Versatility of the anterolateral thigh free flap in the reconstruction of coverage defects of upper and lower limbs

Javier Bennice, Julieta Puig Dubois, Gerardo L. Gallucci,
Pablo De Carli, Jorge G. Boretto

Hand and Upper Limb Surgery Section, Orthopedics Department
"Dr. Prof. Carlos E. Ottolenghi", Hospital Italiano of Buenos Aires,
Ciudad Autónoma de Buenos Aires

Received on December 29th, 2017; accepted after evaluation on January 22nd 2018 • JORGE G. BORETTO, MD • jorge.boretto@hospitalitaliano.org.ar

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Abstract

Introduction: The anterolateral thigh free flap is nowadays one of the most useful reconstructive options. Its versatility is due to the inclusion of different types of tissues in different combinations, a reliable local anatomy and a long pedicle with adequate diameter. The aim of this study is to revise our experience and evaluate the versatility of the flap in the coverage of upper and lower limbs defects.

Materials and Methods: Retrospective study. We considered patients treated for limb defects. We analyzed preoperative, intraoperative and postoperative variables.

Results: We included 12 patients (7 males and 5 females) who averaged 44 years old. Defects were of oncologic (9 cases) and traumatic (3 cases) origin. Defects were in upper limbs in four cases and lower limbs in eight patients. The average time between the defect and the surgery was 8 days. The flap survival rates were of 92%, with one case of failure. The donor site did not show complications. Closure was primary in 10 patients, and we used skin graft in two cases.

Conclusions: The ALT free flap is a valid and most useful strategy for defect coverage of different origins in both upper and lower limbs, because its versatility allows it to get successfully adapted to defects of varied locations and sizes.

Key words: thigh anterolateral free flap; versatility; coverage defect; reconstructive surgery.
Level of evidence: IV

Versatilidad del colgajo libre anterolateral de muslo en la reconstrucción de defectos de cobertura en los miembros superiores e inferiores

Resumen

Introducción: El colgajo libre anterolateral de muslo es actualmente una de las opciones reconstructivas más útiles. Su versatilidad se debe a la inclusión de distintos tipos de tejido en diferentes combinaciones, una anatomía local confiable y un pedículo largo con un calibre adecuado. El objetivo de este estudio es revisar nuestra experiencia y evaluar la versatilidad del colgajo en defectos de los miembros superiores e inferiores.

Conflict of interests: The authors have reported none.

Materiales y Métodos: Estudio retrospectivo. Se consideraron pacientes tratados por defectos en las extremidades. Se analizaron variables preoperatorias, intraoperatorias y posoperatorias.
Resultados: Se incluyeron 12 pacientes (7 hombres y 5 mujeres) con una edad promedio de 44 años. La causa del defecto fue resección oncológica (9 casos) y trauma (3 casos). La localización fue el miembro superior en cuatro casos y el miembro inferior en ocho pacientes. El tiempo promedio entre el defecto y la cirugía fue de 8 días. La tasa de supervivencia del colgajo fue del 92%, con falla en un caso. El sitio donante no presentó complicaciones, el cierre fue primario en 10 pacientes y con injerto de piel en dos.
Conclusiones: El colgajo libre anterolateral de muslo es un recurso válido y de gran utilidad para la cobertura de defectos de diferentes etiologías tanto en los miembros superiores como en los miembros inferiores, ya que su versatilidad permite que se adapte con éxito en defectos de localización y tamaño variados.

Palabras clave: Colgajo libre anterolateral de muslo; versatilidad; defecto de cobertura; cirugía reconstructiva.
Nivel de Evidencia: IV

Introduction

The use of the anterolateral thigh free flap (ALT) has been spreading until it got settled as one of the most useful options for reconstruction of coverage defects in different locations. Since it was described by Song, 1984,[1] its popularity has been on the increase and its use is nowadays widely spread in head and neck reconstruction,[2-5] but it is also most useful in limbs for defects caused by trauma, oncologic resection and burns, among others.

The features that provide the ALT free flap with great versatility are its inclusion of different types of tissues in different combinations, a reliable vascular anatomy, a large skin square, a long pedicle of adequate diameter, minimal morbidity at the donor site, and the possibility of a double surgical team working simultaneously without repositioning the patient. This flap is so rich in available tissues that it offers not only adequate soft tissues coverage, but also useful tools for tendon and vessel reconstruction, and also for muscle transfer.

The aim of this study is to revise our experience with the use of ALT free flap and to assess its versatility in a group of patients with coverage defects of different origin, size, depth and location in both upper and lower limbs.

