Araştırma Makalesi
Research Article

Enhancing Viability of the Muscle-Sparing Latissimus Dorsi Flap

KAS- KORUYUCU LATİSSİMUS DORSİ FLEBİNİN CANLILIĞININ ARTIRILMASI

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ABSTRACT

Aim: The aim of this study is to enhance the viability of the muscle-sparing latissimus dorsi flap. In this study, the muscle-sparing latissimus dorsi myocutaneous flap was designed with the skin paddle of the flap over the distal perforators of the thoracodorsal artery and perforators of the 10th or 11th posterior intercostal arteries. The flap was elevated together with the deep fascia at the base.

Methods: Sixteen flaps were used for the repair of defects in different regions in 14 patients, five female and nine male, with a mean age of 45 years. Flap sizes vary from 9x21 to 14x27 cm. The defects were located in anterior thoracic wall in patient four, arm in patient three, axillary fossa in patient three, deltopectoral region in patient two and posterior thoracic wall in patient two. The mean follow-up period was 13 months.

Result: All flaps survived without total or partial loss. Seroma or contour deformity in the donor area did not develop. A visible scar developed in the donor area in a patient. Flap thinning was performed on two flaps. In all patients, shoulder joint function returned to normal in the last months postoperatively.

Conclusions: If the muscle-sparing latissimus dorsi flap is prepared to include the skin paddle 10th or 11th posterior intercostal arteries and together with the deep fasciae (dorsal thoracic fascia and scarpa's fascia), it can be safely elevated large sizes.

Keywerds: Muscle-sparing latissimus dorsi flap, posterior intecostal artery, dorsal thoracic fascia, scarpa's fascia

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DEU Tıp Derg 2024;38(1): 19-31
J DEU Med 2024;38(1):19-31
doi: 10.18614/deutip.1386328

Gönderim tarihi / Submitted:05.11.2023
Kabul tarihi / Accepted: 01.04.2024

ÖZ

Amaç: Bu çalışmanın amacı kas-koruyucu latissimus dorsi flebinin canlılığını artırmaktır. Bu çalışmada, kas-koruyucu latissimus dorsi kas-deri flebi, flebin deri adası torakodorsal arterin distal perforatörleri ve 10. veya 11. posterior interkostal arterlerin perforatörleri üzerinde olacak şekilde tasarlandı. Flep tabandaki derin fasya ile birlikte kaldırıldı.

Gereç ve Yöntem: Beşi kadın, dokuzu erkek, yaş ortalaması 45 olan 14 hastada farklı bölgelerdeki defektlerin onarımı için 16 flep kullanıldı. Flep boyutları 9x21 ila 14x27 cm arasında değişmektedir. Defektler dört hastada toraks ön duvarında, üç hastada kolda, üç hastada aksiller fossada, iki hastada deltopektoral bölgede ve iki hastada toraks arka duvarında yerleşmişti. Ortalama takip süresi 13 aydı.

Bulgular: Tüm flepler tam veya kısmi kayıp olmadan yaşadı. Donör alanda seroma veya kontur deformitesi gelişmedi. Bir hastada donör alanda gözle görülür bir skar oluştu. İki flep üzerinde flep inceltme işlemi uygulandı. Tüm hastalarda ameliyat sonrası son aylarda omuz eklem fonksiyonları normale döndü.

Sonuç: Kas-koruyucu latissimus dorsi kas-deri flebi, deri adası 10. veya 11. posterior interkostal arterleri ve derin fasyaları (dorsal torasik fasya ve skarpa fasyası) içerecek şekilde hazırlanırsa, büyük boyutlarda güvenli bir şekilde kaldırılabilir.

Anahtar Kelimeler: Kas-koruyucu latissimus dorsi flep, posterior intercostal arter, dorsal torasik fasya, scarpa fasyası

The thoracodorsal artery (TDA) transforms the latissimus dorsi muscle (LDM) into an important reconstruction tool because of its transverse and descending branches and the true (constant-caliber) and choke (reduced-caliber) anastomoses formed by these branches with the branches of the posterior intercostal arteries (PIA) and lumbar arteries (LA) (1,2). These true anastomoses connect the TDA and intercostal artery territories along the mobile length of the latissimus dorsi muscle (3). Because of these anastomoses, the muscle-sparing latissimus dorsi flap, located distally on the skin island, can be elevated. These true anastomoses provided sufficient blood flow to the flap to survive (4).

