The Utility of the Anterolateral Thigh Donor Site in Reconstructing the United States Trauma Patient

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Background: **Identification of a single donor site capable of providing all the components of the soft tissue envelope and the ability to selectively harvest a subset of these components is a central requirement for the microvascular reconstruction of the trauma patient. The anterolateral thigh (ALT) flap's long pedicle and adaptability in supporting a variety of tissues (muscle, fascia, soft tissue) make it a valuable tool for microsurgical reconstruction in these challenging patients. We investigated the utility of the ALT as a donor for microvascular tissue reconstruction in a Level I trauma center.**

Methods: **We conducted a retrospective chart review on all trauma patients treated by the plastic surgery service at the R Adams Cowley Shock Trauma Center who required microsurgical free flap coverage from July 2002 to March 2005. Fifty-eight patients underwent reconstruction of traumatic deformities with 62 microvascular free flaps from the ALT region.**

Results: **Of the 58 patients, 42 were male and 16 were female with an average age of 39 years. Recipient site locations for the 62 flaps were lower extremity, upper extremity, trunk, and head and neck. Analysis of flap anatomy revealed that 43 were fasciocutaneous, 14 were myocutaneous, 2 were adipofascial, and 3 were myofascial (vastus lateralis muscle). Six flaps were based on septocutaneous perforators, whereas the remainder contained myocutaneous perforators. Nine thigh donor sites required a split thickness skin graft, and 53 were closed primarily. The size of the flaps ranged from 36 cm^2 to 600 cm^2.**

Conclusions: **The ALT is a predictable donor site that facilitates a 2-team approach. ALT displays minimal donor site morbidity and in most cases provided sufficient tissue to cover the entire traumatic defect. Our results suggest the ALT is a reliable tissue source and an ideal donor site for the management of complex traumatic wounds in the United States.**

Key Words: **Anterolateral thigh, Microsurgery, Trauma, Free flap, Perforator flap.**

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Microvascular reconstruction of traumatic defects requires identification of a single donor site capable of providing all the components of the soft tissue envelope and the ability to selectively harvest a subset of these components. The anterolateral thigh topography possesses the capacity to fulfill this role. Song et al. in 1984[1] initially described the anterolateral thigh flap (ALT) as a fasciocutaneous flap based on a septocutaneous artery and Koshima in 1993 popularized its clinical application.[2,3] The blood supply to the ALT flap is from the descending branch of the lateral femoral circumflex artery, which is a branch of the profunda femoral artery. The pedicle length ranges from 8 to 16 cm and the vessel diameter ranges from 2 to 3 mm. The lateral femoral circumflex artery also provides branches to the rectus femoris, vastus lateralis, and tensor fascia latae muscles. This artery emerges from the intermuscular space between the mid- to upper-third of the thigh and the cutaneous flap perforator vessels may be either septocutaneous or musculocutaneous.[4–8] The vast territorial distribution of arterial inflow and venous plexus outflow allows for flaps to be harvested up to 30 cm × 17 cm in greatest dimension. Sensate flaps may be harvested if the adjacent femoral cutaneous nerves are included.[1,9,10] In addition, the vastus lateralis and rectus femoris muscles may be included for a musculocutaneous flap. Koshima et al.[2] and Hallock[11] described multiple chimeric combinations of tissues that may be included using the lateral femoral circumflex artery system. A thorough understanding of the thigh topography and variable vascular anatomy is imperative to ensure predictable and reliable flap harvest. Kimata enlightened surgeons by providing detailed anatomic variations of the ALT vascular roadmap.[4,7]

The anterolateral thigh has many advantages, which make it attractive for trauma reconstruction, including large caliber vessels, reliable skin territory, and minimal donor site morbidity.[12] Despite the many advantages and reliability outlined by groups in the Far East, it is rarely a first-line flap in Western societies.[13] Although Pribaz et al.[14] described their experience using the ALT flap in 1995, there have been few published reports in the United States. A strong argument against the use of this flap has been the degree of obesity present

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in the Western population, as it provides a significantly thicker adipocutaneous flap. In pediatric patients, obesity is a less common issue, and therefore the ALT flap is especially useful in these situations. A second and major argument against its use is the steep learning curve associated with the dissection of the pedicle and perforators.[4,10] The variable vascular anatomy and difficult perforator dissection have been strong detractors of enthusiasm in the United States. Although experience within the Far East with the ALT has been remarkable, it has not become a first-line flap in the United States. Within recent years our unit has undergone a major paradigm shift regarding microvascular donor tissue selection. For this reason, we investigated the utility of the ALT topography as a donor for microvascular tissue to determine its superiority over other donor sites for reconstructing a variety of traumatic defects in a US Level I trauma center.