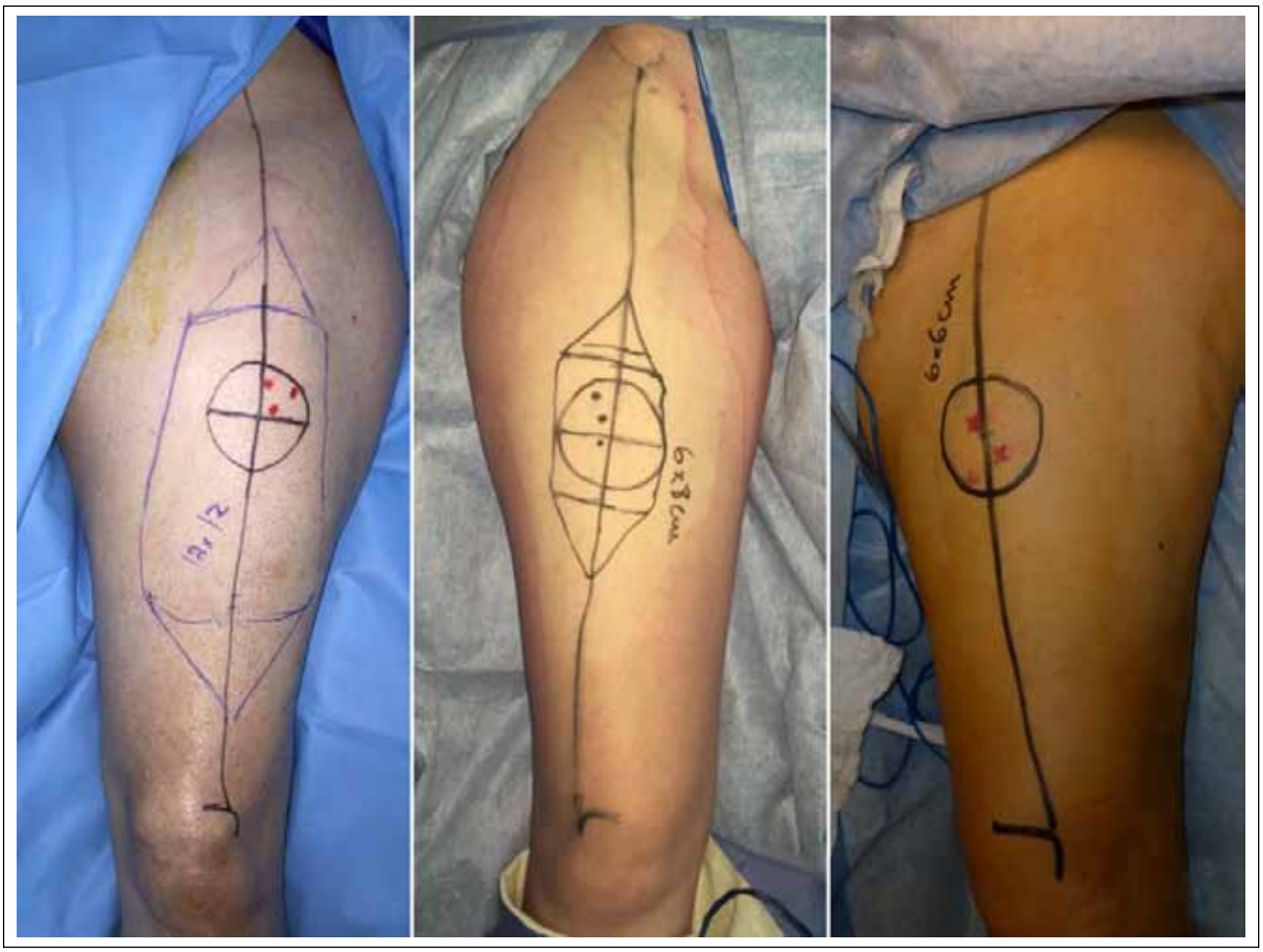
Materials and Methods

We carried out a retrospective study in which we identified all the cases of reconstruction of coverage defects in upper and lower limbs treated with ALT free flap over a period of six years. As inclusion criteria we considered all the patients with defects in different limb locations who received this flap as reconstructive treatment. All the patients were treated by the same surgeon.

Before the surgery, we analyzed diverse patients' demographic variables (age, sex, smoking-status and comorbidities), the reason for the coverage defect, the size and location of the defect, and the time that had passed between the defect and the surgery. In the context of the surgical technique we analyzed the type of flap, the type of arterial and venous suture, the host vessels in use, the flap variable manufactured, the type of closure at the donor site and intraoperative complications. In the end, after the surgery, we evaluated flap survival and complications in both the flap and the donor site.

Surgical technique

With the patient in prone position and under regional and general anesthesia, the flap should be designed drawing a longitudinal line that joins the ASIS and the supero-external angle of the patella, which is located within the projection of the inter-muscular septum between the rectus femoris and the vastus medialis muscles and represents the longitudinal axis of the flap. With the aid of a hand-held Doppler ultrasound, cutaneous perforating vessels should be identified within a 3-to-5 cm-radio from the middle of such longitudinal axis. Next, surrounding the chosen perforating vessels, it is necessary to outline a skin square of the required size for the coverage of the defect (Figure 1). Afterwards the surgeon should prepare the host zone, dissecting the host arterial-venous pedicle, and he or she should reconfirm the size of the coverage defect. It follows an incision in the middle of the anterolateral aspect of the thigh, and dissection should be carried out under magnifying lenses. What comes next is the identification of the perforating arteries of the descending circumflex femoral artery, which now should be dissected in proximal direction. Next a lateral incision should be carried out so as to complete the dissection of the flap. Depending on the features of the coverage defect, the flap may include muscle tissue, tensor fasciae latae muscle, bone tissue, lateral femoral cutaneous nerve and, once the flap has been manufactured, it can certainly be thinned. Before severing the pedicle, it should be verified that the flap has appropriate vascularization with no signs of congestion or insufficient blood supply. Once the surgeon has assessed these variables, it is possible to carry out pedicle ligature and severing, and lift the flap. What comes next is the closure of the donor site, primarily or using skin graft as required. The flap should be taken to the defect zone and sutured