The fact that the TDA is relatively long (5), the vessel diameter is large (6), and its branching pattern facilitates the use of the LDM, both as a pedicle flap in the repair of near defects and as a free flap in the repair of distant defects.

Further, the LDM is widely used as a pedicle or free flap in the repair of various tissue defects, such as muscle (7), musculocutaneous (8-10), and muscle-sparing myocutaneous flaps (11-14).

Studies on the vascular structure of the TDA, PIA, and LA that feed the latissimus dorsi muscle and the dorsal thoracic fascia, which covers the LDM, have made safe use of both extended fasciocutaneous flaps and latissimus dorsi myocutaneous flaps owing to their robust vascular network (13-17).

In addition, studies on Scarpa fascia (SF) have shown that these flaps can extend towards the lateral chest wall when raised together with the SF (18).

Although total or partial latissimus dorsi myocutaneous flaps have a safe vascular structure and allow for a large flap design, their use is limited because they cause common complications such as seroma and limitation of shoulder joint movements (13,14,19-21). These complications can be prevented with TDA perforator flaps or minimized with muscle-sparing latissimus dorsi flaps.

Although TDA perforator-based fasciocutaneous flaps have fewer donor site complications, they allow relatively smaller flap harvests due to their small vascular structures(12). Additionally, partial or total flap loss due to insufficient blood flow, pedicle tension, or shearing can be observed in these flaps.

Recently, muscle-sparing latissimus dorsi myocutaneous flaps have been used to avoid complications of total or partial LD musculocutaneous flaps and TDA perforator flaps prepared from the same donor area (13,14,22).

In this study, we placed the skin island of the muscle-sparing latissimus dorsi flap more caudally, including the vascular territories of the perforators of the PIAs, LAs, and raised it together with the deep fasciae (DTS and SF) at the base of the flap. Thus, we avoided common complications of total or partial LD myocutaneous flaps, such as seroma and limitation of shoulder joint movements(19,20), and complications of TDA perforator flaps, such as complete or partial flap loss (5,12).

Anatomy

The LDM receives blood mainly from the TDA in the proximal portion of the muscle, several segmental perforators of the PIA in the middle portion, and the LA in the distal portion. These arteries form a true anastomosis in the proximal half and a true choke anastomosis in the distal half of the muscle (1,2). True anastomoses connect the TDA and Intercostal artery territories along the length of the latissimus dorsi muscle (3). Therefore, the latissimus dorsi muscle is a suitable muscle-sparing flap. These true anastomoses along the long axis of the muscle provide sufficient blood flow for flap survival (4).

TDA is a branch of the subscapular artery. After providing at least one branch to the serratus anterior muscle (6,16), this artery bifurcated into the transverse and descending branches at the neurovascular hilus (NVH). The NVH is located at a mean of 5.1 cm from the posterior axillary fold and a mean of 2.2 cm from the lateral edge of the LDM (2,23). The mean length of the descending branch was 15.2 cm (23).

Perforators (> 0.5 mm) of the descending branch of the TDA were located between 8 cm and 15.4 cm from the posterior axillary fold (5,24,25) and within 1–4.3 cm from the lateral border of the LDM in the anatomic study (16,24,25). In a clinical study, these perforators were located between 8 cm and 12 cm caudal to the posterior axillary fold and 1–4 cm medial to the lateral margin of the LDM (26). These perforators emerge from the descending branch at an average interval of 3 cm (25). Spinelli et al. reported that two distal perforators or a 3 cm muscle segment on the descending branch of the TDA can be perfused with an extended fasciocutaneous flap as long as it contains the dorsal thoracic fascia (27). Tobin et al. stated that the medial and lateral parts of the LDM can be elevated separately as flaps because of the peculiarity of its neurovascular structure and that the descending branch of the TDA supplies the skin tissue up to the mid-axillary line (16).

Mınabe et al. reported that the perforators of the 10th and 11th posterior intercostal arteries anastomose with the musculocutaneous perforators of the TDA, deep and superficial epigastric arteries, and lumbar arteries(15,28).

