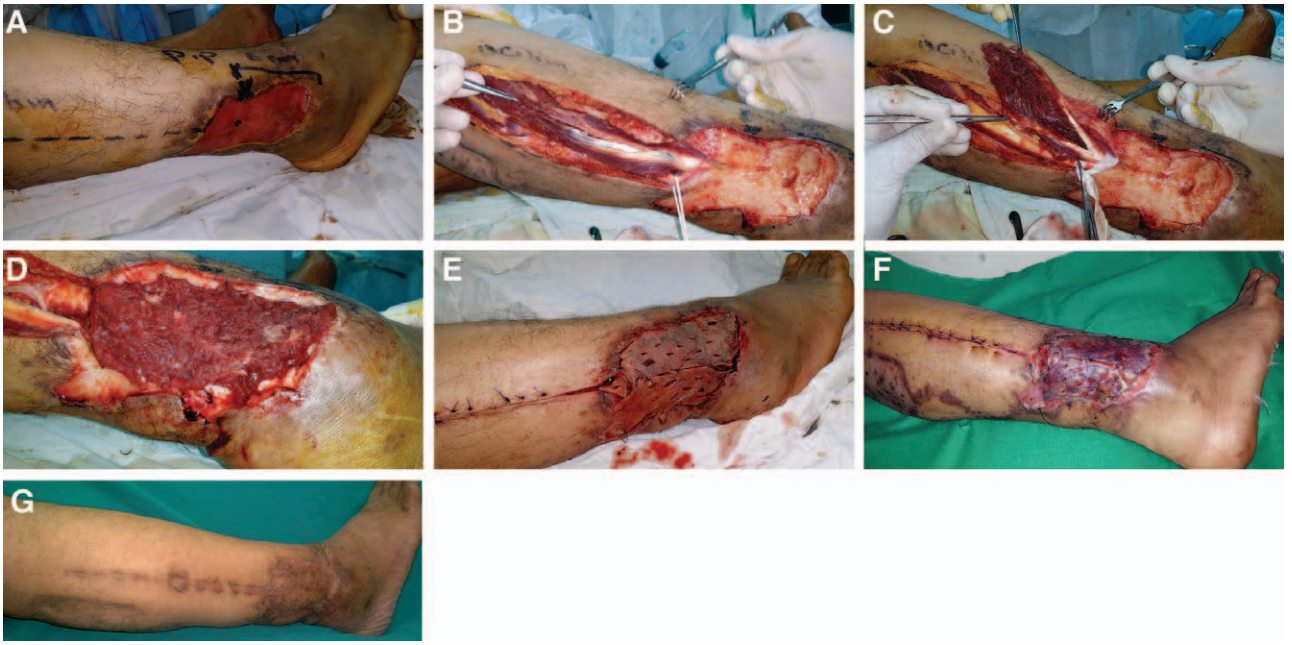

Fig. 4. A, Preoperative chronic leg ulcer, defect diameter, and flap design; B, intraoperative before muscle splitting; C, intraoperative after muscle splitting; D, intraoperative after muscle split and turned to cover the defect; E, intraoperative after graft application; F, 2 weeks postoperative; G, late postoperative 4 month.

In this anatomical region, local tissue availability is limited and provides flaps for only minor defects. Free flaps are essential to treat large defects of the distal third of lower legs because of good 3-dimensional designs and adequate tissue volume.[6] However, the disadvantages include the need for an expert surgeon, donor-site morbidity, increased operation time, use of a major vessel of the leg, and costly microsurgical techniques. In addition, not all patients are willing or healthy enough to undergo free tissue transfer procedures. However, regional flaps can provide a reasonable first-line option for small and midsize defects. Adipofascial flaps are suitable for small-to-moderate defects in the distal lower leg and have the advantages of versatility and simplicity.[19]

However, elderly patients or patients with peripheral vascular insufficiency are not good candidates for this procedure because of its high complication rate.[20] Moreover, adipofascial flaps do not carry as

