Functional Outcomes of Posttraumatic Lower Limb Salvage: A Pilot Study of Anterolateral Thigh Perforator Flaps Versus Muscle Flaps

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Background: **Functional outcomes of lower extremity reconstruction compared with amputation have been evaluated. However, there are little comparative data among the different reconstructive options. With the recent increase in perforator flaps, we compared the functional outcomes of muscle and perforator flaps.**

Methods: **We conducted a retrospective review of 136 lower extremity trauma patients who underwent reconstruction with either a free muscle or perforator flap during a 7-year period. Forty-two of these patients completed the study. Patients answered the short musculoskeletal functional assessment form and supplemental questions. A physical therapist evaluated performance of physical tasks. Donor site sensation was measured with the pressure specified sensing device. Radiographic fracture union was evaluated by an orthopedic surgeon.**

Results: **Of the 42 patients enrolled, 20 had coverage with perforator flaps and 22 with muscle flaps. Quality of life and functional outcomes demonstrate no difference ($p > 0.05$). Ninety-three percent of patients would go through the limb salvage process to avoid amputation. Sensation at the donor site was diminished in all patients; however, the perforator flap donor site had more significant sensory loss ($p = 0.005$). Time to bony union ($p = 0.51$), union in the presence of infection ($p = 0.85$), and infection after flap ($p = 0.87$) was not related to flap type.**

Conclusion: **Both muscle and perforator flaps provide vascularized coverage, which nourishes the fracture but muscle flaps pilfer a functional unit which may not be inconsequential in a patient trauma. This pilot study suggests that functional outcomes of perforator skin flaps are equal to muscle flaps and a larger prospective study is warranted.**

Key Words: **Lower limb salvage, Anterolateral thigh flap, Muscle flap, Lower extremity reconstruction.**

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Functional outcomes of lower extremity reconstruction with free tissue transfer compared with amputation have been studied extensively. The Lower Extremity Assessment Project study demonstrated that the functional outcomes of patients who underwent reconstruction and limb salvage were equivalent to those who had amputations, at 2 years.[1] However, there are limited data comparing functional outcomes among the different types of coverage options. Pollak et al.[2] found that there were fewer short-term (occurring within the first 6 months) wound complications (wound infection, flap revision, and flap loss) when free flaps were used over rotational flaps. This is in contrast to the findings of Parrett et al.[3] who report a recent trend away from free tissue transfer toward local flaps and wound care. The field of microsurgery has advanced such that free flap success rates approach 100% in experienced hands and nearly every inch of the body can be harvested as a flap. The focus has shifted toward ideal tissue selection to achieve optimal functional and cosmetic results as well as reduced donor site morbidity. There has been an increase in the use of perforator flaps versus muscle flaps with skin grafts for reconstruction of traumatic lower extremity wounds. The purpose of this study was to compare functional outcomes of perforator skin flaps with muscle flaps in patients with lower extremity trauma.

PATIENTS AND METHODS

Following Institutional Review Board approval, 136 patients were identified who underwent lower extremity reconstruction with a free flap between 1998 and 2005. Patients with rotational flaps or subsequent amputations (below the knee, n = 12; above the knee, n = 2; n = 9 in patients with muscle flaps; n = 5 in patients with fasciocutaneous flaps) were not included in the study. Patients with amputations were excluded as most had not received a prosthesis and therefore, not ambulatory or had not undergone enough rehabilitation to be ambulatory at the time of the study. Forty-two patients were willing to participate. We were not able to contact 67 patients, 9 patients were deceased, and 18 declined to participate (too far to travel n = 10, not interested n = 8). After informed consent, patients completed a questionnaire which included the short musculoskeletal functional assess-

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ment form and questions written by the investigators; photographs of the donor site and the flap were evaluated by a nonplastic surgeon; five physical tasks were evaluated by a physical therapist blinded to the reconstructive procedure; the sensation of the donor site was evaluated using the pressure specific sensing device. Physical tasks evaluated by the physical therapist included walking 150 feet with notation of gait devations, tandem stand, tandem walk, climbing up and down, and sit to stand five times. The questions written by the investigators included level of education, involvement in a lawsuit, current pain level, employment status prereconstruction and postreconstruction, and confidence in ability to make full recovery.

Additional data collected from charts included age, gender, race, Injury Severity Score (ISS), mechanism of injury, types of fractures, contralateral lower extremity injury, months postflap reconstruction, time to bony union, and complications. The indication for free tissue transfer was Gustillo IIIB or IIIc fractures, degolving injury or exposed hardware in the distal one third of the leg. The choice of donor site was determined by the surgeon's experience and clinical judgment. Radiographs were read by a blinded board certified orthopedic traumatologist to determine boney union.

Student's *t* test, Fischer's exact test and logistic regression were used to analyze differences in functional outcomes, quality of life and satisfaction, and time to bony union.

