

ORIGINAL RESEARCH

Versatility of the Free ALT Flap for Upper and Lower Limbs Coverage Defects Reconstruction. A Consecutive Case Series

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Introduction: The anterolateral thigh free flap was expanded to establish itself as one of the most useful options for the reconstruction of defects in different locations. We present our experience with free ALT flap for functional coverage of different upper and lower limb defects.

Methods: Retrospective study of cases of reconstruction in a period of 6 years. In the preoperative period, demographic variables, causes of the defect, size and location of the defect and time between the defect and surgery were analyzed. From the surgical technique, the type of anastomosis performed and the type of closure of the donor site were analyzed. Finally, during the postoperative period, the survival of the flaps and the complications of the flap and the donor site were evaluated.

Results: We included 7 men and 5 women with an average age of 44 years. The defects were caused by oncological resection in 9 patients and by trauma in 3. The defect was in the upper limb in 4 cases and 8 in the lower limb. The size of the flap varied from 6 to 20 cm in length and from 3 to 12 cm in width. The survival rate of the flap was 92%, presenting failure only in one case. The donor site presented no complications.

Conclusion: The anterolateral thigh free flap is a useful resource for the coverage of defects of different etiologies both in the upper limbs and in the lower limbs since its versatility allows it to adapt successfully in varied defects.

Keywords: ALT flap; reconstructive surgery; versatility; free flap; microsurgery

Introduction

The anterolateral thigh (ALT) flap has become the work-horse flap for soft-tissue reconstructions, mainly in head and neck surgery, due to its great versatility for soft tissue reconstructions [7, 8, 10].

Since Song et al. [19] introduced this flap in 1984, it has gained popularity because of several advantages. The flap can be harvested simultaneously as two-team work. The operation time could be shortened. The pedicle length is long enough to anastomosis with recipient vessels and could be lengthened by proximally eccentric placement of the perforator, so avoiding vein graft. The large caliber of pedicle vessels makes microsurgical anastomosis easier.

ALT flap could serve as fasciocutaneous, adipofascial, or myocutaneous flap as needed, having great volume variability. Pliability could be achieved by primary thinning. Bulkiness could be added by incorporation of the deepithelialized skin or a portion of muscle cuff (vastus lateralis), furthermore the fascia lata can be included for sling or tendon reconstruction.

A sensate flap can be harvested by including the lateral femoral cutaneous nerve; furthermore, the flap pedicle could bridge the vascular gap as flow-through flap, especially in mangled extremities.

Last but not least, the donor site morbidity is minimal.

We present our experience with free ALT flap for functional coverage of different upper and lower limb defects.

Methods

For the purpose of this retrospective study, we reviewed medical records of patients who had had upper and lower extremities soft-tissue defects reconstruction with a free ALT flap over a 6-year period at a large tertiary academic hospital. We followed the PROCESS guideline to report this case series [2]. Every patient gave their informed consent to be treated, understanding the risk and the objectives of the treatment.

Demographic variables (gender, age and comorbidities), cause, size and site of the defect, and the time between the defect and the reconstructive surgery were recorded as preoperative variables. The intraoperative variables analyzed were flap type, arterial and venous anastomosis performed, recipient vessels used, type of donor site closure and, intraoperative complications.

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Furthermore, we assessed the flap survival rate and the postoperative complications of the flap and the donor site.

Surgical Technique

All operations were performed by the senior author (JB), an orthopaedic surgeon specialized in hand and upper extremity surgery and microsurgery with more than 10 years' experience.

Preoperative evaluation included laboratory studies to test blood cells count and coagulation test. Pulses were evaluated in the extremities to be reconstructed. Doppler ultrasound, angiography or CT-angiogram were performed in case of any suspicion of vascular anomaly or lack of arterial patency.

General anesthesia and perineural catheter in the recipient extremity was used in all patients. Perineural catheter with infusion pump was used during the first three to five days. At the beginning of this series, peridural catheter was used in patients with lower extremity reconstruction. However, due to the risk of epidural haematoma the analgesia protocol was changed to perineural catheter.