Table 1. Summary of Clinical Cases

Patient Number	Age and Sex	Injury Type and Site	Defect Size (cm): Length × Width	Previous Procedure Done for the Patient	Muscle Flap Width Size (cm) before Splitting	Muscle Flap Width Size (cm) after Splitting	Follow-up (mo)	Outcome	Complications
1	50-year-old male	Chronic ulcer posttraumatic, above lateral malleolus	9×10	Dressing	6	10	6	Successful	Partial graft loss, healed by dressing
2	45-year-old male	Chronic ulcer posttraumatic, above lateral malleolus and ankle	10×10	Sural flap failed	6	10	3	Successful	None
3	38-year-old male	Chronic ulcer postburn, above medial malleolus	8×9	Split skin graft	5	9	3	Successful	Partial graft loss healed by dressing
4	20-year-old male	Chronic ulcer posttraumatic, over Achilles tendon	12×10	Dressing	6	10	5	Successful	None
5	31-year-old male	Chronic ulcer postburn, anterior ankle and lateral malleolus	6×7	Dressing	4	7	2	Successful	None
6	30-year-old female	Posttraumatic ulcer, lateral malleolus and lateral aspect of ankle	12×6	Split skin graft	4	6	4	Successful	None
7	6-year-old male	Postburn unstable scar, over Achilles tendon	10×8	Dressing	5	8	1	Successful	Donor site disruption healed by a secondary intention
8	28-year-old male	Chronic ulcer lower leg and lateral malleolus	12×10	Split skin grafting	6	10	2	Successful	None
9	35-year-old female	Posttraumatic ulcer, lateral malleolus and lateral aspect of ankle	12×6	Split skin graft	4	6	2	Successful	None
10	15-year-old male	Posttraumatic exposed lower part of tibia and medial malleolus	10×6	Dressing	4	7	1	Successful	None

much resistance to bacterial infection as muscle flaps. The distally based sural flap introduced by Masquelet et al[21] represents an excellent option for the reconstruction of large skin and soft-tissue defects of the lower leg and foot. Furthermore, perforator-based flaps can provide excellent solutions because of their match in tissue texture and thickness, and they are relatively quick procedures. However, primary closure of the donor-site defects can be problematic and can demonstrate an inability to fill tissue cavities after serial debridements. The peroneus brevis flap adds several advantages to the available reconstructive techniques: the donor site can always be closed primarily, leaving a thin, rather inconspicuous scar over the lateral aspect of the leg, which is cosmetically acceptable[15, 22]; the flap is very malleable and can fill a defect; and the flap is relatively reliable, even in high-risk patients with a number of comorbidities.[23] Additional advantages include its ability to be harvested as a composite flap with a fibula segment, which may provide a vascularized bone segment, and the option of using it as a free flap with very low donor-site morbidity.[24] It has also been described for small-to-medium sized defects. Lyle and Colborn[25] reported on the transposed peroneus brevis muscle flap to cover a limited (3 cm) defect of the distal third of the leg. Hughes and Mahoney[26] demonstrated that the flap could cover 4 cm above the lateral malleolus and 2 cm above the tip of the fibula. El-Khatib[27] demonstrated that a longitudinal vertical split of the peroneus muscle allows for the coverage of medium-sized defects of up to 7 cm.

In this study, I performed open-book splitting to the proximal part of the muscle belly from its superficial outer surface, which increased its width to cover a large defect of up to 12 cm in length and 10 cm in width.

CONCLUSIONS

Open-book splitting of the distally based peroneus brevis muscle flap is ideally suited for moderate to large defects in the distal third of the lower leg and ankle. This modification of the distally based peroneus brevis muscle flap offers a convincing alternative for covering large defects of up to 12 × 10 cm in the distal leg and ankle region.