RESULTS

Of the 42 patients enrolled in the study, 20 underwent reconstruction with an anterolateral thigh flap, 8 with a gracilis and 14 with a rectus abdominis flap (Fig. 1, A and B). There was no significant difference in sociodemographic characteristics or ISS between the two groups. The patients were relatively young with an average age of 42 years, the majority were male (67%), and the mechanism of injury was largely blunt (95%). Twelve patients had contralateral orthopedic injuries. The defect location was primarily the distal third of the leg (n = 27) followed by the middle third (n = 6), foot (n = 5), and then proximal third (n = 3). The anterolateral thigh flap was harvested from the injured leg in 9 of 20 patients. The gracilis flap was harvested from the injured leg in seven of the eight patients who received gracilis flaps. Average follow-up time was 18 months in the perforator flap group and 47 months in the muscle flap group.

Sixty-two percent of patients returned to work (14 of 22 in the perforator flap group and 12 of 20 in the muscle flap group), 26% of patients did not return to work as a direct result of the injury (5 of 22 perforator flap group 6 of 20 in muscle flap group), and 19% of patients did not return to work but was not related to the injury (4 of 22 perforator flap group 4 of 20 in muscle flap group). Return to work was associated with higher physical scores ($p < 0.01$, Fisher's exact test) but was not associated with age, gender, education level, or pain score. Thirteen patients were involved in lawsuits and while there was a trend toward decreased functional scores it was not statistically significant.

Quality of life and functional outcomes measured by the short musculoskeletal functional assessment and physical tasks failed to detect a difference ($p > 0.05$, *t* test). Satisfaction with cosmetic appearance was not different ($p > 0.05$, Fisher's exact) with a trend toward women being less satisfied than men overall ($p = 0.06$, logistic regression). Ninety-three percent of patients would go through the limb salvage process to avoid amputation. The three patients (two muscle flaps, one fasciocutaneous flap) who would have preferred an amputation had a pain score greater than two standard deviations above the mean. Sensation at the donor site, measured with pressure specific sensing device, was diminished in all patients; however, the perforator flap donor site had more significant sensory loss ($p = 0.005$) (See Table 1).

Time to bony union was not related to the type of flap used ($p = 0.51$, *t* test). Union in the presence of infection was not affected by flap type ($p = 0.85$, logistic regression). Infection after flap was not related to flap type ($p = 0.87$, logistic regression) (see Table 1).

DISCUSSION

There has been a trend toward perforator-based flaps as they spare functional muscle units. The morbidity of myocutaneous and perforator based flaps has been compared extensively in the breast literature. It is established that preservation of the rectus abdominis muscle either in a deep inferior epigastric perforator flap or a muscle sparing transverse rectus abdominis muscle flap decreases donor site morbidity.[4,5] It would reason that preservation of functional muscle units (i.e., rectus abdominis and latissimus dorsi) in debilitated and injured trauma patients would achieve better functional outcomes.

Bosse et al.[1] found that functional outcomes at 2 years were the same in patients with lower extremity amputation and salvage when controlled for ISS. In our opinion, salvage should be attempted in the majority of cases. In this study, we found that all patients would go through the lengthy salvage process again to save the leg. Only two patients would have preferred an amputation at the outset and this correlated with a high level of persistent pain.

Physical and psychosocial functioning in both groups was comparable to outcomes reported in other lower extremity trauma series. Return to work among our patients was 62% and 58% in the Lower Extremity Assessment Project study cohort.[6] MacKenzie et al.[6] found that physical functioning, pain, one's belief in the ability to return to work, age, and education were all predictors of return to work. In our study, only physical function score correlated with return to work. Although emotional score did not correlate with return to work physical function and emotional score were highly correlated.

Donor site morbidity was minimal in all patients. Sensory loss was present in all donor sites although this was not

