Anterolateral Thigh Flap for Reconstruction in Postburn Axillary Contractures

Hung Chang Chen, MD, Katie P. Wu, MD, Cheng-I Yen, MD, Yen-Chang Hsiao, MD, Shih-Yi Yang, MD, Jui-Yung Yang, MD, Cheng-Jen Chang, MD, PhD, Shu-Yin Chang, MD, and Shiow-Shuh Chuang, MD

Background: Reconstruction of postburn axillary contractures is difficult and particularly challenging without healthy adjacent soft tissue for axillary scar resurfacing. In this case, a free soft-tissue transfer is among the best treatment options. Here, we describe our experience with free anterolateral thigh (ALT) flap for reconstruction in postburn axillary contractures.

Methods: We enrolled 10 patients with postburn axillary contractures from August 2003 to July 2015. They all underwent wide scar contracture release through a transverse incision from the anterior axillary fold to the posterior axillary fold. The ALT flap was subfascially raised. The huge soft tissue defect after scar release was resurfaced with the ALT flap.

Results: Eight male patients and 2 female patients (age, 16–64 years; mean, 46 years) were included. The mean total burn surface area, follow-up time, duration between injury onset and free-flap transfer surgery, and flap size were 48%, 27 months, 7.7 months, and 12×23 cm^2, respectively. The most common recipient vessels were the thoracodorsal artery and vein (77%). The mean improvement in the range of motion of shoulder abduction was 86 degrees (range, 60–130 degrees). The mean operative time was 7 hours. All flaps survived without reexploration or failure. All but 1 donor site was managed by split-thickness skin grafting. No infection, hematoma, or deaths were noted postoperatively. Transient brachial palsy was noted in a 16-year-old male patient postoperatively, with full recovery 3 months after.

Conclusions: For postburn axillary contractures without healthy adjacent soft tissue for scar resurfacing, ALT flap reconstruction represents a suitable treatment option. It allows simultaneous surgery on both the donor and recipient sites, without the need to change the patient's position. Furthermore, the ALT flap provides sufficient soft tissue and blood flow for reconstruction, leading to satisfactory functional outcomes.

Key Words: anterolateral thigh flap, axillary scar contractures, burn injury, scar contractures, postburn scar reconstruction, shoulder abduction

(*Ann Plast Surg* 2017;79: 139–144)

The axilla is a unique, 3-dimensional pyramid-shaped hollow formed under the junction of the upper extremity and trunk.[1] The axillar region is an area with multidirectional activity. Axillary scar contractures frequently develop after deep second- to third-degree burn injury to the tissues over the axilla, and cause limitation of the shoulder range of motion (ROM). The normal and functional (with respect to daily activities) values for shoulder abduction ROM are 184 and 130 degrees, respectively.[2]

Received November 28, 2016, and accepted for publication, after revision February 7, 2017.

From the Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, College of Medicine, Chang Gung University, Taipei, Taiwan.

The material is original. It has not been published elsewhere or submitted for other publications simultaneously.

Conflicts of interest and sources of funding: No funding received for this work from any of the following organizations: National Institutes of Health (NIH); Wellcome Trust; Howard Hughes Medical Institute (HHMI); RCUK; and other(s).

Reprints: Shiow-Shuh Chuang, MD, Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, 5, Fu-Hsing Street, Kweishan, Taoyuan 333, Taiwan. E-mail: Sschuangtw@gmail.com.

ISSN: 0148-7043/17/7902–0139

DOI: 10.1097/SAP.0000000000001097

Huang et al[3] used ROM decrease to define the severity of axillary contracture as follows: mild, less than 25%; moderate, 25% to 50%; and severe, greater than 50%.

Many classifications for axillary scar contractures are based on the degree of anatomical damage to the axilla.[4–7] The key criterion in such classifications is involvement of the dome of the axilla. If the axillary dome is spared, the recommended treatment in most cases includes releasing the contracture and resurfacing it by using local cutaneous tissue (Z-plasty, V-Y advancement, and so on). However, if the dome is damaged, the entire scar tissue must be resurfaced by using local or distant flaps.[8]

Reconstruction of postburn axillary contractures is difficult and particularly challenging when no healthy adjacent soft tissue is found for axillary scar resurfacing. In this case, a free soft tissue transfer is one of the best treatment options. In this study, we describe our experience with free anterolateral thigh (ALT) flap for reconstruction in postburn axillary contractures.