MATERIALS AND METHODS

To investigate potential versatility of the anterolateral thigh region donor site a retrospective chart review was conducted of all trauma patients treated by the plastic surgery service at the R Adams Cowley Shock Trauma Center who required microsurgical free flap coverage from July 2002 to July 2005. Of 111 free tissue transfers for traumatic defects, 58 patients underwent reconstruction with tissues from the anterolateral thigh region based on the lateral circumflex femoral artery system. Data extracted during chart review included age, gender, mechanism of injury, body mass index (BMI), injury severity score, location of soft tissue defect, size of flap, tissue composition of flap, number of perforators, and complications.

All flaps were harvested in a similar fashion. A line was drawn from the anterior superior iliac spine to the superior lateral patella, the perforators were identified with a Doppler and the dimensions of the flap were outlined. The perforators were carefully dissected down to the fascia lata and followed in a retrograde fashion within the septum between the rectus femoris and the vastus lateralis (septocutaneous) or through the vastus lateralis muscle (musculocutaneous) until we can visualize the lateral circumflex femoral artery and vein. A cuff of vastus lateralis can be included.

RESULTS

Fifty-eight patients had 62 microsurgical reconstructions with tissues from the anterolateral thigh region at our institution. Four patients had a second free flap caused by the loss of their first free flap. Of the 58 patients, 42 (72%) were male and 16 (28%) were female with an average age of 33 years (range 13–74 years). The average BMI was 29 with a range of 21 to 42. The cut off for obesity is 30. The mean injury severity score (ISS) was 17.9 $\pm$ 8 with blunt mechanism of injury accounting for the majority (91%) of the injuries (n = 53). Orthopedic injuries were the most common associated injury, with tibia fractures being the most common (n = 36), followed by fibula (n = 32), calcaneus (n = 5), metatarsal (n = 3), femur (n = 2), and maleolar (n = 2).

Recipient site locations were lower extremity (52 flaps), upper extremity (3 flaps), trunk (1 flap), and head and neck (6 flaps). Analysis of flap anatomy revealed that 43 were fasciocutaneous, 14 were myocutaneous, 2 were adipofascial, and 3 were myofascial (vastus lateralis muscle). Six flaps were based on septocutaneous perforators (9.6%), and the remainder contained myocutaneous perforators. The average number of perforators used in each flap was 1.6 (range 1–4). The donor site closure was also evaluated and 9 thigh donor sites required a split thickness skin graft (14.5%), whereas 52 could be closed primarily (85.5%). The size of the flaps ranged from 36 cm^2 (6 cm $\times$ 6 cm) to 600 cm^2 (20 cm $\times$ 30 cm), with an average of 185 cm^2 (SD 118 cm^2).

The microsurgical transplantation success rate was 93.5%. Four flaps failed as a result of venous thrombosis at the microvascular anastomosis. One flap had significant partial loss, but was considered successful, as the fracture site remained covered. Three patients, despite successful soft tissue coverage, went on to have delayed below knee amputations secondary to chronic pain and poor bone healing. Motor and sensory deficits related to flap harvest were difficult to assess because 48 of the flaps were taken from the injured leg. We will present brief outlines and clinical photographs of four representative cases.

CASE REPORTS

Case 1

A 50-year-old man sustained an open tibia/fibula fracture of the distal third of his left lower extremity in a motorcycle crash (Fig. 1). A 20 cm $\times$ 6 cm fasciocutaneous ALT flap was used to resurface the exposed bony and soft tissue defect

Fig. 1. *Case 1: Open left distal tibia-fibula fracture.*

Fig. 2. *Case 1: Coverage of defect with fasciocutaneous ALT flap.*

Fig. 3. *Case 1: 10-month follow-up. Recipient site.*

Fig. 4. *Case 1: 10-month follow-up. Donor site.*

Fig. 5. *Case 2: Open left distal tibia wound after debridement for osteomyelitis.*

5 days after injury (Fig. 2). His 10-month follow-up photograph shows excellent soft tissue coverage (Fig. 3) and a well-healed donor site (Fig. 4).

Case 2

A 15-year-old obese girl sustained a left middle-third tibia/fibula fracture that was complicated by nonunion and osteomyelitis (Fig. 5). Because of the osteomyelitis, a muscle flap was chosen. A free vastus lateralis muscle flap with split thickness skin graft was used to obturate the bony defect and cover a 3 cm × 8 cm soft-tissue defect of the distal tibia (Figs. 6 and 7).

