

Role of Anterolateral Thigh Flaps in Distal Lower Extremity Reconstruction: Assessment of Functionality, Aesthetics, and Patient Satisfaction

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Abstract

Background Distal lower extremity reconstruction presents many challenges due to the suboptimal vascular supply, the weight-bearing necessity, movement, and multiple tissue types that can be easily damaged by trauma, from bones, tendons, ligaments, muscle, and soft tissue loss. The anterolateral thigh flap provides a reconstructive option for large defects with good coverage and minimal donor-site morbidity.

Methods After a chart review of all anterolateral thigh flaps, the patients were contacted to take a survey regarding their satisfaction and functional ability and to meet for measurements of their feet after debulking procedures.

Results A total of 13 patients were included in the study, with traumatic injuries comprising 84% of cases. There was a significant difference in sizes of the midfoot (mean: 10.27 vs. 9.53, $p = 0.004$) and the hindfoot (mean: 12.92 vs. 12.2, $p = 0.023$) when comparing the affected side to the unaffected side. The majority, 77%, of our patients underwent debulking procedures. Overall, 75% of traumatic injury patients had > 90% maximum functionality score. All posttraumatic reconstruction results were rated satisfied to very satisfied by the patients. All posttraumatic patients were able to walk after their procedures, although three patients did require custom-made shoes with inserts or braces.

Conclusion The anterolateral thigh flap is a versatile reconstructive option that can be used in the distal lower extremity and is especially useful after a traumatic injury as it allows for functional recovery and high patient satisfaction after debulking.

Keywords

- ▶ anterolateral thigh flap
- ▶ soft tissue reconstruction
- ▶ lower extremity

Free flap reconstruction of soft tissue defects in the distal lower extremity presents inherent challenges given the suboptimal vascularity of the distal limb, and continuous weight-bearing forces, movement, and friction. Successful

repair in this anatomic region is even more difficult in the posttraumatic patient, as free tissue transfers must contend with additional constraints of possible concomitant bone and ligamentous injury, vascular compromise, and

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extensive soft tissue injuries that extend beyond the immediate wound. Although muscle and musculocutaneous flaps are taken from latissimus dorsi or rectus abdominus donor sites have traditionally been utilized for coverage of such defects, in recent times there has been increasing evidence to support the use of the free fasciocutaneous anterolateral thigh (ALT) flap in posttraumatic reconstruction of the distal lower limb.¹⁻⁴ Many features of the ALT flap make it ideal for soft tissue repair in the distal lower limb, including its large skin territory, long, and robust vascular pedicle, the potential for sensory preservation, and minimal donor-site morbidity.¹ First described by Song et al as a novel free flap concept for head and neck reconstruction, the ALT flap has since established itself as an excellent choice for primary coverage of traumatic soft tissue defects in the lower extremity.⁵⁻⁷ Song et al first described a possible area of 800 cm², with a pedicle that ranged from 10 to 12 cm, although pedicles have been reported up to 16 cm, and a thickness that varied along its length from 1 to 3 cm.⁵⁻⁸ The ALT is a versatile flap which can cover a variety of anatomic sites including the scalp, head and neck, trunk, and lower extremity with a low rate of dehiscence (3.8%), hematoma/seroma (1-2%), and skin grafting for the donor site (14.5%), it is an aesthetic choice with a scar easily hidden by wearing pants or shorts.^{5,9}

In this study, we reviewed our use of the free ALT flap for posttraumatic reconstruction of complex soft tissue defects in the lower extremity. Specifically, we evaluated flap outcomes and patient satisfaction from a functional and aesthetic standpoint. There has been a paucity of research focusing on patient-centered outcomes as shown in a review by Economides et al¹⁰ and we aimed to remedy this in our patient population.