Owing to this vascular network, the muscle-sparing latissimus dorsi myocutaneous flap can be elevated in a more anterior extension and larger dimensions on the SF. The SF covering the lateral and anterior abdominal walls was used as a pedicle or free flap based on the superficial inferior epigastric artery (18).

The dorsal thoracic fascia (DTF) is an anatomical layer that almost covers the posterior hemithorax; its borders were defined by Kim et al.(29). The DTF is mainly supplied by the cutaneous branches of the circumflex scapular artery (CSA) (ascending, horizontal, and descending). These cutaneous branches of the CSA and the perforating branches of the PIA and TDA formed a vascular network within the DTF (30). The vascular network within the DTF and its connections allows the transfer of an extended latissimus dorsi musculocutaneous flap in which the cutaneous portion of the flap is significantly larger than the latissimus muscle(29). The vascular structures of the

LDM, SF, and DTF described above form the basis for our flap technique.

Patients and methods

Between 2019–2022, 16 large defects that developed after tumor and hidradenitis suppurativa (HS) excision in 14 patients (9 male and 5 female) were repaired using a muscle-sparing latissimus dorsi flap. All patients were informed of the limitations of shoulder joint movements that may develop after surgery.

Of the defects, 11 were due to tumor excision, five were due to HS, two of these HS excisions were bilateral. Of the excised tumors, two were malignant melanoma, 3 recurrent Invasive ductal carcinomas in women, one primary Invasive ductal carcinoma in a man, and five Dermatofibrosarcoma protuberans (DFSP).

Defect locations were 4 anterior thoracic walls, three lateral arms, five axillary fossa, and two deltopectoral and two posterior thoracic wall regions. The mean patient age was 45 (18–72) years, and the mean follow-up period was 13 (7–19) months. The flap sizes ranged from 11 × 21 cm to 14 × 27 cm.

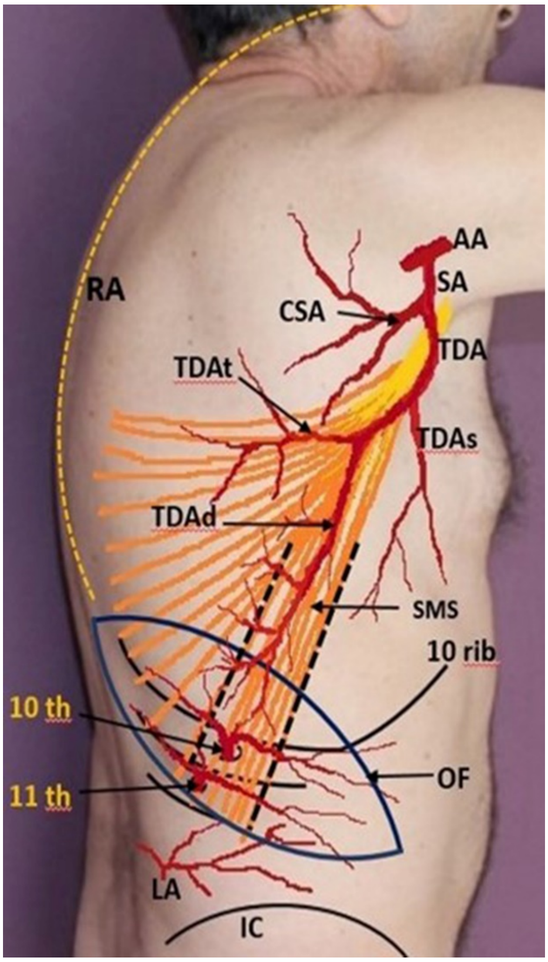
Exercises were recommended to the patients to minimize the development of limitation of motion in the shoulder joint from the 3rd postoperative week.

At the 6th and 12th months postoperatively, the patients were evaluated for complications, such as limitation of shoulder joint movements, scarring, and contour deformity in the donor area.