▲ **Figure 1.** Design of thigh anterolateral flap of different skin square sizes, depending on the defect to reconstruct. The marks within the central circumference point at the cutaneous vessels assessed by Doppler.

except in the pedicle area for local coverage. The pedicle of the flap should be laid avoiding torsion, and it should be sutured to the host vascular bundle using microsurgical arteriorrhaphy and venorrhaphy. The patient should be given i.v. 70 U/kg heparin before releasing the vascular clamps. What follows is the release of the haemostatic cuff with verification of adequate flap revascularization without venous congestion or signs of insufficient blood supply. Skin closure should now be completed above the pedicle with drainages and, finally, the adequate vascularization of the flap should be assessed using a hand-held Doppler ultrasound. **VIDEO** ▶

Postoperative care

After the surgery patients should be taken to the ward, preferably on individual premises, for temperature management into the room. Blood supply to the flap should be monitored with hand-held Doppler ultrasound, every 2 to 3 hours, as estimated to be necessary by clinical evaluation. As of postoperative day 1, the patient should be given antithrombotic prophylaxis with prophylactic doses of low molecular weight heparin (subcutaneous enoxaparin) and 100 mg/day-salicylic acid. Heparin should be continued for three weeks and, salicylic acid, for six weeks. The patient should undergo daily lab check-ups so as to keep his or her HTC above 30%. Were these figures to go down, the patient should be given blood transfusion.

Results

Over a period of 6 years, from January 2011 to May 2017, we identified 12 patients who met the inclusion criteria. The group was made up of seven males and five females who averaged 44 years old (ranging from 13 to 78). Defects were caused by oncologic resection (9 cases) and trauma (3 cases). Four of them involved the upper limbs and eight, the lower limbs. The average time between cov-

erage defect and surgery was 8 days (ranging from 0 to 16) (Table 1).

The size of the skin square was, on average, 13 cm in length (ranging from 6 to 20) and 8 cm in width (ranging from 3 to 12). It was a fasciocutaneous flap (subfascial dissection) in 10 cases and a fat-cutaneous flap (supra-fascial dissection) in two of them. In three patients, the fasciocutaneous flap was thinned (Figure 2). In two cases, the pedicle had active blood supply (Figure 3) whereas in another one we used a chimerical pedicle by including tensor fasciae latae muscle for tendon reconstruction (Figure 4). In five cases, arteriorrhaphy was termino-terminal and, in seven, termino-lateral. Venorrhaphy was termino-terminal in 10 cases and termino-lateral in two. In all the patients with coverage defects in upper limbs, host vessels were those in the radial bundle, whereas in lower limbs, host vessels varied, the most frequently used being the posterior tibial bundle, in five cases.

Closure at the donor site was primary in 10 cases and required skin graft in two patients. In the cases of primary closure, the average size of the flap was 11.8 x 8.5 cm and, in the cases that required skin graft, it was 19 x 11.5 cm (Figure 5). Our patients did not undergo intraoperative complications. However, one patient suffered

Table 1. Demographic data

Caso	Sex	Age	Smoking-status	Comorbidity	Defect origin	Location of defect	Size of defect (length x width, cm)	Time between defect and reconstruction (days)
1	F	19	No	No	Synovial sarcoma	Right wrist (back)	11 x 3.5	13
2	M	45	No	Dyslipidemia	Soft tissues sarcoma	Right wrist (back)	11 x 6	9
3	M	78	No	Cataract, corneal transplant	Trauma (degloving)	Right wrist and forearm (back)	18 x 7	15
4	M	58	No	HBP, congestive heart failure, atrial fibrillation	Fasciotomy due to posttraumatic compartment syndrome	Right wrist (palm)	12 x 3	7
5	F	44	No	Systemic lupus erythematosus	Soft tissues sarcoma	Left foot (heel)	6 x 8	16
6	M	42	Sí	No	Epitheloid sarcoma	Right ankle (lateral)	18 x 12	7
7	M	53	Sí	HBO, Obesity	Spinocellular carcinoma	Left foot (sole)	6 x 6	0
8	M	21	Sí	No	Chronic knee osteomyelitis. Femur open fracture	Left knee (anterior)	20 x 11	9
9	F	64	No	Eosinophilic fasciitis	Spinocellular carcinoma	Left foot (back)	15 x 10	4
10	F	13	No	No	Soft tissues sarcoma	Left ankle (lateral)	11 x 6	7
11	F	45	No	HTLV1	Soft tissues sarcoma	Right ankle (lateral)	19 x 8	14
12	M	44	Sí	Hypothyroidism	Dermatofibrosarcoma protuberans	Left ankle (medial)	14 x 12	0

M = male, F = female, HTLV1 = lymphotropic virus of tropical areas.