The flap was raised as described in literature [7, 11]. If sole reconstruction or thin flap were needed, suprafascial harvesting were performed. Final thinning of the flap according to the recipient site requirements was done before clamping the flap' vessels.

Insetting of the flap was performed according to the preoperative planning, allowing a three-dimensional reconstruction of the defect and taking care of the final aesthetic results. Heparin (70 U/kg) was intravenously administered before releasing the vascular clamps. Tourniquet was

released and adequate revascularization of the flap was assessed. Finally, the adequate vascularization of the flap was evaluated with hand-held Doppler ultrasound.

Primary closure of the donor site was attempted in every case and, if not possible, full-thickness skin graft was performed.

Postoperative

After the surgery, the patients were transferred to an individual hospital room, with room temperature control. Perfusion of the graft was assessed by hand-held Doppler ultrasound performed every 2 or 3 hours depending on the clinical assessment. Since the first postoperative day, low molecular-weight heparin (Enoxaparine) and aspirin (100 mg/day) was administered for thromboembolism prophylaxis. The heparin was maintained for 3 weeks and the aspirin for 6 weeks. Daily laboratory tests were carried out in order to maintain the hematocrit above 30%. If the values were lower than this parameter, transfusions were indicated.

Results

During the 6 years period, from January 2011 to May 2017, twelve patients were included with ALT free flap in both, upper and lower extremities coverage defects. There were seven men and five women with an average age of 44 years (range 13 to 78 years). In 9 cases the cause of the defect was a tumor resection and, in the rest the defect was due to trauma. In 4 cases the defect was in the upper extremity and in 8 cases in the lower extremity. The mean time between the defect and the reconstructive surgery was 8 days (range 0 to 16 days) (**Table 1**). Six out of the eight

Table 1: Demographics data.

Case	Gender	Age	Smoking	Comorbidities	Cause of the defect	Defect zone	Size of the defect (length × wide in cm)	Time between defect and reconstruction (days)
1	F	19	No	No	Synovial sarcoma	Dorsal right wrist	11 × 3,5	13
2	M	45	No	Dyslipidemia	Synovial sarcoma	Dorsal right wrist	11 × 6	9
3	M	78	No	Cataract. Corneal transplant	Trauma (degloing)	Dorsal right wrist and forearm	18 × 7	15
4	M	58	No	HBP, HF, AF	Post infection defect	Volar right wrist	12 × 3	7
5	F	44	No	SLE	Clear cells sarcoma	Left heel	6 × 8	16
6	M	42	Si	No	Squamous cell carcinoma	Lateral right ankle	18 × 12	7
7	M	53	Si	HBP, obesity	Epithelioid sarcoma	Left forefoot	6 × 6	0
8	M	21	Si	No	Open fracture of the distal femur. Chronic osteomyelitis.	Anterior aspect of the left knee	20 × 11	9
9	F	64	No	Eosinophilic fasciitis	Squamous cell carcinoma	Dorsal left foot and ankle	15 × 10	4
10	F	13	No	No	Angiomatoid fibrohistiocytoma	Lateral left ankle	11 × 6	7
11	F	45	No	HTLV-1	Malignant fibrohistiocytoma	Lateral right ankle	19 × 8	14
12	M	44	Si	Hypothyroidism	Dermatofibrosarcoma	Medial left ankle	14 × 12	0

cases with lower extremity reconstruction had a preoperative vascular imaging evaluation (1 doppler ultrasonography, 1 angiogram and 4 CT-angiogram). One of the 4 cases with upper extremity reconstruction had a CT-angiogram.