Surgical Technique

All surgeries were conducted under general anesthesia. Following the excision of tumors or hidradenitis suppurativa, patients were positioned in the lateral decubitus position with the upper arm abducted 90° or more, depending on the location of the defect areas. The lateral border of the latissimus dorsi muscle was palpated under the skin and marked along the posterior axillary fold. The locations of the descending branch of the thoracodorsal artery and the 10th and 11th posterior intercostal arteries were determined with Doppler probe. The dimensions and localization of the flap skin paddle were determined based on the dimensions of the defect area and its distance from the neurovascular hilus (pivot point) (Figure 1). Subsequently, the outline of the flap skin paddle was incised into the underlying muscles.

Figure 1. Pertinent anatomy of The Muscle-Sparing Latissimus Dorsi Flap.



AA, axillary arter; SA,subscapular artery; CSA,circumflex scapular artery; TDA,thoracodorsal artery; TDAs,serratus anterior muscle branch of the TDA; TDAd,descending branch of the TDA;TDAt,transverse branch of theTDA; SMS, splitt muscle segment; 10Th, 10th PIA; 11Th, 11Th PIA; LA,lumbar artery;IC,Iliac crest; OF,outline of the flap, RA,rotation arc of the flap.

Flap dissection was performed in the subfascial plane, commencing from the lateral or anterior margin between the deep fascia and muscle. Upon reaching the lateral edge of the latissimus dorsi muscle, the dissection continued for approximately 5-6 cm in the submuscular plane. The 10th and 11th intercostal arteries were identified, ligated, and excised during the dissection process. The medial part of the flap was then dissected, followed by the dissection of the lateral part in the subfascial plane until only 4-5 cm remained from the lateral border of the latissimus dorsi muscle.

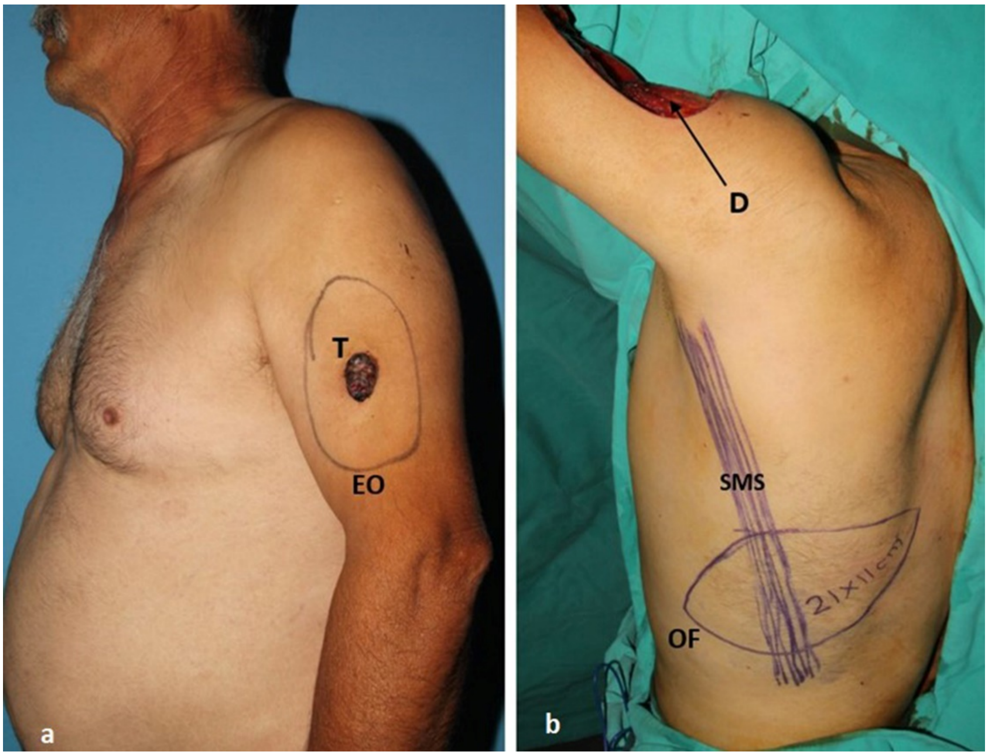
Finally, the distal end of the muscle segment was cut approximately 4-5 cm from the lateral edge of the latissimus dorsi muscle, and this segment was dissected parallel to the muscle fibers up to the neurovascular hilus with a skin island on it. The nerve innervating the split muscle segment (SMS) was cut at the point where it entered the muscle. The fully elevated flap was then adapted to the defect area and either directly transposed or tunneled, depending on the placement of the defect area. The donor area was undermined in the suprafascial plane in the cranial and caudal directions to reduce the tension that may occur in the suture line, and then directly closed in two layers .