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REFERENCES

1. Yang D, Morris SF. Reversed sural island flap supplied by the lower septocutaneous perforator of the peroneal artery. *Ann Plast Surg.* 2002;49:375–378.
2. Voche P, Stussi JD, Merle M. [The supramalleolar flap. Our experience in 35 cases]. *Ann Chir Plast Esthet.* 2001;46:112–124.
3. Lin SD, Chou CK, Lin TM, et al. The distally based lateral adipofascial flap. *Br J Plast Surg.* 1998;51:96–102.
4. Parrett BM, Matros E, Pribaz JJ, et al. Lower extremity trauma: trends in the management of soft-tissue reconstruction of open tibia-fibula fractures. *Plast Reconstr Surg.* 2006;117:1315–1320
5. Benito-Ruiz J, Yoon T, Guisantes-Pintos E, et al. Reconstruction of soft-tissue defects of the heel with local fasciocutaneous flaps. *Ann Plast Surg.* 2004;52:380–384.
6. Gonzalez MH, Tarandy DI, Troy D, et al. Free tissue coverage of chronic traumatic wounds of the lower leg. *Plast Reconstr Surg.* 2002;109:592–600.
7. Eyssel M, Dresing K. [The peroneus brevis muscle flapplasty. A simple procedure for covering fibular soft tissue defects after osteosynthesis]. *Unfallchirurg.* 1989;92:85–91.
8. Koski EA, Kuokkanen HO, Tukiainen EJ. Distally-based peroneus brevis muscle flap: a successful way of reconstructing lateral soft tissue defects of the ankle. *Scand J Plast Reconstr Surg Hand Surg.* 2005;39:299–301.
9. Pers M, Medgyesi S. Pedicle muscle flaps and their applications in the surgery of repair. *Br J Plast Surg.* 1973;26:313–321.
10. Pers M, Medgyesi S, Kirkby B. Peroneus brevis muscle flap. In: Strauch B, Vasconez LO, Hall-Findlay EJ, Lee BT, eds. *Grabb's Encyclopedia of Flaps.* Vol. 3, 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2009:1408–1409.
11. Barr ST, Rowley JM, O'Neill PJ, et al. How reliable is the distally based peroneus brevis muscle flap? *Plast Reconstr Surg.* 2002;110:360–362.
12. Saydam M, Yilmaz S, Seven E. Distal peroneus brevis muscle flap. *Plast Reconstr Surg.* 2002;110:351–356
13. Mathes SJ, Nahai F. Peroneus brevis flap. In: Mathes SJ, Nahai F, eds. *Reconstructive Surgery: Principles, Anatomy and Technique.* New York: Churchill-Livingstone; 1997: 1437–1446.
14. Mathes SJ, Nahai F. Classification of the vascular anatomy of muscles: experimental and clinical correlation. *Plast Reconstr Surg.* 1981;67:177–187.
15. Eren S, Ghofrani A, Reifenrath M. The distally pedicled peroneus brevis muscle flap: a new flap for the lower leg. *Plast Reconstr Surg.* 2001;107:1443–1448.
16. Yang YL, Lin TM, Lee SS, et al. The distally pedicled peroneus brevis muscle flap: anatomic studies and clinical applications. *J Foot Ankle Surg.* 2005;44:259–264.
17. McHenry TP, Early JS, Schacherer TG. Peroneus brevis rotation flap: anatomic considerations and clinical experience. *J Trauma.* 2001;50:922–926.
18. Villarreal PM, Monje F, Gañán Y, et al. Vascularization of the peroneal muscles. Critical evaluation in fibular free flap harvesting. *Int J Oral Maxillofac Surg.* 2004;33:792–797.
19. Lai CS, Lin SD, Chou CK. Clinical application of the adipofascial turnover flap in the leg and ankle. *Ann Plast Surg.* 1992;29:70–75.

20. Hallock GG. Complications of 100 consecutive local fasciocutaneous flaps. *Plast Reconstr Surg*. 1991;88: 264–268.
21. 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*. 1994;93:1026e7
22. Lorenzetti F, Lazzeri D, Bonini L, et al. Distally based peroneus brevis muscle flap in reconstructive surgery of the lower leg: postoperative ankle function and stability evaluation. *J Plast Reconstr Aesthet Surg*. 2010;63:1523–1533.
23. Bach AD, Leffler M, Kneser U, et al. The versatility of the distally based peroneus brevis muscle flap in reconstructive surgery of the foot and lower leg. *Ann Plast Surg*. 2007;58:397–404
24. Schmidt AB, Giessler GA. The muscular and the new osteomuscular composite peroneus brevis flap: experiences from 109 cases. *Plast Reconstr Surg*. 2010;126:924–932.
25. Lyle WG, Colborn GL. The peroneus brevis muscle flap for lower leg defects. *Ann Plast Surg*. 2000;44:158–162.
26. Hughes LA, Mahoney JL. Anatomic basis of local muscle flaps in the distal third of the leg. *Plast Reconstr Surg*. 1993;92:1144–1154.
27. El-Khatib HA. The split peroneus muscle flap: a new flap for lower leg defects. *J Plast Reconstr Aesthet Surg*. 2007;60:898–903.