The range of the skin paddle size was 6 to 20 cm for the length (mean 13 cm) and 3 to 12 cm for the width (mean 8 cm). Eight out of 12 flaps were fasciocutaneous and 4 were adipocutaneous (Figures 1 and 2). Two were thinned and used also as flow-through flaps (Figures 3 to 5). Finally, we used one conjoint flap with fascia lata to reconstruct the extensor tendons of the toes and hallux. The arterial anastomosis were end-to-end in 5 cases and end-to-side in 7 patients. The vein anastomosis were end-to-end in 10 cases and end-to-side in 2 patients. The radial pedicle was the recipient vessel in all the patients with defects in upper extremity, and the posterior tibial pedicle was the most commonly used recipient vessel (5 cases) in the patients with defects in lower extremities (Figures 6 and 7). All but two patients had primary closure of the donor site. The average flap size was 11,8 × 8,5 cm when the donor site closed primarily and the average flap size was 19 × 11,5 cm when a skin graft was used. None of the patients had any intraoperative complications. However,

in one patient thrombosis was observed intraoperatively in satellite veins of the anterior tibial pedicle, which was confirmed by venotomy, and the peroneal pedicle have to be used. In another patient the muscular perforators were not identified on the vastus lateralis but on the rectus



Figure 3: A) and B) Post oncological resection defect of the lateral aspect of the ankle.



Figure 1: A) and B) Tridimensional heel defect from tumor resection in a 42 years-old woman.

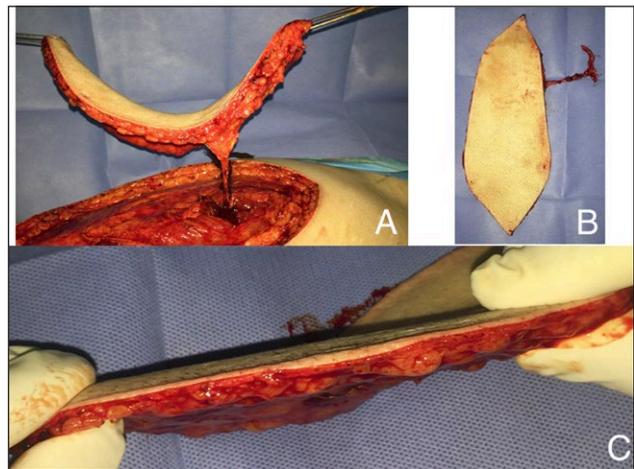


Figure 4: A) Suprafascial harvest of the ALT. B) ALT flap harvested as a flow-through flap. C) Thinning of the ALT flap.



Figure 2: A) and B) Good contour and aesthetic results at thirteen months follow-up. C) Result of the donor site closure with skin graft.

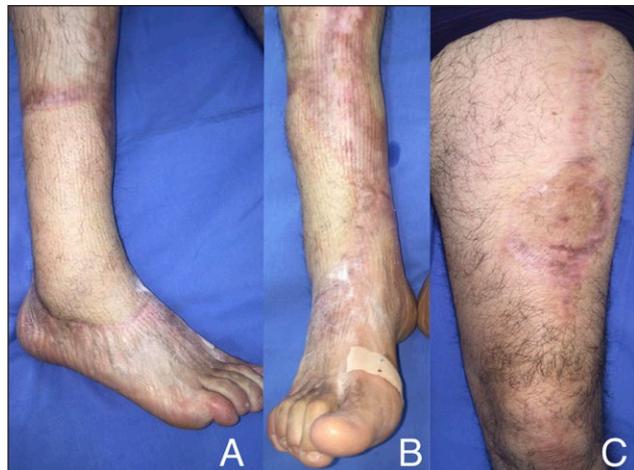


Figure 5: A) and B) Six months postoperative result with good contour allowing to used normal shoes. C) Donor site aesthetic result with primary closure.

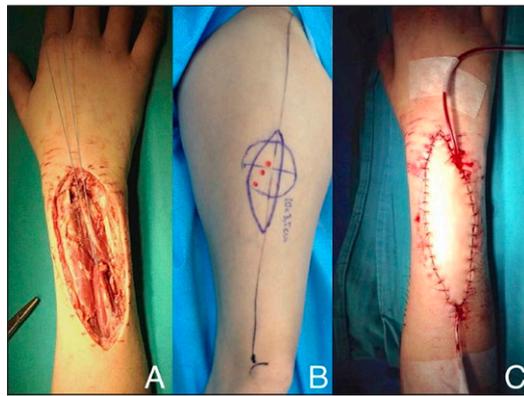


Figure 6: **A)** Defect of extensor tendons and coverage of the dorsal wrist after oncological resection. **B)** Flap designing. The location of the main cutaneous perforators was detected with a hand-held Doppler ultrasound. **C)** Flap inseting.

