European Review for Medical and Pharmacological Sciences 2023; 27: 7005-7011

Can anterolateral thigh flap be a rescuer in lower extremity injuries?

N. ATILGAN[1], B. IPEK[2], N. DUMAN[3], O. ORHAN[4], M. YILMAZ[5]

[1]Department of Hand Surgery, Sanliurfa Mehmet Akif Inan Training and Research Hospital, Sanliurfa, Turkey
[2]Department of Plastic and Reconstructive Surgery, Sanliurfa Mehmet Akif Inan Training and Research Hospital, Sanliurfa, Turkey
[3]Department of Orthopedics and Traumatology, Faculty of Medicine, Uskudar University, Istanbul, Turkey
[4]Department of Orthopedics and Traumatology, Harran University, Sanliurfa, Turkey
[5]Department of Orthopedics and Traumatology, Private Deva Hospital, Gaziantep, Turkey

Abstract. – OBJECTIVE: The lower extremity contains a variety of functional structures therefore re-establishing soft tissue coverage in large-scale injuries is a challenging procedure. Microsurgery has made progress in reducing donor morbidity and achieving a functional and aesthetic appearance in recent years. This study aimed to apply anterolateral thigh (ALT) flap to tissue defects in the lower extremity and to discuss the results.

PATIENTS AND METHODS: Twenty-three patients who were admitted to our hospital with lower extremity trauma and underwent ALT flap surgery due to soft tissue defect between November 2020 and March 2022 were included in the study. Patients' demographic data, the applied surgical procedure, the development of postoperative complications, and postoperative functional results were evaluated.

RESULTS: Twenty-three patients were included in this research. The mean age of the patients was 36.56±14.67 (10-61). Of these patients, 3 were female (13%), and 20 were male (87%). The most common etiology was traffic accident (n=8, 34%), followed by gunshot injuries (n=5, 21%), electrical burn (n=4, 17%), open fractures (n=2, 7%), infection (n=2, 7%), diabetic foot (n=1, 4%), skin tumor (n=1, 4%). Flaps were raised from the contralateral extremity in twelve patients (52%) and on the ipsilateral extremity in eleven patients (48%). The average time from first trauma to free flap surgery was 10.7±5 days (4-22). The average postoperative hospitalization was 13.6 days (9-23 days). The average follow-up time of patients was 8 months (3-13 months). The donor site is closed with primary saturation in 19 patients (82%) and closed with split-thickness skin grafting in 4 patients (18%). Our overall success rate was 96%. We had only one total flap failure out of twenty-three patients (4%).

CONCLUSIONS: ALT-free flap is an excellent choice for reconstructing lower extremity complex defects. For experienced surgeons, the ALT flap can be used successfully in the treatment of soft tissue defects of variable size in the lower extremity.

Key Words:
ALT flap, Lower extremity, Injury.

Introduction

Microvascular free flap surgeries are the mainstay of lower extremity reconstruction, especially defects distal to the knee, and anterolateral thigh flap (ALT) is one of the most popular free flaps used in lower extremity reconstruction. First described in 1984 by Song et al[1], ALT flap gained popularity in every aspect of reconstructive surgeries. The advantages of this method can be attributed to the versatility of the ALT flap, long pedicure length, the possibility of obtaining large flaps, and low donor site morbidity[2].

Anterolateral thigh free flap is an excellent choice for defects in the lower extremity distal to the knee, and can also be used as a pediculed flap from the knee to the groin area in the upper 1/2 of lower extremities[3]. ALT can be harvested as large as 35 cm long and 25 cm wide and can cover very large defects without the need for a skin graft on top of the flap. ALT flap's skin paddle is very versatile and thus can cover a large variety of defects. ALT flaps' pedicle length can be up to 8 to 16 cm long, which is helpful in trauma cases as it gives the surgeon the opportunity to do the vascular anastomoses out of the trauma zone without the need for vein grafts compared to short pediculed flaps. When looking at all the benefits of ALT flap, it is undoubtedly easy to see why it has become a workhorse flap for free flap reconstructions[3].