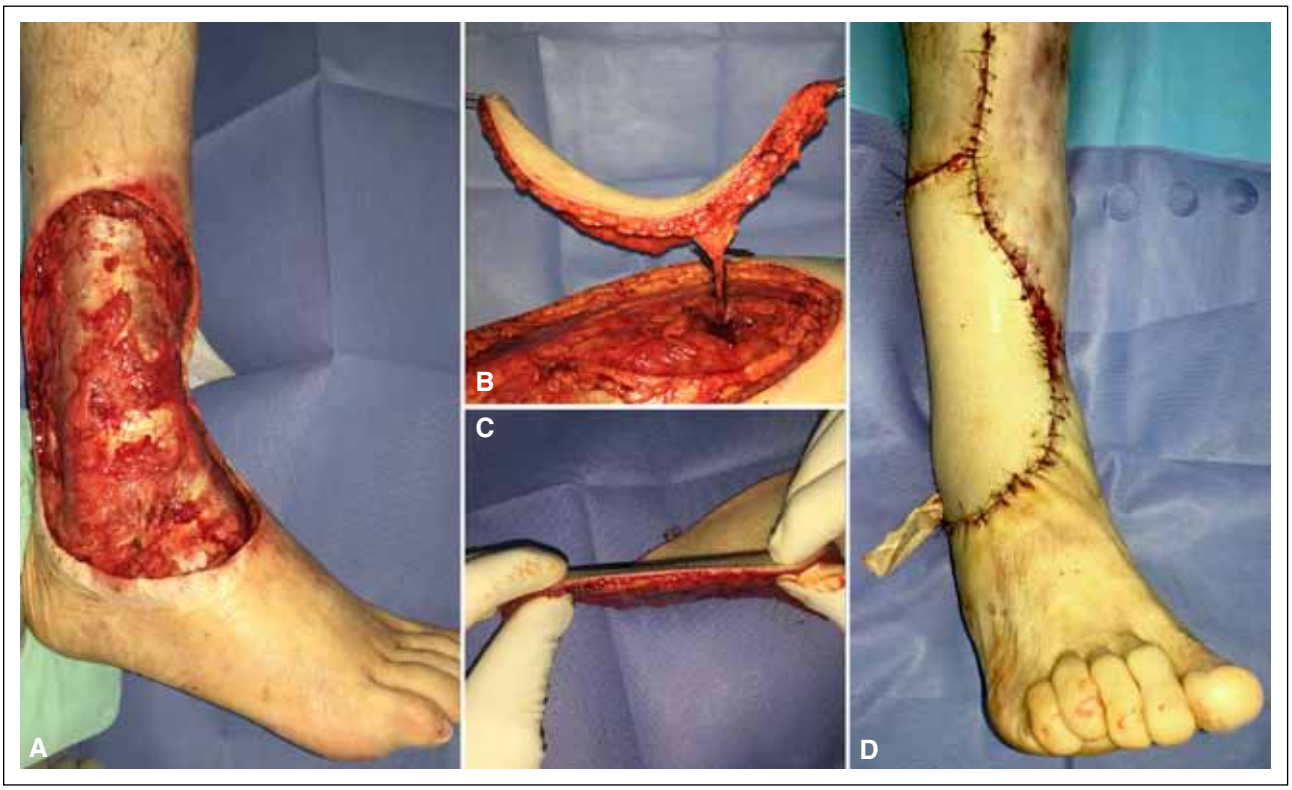


Figure 2. A. Defect after oncologic resection on the lateral aspect of the ankle. **B**. Thigh anterolateral flap with its muscular perforating artery. **C.** Thinning of the flap. **D.** Immediate postoperative results after positioning and suturing flap and vessels.