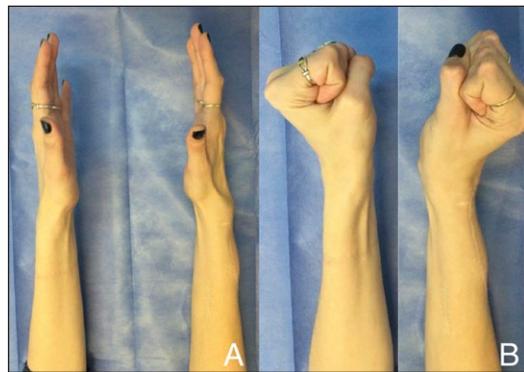


Figure 7: **A)** and **B)** Functional and aesthetic results at 12 months follow-up.

femoris (**Table 2**). Intraoperative and/or postoperative transfusion requirement was needed in 7 patients. The average transfusion requirement was 1,8 during the hospitalization (range 1 to 3).

Eleven out of the twelve flaps survive. Complete flap loss occurred in one pediatric patient and partial flap loss in one case. A patient who had complete flap loss, caused by venous thrombosis, required a second flap (Latissimus Dorsi). The patient who suffered a partial necrosis required revision of the pedicle at 24 hours postoperatively due to lack of Doppler signal, but intraoperatively not vascular thrombosis was found. There were not any other postoperative complications. Two patients suffered amputation of the lower extremity with the flap due to other causes than flap complication. In one case due to refractory osteomyelitis to medical and surgical treatment, and in the other case due to oncological recurrence. In both cases, the amputation occurred after one year of follow-up. No complications were recorded at the donor site.

Discussion

The benefits of the anterolateral thigh flap have been widely reported in head and neck reconstruction; which allow the surgeon to provide a custom-designed reconstruction to suit the particular needs of the patient [21, 5].

Although originally described as a free cutaneous flap based on a septocutaneous vessel, in fact, only 12 to 18 percent of anterolateral thigh flaps are septocutaneous, and most vessels are musculocutaneous perforators traversing the vastus lateralis muscle [7]. The variability of perforators and the difficult dissection of the musculocutaneous perforator may be the major challenge for a surgeon, especially at the beginning of the learning curve,

Table 2: Intraoperative data.

Case	Flap	Variant	Number and type of perforants	Recipient vascular pedicle	Suture	Arterial anastomosis	Venous anastomosis	Donor site closure
1	Fasciocutaneous	–	1 Septal	Radial	Nylon 10-0	end-to-side	end-to-end	Primary
2	Fasciocutaneous	–	2 Muscular	Radial	Nylon 10-0	end-to-end	end-to-end	Primary
3	Fasciocutaneous	–	2 Muscular	Radial	Nylon 9-0	end-to-side	end-to-end	Primary
4	Fasciocutaneous	–	1 Septal	Radial	Nylon 10-0	end-to-side	end-to-end	Primary
5	Adipocutaneous	–	1 Muscular	Posterior Tibial	Nylon 9-0	end-to-side	end-to-end	Primary
6	Adipocutaneous	Thinned/flow-through	2 Muscular	Anterior Tibial	Nylon 9-0	end-to-end	end-to-end	Skin graft
7	Adipocutaneous		1 Muscular	Medial plantar artery	Nylon 9-0	end-to-side	end-to-side	Primary
8	Fasciocutaneous		1 Muscular	Femoral	Nylon 9-0	end-to-end	end-to-side	Skin graft
9	Fasciocutaneous	–	1 Muscular	Posterior Tibial	Nylon 9-0	end-to-side	end-to-end	Primary
10	Adipocutaneous	Thinned/flow-through	1 Muscular	Posterior Tibial	Nylon 9-0	end-to-end	end-to-end	Primary
11	Fasciocutaneous	Thinned/Conjoined flap (fascia lata)	2 Muscular	Peroneous	Nylon 9-0	end-to-end	end-to-end	Primary
12	Fasciocutaneous	–	2 Septal	Posterior Tibial	Nylon 9-0	end-to-side	end-to-end	Primary

causing a prolonged operation time. However, once the technique of intramuscular dissection of perforators vessels became popularized, a high reliability and rate of survival have been reported in most case series.