Corresponding Author: Numan Atilgan, MD; e-mail: doktor_dao@hotmail.com

In our study, we analyzed lower extremity reconstructions using anterolateral thigh-free flaps, reviewed demographic, preoperative, intraoperative, and postoperative data, and reviewed the literature to determine the efficiency of ALT-free flap in lower extremity reconstruction.

Patients and Methods

Study Design

The study was approved by the local ethics committee of Şanlıurfa Harran University Medical University Medical Faculty (Decision No. 06.05.2022-127416), in accordance with the Declaration of Helsinki. This retrospective study was conducted on patients who applied to the outpatient clinic of plastic, reconstructive and aesthetic surgery and hand surgery departments between November 2020 and March 2022. Data were collected from patients with lower extremity tissue defects who were reconstructed with anterolateral thigh free flap who were referred to these departments from the emergency department or other clinics. Informed consent was obtained from each patient before surgery. Patients from the emergency department were stabilized and then hospitalized, and routine blood workup, electrocardiogram (ECG), and chest X-rays were obtained from all the patients. Further investigations were made preoperatively for patients with comorbidity if the anesthesia department requested it. Debridement and bone fixation surgeries were performed by the relevant clinics. When all the necessary preoperative preparations were finished final reconstruction with the ALT-free flap was planned. Postoperatively, patients are followed closely for hematomas, vascular compromise, and other complications in the first 48 hours. Routine cefazolin 2x1 gr was administered to all patients postoperatively, as well as to trauma patients during their hospitalization. Patients showing signs of infection were given broad-spectrum antibiotic therapy. All patients were administered subcutaneous enoxaparin postoperatively (4,000-6,000 IU depending on the patient's age, weight, and comorbidities). Patients were taken into emergency surgery if bleeding or vascular compromise was suspected. Patients were hospitalized for at least 10 days and even more in cases of concurrent complications. Patients were discharged with oral antibiotics and analgesics and were recommended daily wound dressing changes.

Surgical Technique

The surgical process was carried out by two surgeons. Surgical loops and headlights are used. One surgeon prepared the recipient site, first starting with debridement of the wound and bone fixation, tendon, muscle, and nerve repairs. Afterward, the recipient's vessels were found and prepared as one artery and two veins. The second surgeon simultaneously started flap elevation. First, drawings were made: the superior anterior iliac spine and superior lateral border of the patella were marked, and a line was drawn connecting two landmarks. This line also corresponds to the intermuscular septum between the rectus femoris muscle and the vastus lateralis muscle. The middle point of the line was measured and marked. A circle with a 3 cm radius was drawn. Perforators are mostly found in this area, usually on top of the line or inferior to the line, especially the inferior lateral quadrant of the circle. A handheld intraoperative doppler probe can be used to find perforator locations to ease the dissection. Flap size will be determined according to the defect size. The flap was calculated to be slightly larger than the defect, taking into account the 3D volume of the flap that would facilitate closure. However, the tail of the flap was used to cover a portion of the pedicle for tension-free closure. The flaps height was arranged 1/3 superior to the line and 2/3 inferior to the line, and the middle point of the flap is placed in the middle point of the line, but the flap can also be placed eccentrically to take advantage of the perforator position.

After drawings were planned, a skin incision was made on the superior-medial side, incising 2/3 of the flap and leaving 1/3 of intact skin on the lateral. This maneuver leaves the surgeon the chance to salvage the flap if planned perforators are found unsuitable. If the ALT flap is abandoned, the skin incision gradually widens laterally, and a new free-style perforator is sought. If this plan also fails, the tensor facia lata flap can be planned by tailoring and extending the incisions. Another option is to change to an anteromedial thigh flap.

Skin, subcutaneous fat, and muscle fascia were incised, and sub-facial dissection was made with proactive hemostasis. Dissection was advanced until the skin perforators were found. After perforators were chosen, a skin incision was made in the inferior side of the flap, leaving a pedicle of skin intact on the medial side to secure the flap from falling and putting tension, and avulsion on the perforators.