CASE REPORTS

Case 1:

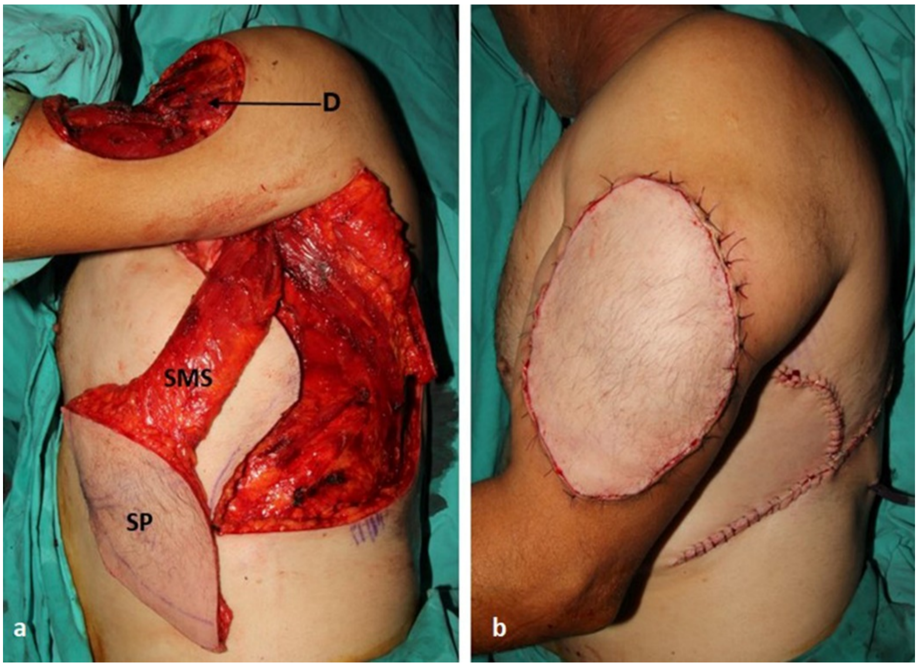
A 56-year-old male with malignant melanoma of the left lateral arm was referred for treatment (Figure 2, a). The lesion was excised from the lateral base with wide surgical margins (Figure 2, b).

Figure 2. Preoperative and intraoperative view of Case 1. a, Malignant melanoma on the lateral surface of the left arm. b, Drawing of the 11x21 cm sized flap after the tumor excision. EO,excision outline of the tumor; T,tumor;D,defect.



Additionally, axillary lymph node dissection was performed, including the level 2 axillary lymph nodes. A muscle-sparing latissimus dorsi flap with a caudally transverse skin paddle (11 × 21 cm) was elevated (Figure 3, a) and transposed into the defect area through a subcutaneous tunnel and sutured. The donor area was closed directly (Figure 3, b).

Figure 3. Appearance of the flap elevation and adaptation to the defect. a, View of the defect and the elevated flap. b, Flap sutured to defect and donor area closed primarly. SP,skin paddle.