PATIENTS AND METHODS

A retrospective study was conducted at our institution. We enrolled 10 patients with postburn axillary contractures, who were treated by using the ALT flap at our hospital between August 2003 and September 2015. After the acute axillary burn wound healed, the patient will undergo active rehabilitation for 3 to 6 months. The rehabilitation regimen focused on shoulder scar compression, massage, soft tissue mobilization and stretching, and increasing ROM. We followed up patients regularly in the clinic. If the patient showed improvement, rehabilitation continued. If the shoulder ROM remains stationary despite active rehabilitation for 3 months, surgery will be suggested. The indications for free soft-tissue transfer for axillary scar contracture reconstruction were as follows: moderate-to-severe axillary scar contracture (ROM decrease >25%), axillary scar contracture involving the dome, and the absence of healthy adjacent soft tissue for axillary scar resurfacing. "Healthy soft tissue" means non-scarred soft tissue with acceptable pliability and elasticity for the functional ROM. Tissue with heterogeneous scarring cannot be used optimally for the donor flap.

Wide scar contracture release was achieved through a transverse incision from the anterior axillary fold to the posterior axillary fold, which resulted in shoulder ROM values greater than 130 degrees. The dissection was performed to the subfascial level (axillary fascia, derived from the pectoral fascia, between the inferolateral part of the pectoralis major [PM] and latissimus dorsi [LD]). Because the adjacent soft tissues all showed hypertrophic scars and no healthy suitable tissue was found for axillary scar resurfacing, the large soft tissue defect that resulted from scar release was resurfaced by using the ALT flap. All the ALT flaps were harvested from the subfascial level.

After the reconstructive surgery, an airplane splint is fabricated to protect the free flap and to maintain shoulder in 90 degrees abduction and 15 to 20 degrees adduction for 1 week. Although the shoulder is immobilized, active ROM of the ipsilateral elbow and hand is encouraged. After 1 week shoulder immobilization, we gradually started shoulder scar compression, massage, soft tissue mobilization and stretching, and increasing ROM.

The following data were recorded and expressed as mean ± standard deviation: patient demographic data, including age and sex, total burn surface area (TBSA), preoperative (pre-op) and postoperative (post-op) ROM of shoulder abduction, ROM gain% = (post-op ROM − pre-op ROM)/pre-op ROM × 100%, time from injury to reconstructive surgery, operative duration and follow-up duration, and ALT flap size.

RESULTS

The study included eight male and two female patients, aged between 16 and 64 years (mean, 46 years) with an average TBSA of 48%. The mean follow-up duration was 27 months. The mean duration between the onset of injury and the free-flap transfer surgery was 7.7 months. The mean flap size was 12 × 23 cm. The most common recipient vessels were the thoracodorsal artery and vein (77%). The mean gain in the ROM of shoulder abduction was 86 degrees (ROM gain% = 177%). The mean operative time was 7 hours. Rehabilitation started 7 days postoperatively. All flaps survived without reexploration or failure. A large ALT flap (mean, 12 × 23 cm) was required to resurface the scarred axillary tissue. Most ALT donor sites could not be closed primarily, except for one case. Split-thickness skin grafting (STSG) was used to cover donor ALT sites with a width greater than 8 cm. All the ALT donor sites healed well. No major donor site morbidity was noted. Some patients experienced temporary numbness in the ALT donor site after the STSG coverage; however, all patients had recovered at 6 months follow-up. In the postoperative period, no infection, hematoma, or death was noted (Table 1). Transient brachial palsy was noted postoperatively in a 16-year-old male patient; however, it resolved completely after 3 months. We further described two cases considered in this study.