Subfacial dissection was made on the inferior to perforators. Surgeons can put fingers inferior to perforators to protect the perforators, and dissection can be advanced in a fast and easy manner with confidence until reaching the fingers. At this point, the intermuscular septum was separated between the rectus femurs and the vastus lateralis with blunt dissection. Descending branch of the lateral circumflex femoral artery (LCFA) is the main pedicule of the flap. Pedicle was found, and at this point, the surgeon proceeded to intramuscular dissection of the perforators up to the main pedicle. Perforators usually give branches to lateral and inferior inside the muscle, thus, intramuscular dissection can be done safely superior to perforators. The muscle was held with forced and incised using bipolar cautery, leaving the perforator naked. If the perforator was septocutaneous this intramuscular direction step was not necessary. The lateral and inferior branches of the perforator were ligated, and dissection continued until the main pedicle. This step was repeated if there was more than one perforator. The main pedicle was ligated distal to the most distal perforator leaving a one cm safety margin. At this point flap, the skin was incised completely, and the flap was elevated. The main pedicle dissection was continued until the desired length and thickness of the pedicle were achieved. The flap was then separated, and adaptation was made to the recipient site; anastomoses were done in a meticulous manner. 5,000 IU heparin was administered intravenously after anastomoses were completed. The donor site was closed primarily whenever possible, and split-thickness skin grafting was used if the donor site could not be closed primarily. A Hemovac drain was used for the donor site. Penrose drains were used in the recipient site. Skin saturation and wound dressings were applied. Images of the ALT flap surgical technique are shown in Figures 1-3.

Statistical Analysis

The data obtained from the research were transferred from the Excel file to the database created in the SPSS (Statistical Package for Social Sciences, USA) 27.0 (IBM Corp., Armonk, NY, USA) package program, and statistical analyzes were made with this program. As descriptive statistics, arithmetic mean ± standard deviation and median (minimum, maximum) were used to summarize numerical data, and numbers and percentages were used to summarize categorical data.

Results

23 patients were included in this research. The mean age of the patients was 36.56±14.67 (10-61). Of these patients, 3 were female (13%), and 20 were male (87%). The most common etiology was traffic accident (n=8, 34%), followed by gunshot injuries (n=5, 21%), electrical burn (n=4, 17%), open fractures (n=2, 7%), infection (n=2, 7%), diabetic foot (n=1, 4%), and skin tumor (n=1, 4%). 16 patients were smokers (70%), and seven patients were nonsmokers (30%). The defect was on the right extremity in twelve patients (52%) and on the left in eleven patients (48%). Flaps were raised from the contralateral extremity in twelve patients (52%) and on the ipsilateral extremity in eleven patients (48%). All the patients, except the patient with the skin tumor, had debridement done, and eleven patients (47%) had bone fixation surgeries before their final reconstruction. The average time from first trauma to free flap surgery was 10.7±5 days (4-22). The most common location of the defects was the dorsum of the foot (n=11, 47%), followed by the anterior aspect of the tibia (n=3, 13%), heel (n=2, 8%), plantar aspect of the foot (n=2, 8%), knee (n=2, 8%) and ankle (n=1, 4%). Defect size ranged from 4x5 cm to 20x15 cm, and the average defect area was 99.04 cm^2 (300-20 cm^2). Flap size ranged from 6x5 cm to 22x18 cm, and the average flap area was 134.6 cm^2 (396-30 cm^2). Average pedicle length 10.17