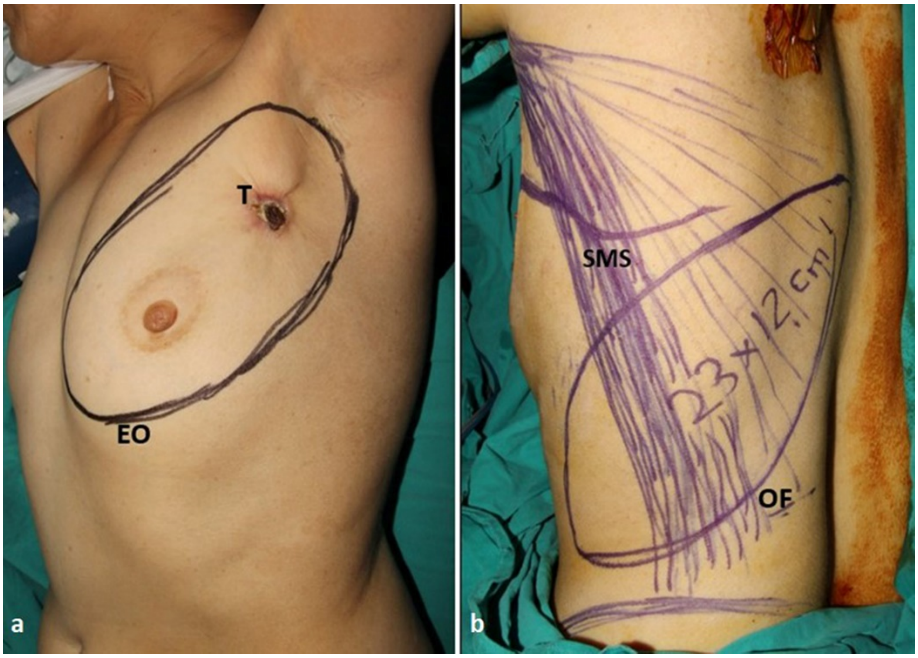
The flap healed without any complications (Figure. 4).

Figure 4. The appearance of the flap 4 months after the operation.

Case 2: A 48-year-old female with invasive ductal carcinoma of the left breast was referred for treatment (Figure 5, a). The lesion was excised at the base of the pectoralis major muscle from wide lateral surgical margins.

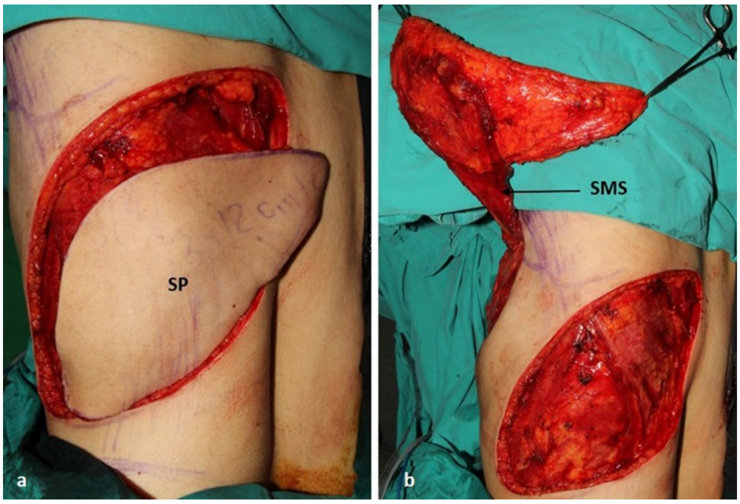
Additionally, axillary lymph node dissection was performed, including the level 3 axillary lymph nodes.

Figure 5. Preoperative and intraoperative view of the Case 2. a, Invasive ductal carcinoma of left breast. b, Drawing of the 12x23 cm sized flap with caudally oblique placed skin padle.



A muscle-sparing latissimus dorsi flap with a caudally oblique skin paddle (12 × 23 cm) was planned and elevated (Figure 5,b; Figure 6, a).

Figure 6. Intraoperative view of the flap. a, View of the flap after the completed elevation. b, appearence of the posterior surface of the flap after the transposed to the defect through a subcutaneous tunnel.



The flap was transposed into the defect area through a subcutaneous tunnel and sutured. The donor area was closed directly (Figure 6,b; Figure 7, a).