Case 3

A 45-year-old woman sustained severe soft tissue avulsion of the dorsum of the left forearm and hand with open radius and ulnar shaft fractures, and extensive extensor ten-

Fig. 6. *Case 2: Coverage of defect with skin graft and vastus lateralis muscle flap.*

Fig. 7. *Case 2: One-year follow-up.*

don injury (Fig. 8). Seven days after the injury, an 8 cm × 30 cm musculocutaneous ALT flap was used to cover the wound (Figs. 9 and 10). This flap was debulked and contoured to achieve optimal esthetic results.

DISCUSSION

Reconstruction of complex traumatic defects requires that the basic tenets of the reconstructive ladder be judiciously applied while paying attention to specific patient considerations. Unfortunately, patients encountered at a Level I trauma center present with complex wounds that routinely eliminate less complex management options resulting in climbing the rungs of the ladder to the level of free tissue transfer. During the last decade there has been a paradigm shift regarding microvascular free tissue transfer. The Lower Extremity Assessment Project (LEAP) has prospectively evaluated 601 trauma patients with high-energy lower extremity injuries. The LEAP Study Group reported that free flap coverage of severe underlying osseus injuries had fewer wound complications requiring operative intervention than local rotational flap coverage[15] and that soft-tissue injury severity had the greatest impact on the decision between amputation and limb salvage.[16] Improved survival rates after trauma have allowed surgeons to focus on flap refinement rather than flap survival, resulting in greater emphasis on donor site morbidity, function, as well as esthetics.

The reconstructive surgeon is routinely faced with the arduous task of choosing the ideal flap for the recipient

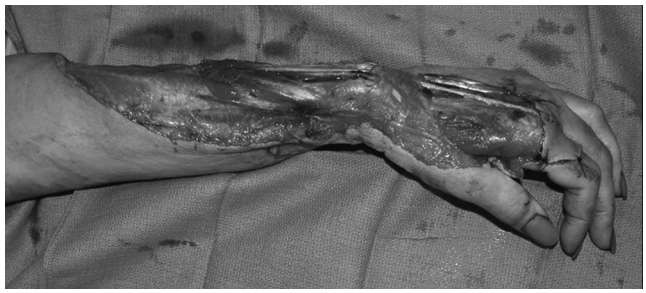

Fig. 8. *Case 3: Avulsive soft-tissue defect of left distal forearm and hand after motor vehicle collision.*

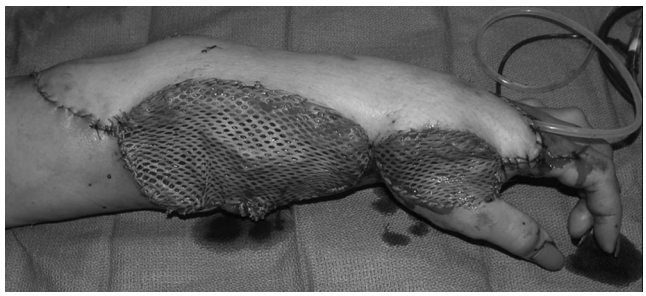

Fig. 9. *Case 3: Coverage of defect with myocutaneous ALT flap and skin graft, after repair of osseus and tendinous injuries.*

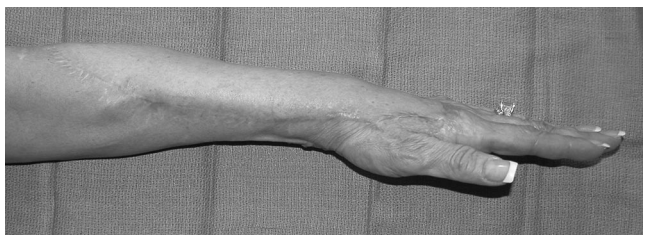

Fig. 10. *Case 3: One year follow-up subsequent soft tissue rearrangement.*

defect. Many free flaps such as the rectus abdominis, gracilis, latissimus dorsi, radial forearm, scapular, and parascapular, have been thoroughly described in the literature and are currently available for microvascular reconstruction. For the complex trauma patient, donor selection is of utmost importance. Routinely, the use of local tissues is avoided, for two reasons: (1) local tissues are often within the zone of injury, and (2) local tissues may be required to cover the proximal stump of the below knee amputation if limb salvage is not successful.

Our experience has found the ALT region has proven to be a predictable donor site for patients in a Level I trauma center; applications have included complex defects of the upper and lower extremities, craniofacial regions, and the trunk. The advantages of this donor site are several: convenience of allowing a two-team approach, provision of multiple tissue types from one site, and reduced donor site morbidity by allowing primary closure in most cases. In addition, the patient with multiple injuries may not be suitable for general anesthesia, and therefore flaps from and to defects of the lower extremity can be performed under regional epidural anesthesia. Although epidural anesthesia is controversial for flap survival because of its negative impact on microcirculatory flow,[17,18] it is thought by our group to be a sound choice in the occasional patient.