CASE REPORTS

Case No. 6

The patient was a 16-year-old man with 65% TBSA resulting from electrical burn injury to the face, trunk, right axilla, upper limb, and right lower limb. He was initially treated with STSG. However, during the ensuing 10 months, he developed scar contracture of the right axilla, which reduced the range of shoulder abduction to 120 degrees (Fig. 1). He was referred for scar contracture release surgery.

The contracture was released through a transverse incision from the anterior axillary fold to the posterior axillary fold, with dissection to the subfascial level, until an unrestricted abduction ROM greater than 130 degrees was obtained in the shoulder joint. The resulting soft tissue defect measured 12 × 16 cm^2. A flap of this size was designed and harvested from the left ALT (Fig. 2, left), and the defect was resurfaced (Fig. 2, right). The recipient vessels were the thoracodorsal artery and the concomitant vein. The donor site was skin grafted.

Right brachial plexus palsy was noted immediately after surgery; however, it resolved completely 3 months after. The brachial palsy may have been caused by prolonged axilla traction (approximately 2 hours) during the scar release and vessel anastomosis. The patient had an otherwise uneventful postoperative course, and all wounds healed primarily. Six months postoperatively, the ROM of shoulder abduction was 180 degrees (Fig. 3).

Case No. 8

The patient was a 45-year-old man with 30% TBSA, resulting from flame burn injury to the face, left axilla, chest wall, abdomen, back, and left upper limb. Left axillary scar contracture developed after initial STSG treatment and rehabilitation, restricting shoulder abduction to 30 degrees (Fig. 4).

TABLE 1. Patients' Profiles

Case No.	Age, y	Sex	Injury Mechanism	TBSA, %	Timing, mo	OP Duration, h	Pre-op Shoulder Abductive ROM, degrees	Post-op Shoulder Abductive ROM, degrees	ROM Gain (%), degrees	Flap Size, cm	Follow-up Time, mo	Flap Donor Site
1	59	M	Scald burn	31	8	7.5	60	165	105 (175%)	11x23	20	STSG
2	50	M	Flame burn	50	14	6	60	170	110 (183%)	13x20	42	STSG
3	64	M	Scald burn	30	3	6	75	160	85 (113%)	15x24	36	STSG
4	47	F	Flame burn	80	10	6	100	160	60 (60%)	14x24	52	STSG
5	44	M	Flame burn	65	5	7	40	150	110 (275%)	8x15	48	Primary closure
6	16	M	Chemical burn	65	10	9	120	155	35 (29%)	12x16	12	STSG
7	58	M	Electrical burn	40	4	8	60	120	60 (100%)	15x27	14	STSG
8	45	M	Flame burn	30	7	8	30	160	130 (433%)	12x30	16	STSG
9	34	F	Flame burn	50	9.5	7	40	150	110 (275%)	10x23	17	STSG
10	45	M	Flame burn	40	7	7	40	90	50 (125%)	14x26	14	STSG
Mean	46			48	7.7	7	62	148	86 (177%)	12x23	27	
S.D.	13			16	3.1	0.9	27	23	30		15	

F, female; M, male; timing, the timing of free flap transfer after injury; OP, operative.

FIGURE 1. Preoperative ROM with respect to shoulder abduction for a 16-year-old male patient with 65% TBSA. A, Lateral view, (B) Front view, and (C) Posterior view.

The left axillary scar contracture was fully released, with dissection to subfascial level, to attain an unrestricted abduction ROM greater than 130 degrees. The resulting soft-tissue defect measured $12 \times 30\ cm^2$, and was resurfaced by using a flap from the right ALT. The recipient vessels were the thoracodorsal artery and the concomitant vein. The donor site was skin grafted.

The patient had a smooth postoperative course, and all wounds healed primarily. Eight months postoperatively, the ROM of shoulder abduction was 180 degrees (Fig. 5).