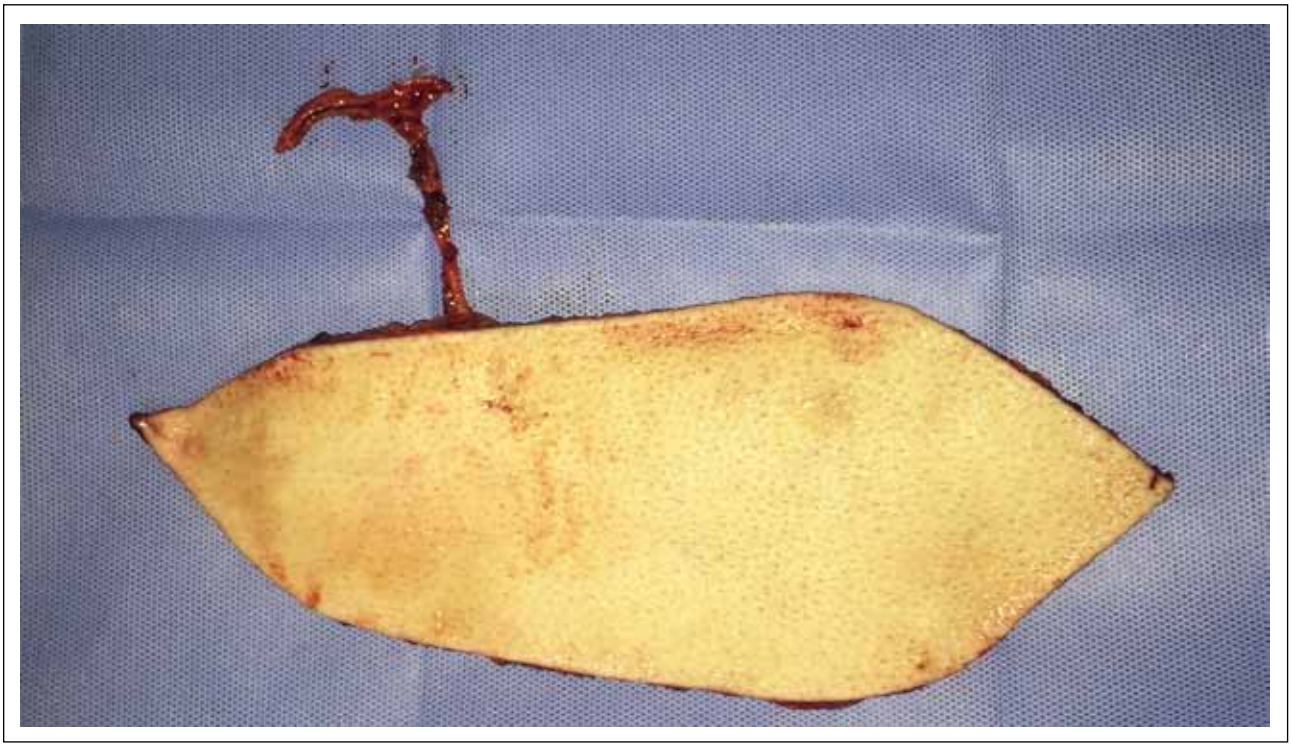


Figure 3. Variant of thigh anterolateral flap with vascular pedicle which includes a proximal "T" to manufacture a flap with active blood supply.

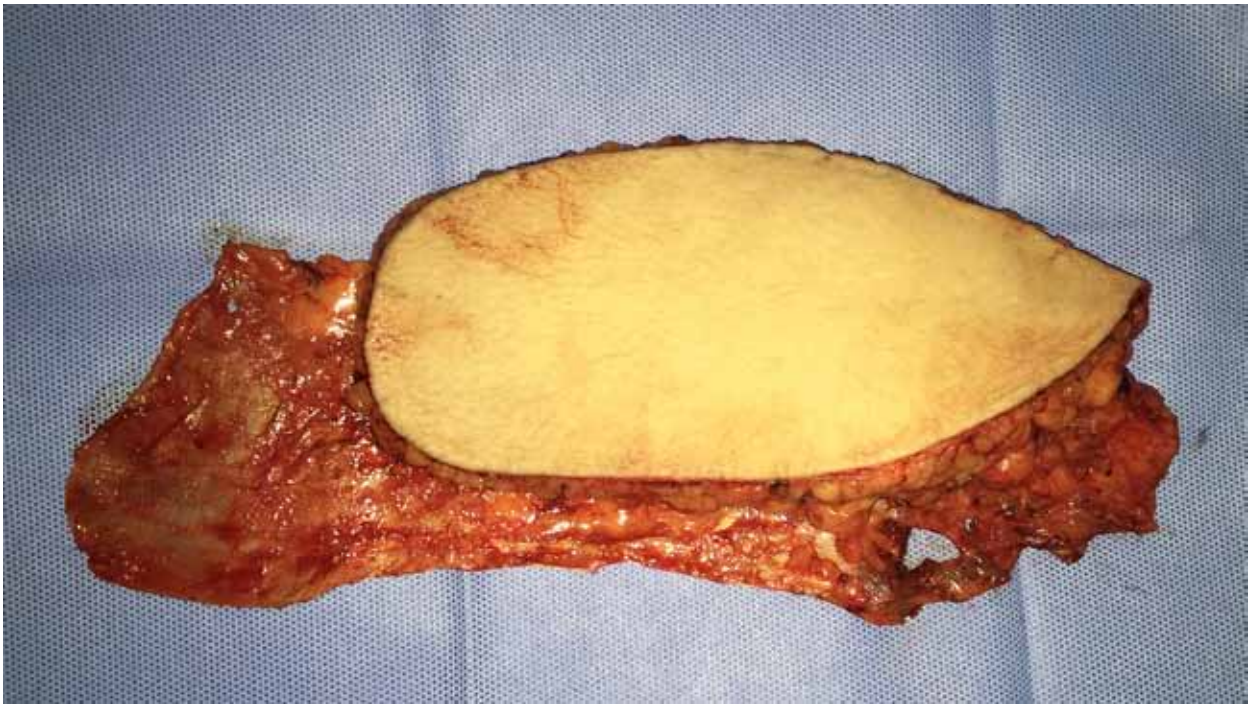


Figure 4. Variant of thigh anterolateral flap which includes tensor fasciae latae muscle for tendon reconstruction.

Figure 5. A. Closure of donor site without skin graft. Immediate postoperative results and results after a 6-month follow-up. **B.** Closure of donor site with total width-skin graft. Immediate postoperative results and results after an 8-week follow-up.

venous thrombosis in the satellite veins of the anterior tibial bundle during the surgery, what was confirmed by venotomy, and we had to use the fibular bundle. In another patient, the muscle perforating vessels were not identified on the vastus medialis muscle but on the rectus femoris muscle instead (Table 2). Seven out of the 12 patients in this study required RBC transfusion during the surgery or afterwards. Among these ones, the average was 1.8 during hospital stay (ranging from 1 to 3).