The versatility of the ALT flap has been defined by the possibility of harvesting multiple tissue components in various combinations and also in different thickness. Moreover, the reliable size and the length of the pedicle allow performing the microsurgical anastomosis out of the injured site or even in a flow-through-fashion flap for vascular reconstruction. We have performed two flaps as flow-through in this series, both in lower extremity.

With regard to multiple tissue components, the flap can be harvested as a myocutaneous flap (vastus lateralis muscle) based on the descending branch of the lateral circumflex femoral artery. This muscle could be used as a functional muscle transfer or it can also be used to obliterate a third space. It should be noted that as a functional muscle transfer it can also be used the rectus femoris muscle based on an independent pedicle from the lateral circumflex femoral system. In extremities reconstruction, the fascia lata could be harvested with the ALT flap as a conjoined flap to reconstruct a tendinous defect [12]. In this case series we used the conjoined flap to reconstruct the extensor digitorum longus and extensor hallucis longus tendons in one patient.

Adipocutaneous flaps can be useful when no gliding surface is needed in the recipient site. Although suprafascial harvesting of the ALT flap has been used to avoid bulkiness of the flap and diminishing the morbidity of the donor site, we found that adipocutaneous flap is useful in weight-bearing reconstruction surface not only to improve the contour but also to provide a more stable surface. Although Pappalardo et al. [14] have shown good results with fasciocutaneous ALT, we agree with Hong and Kim [9] that adipocutaneous flaps improve stability avoiding slippage.

Bulkiness or thinning of the flap can be customized to improve contour of the reconstruction. Suprafascial harvesting of the flap has several advantages not only in aesthetic results of the recipient site but also minimizing the morbidity of the donor site [13]. While thinning the ALT has been linked to increased rates of partial thickness and/or complete flap loss, recent papers by Seth and Iorio and Diamond et al. [17, 6] have shown that the use of suprafascial flap dissection and thinning yield acceptable morbidity. We performed immediate flap thinning in cases of ankle reconstruction to improve contour. Although the only flap we lost it had been thinned, the cause was a venous thrombosis cause by a compressive haematoma, and not the interruption of the flap's microcirculation as has been mentioned [4, 18].

Morbidity of the ALT flap donor site has been analyzed by several authors [15, 20]. While the vast majority of patients have limited donor site morbidity, there have been occasional isolated reports of significant complications. Compartment syndrome has been reported after primarily closure of the donor site [1] or after imbrication of the deep fascia [16]. The most common complications are muscle related. Although muscle herniation has been identified in several cases, it was not possible to establish a correlation with direct fascial closure or not [3]. Weakness

of the lower extremity has also been reported; however, the strength is restored within the postoperative 6 months.

This study has several limitations. The first one is related to the retrospective nature of this study. The second one is about the different soft tissue defects at different localizations. However, different sizes and localizations let us to evaluate the versatility and customization of the ALT free flap in the extremities as it was the purpose of the study.

Conclusion

The free ALT flap is a versatile reconstructive option that allow to treat defects at different locations in the extremities. Customization of the ALT flap achieve reconstruction in three-dimension defects yielding good contour and aesthetic results. However, further studies need to be done to compare the versatility of both the ALT flap with the subscapular artery system.

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Competing Interests

The authors have no competing interests to declare.

Author Contributions

Boretto Surgeon/Manuscript, Bennice Manuscript, Thione Manuscript, Gallucci Manuscript, De Carli Manuscript.

Guarantor

Jorge G Boretto is the guarantor.

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