DISCUSSION

Axillary scar contractures frequently develop after severe burn injuries. The level of scar contracture release is an important factor affecting functional outcomes. During scar release surgery for moderate-to-severe axillary scar contracture with involvement of the axillary dome, dissection was extended to the subfascial level (axillary fascia, derived from the pectoral fascia, between the inferolateral part of the PM and LD muscles) to attain an unrestricted abduction ROM greater than 130 degrees, which is the reference value for functional ROM (ie, ROM required for daily activities). Dissection to the subcutaneous level achieved only a moderate increase in unrestricted abduction ROM (Fig. 6, above). Upon extending the dissection to the subfascial level, the unrestricted abduction ROM increased significantly (Fig. 6, below). The dissection required to fully release the axillary scar contracture may result in a large skin and soft-tissue defect.

Skin grafts are relatively simple to design and apply. However, grafted skin lacks elasticity and has a tendency to develop secondary contracture, in addition to being prone to infection.[9] Flaps show less secondary contracture, and they do not require prolonged splinting. Flaps from donor sites adjacent to the axilla are best suited for resurfacing defects that resulted from the full release of axillary scar

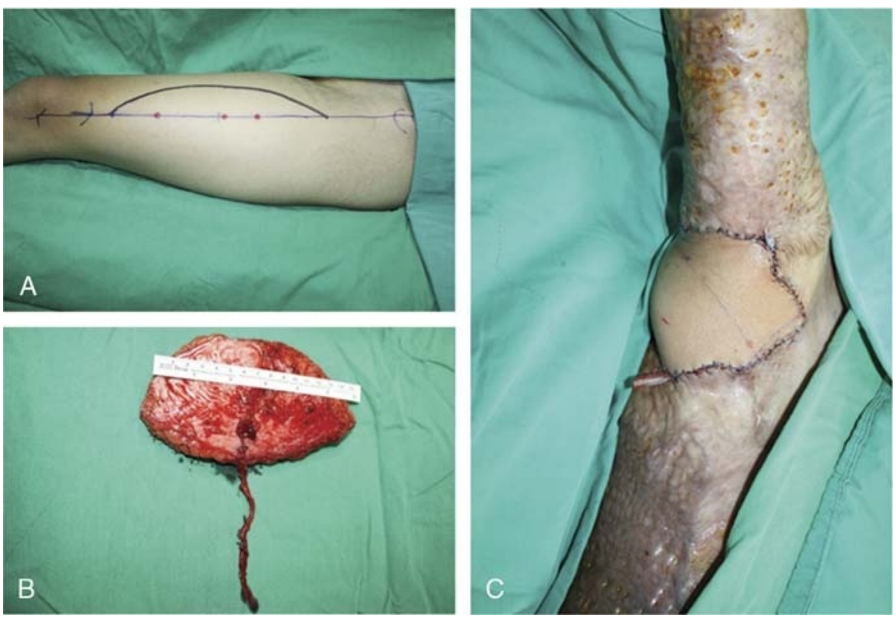

FIGURE 2. ALT flap design (A), harvest (B), and inset (C) for a 16-year-old male patient with 65% TBSA.