The flap survival rate was 11/12 cases (Figures 6-9). There was only one case of flap failure with total necrosis due to venous thrombosis; the resulting defect was reconstructed by a latissimus dorsi flap, and the patient did well. Another patient required revision of the pedicle 24 hours after the surgery because there was not Doppler signal, and suffered partial necrosis, but we did not verify vascular thrombosis during the surgery. We did not identify any other postoperative complication. Two patients suffered amputation in the flap zone, but due to unrelated reasons: one of them due to osteomylitis resistant to medical and surgical treatment, and the other one due to their oncologic disease. Both patients underwent amputation after one-year follow-up. The donor site did not show complications.

Table 2. Intraoperative data

Case	Type of flap	Variant	Number and type of perforating arteries	Host vascular bundle	Stitches	Arterial anastomosis	Venous anastomosis	Closure of donor site
1	Fasciocutaneous	-	1 septal	Radial	10-0 Nylon	End-to-side anastomosis	End-to-end anastosmosis	Primary
2	Fasciocutaneous	-	2 muscular	Radial	10-0 Nylon	End-to-end anastosmosis	End-to-end anastosmosis	Primary
3	Fasciocutaneous	-	2 muscular	Radial	9-0 Nylon	End-to-side anastomosis	End-to-end anastosmosis	Primary
4	Fasciocutaneous	-	1 septal	Radial	10-0 Nylon	End-to-side anastomosis	End-to-end anastosmosis	Primary
5	Fat-cutaneous	-	1 muscular	Posterior tibial	9-0 Nylon	End-to-side anastomosis	End-to-end anastosmosis	Primary
6	Fasciocutáneo	Thinned/ Large skin square/Active blood supply	2 muscular	Anterior tibial	9-0 Nylon	End-to-end anastosmosis	End-to-end anastosmosis	Skin graft
7	Fat-cutaneous	Small skin square	1 muscular	Medial plantar	9-0 Nylon	End-to-side anastomosis	End-to-side anastomosis	Primary
8	Fasciocutaneous	Large skin square/Long vascular pedicle	1 muscular	Femoral	9-0 Nylon	End-to-end anastosmosis	End-to-side anastomosis	Skin graft
9	Fasciocutaneous	-	1 muscular	Posterior tibial	9-0 Nylon	End-to-side anastomosis	End-to-end anastosmosis	Primary
10	Fasciocutaneous	Thinned/ Active blood supply	1 muscular	Posterior tibial	9-0 Nylon	End-to-end anastosmosis	End-to-end anastosmosis	Primary
11	Fasciocutaneous	Thinned/ Large skin square/ Chimerical (tensor fascia latae muscle)	2 muscular	Fibular	9-0 Nylon	End-to-end anastosmosis	End-to-end anastosmosis	Primary
12	Fasciocutaneous	-	2 septal	Posterior tibial	9-0 Nylon	End-to-side anastomosis	End-to-end anastosmosis	Primary

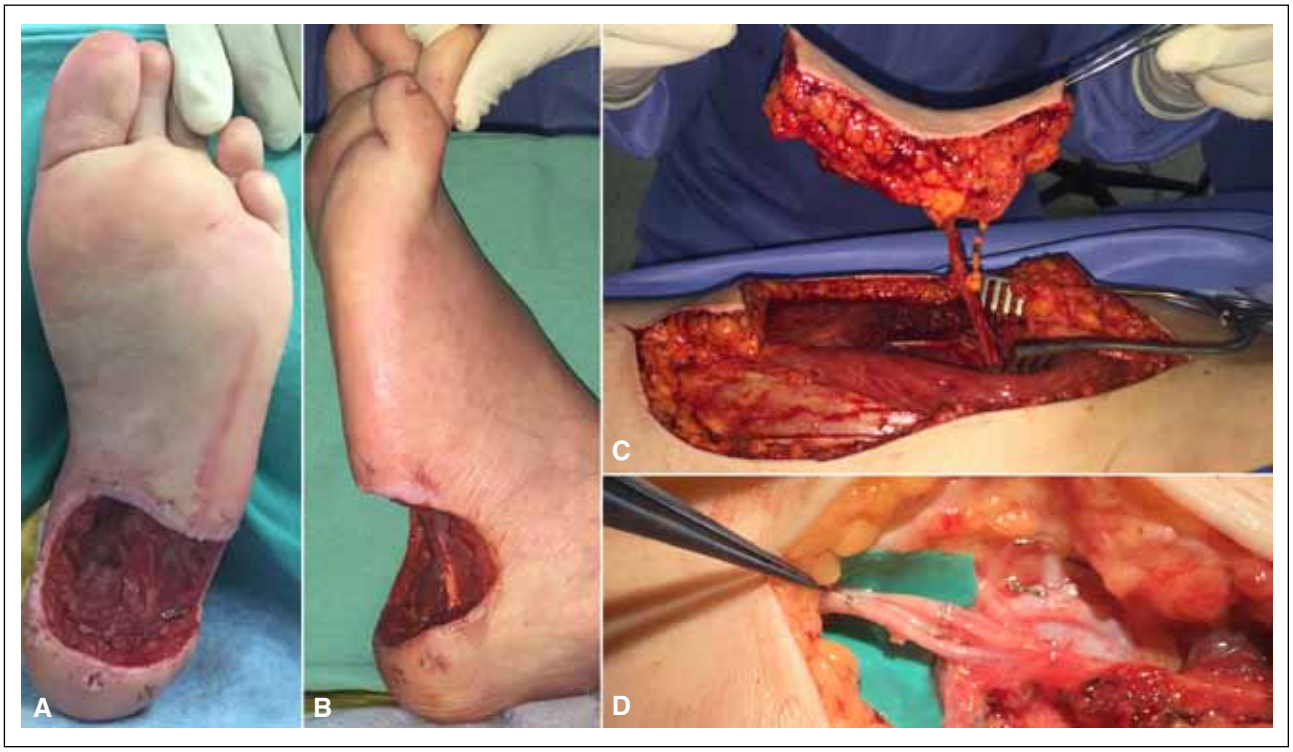


Figure 6. Case 5. A and B. Defect after oncologic resection of soft tissues sarcoma. **C**. Fat-cutaneous thigh anterolateral flap with muscular perforating artery. **D**. Microsurgical termino-lateral arterial suture and termino-terminal venous suture.