The microsurgical unit at Chang Gung Memorial Hospital has proven its dependability and versatility with its experience of 672 ALT flaps.[13] Although the advantages of the ALT flap have been clearly delineated, it has not been established as a primary option for microsurgical reconstruction in the United States.

One major reason for its lack of favor has been its potentially complicated distribution of perforators, the dissection of which may be difficult and time consuming.[3,7,8,12] Song and Xu described the vascularity of these perforators as septocutaneous or musculocutaneous.[1,8] Kimata further refined the understanding of the patterns of perforators and demonstrated that the musculocutaneous perforators were more common than septocutaneous perforators, 81.9% versus 18.1%.[4] A conventional hand-held Doppler facilitates identification of the perforator distribution preoperatively. After identification of the perforators intraoperatively using loupe magnification, retrograde dissection to the level of the main pedicle may be time consuming but provides safety and reliability.

Superiority of musculocutaneous flaps as compared with fasciocutaneous flaps in management of closed wound spaces inoculated with bacteria has been noted in the canine model.[19] Based on our experience, one could further develop the argument that fasciocutaneous flaps, as compared with free muscle flaps covered by split thickness skin grafts, may offer greater durability and serviceability.

Another potential disadvantage of this flap is the thickness of the subcutaneous tissues. Unlike the Asian population, Westerners tend to have greater fullness of the thigh, specifically the adipose layer. At our institution, we avoid the use of adipocutaneous ALT flaps in obese patients and circumvent this obstacle by utilizing other anterolateral thigh tissues, i.e., vastus lateralis muscle in combination with a split thickness skin graft. Although this method of reconstruction may be considered antiquated, it has proven to be useful in lower extremity reconstruction of obese patients. Other options include thinning of the flap during flap harvest or performing debulking several months postoperatively.[20,21]

Analysis of our institutional experience demonstrates that the majority of cases were fasciocutaneous; however, we were able to adapt and tailor the flaps to a range of defects. These defects were in the head and neck, upper extremity, and lower extremity, but were concentrated in the lower extremity. The number of upper extremity reconstructions in this study is disproportionately small because these are handled by a separate hand service, who tend to perform their own reconstructions.

Other free tissue transfers based on the lateral femoral circumflex artery system may be independent, chimeric, or composite. For example, the vastus lateralis muscle may be taken with (composite) or without (independent) the cutaneous tissues. Also, an adipofascial ALT flap can be harvested without the cutaneous component.[22] The adidipofascial flap includes only the fascia and 2 to 3 mm of adipose layer, as seen in case 3. An example of a true chimeric flap based on the lateral circumflex femoral artery system is the combined ALT skin flap based on the descending branch with a vascularized iliac crest bone flap based on the ascending branch of the lateral circumflex femoral artery.[2,6]

Management of the donor site deformity, although relatively minimal, has been challenging. The esthetic and functional deformity of the donor site is minimized be avoiding severe damage to the vastus lateralis muscle, cutting the arterial pedicle to the rectus femoris, and skin grafting the donor site.[11] The Chang Gung Memorial experience demonstrates that primary closure of the defect can be performed comfortably when the defect is 6 to 9 cm or less. In their hands, any defect greater than 6 to 9 cm in width required a skin graft.[12] A recent modification includes flap harvest in a suprafascial fashion.[12] This allows for fascial imbrication during closure, which aids in reducing the overall width, thereby providing the routine ability to close defects primarily up to 10 cm in width. Of note, 1 donor defect of a 12-cm flap was closed primarily using this technique. Studies are currently underway to determine potential detriment on the thigh compartment pressures with this type of fascial closure. However the addition of a skin graft over the donor defect minimally increases the donor site morbidity. Within 3 months, the tissues are sufficiently supple to allow skin graft excision and primary closure, in conjunction with liposuction if required. The majority of donor sites could be primarily closed, and the ALT provided sufficient soft tissue to close the traumatic defect primarily. This is especially valuable in the distal lower extremity and ankle. The donor site morbidity can be

further limited by harvesting the flap from the injured leg. Impairment of quadriceps function after harvest of the vastus lateralis has been debated. Kuo et al. demonstrated a minimal to nondetectable change in isokinetic or isometric measures of the quadriceps after muscle harvest.[23]

In summary, the anterolateral thigh region provides all required components of the soft tissue envelope needed for reconstruction of complex traumatic defects. In our unit, the ALT has proven to be a versatile microvascular free flap with minimal morbidity. With increased surgical refinements we think the anterolateral thigh will become the ideal source of tissue for management of complex traumatic wounds of the head and neck, torso, and extremities in the United States.

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