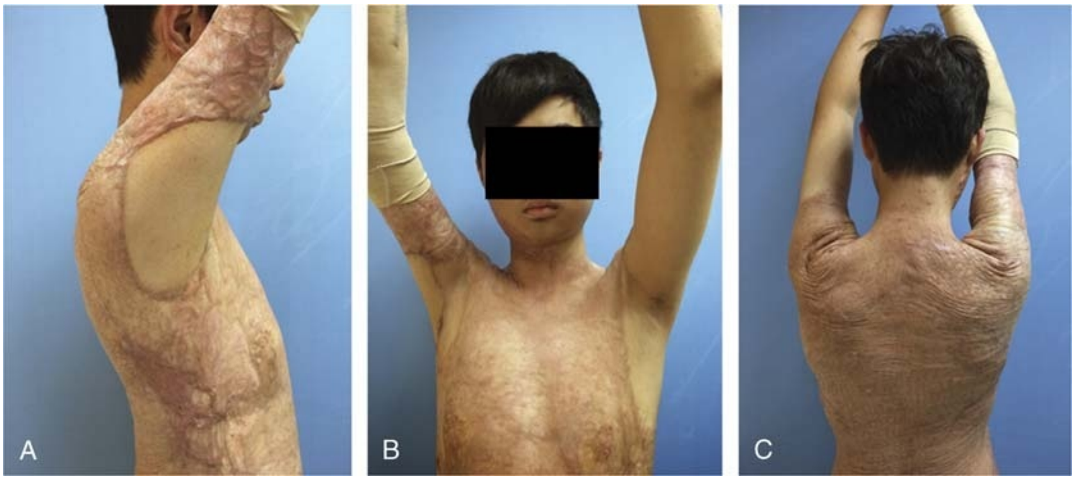

FIGURE 3. Postoperative (6 months) ROM with respect to shoulder abduction for a 16-year-old male patient with 65% TBSA. A, Lateral view, (B) Front view, and (C) Posterior view.

contractures. Many flaps from donor sites adjacent to the axilla can be used for reconstruction, such as the LD[10] or PM musculocutaneous flaps, as well as the parascapular,[11] scapular, and ascending scapular[12] fasciocutaneous flaps. Between August 2003 and September 2015, our standard protocol was to replace most of the scarred axillary tissues with non-scarred healthy (pliable and extensible) adjacent tissues. Pedicled parascapular and LD flaps are 2 of the most selected flaps used to resurface the axillary scarred area.

If no suitable adjacent soft tissue was found for axillary scar resurfacing, a free soft-tissue transfer is one of the most optimal treatment options. The decision tree for reconstruction of postburn axillary contractures is shown in Figure 7. The enrolled patients from our institution underwent axillary reconstruction with the free ALT flap. This method allows simultaneous surgery on both the donor and recipient sites, without the need to change the patient's position. Furthermore, ALT provides sufficient soft tissue and blood flow for the reconstruction, leading to satisfactory functional outcomes, as shown in our series.

Reconstruction with ALT flaps was first proposed by Song et al.[13] The approach has gained international popularity, and is now widely used for many kinds of microsurgical reconstructions. The use of ALT flaps has disadvantages related to anatomic variations and the steep learning curve of the procedure; however, various techniques have been developed to address the issues that arise during ALT flap harvesting.[14–16]

In obese patients, the bulkiness of the ALT flap is another disadvantage because it limits upper-limb adduction and can be aesthetically unsatisfactory. To achieve a good contour of the axilla, flap bulkiness can be addressed by thinning the flap during surgery,[17] or by performing flap debulking 6 months postoperatively. In most of the patients included in our study, the ALT flap progressively shrank to an acceptable size during the first 6 months after reconstruction, and no patient required flap debulking.

The thoracodorsal artery is one of the terminal branches of the subscapular artery, and its anatomy has been well studied.[18] This artery is deep and acquires little damage during a burn injury. Moreover, its anatomic variation is low, and its caliber matches that of the donor vessel of the ALT flap. Owing to these considerations, the thoracodorsal artery was the most common recipient vessel in this study.

Very few studies have reported on free flap reconstruction for axillary scar contractures. Ogawa et al[9] performed a retrospective study