Figure 7. Case 5. A and B. Immediate postoperative results. **C and D**. After a 6-month follow-up.

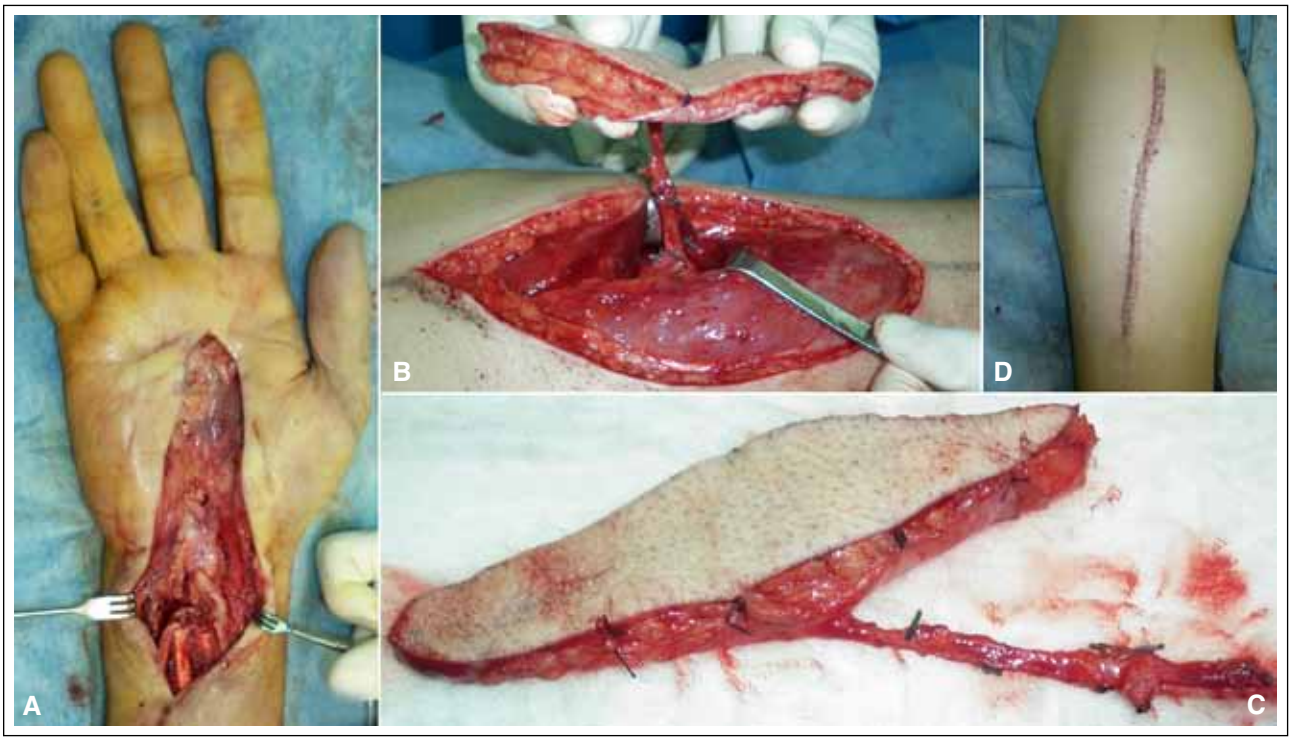


Figure 8. Case 4.A. Defect of coverage after debridement in chronic infection in right hand zones III and IV. **B**. Fasciocutaneous thigh anterolateral flap with septal cutaneous artery. **C**. Flap with 10 cm-length pedicle. **D**. Primary closure of donor site.

Figure 9. Results after a 2-year follow-up in reconstruction of flexor tendons and median nerve.

Discussion

The aim of this study was to evaluate the versatility of the ALT free flap in a group of patients with coverage defects in upper and lower limbs which had heterogeneous origin, size, depth and location.

In head and neck reconstruction, the use of ALT free flap is widely spread, and there are multiple series showing their versatility and efficiency in such location. In a Park and Miles bibliographic revision,[3] they report the extensive use of these types of flats in complex reconstruction of head and neck, with good functional and esthetic results. Gedebou et al.[6] published their experience with 1284 ALT free flaps manufactured over a period of 10 years for localized defects, mostly in head and neck, whereas Demirkan et al.[2] had high rates of therapeutic success and reported its versatility in a wide series of 60 ALT free flaps in 59 patients with reconstructive maxillofacial surgery. On the other hand, Horns et al.[7] compared 85 reconstructions in large head and neck coverage defects carried out either with ALT free flap or with latissimus dorsi muscle and got higher survival rates and less morbidity at the donor site with the use of ALT free flap. These types of flaps are also extremely useful in head and neck defects of oncologic origin. Mureau et al.[8] published the use of ALT free flap in 23 patients with extensive facial defects of oncologic origin, with satisfactory functional and esthetic results, whereas Shieh et al.[9] got good results in 37 patients with defects consecutive to oncologic resection.