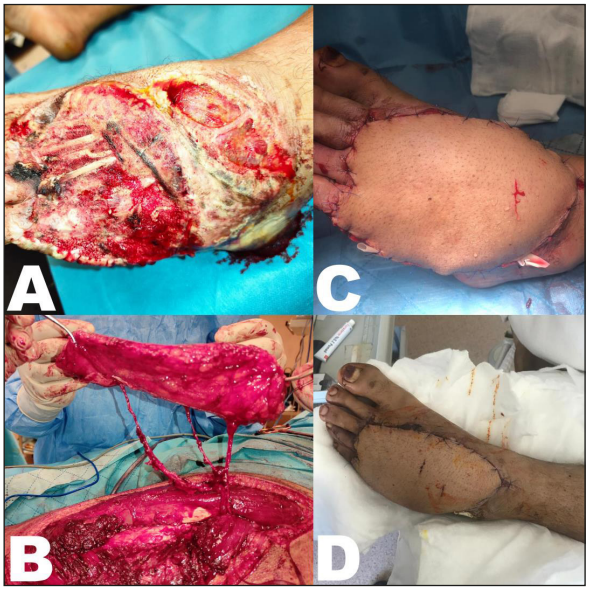

Figure 1. **A**, Defect on the dorsum of the foot. **B**, ALT flap with 3 perforators elevated (**C**) ALT flap adaptation to defect immediate postoperative photo (**D**) Flap postoperative 24th hour.

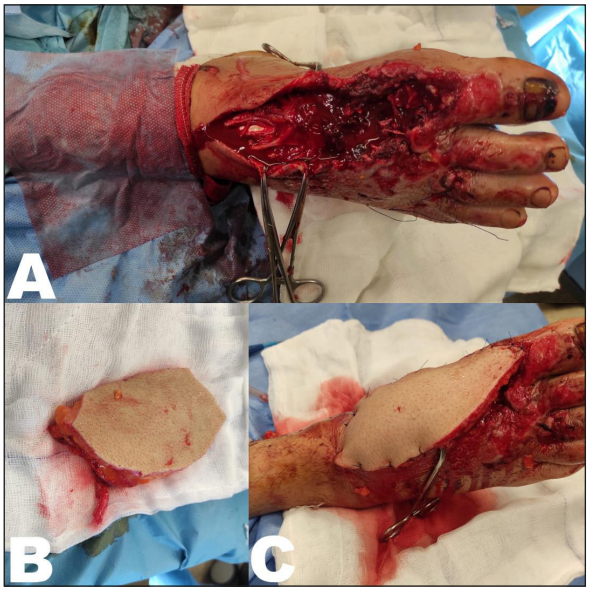

Figure 2. **A**, Defect on the dorsum of the foot. **B**, ALT free flap before adaptation and anastomoses. **C**, Flap after adaptation and anastomoses.

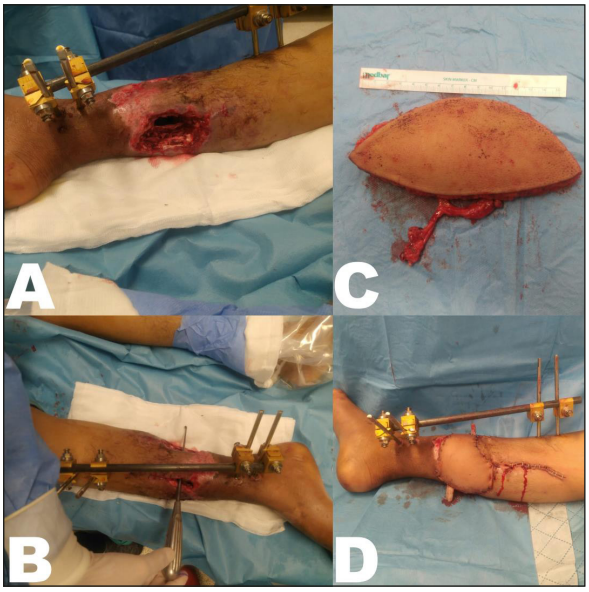

Figure 1. **A-B**, Defect extending from posterior to the anterior leg. **C**, ALT free flap before adaptation and anastomoses. **D**, Flap after adaptation and anastomoses.