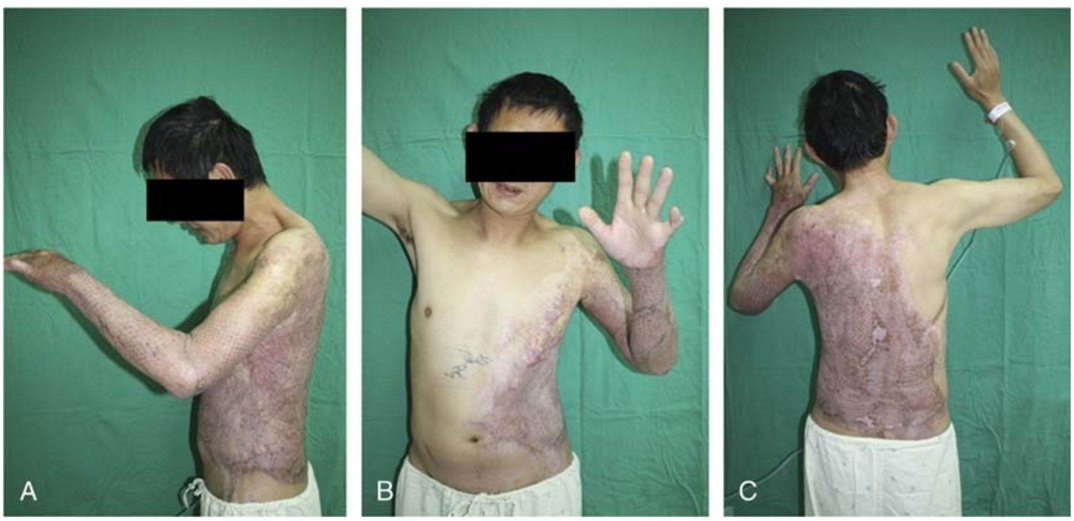

FIGURE 4. Preoperative ROM with respect to shoulder abduction for a 45-year-old male patient with 30% TBSA. A, Lateral view, (B) Front view, and (C) Posterior view.

FIGURE 5. Postoperative (8 months) ROM with respect to shoulder abduction for a 45-year-old male patient with 30% TBSA. A, Lateral view, (B) Front view, and (C) Posterior view.

FIGURE 6. Dissection depth during scar release surgery. A, Dissection to the subcutaneous level achieved only a moderate increase in unrestricted abduction ROM; the target functional ROM value of 130 degrees was not achieved. B, Upon extending the dissection to the subfascial level, unrestricted abduction ROM increased significantly, achieving functional and normal ROM (180 degrees).

of 134 axilla treated in 124 cases of axillary scar contractures. Only one case was reconstructed by using the free ALT flap. In contrast, Moroz et al[19] presented their experience of free scapular flap for axillary scar contracture reconstruction when scars occupy all the surfaces of a joint and the axilla. However, they did not mention the number of cases they studied.

There is a paucity of literature on free flap reconstruction in postburn axillary scar contractures. The present study is the first single-center case-series report on the use of ALT flap transfer for postburn axillary contracture reconstruction. We aimed to explore the potential of other treatment options for axillary scar reconstruction in the future.

CONCLUSIONS

For postburn axillary contractures without healthy adjacent soft tissue for scar resurfacing, ALT flap reconstruction represents a suitable treatment option. It allows simultaneous surgery on both

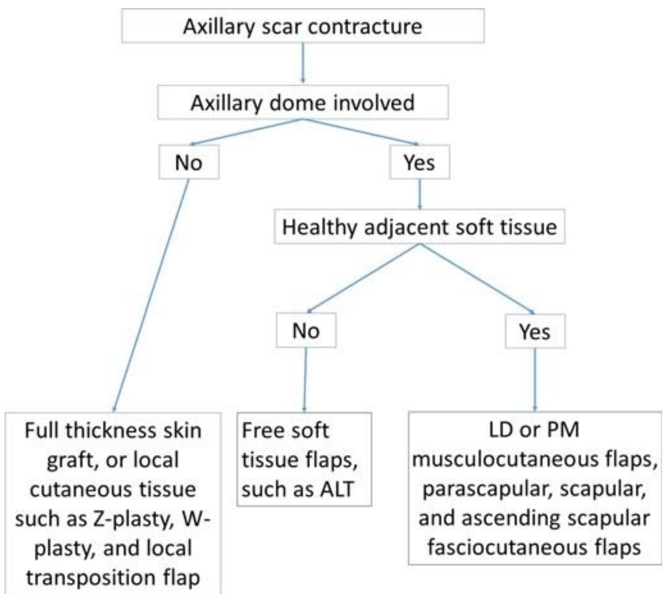

FIGURE 7. Decision tree for reconstruction of postburn axillary contractures.

the donor and recipient sites, without the need to change the patient's position. Furthermore, ALT provides sufficient soft tissue and blood flow for the reconstruction, leading to satisfactory functional outcomes, as shown in our series.

ACKNOWLEDGMENT

Informed consent was received for publication of the figures in this article.