Methods

This was a retrospective chart review of all ALT flaps done from 2010 to 2014 after the chart review was completed, we then contacted the patients. A total of 14 patients were found to have undergone an ALT flap to the lower extremity. Patient charts were reviewed for background information regarding the nature of the initial injury, specifics regarding location and size of the defect, initial, and secondary procedures performed, the requirement for skin grafting and postoperative complications. When the patients were contacted, they were asked if they would participate in a survey about their functional and aesthetic outcomes and if they would be willing to have a member of the research team meet them and take measurements of their lower extremities to compare the affected side to the unaffected side. The survey included the ability to wear shoes, subjective comparison to opposite side, pain, wounds, the ability to ambulation, activity level, and patient satisfaction level. Five of the six patients who were measured consented to do the Lower Extremity Function Scale (LEFS) to measure their functional limitations.¹¹ Statistical analysis was performed with SPSS v22 (IBM Corp.) and included descriptive analysis and *t*-test, with significance set at $p < 0.05$.

Table 1 Demographics

	N (%)
Age (y)	42.07 (range: 9-78)
Gender	
Male	12 (92.3)
Female	1 (7.7)
Cause of injury	
Trauma	11 (84.6)
Necrotizing fasciitis	1 (7.7)
Nonhealing ulcer	1 (7.7)

Results

A total of 13 patients were included in this study with demographics shown in ►Table 1. Out of these 13, 11 underwent flap reconstruction secondary to traumatic injury, while the remaining 2 underwent reconstruction for necrotizing fasciitis and a nonhealing diabetic ulcer, individual characteristics seen in ►Table 2 (►Figs. 1-4). The causes of the traumatic injuries varied, including motor vehicle collisions, motorcycle accidents, and injuries related to lawn mowers and workplace hazards. The nature of these injuries included crush, avulsion, degloving, dislocation of joints, fractures, lacerations, amputations, compartment syndrome, and ligamentous injury. The defects that were covered ranged in size from 50 to 350 cm² with a mean of 128.8 cm². Overall, 46% of patients required additional coverage with a split-thickness skin graft, and 7.7% required a full-thickness skin graft due to the extensive and multifocal nature of their traumatic injuries. Six patients consented to participate in a postoperative survey, with five patients completing the LEFS. We found that three patients reported >90% of maximal functionality while the other two reported a 45 to 50% functional score. Patients reporting lower functional outcomes included the only nontraumatic injury patient who presented with a chronic nonhealing foot ulcer and a patient who suffered severe traumatic crush injury with degloving and a partial amputation of the foot. It should be noted that the patient who suffered the severe crush injury was very satisfied with the results, had minimal pain, and was able to ambulate comfortably with a brace. The patient with the chronic ulcer was the only patient who was unsatisfied with his result due to the increased size of his affected foot with the added bulk kept to prevent recurrence of the chronic ulcer over a bony prominence. He can walk only with a walker and also uses a wheelchair, but has no pain, and has had no ulcers. Ten of the patients included in this series had at least one debulking procedure including five of the six patients that were able to be contacted, and these five patients were satisfied or very satisfied.

None of the patients surveyed had ulcers or chronic pain. Only one patient was unable to wear shoes due to the size of the flap, while the remaining patients were able to wear

Table 2 Individual defect characteristics. Time to surgery in days from date of initial injury, if any

Patient	Type of injury	Size of defect (cm)	Area of defect (cm ²)	STSG?	Time to surgery (d)	Postoperative complications	Debulking procedures
1	Dorsal foot avulsion injury (→ Figs. 1–4)	8 × 12	96	No	15	None	1
2	Medial foot and ankle degloving injury	22 × 10	220	Yes (60 cm ²)	11	Full-thickness distal flap necrosis	2
3	Dorsal foot crush injury	12 × 15	180	FTSG (9 cm ²)	407	Acute blood loss requiring transfusion	1
4	Dorsal foot crush injury (MVA)	10 × 6	60	No	46	None	1
5	Medial foot complex injury (MVA)	13 × 7	91	Yes (52 cm ²)	11	None	1
6	Calcaneal foot chronic nonhealing ulcer	12 × 10	120	No	N/A	None	0
7	Dorsal foot degloving injury	10 × 5	50	No	8	Right thigh hematoma	1
8	Dorsal foot degloving injury	8 × 9	72	No	9	None	1
9	Medial foot and ankle avulsion injury	14 × 7	98	Yes (98 cm ²)	11	None	1
10	Degloving injury	11 × 7	77	No	5	None	1
11	Necrotizing fasciitis	14 × 25	350	Yes (120 cm ²)	11	Flap congestion; MRSA	0
12	Traumatic amputation	20 × 9	180	Yes (189 cm ²)	15	Nonunion of 2nd metatarsal head, digital nerve neuroma	2
13	Dorsal foot degloving injury	8 × 10	80	Yes (50 cm ²)	0	Venous thrombus; hematoma, partially failed free ALT flap	0

Abbreviations: ALT, anterolateral thigh; MRSA, methicillin-resistant *Staphylococcus aureus*; MVA, motor vehicle accident; N/A, not applicable; STSG, split-thickness skin graft.