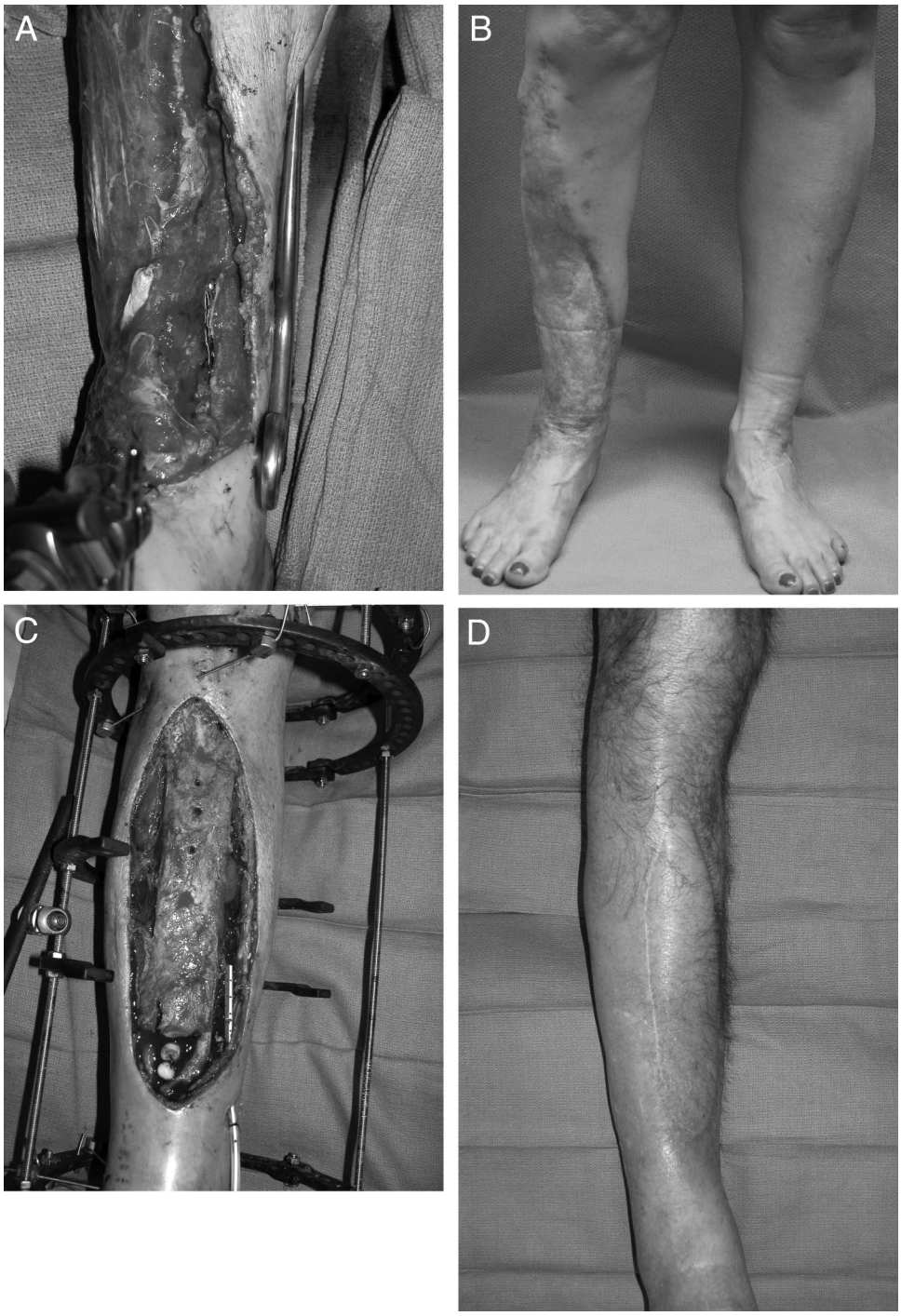

Fig. 1. *(*A*) Preoperative defect of a lower extremity wound (*B*) Postoperative photograph of a rectus abdominis muscle flap with split thickness skin graft to the large traumatic lower extremity defect in* (A) (C) *Preoperative defect of a lower extremity wound (*D*) Postoperative photograph of an anterolateral thigh flap to the large traumatic lower extremity defect in* C.

a major complaint in any of the patients. Balance was affected in all patients. Historically, people have advocated muscle flaps for coverage of open lower extremity wounds. Our study indicates that both flaps have equal functional and quality of life outcomes. The ultimate goal of stable wound coverage and bony union was achieved with both flap types even in the presence of infection. Until recently muscle flaps were advocated for coverage of infected wounds and osteomyelitis. Several recent articles have demonstrated equivalence in healing or clearance of infection for fasciocutaneous and muscle flaps, which was consistent with the findings of our study.[7–10]

Both fasciocutaneous and muscle flaps provide vascularized tissue, which protects and nourishes the fractured bone

Table 1 **Patient Outcomes Data**

	Perforator Flaps (N = 20)	Standard Deviation	Muscle Flaps (N = 22)	Standard Deviation	*P*
Age (yrs)	40	12.15	43	13.24	0.45
Physical function score	13.78	5.36	14.9	5.34	0.47
Quality of life/ emotional score	21.1	5.34	22.9	7.05	0.19
Pain score	2.6	2.21	2.2	2.14	0.60
Satisfaction with appearance	13/20	—	12/22	—	0.35
Sensation at donor site	78.3	34.1	48.9	28.04	0.005
Nonunion postflap	5/20	—	3/22	—	0.85
Time to union (mo)	7.9	5.9	8	4.44	0.51
Incidence of infection postflap	10/20	—	9/22	—	0.87

but muscle flaps pilfer a full muscle unit which may not be inconsequential in a patient trauma. In addition to preserving motor units, we have found that perforator skin flaps are easier than muscle flaps to elevate when delayed bone grafting or fixation is required as they do not form a dense-fibrotic scar to the underlying bone and soft tissue.

Although this was a small retrospective pilot study, a larger powered prospective study with more specific tests of functions may be necessary to discern a difference between perforator and muscle free flaps. Patients were not randomized to a specific flap type. Follow-up time was longer in the muscle flap group and reflects a paradigm shift at our institution away from free muscle flaps toward perforator flaps. Future prospective studies are warranted and should focus on subtle differences in donor site morbidity as well as ease of secondary orthopedic procedures after flap coverage. Although perforator flaps are associated with a steeper learning curve and possible increased anesthesia time, should the reconstruction fail only skin and fat is lost, not a functional motor unit?

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