On the other hand, the ALT free flap is also most useful for reconstruction in limb coverage defects of varied origins such as trauma, oncologic resection and burns. Bibbo et al.[10] compared flaps in reconstruction in lower limb coverage defects due to trauma—49 cases of ALT free flap vs. 51 patients who had got otherwise. They got equal or better results with ALT free flaps, which they highlight for their versatility, since these flaps can include multiple tissues in the same piece. There are also reports on series with fewer cases of use of ALT free flap for reconstruction in upper limb coverage defects, such as Wang et al.'s[11] who reported 15 patients with good results, and Javaid and Cormack's [12] who published seven cases of reconstruction in hand defects due to trauma.

On the other hand, Engel et al.[13] reported a series of 70 patients who had undergone 54 lower limb reconstructions and 11 upper limb reconstructions, with good results and survival rates of 96%. Kuo et al.[14] reported 140 reconstructions with ALT free flap, 45 in lower limbs and 13 in upper limbs, with survival rates of 92% and minimal morbidity at the donor site. Wei et al.[15] highlight the versatility of the flap in a series of 672 cases: 58 in upper limbs and 121 in lower limbs. It is worth mentioning that survival rates in our study were 92%, similar to those reported in specialized bibliography.

The use of the ALT free flap has been on the increase, especially due to its versatility. These features have to do with their inclusion of different types of tissues in different combinations, and with the possibility of taking a large, up to 25 x 35 cm-skin square, and a long, up to 12 cm-long pedicle with adequate diameter (average artery diameter: 2.1 mm and average vein diameter: 2.3).[16] This allows the surgeon to carry out reconstruction with a tailor-made design for every patient's needs. As a matter of fact, this flap is so rich in available tissues that it offers not only adequate soft tissues coverage but also the tools for tendon and vessel reconstruction, and also for muscle transfer. The technique of the chimerical ALT free flap was described by Hallock[17] for the first time, and consists of independent designs for the different flaps with different anatomic components in each flap, but all of them supplied by a same pedicle, what is usually most useful in selected cases for complex reconstruction. The use of chimerical flaps for the coverage of large posttraumatic defects in limbs is associated with good results. For example, Zheng et al.[18] reported 22 chimerical ALT free flaps including skin, muscle and fascia for the coverage of soft tissues defects in lower limbs (10 cases) and upper limbs (12 patients), and Kim et al.[19] reported 12 cases of chimerical flaps made up of vastus lateralis muscle in lower limbs. In this study, we report one case of use of a chimerical flap made up of tensor fasciae latae muscle for reconstructing the toes extensor apparatus.

Another valid strategy for flap adaptation to the host site is the possibility to carry out flap thinning. Alkureishi et al.[20] in a corpse study report that the thinning of the ALT free flap may reduce blood supply because of the injury of the arterial plexus within the deep fascia, which by means of its links with the subdermal plexus, nourishes the flap skin; however, in a recent study, Diamons et al.[21] did not find any significant differences in the complications associated with neither the flap not the donor site between a patients cohort with usual flap-thickness and another patients cohort with thin flapping. Aldani et al.[22] reported nine cases of thinned ALT flaps for coverage defects in the back and palm of the hand, of varied origins such as trauma, burn, and severe contracture. In our study, we used thinned flaps in three cases for the reconstruction of ankle coverage defects, with good esthetic results. Although there are reports on anatomic variations in the vascular pedicles of the descending circumflex femoral artery in which this flap is based on, [23,24] and careful dissection should be conducted so as to avoid complication, this flap has reliable local anatomy as an advantage.

On the other hand, morbidity is minimal at the donor site, but for leaving a thigh inferolateral zone with numbness when the superficial femoral cutaneous nerve is included, what improves with time. With respect to morbidity, Kimata et al.[25] reported it to be minimal in the cases of primary closure and they report that morbidity might

only increase when skin graft is required for large defects at the donor site, or when the vastus lateralis muscle is included in the flap. Moreover, Agostini et al.[26] carried out a systematic revision of the bibliography aimed at the complications occurring specifically at the donor site in these flaps and concluded that complications rates are low, but identified certain factors that may increase morbidity at the donor site, such as >12 cm-skin squares, the dissection of the pedicle in proximal direction in the direction of the descending circumflex femoral artery, the extensive inclusion of fascia, the sacrifice of the main motor branch of the vastus lateralis muscle, and the lack of adequate hemostasis. In our study, the closure of the donor site was primary in 10 cases and only two cases required skin graft. We got large skin squares in three patients with extensive defects, with no complications at the donor site in any case.

Conclusions

The ALT free flap is one of the most useful reconstructive options for defect coverage in different locations. Its use is on the increase and, nowadays, it is the flap of first choice in many Centers.

Our results confirm that this flap is a valid, most useful strategy for defect coverage of different origin in both upper and lower limbs, because its versatility allows it to get successfully adapted to defects of varied locations and sizes.

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