cm (8-14 cm). Five patients had an additional intervention on their bone fractures (23%), and two patients had finger amputations (8%) simultaneous to their final reconstructive free flap surgeries. The postoperative complication rate was 30% (seven patients out of twenty-three). The most common complication was surgical site infection, seen in three patients (13%). All three patients were treated with a broad-spectrum antibiotic, and two of the patients required additional debridement for infection control. All three patients recovered. The second most common complication was partial flap loss, which was seen in two patients (8%). Debridement of necrotic areas was done, and split-thickness skin graft was used for reconstruction. Prolonged serous discharge was seen in one patient (4%), and debridement and washing of the surgical site were done. Only one patient had total flap failure (4%). Debridement and skin grafting were administered for reconstruction. The average surgery time was 247.3 minutes (290-190 minutes). The most common artery chosen for anastomoses was the anterior tibial artery (n=9, 39%), followed by the posterior tibial artery in eight patients (34%), medial plantar artery in three patients (13%), and dorsalis pedis artery in three patients (13%). End-to-end anastomoses was the preferred anastomoses technique, and it was used in 20 patients (86%), while end-to-side anastomoses was used in three patients (14%). All the patients had 2 venous anastomoses made. A deep venous system was preferred in 14 of the patients (60%), the combination of deep and superficial venous systems was preferred in five patients (21%), and a superficial venous system was preferred in four patients (17%) for venous anastomoses. The average postoperative hospitalization was 13.6 days (9-23 days). The average follow-up time of patients was 8 months (3-13 months). The donor site is closed with primary saturation in 19 patients (82%) and closed with split-thickness skin grafting in 4 patients (18%). Two patients required debunking surgery on their flaps in the long-term follow-up. Intraoperative complications were seen in six patients (26%). Anastomoses thrombosis in four patients (17%) and vasospasm in two patients (9%). Re-anastomoses was made to resolve thrombotic anastomoses, and warm wet gauze and papaverine irrigation were used to resolve vasospasm. All the intraoperative complications were resolved after the interventions.

Discussion

Free flaps are an important part of lower extremity reconstruction, especially in the distal knee, used by reconstructive surgeons. Defects requiring flap coverage such as bone, tendon, nerve, and vascular tissue exposed defects, osteomyelitis-related defects, and diabetic foot ulcers can be difficult in the lower extremity. Free flaps have the advantages

of covering large defects, bringing vascularized tissue to an avascular area, and being resistant to infection[4,5]. Also, free flap surgery can salvage extremities with complex traumas that otherwise would lead to amputations. Thus, a reconstructive ladder, when it comes to lower extremity reconstruction, can become a reconstructive elevator, and microsurgical free flap transfer can become the first treatment choice in many patients[6].

The anterolateral thigh flap has become a workhorse flap since its first description by Song et al1 due to its advantages, like largely available skin paddle that can be harvested, long pedicle, versatility and malleability of tissue with different tissue components that can be harvested with the flap, low donor site morbidity and decreasing of operative time by using two team approach[7-9]. Disadvantages can be counted as donor site closure requiring skin grafting in large flaps, unavailability of perforators in rare cases, long learning curve and bulky flap in obese patients[10,11].

In our cases, we benefited from the advantages of the ALT flap mentioned in the literature. We used 22x18 (396 cm^2) ALT flaps for the repair of 20x15 cm (300 cm^2) defects. Taking into account the 3D nature of the defect and flap, we harvested the flaps 10-50% larger than the defects. Also, defects with irregular shapes might need harvesting larger flaps and flap tailoring while adapting. Defects covering more than one side of the extremity, defects that are not large in volume, and defects that require the closure of dead spaces are some of the other reasons for larger flaps to be removed. We planned our flaps with a higher length-to-width ratio to ease the closure of the donor site. Our experience showed that the narrower and longer the flap, the easier the donor site closing. But the length-to-width ratio is not the only variation determining whether the donor site can be closed by primary saturation or not. Patient variabilities have a role as well, like weight and body fat percentage of the patient, length of the leg, and skin laxity. The same sized flap can be closed in a thin patient with lax skin but might need a skin graft in an obese patient. The literature recommends skin grafting for flaps wider than 7-9 cm, but we were able to close flaps wider than 9 cm without any complications[12]. Our widest flap that could be closed primarily was 12 cm. Avoiding skin grafting for donor site closure allows for a better cosmetic result, decreasing surgery time and avoiding another scar for the graft donor site. But if in doubt, we would recommend using skin grafting rather than risking a postoperative donor site complication like wound dehiscence or compartment syndrome.