Fig. 1 Patient 1 intraoperative exposure after left dorsal foot crush and avulsion injury from golf cart accident.



Fig. 2 Patient 1 immediate postoperative image after ALT flap. ALT, anterolateral thigh.



Fig. 3 Patient 1, 2 months after debulking procedure.

shoes comfortably, with three patients requiring custom-made shoes with inserts (►Table 3).

Six patients were able to be contacted and consented to have measurements of bilateral lower extremities taken (►Table 4). With the hypothesis that the surgical limb with flap inset would be significantly larger than the nonsurgical limb, it was found that there was a statistically significant difference in both the midfoot (mean: 10.27 vs. 9.53, $p = 0.004$) and the hindfoot (mean: 12.92 vs. 12.2,



Fig. 4 Patient 1, 1.5 years after debulking. The patient is able to ambulate and wear regular shoes without limitation or activity.

$p = 0.023$). There was no statistical difference between the forefoot (mean: 9.04 vs. 8.98, $p = 0.45$) and the ankle (mean: 10.75 vs. 10.42, $p = 0.25$). Similar results were obtained when we evaluated only patients who underwent reconstruction secondary to traumatic injury, with a statistically significant difference in both midfoot ($p = 0.009$) and hindfoot ($p = 0.03$) measurements.

Discussion

Reconstruction of soft tissue defects in the distal lower extremity remains challenging, particularly in the posttraumatic setting. In the literature, the fasciocutaneous ALT flap has established itself as a versatile alternative to the traditional musculocutaneous flap for the repair of such defects, with the additional benefit of functional muscle unit preservation at the donor site. The ALT flap offers an expansive territory of coverage secondary to robust perfusion from perforator arteries that arise from the descending branch of the lateral femoral circumflex artery. Koshima et al reported a potential surface area of 25×18 cm in the nonthinned flap, while others have more recently described success with flaps of up to $35 \text{ cm} \times 15 \text{ cm}$.^{1,3,7} The long vascular pedicle of the ALT flap ensures flap viability in the traumatic foot by allowing for microvascular anastomosis to a healthy recipient vessel located sufficiently far away from the site of injury. In a patient who has suffered an injury to his foot, the intrinsic thickness of the subcutaneous fat layer in the ALT flap is helpful and sometimes requisite for primary reconstruction and stabilization. In the postoperative phase, however, excess thickness of the ALT flap is a common source of dissatisfaction among patients, as it may interfere with normal functionality, ability to wear shoes and achievement of satisfactory cosmesis. One solution to minimize such potential complications is to perform primary thinning of the ALT flap during initial reconstruction. Kimura et al and others have reported success with 3 to 4 mm flaps that can span up to 13 cm in radius from the point at which the perforating vessel enters the skin.^{1,12,13} In Western countries ALT flaps are on average considerably thicker; excessive thinning has been associated with increased flap

Table 3 Patient functionality survey and satisfaction

Patient	Time since initial surgery (d)	Ability to wear shoes	Ability to ambulate	Activity level	Pain	LEFS score (max = 80)	% of maximal function	Overall satisfaction
1	732	Wears regular shoes	Unimpaired	Unaffected	Occasional sharp pain	79	98.75	Very satisfied
2	1,124	Brace + custom-made shoe	Impaired, requires walker or wheelchair	Decreased	None	41	51.25	Very satisfied
3	1,561	Custom-made shoes with insert	Unimpaired	Unaffected	None	80	100	Very satisfied
4	1,337	Wears custom-made shoes	Mildly impaired, uses walking cane	Decreased	None			Satisfied
6	359	Unable to wear shoes	Impaired, requires walker or wheelchair	Decreased	None	36	45	Unsatisfied
7	799	Wears regular shoes	Unimpaired	Unaffected	Occasional tenderness	76	95	Very satisfied

Abbreviations: LEFS, Lower Extremity Function Scale; max, maximum.
 Note: Patient number correlates to same patient number in ▶ **Table 2**.