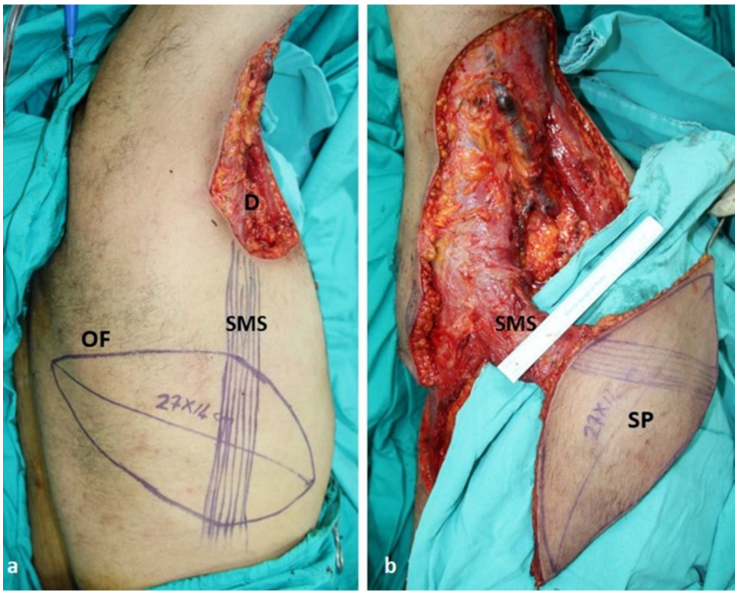
In the 6-month postoperative follow-up, shoulder joint movements returned to a normal level, and minimal scarring occurred in the donor area (Figure 7, b).

Figure 7. Intraoperative and postoperative view of the flap and donor area. a, View of the flap after the sutured to the defect and the primary closed of the donor area. b, The appearence of the flap and donor area at the 30 th month postoperatively.

Case 3:

A 46-year-old male patient was referred to our hospital for treatment of bilateral axillary hidradenitis suppurativa (HS). The right axillary lesion was initially examined. Methylene blue was injected into the skin fistulas to determine the subcutaneous borders of the lesion, and the lesion was excised at the base and lateral free margins. A muscle-sparing latissimus dorsi flap with a caudally oblique and more laterally extended skin paddle (14 × 27 cm) was planned (Figure 8,a). The flap was elevated to a height of 4.5 cm splitted muscle segment (Figure 8, b).

Figure 8. Intraoperative view of Case 3. a, The defect formed after excision of the axillary HS on the right side of the patient and drawing of the large (14x27 cm) sized flap with caudally oblique placed skin paddle. b, Elevated of the flap on the 4.5 cm width split muscle segment of the latissimus dorsi muscle.



After elevation, the flap was directly transposed into the defect and sutured. The donor area was primarily closed (Figure 9, a). The flap healed without complications, and minimal scarring developed in the donor area (Figure 9, b).

Figure 9.Intraoperative and postoperative view of the flap and donor area. a, The flap sutured to defect after the elevation and primary closure of the donor area. b, The appearance of the flap and the donor area at the 3th month postoperatively. Note: Minimal visible scar is seen in the anterior border of the flap and in the donor area, although there is no insufficiency in shoulder joint movements.

RESULTS

All the flaps survived without complete or partial loss. No lesions (malignant tumors or HS) recurred. None of the patients developed a seroma or contour deformity in the donor area. One patient exhibited a visible scar at the donor site. Two flaps used for axillary fossa repair were thinned 3 months after the first operation. The limitation of shoulder joint function, which developed in the first weeks after surgery, was minimized by functional shoulder exercises and returned to normal in all patients in the last months. All patients evaluated the functional and aesthetic results as satisfactory.

DISCUSSION

A partial or total latissimus dorsi musculocutaneous flap is generally not used unless extensive defect repair or functional muscle transfer is required. Muscle bulk in the recipient area and donor area deformities, such as seroma, contour deformity, and limitation in shoulder joint movements, are common (13,14,19-21). These complications can be prevented with thoracodorsal artery (TDA) perforator flaps or minimized with muscle-sparing latissimus dorsi (LD) flaps (14). TDA perforator flaps require expensive imaging modalities, extensive operating times, and advanced technical skills (13,14). Complication rates (transient venous congestion and marginal necrosis) are higher than muscle-sparing flaps (12), and flap sizes are smaller than those of muscle-sparing flaps (12,14).

Angrigiani et al. used an extended thoracodorsal artery perforator flap for breast repair (17). However, the authors reported that resection of the distal underperfused area may be required. Flap dissection was performed in the suprafascial plane. In other words, they did not include deep thoracodorsal fascia (DTF) in the flap. These authors might have elevated their flaps more safely if they had included DTF at the base of the flap. The dorsal thoracic fascia feeds the skin and subcutaneous tissue of a large area on the posterior and lateral backs, both by self-supplying arteries and by anastomosing these arteries with adjacent arteries.