We have used two team approach in all the cases. This decreased the operative time and also decreased the surgeon fatigue, thus resulting in better outcomes. ALT flap can be too bulky in overweight and obese patients. This might require a second debunking operation during the follow-up of the patient. This also depends on the location of the defect. A bulky flap on the foot might create problems for wearing shoes. The patient might require a larger shoe on the foot with the flap. The plantar aspect of the foot is a pressure-bearing area, especially in the calcaneal area. Although bulky flaps are more resistant to pressure, too bulky flaps can also cause walking problems for the patient and may require a debulking operation. We performed debulking operations on two patients out of twenty-three patients (8%). Defects were on the heel area and dorsal foot. Debulking surgeries are performed at least three to six months after the flap surgery. This allows for angiogenesis and remodeling of the flap, so it can be vascularized in a random pattern, thus facilitating the debulking operation. So, this allows for lymphedema subsiding. Also, if the patient requires another revision or intervention on the flap or the concomitant sequelae, these can be done in the same operation. We did the debulking by making an incision on one side of the flap leaving 50% of the skin intact on the total flap circumference. We then raise the flap 5-10 mm thicken, depending on the case and excise the excess fatty tissue underneath the raised flap that is attached to the floor of the flap. Flaps that are too bulky might need more than one debulking operation, but we did not need a second debulking on any of our patients.

Our overall success rate was 96%. We had only one total flap failure out of twenty-three patients (4%). This is similar to results in the literature of free flap series that has trauma and oncologic patients[13,14]. There are studies with higher success rates, up to 99%, but usually, these series include only or mostly breast reconstruction patients and few-to-no trauma or head and neck oncologic reconstruction cases[15,16]. We attributed our success rate to meticulous surgical technique, always checking and revising anastomoses in case of doubt. However, close postoperative follow-up of the patients and early intervention in any complication, such as hematoma or vascular compromise, increased our success rate. Postoperatively, flaps are checked every two hours in the first

24 hours and every four hours in the second 24 hours. Flap monitoring is done by clinic nurses, and flap color, temperature, capillary refill, texture, and needle pricking to check bleeding are used for determining the flap viability. If any irregularity is seen on-call doctor checks the patient, and early intervention is made.

Limitations

There are some limitations in our study. Due to the insufficient number of patients in our study, the effect of smoking on ALT-free flap could not be evaluated. As the number of patients was not homogeneously distributed according to the flap site, the evaluation of union rates differed greatly.

Conclusions

ALT-free flap is an excellent choice for reconstructing lower extremity complex defects. It has many advantages, which makes it a workhorse flap for lower extremity reconstruction. We have used ALT free flap in lower extremity reconstruction and believe it is one of the best choices for lower extremity reconstruction.

Conflict of Interest

The Authors declare that they have no conflict of interest.

Funding

None.

Informed Consent

The authors declare that the patients included in the study signed informed consent forms to use their medical information in the studies.

Authors' Contributions

Concept: N.A., N.D., M.Y.; Design: N.A., M.Y.; Supervision: M.Y., O.O., B.I.; Funding: N.A., N.D., M.Y.; Materials: M.Y., N.A.; Data: N.A., N.D., O.O., B.I.; Analysis: N.A., NA.D., O.O., B.I.; Literature search: N.A., N.D., M.Y., B.I.; Writing: N.A., N.D.; Critical revision: M.Y., N.D., O.O.

Ethics Approval

Ethics committee approval was obtained for the study, titled "Reconstruction Results with Anterolateral Thigh Flap in Lower Extremity Tissue Defects", from Harran University Faculty of Medicine Clinical Research Ethics Committee for the 03-row session dated 06.05.2022 (Approval Number: 127416).