Table 4 Foot measurements and correlations

Patient	Qualitative assessment	Forefoot (in)		Midfoot (in)		Hindfoot (in)		Ankle (in)	
		Affected	Unaffected	Affected	Unaffected	Affected	Unaffected	Affected	Unaffected
1	Mostly symmetrical	8.5	8.7	10	9.25	12.5	11.25	10.5	9.1
2	Mostly symmetrical	8.25	8.1	10.1	9.1	12.5	12.1	11.75	10.25
3	Significantly smaller	N/A	8.6	11	9.6	15	13.25	11.8	10.9
4	Mostly symmetrical	9.25	9.25	10	9.75	10.5	9.875	12.5	13
5	Mostly symmetrical	9	9.5	10.5	10	13	13	9	9
6	Significantly larger	10.2	9.75	10	9.5	14	13.75	11.25	10.25
t-Test (p value)			0.453		0.004		0.023		0.25
Trauma t-test (p value)			0.199		0.009		0.03		0.25

Abbreviation: N/A, not applicable.
 Note: Patient number correlates to same patient number in ▶ **Table 2**.

morbidity.¹⁴ Consequently, in the setting of traumatic injury, surgical debulking is done at a later time. In our study, 77% of patients underwent at least one debulking procedure. While there remained a statistically significant difference in foot size among these patients, all posttraumatic patients who underwent secondary debulking procedures were satisfied with the results. In the cases presented, the only patient who reported dissatisfaction was the patient who received ALT flap coverage for a chronic diabetic ulcer. This patient was not offered a secondary debulking procedure, as it was believed that the patient would require the extra flap thickness to prevent ulcer recurrence. Liposuction has also been supported in the literature as a less invasive alternative to surgical debulking for secondary thinning and contouring of the ALT flap.^{15,16}

The ALT flap is an important tool for soft tissue reconstruction of the distal lower extremity in the posttraumatic setting. The primary reconstruction requires a robust, well-perfused flap with maximal healing potential. After success with the immediate reconstruction, our focus then shifts toward optimization of the functional and aesthetic outcome. The ALT flap has excellent debulking potential; this is crucial in the lower extremity, where the ability to ambulate and wear normal shoes is highly dependent on the size of the flap and the mobility of the underlying joints and tendons. All of our posttraumatic patients that were able to be surveyed were satisfied to greatly satisfied with their results after debulking procedures were finished, and three of the four patients who completed the LEFS survey had $\geq 95\%$ functionality. Secondary reconstructive procedures are often necessary and need to be part of the algorithm of lower extremity salvage.¹⁷ However revisions and debulking surgeries are not just aesthetic but are functional as means to improve range of motion and ability to wear normal shoes in cases of foot and ankle reconstruction. Recent trends have been to elevate the ALT flap at the suprafacial or suprascarpal level to provide a thinner flap, which allows for fewer debulking procedures, and has been shown to have good outcomes by Seth and Iorio¹⁸ who looked at a series of 25 patients with flaps placed all over the body. The superthin ALT is an acceptable technique with strong outcome if there is time to plan the surgery and the patient is stable, but in our series many of our trauma patients had exposed bone and hardware from concomitant or recent orthopedic procedures there was the need to take a musculocutaneous ALT flap which would preclude the use of the superthin ALT or individual factors from these multitrauma patients lead us to a thicker flap with a shorter operative time with the plan to debulk the flap when the patient is recovered. A full-thickness ALT allows for easy debulking and a high satisfaction rating among our surveyed patients.

The weaknesses of this study are the small number of patients and our inability to follow-up with several patients. Several patients in the study could not be contacted as they were illegal immigrants without physical addresses, working telephone numbers, or any listed means of communicating with them, and one patient who was contacted declined to participate.

Conclusion

In our experience, the free ALT flap is a versatile option for free tissue transfer that may be safely considered in the reconstruction of large and complex traumatic soft tissue defects of the distal lower extremity. In addition to its reconstructive potential, it has excellent functional and aesthetic results which may be achieved through secondary surgical debulking.

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