Mineba et al. stated in their study of the DIA perforator flap that the deep fascia is dispensable for flap vascularity(28). However, we do not think so. Especially in large flaps, the dorsal thoracic fascia, owing to the vascular network it contains, makes an important contribution to the blood supply to the subcutaneous and skin tissues(29). The marginal necrosis seen in the 27x11 cm flaps of Mineba et al. might have been greater because they did not include the deep fascia in their flaps. This was because they used two small DIA perforators.

In another thoracodorsal artery perforator flap study, large flaps up to 30 × 11 cm were removed(31). This study strongly suggested that the superficial vein distal to the flap should be included in supercharged venous drainage. Supercharging techniques are laborious and require extensive expertise. Moreover, usable superficial veins may not always be found in the distal part of the flap or recipient area.

The pedicled descending branch muscle-sparing latissimus dorsi flap was developed to rule out ischemic complications such as venous congestion and marginal necrosis of TDA perforator flaps(12,23). In addition, with this method, donor area deformities such as seromas and limitations in shoulder joint movements of total or partial latissimus dorsi musculocutaneous flaps are avoided(11,23).

We used a modified muscle-sparing latissimus dorsi flap to avoid complications associated with total or partial latissimus dorsi musculocutaneous flaps and TDA perforator flaps. Because of the true anastomoses between the arteries supplying the latissimus dorsi muscle, we planned for the flap skin island to be located distally. We placed the flap skin paddle in a slightly transverse or oblique orientation in the area where a muscle segment 3-5 cm from the lateral edge of the latissimus dorsi muscle intersects the 10th or 11th intercostal space. Thus, more than one TDA perforator in the elevated muscle segment and vascular anastomoses of these perforators with the 10th or 11th intercostal artery perforators were included in the flap skin paddle.

In addition, damage to the subcutaneous vascular network was prevented by subfascial dissection.

We included the vessels in the DTF at the back of the flap and the vessels on the SF in the anterior part of the flap. Thus, we safely removed the 14x27 cm flap. Although our technique is similar to the currently used muscle-sparing latissimus dorsi flap technique (11,12,14,19,20,23,32), which uses the descending branch of the TDA and its perforators, a 3-5 cm muscle strip around the pedicle, it differs from these techniques in four aspects.

First, we placed the flap skin paddle in the area where the lateral muscle segment of the latissimus dorsi intersected the 10th or 11th intercostal space. Thus, we were able to elevate larger flaps by including the vascular territories of the 10th or 11th intercostal artery perforators on the lateral chest wall into the flap.

Second, because the flap skin paddle was located more caudally, both a wider skin paddle of the flap and a longer rotation arc were obtained by including the vascular territory of the lumbar arteries in the flap.

Third, we avoided injury to the subcutaneous vascular plexus within the subcutaneous fat via subfascial dissection.

Fourth, we were able to elevate a larger flap more safely by including the DTF in the posterior part of the flap and the SF in the anterior part.

Our technique is very similar to that described by Minabe et al. in terms of flap skin paddle placement(15). However, in our technique, the muscle pedicle width (maximum, 5 cm) was half the pedicle width of the authors. In addition, our flap sizes (up to 14 cm × 27 cm) were larger than theirs.

We can explain the fact that flaps can be elevated without partial or total loss with a significant contribution of the deep fasciae to flap viability. Although minimal donor site deformities, such as transient limitation of shoulder joint movements and minimal scarring, developed, total or partial necrosis did not develop in any flap. In conclusion, we believe that the inclusion of the 10th or 11th posterior intercostal artery perforators and DTF and SF in the flap facilitates the elevation of larger flaps with a longer rotation arc, and therefore, the closure of larger and more distant defects.

Conclusions

Muscle-sparing LD flaps can be raised to larger sizes and are safer if the flap is planned with the center of the skin paddle over the perforators of the 10th or 11th posterior intercostal artery and elevated together with the deep fasciae at its base. Our clinical results showed that the 10th and 11th PIA and the deep fasciae contributed significantly to flap viability in muscle-sparing latissimus dorsi flaps.

Acknowledgments

The authors thank the patients who participated in this study, and the staff of our clinic and operating room, especially the nurses.

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