REFERENCES

1. Woodbourne RT. *Essentials of Human Anatomy*. 4th ed. New York: Oxford University Press; 1969.
2. Namdari S, Yagnik GP, Ebaugh DD, et al. Defining functional shoulder range of motion for activities of daily living. *J Shoulder Elbow Surg*. 2012;21:1177–1183. http://dx.doi.org/10.1016/j.jse.2011.07.032.
3. Huang TT, Blackwell SJ, Lewis SR. Ten years of experience in managing patients with burn contractures of axilla, elbow, wrist, and knee joints. *Plast Reconstr Surg*. 1978;61:70–76.
4. Achauer BM. The axilla. In: Achauer BM, ed. *Burn Reconstruction*. New York: Thieme Medical Publishers; 1991:87–99.
5. Hallock GG. A systematic approach to flap selection for the axillary burn contracture. *J Burn Care Rehabil*. 1993;14:343–347.
6. Grishkevich V. The basic types of scar contractures after burns and methods of eliminating them with trapezeplasty flaps. *Plast Reconstr Surg*. 1991;88:1044–1054.
7. Salisbury RE, Bevin AG. The axilla. In: Salisbury RE, Bevin AG, eds. *Atlas of Reconstructive Burn Surgery*. Philadelphia: W.B. Saunders; 1981:108–111.
8. Yang JY. Reconstruction of axillary contracture. In: McCauley RL, ed. *Functional and Aesthetic Reconstruction of Burned Patients*. New York: Taylor & Francis; 2005:367–378. http://dx.doi.org/10.1201/b14112-28.
9. Ogawa R, Hyakusoku H, Murakami M, et al. Reconstruction of axillary scar contractures—retrospective study of 124 cases over 25 years. *Br J Plast Surg*. 2003;56:100–105. http://dx.doi.org/10.1016/S0007-1226(03)00035-3.
10. Wilson IF, Lokeh A, Schubert W, et al. Latissimus dorsi myocutaneous flap reconstruction of neck and axillary burn contractures. *Plast Reconstr Surg*. 2000;105:27.
11. Shalaby HA. Island parascapular flap for the treatment of diffuse axillary burn scar contracture. *Ann Medit Burns Club*. 1995;8.
12. Maruyama Y. Ascending scapular flap and its use for the treatment of axillary burn scar contracture. *Br J Plast Surg*. 1991;44:97–101.
13. Song YG, Chen GZ, Song YL. The free thigh flap: a new free flap concept based on the septocutaneous artery. *Br J Plast Surg*. 1984;37:149–159.
14. Kimata Y, Uchiyama K, Ebihara S, et al. Anatomic variations and technical problems of the anterolateral thigh flap: a report of 74 cases. *Plast Reconstr Surg*. 1998;102:1517–1523.
15. Lee YC, Chen WC, Chou TM, et al. Anatomical variability of the anterolateral thigh flap perforators: vascular anatomy and its clinical implications. *Plast Reconstr Surg*. 2015;135:1097–1107. http://dx.doi.org/10.1097/PRS.0000000000001103.
16. Lu JC, Zelken J, Hsu CC, et al. Algorithmic approach to anterolateral thigh flaps lacking suitable perforators in lower extremity reconstruction. *Plast Reconstr Surg*. 2015;135:1476–1485. http://dx.doi.org/10.1097/PRS.0000000000001930.
17. Adani R, Tarallo L, Marcoccio I, et al. Hand reconstruction using the thin anterolateral thigh flap. *Plast Reconstr Surg*. 2005;116:467–473. http://dx.doi.org/10.1097/01.prs.0000173059.73982.50.
18. Jesus RC, Lopes MC, Demarchi GT, et al. The subscapular artery and the thoracodorsal branch: an anatomical study. *Folia Morphol* (*Warsz*). 2008;67:58–62. http://dx.doi.org/10.5603/FM.2014.0073.
19. Moroz VY, Yudenich AA, Sarygin PV, et al. The elimination of post-burn scar contractures and deformities of the shoulder joint. *Ann Burns Fire Disasters*. 2003;XVI.