ORCID ID

Numan Atilgan: 0000-0001-7184-978X
Bugra Ipek: 0000-0002-4796-2560
Numan Duman: 0000-0002-0183-4520
Ozlem Orhan: 0000-0001-7508-135X
Mehmet Yilmaz: 0000-0002-1366-9163

References

1) 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.
2) Cigna E, Minni A, Barbaro M, Attanasio G, Sorvillo V, Malzone G, Chen HC, Ribuffo D. An experience on primary thinning and secondary debulking of anterolateral thigh flap in head and neck reconstruction. Eur Rev Med Pharmacol Sci 2012; 16: 1095-1101.
3) Molteni G, Gazzini L, Albi C, Fior A, Nocini R, Marchioni D. Donor site aesthetic and functional outcomes: comparison between radial forearm free flap and anterolateral thigh free flap. Eur J Plast Surg 2022; 45: 409-414.
4) Zweifel-Schlatter M, Haug M, Schaefer DJ, Wolfinger E, Ochsner P, Pierer G. Free fasciocutaneous flaps in the treatment of chronic osteomyelitis of the tibia: a retrospective study. J Reconstr Microsurg 2006; 22: 41-47.
5) Kovar A, Colakoglu S, Iorio ML. Choosing between Muscle and Fasciocutaneous Free Flap Reconstruction in the Treatment of Lower Extremity Osteomyelitis: Available Evidence for a Function-Specific Approach. J Reconstr Microsurg 2020; 36: 197-203.
6) Miller EA, Friedrich J. Soft Tissue Coverage of the Hand and Upper Extremity: The Reconstructive Elevator. J Hand Surg Am 2016; 41: 782-792.
7) Nosrati N, Chao AH, Chang DW, Yu P. Lower extremity reconstruction with the anterolateral thigh flap. J Reconstr Microsurg 2012; 28: 227-234.
8) Kozusko SD, Liu X, Riccio CA, Chang J, Boyd LC, Kokkalis Z, Konofaos P. Selecting a free flap for soft tissue coverage in lower extremity reconstruction. Injury 2019; 50 Suppl 5: S32-S39.
9) Hsu CC, Loh CYY, Wei FC. The Anterolateral Thigh Perforator Flap: Its Expanding Role in Lower Extremity Reconstruction. Clin Plast Surg 2021; 48: 235-248.
10) Demirtas Y, Kelahmetoglu O, Cifci M, Tayfur V, Demir A, Guneren E. Comparison of free anterolateral thigh flaps and free muscle-musculocutaneous flaps in soft tissue reconstruction of lower extremity. Microsurgery 2010; 30: 24-31.
11) Lee SH, Suh JT, Ahn TY, Hong SM, Lee HY. Differences between the Upper Extremity and the Lower Extremity in Reconstruction Using an Anterolateral Thigh Perforator Flap. Clin Orthop Surg 2017; 9: 348-354.
12) Hanasono MM, Skoracki RJ, Yu P. A prospective study of donor-site morbidity after anterolateral thigh

fasciocutaneous and myocutaneous free flap harvest in 220 patients. Plast Reconstr Surg 2010; 125: 209-214.

13) Farquhar DR, Masood MM, Pappa AK, Patel SN, Hackman ATG. Predictors of Adverse Outcomes in Free Flap Reconstruction: A Single-Institution Experience. Otolaryngol Head Neck Surg 2018; 159: 973-980.

14) Lin Y, He JF, Zhang X, Wang HM. Intraoperative factors associated with free flap failure in the head and neck region: a four-year retrospective study of 216 patients and review of the literature. Int J Oral Maxillofac Surg 2019; 48: 447-451.

15) Carney MJ, Weissler JM, Tecce MG, Mirzabeigi MN, Wes AM, Koltz PF, Kanchwala SK, Low DW, Kovach SJ, Wu LC, Serletti JM, Fosnot J. 5000 Free Flaps and Counting: A 10-Year Review of a Single Academic Institution's Microsurgical Development and Outcomes. Plast Reconstr Surg 2018; 141: 855-863.

16) Prantl L, Moellhoff N, Fritschen UV, Germann G, Giunta RE, Zeman F, Kehrer A, Lonic D, Broer PN, Ehrl D, Heidekrueger PI. Impact of Smoking Status in Free Deep Inferior Epigastric Artery Perforator Flap Breast Reconstruction: A Multicenter Study. J Reconstr Microsurg 2020; 36: 694-702.