The Gracilis Free Flap Revisited: A Review of 25 Cases of Transfer to Traumatic Extremity Wounds

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Trauma to the extremities often results in a complex bony and soft-tissue injury requiring free flap reconstruction. Muscles from various body sites have been used in extremity reconstruction since the early 1970s. The gracilis muscle is usually not considered the first choice for free flap reconstruction of these defects. It is usually relegated to small defects or used to reanimate the face. Our purpose is to present our experience with the gracilis muscle as a first-choice flap in reconstruction of traumatic extremity defects. A retrospective review of all gracilis muscle free flap transfers for traumatic extremity wounds between 1988 and 1995 at the Naval Medical Center Portsmouth was performed. Twenty-five patients age 20 to 71 years (mean, 29.7 years) underwent 26 free flaps to the lower leg, ankle, foot, or forearm to cover traumatic wounds. Defects ranged in size from 3 × 3 cm (9 cm^2) to 13 × 18 cm (234 cm^2), with a mean of 75.5 cm^2. There were no flap losses and all wounds healed. Nine patients experienced 11 complications, which consisted of minor wound separation (16%), wound infection (12%), partial or complete loss of split-thickness skin graft (8%), thrombosis of graft with successful revascularization (4%), and nonunion of an underlying fracture (4%). Our overall success rate for gracilis free flap reconstruction of traumatic wounds is 100%. The gracilis free muscle flap has become our first option for tissue coverage in traumatized extremities. It leaves minimal functional defect limited to the side of the primary injury and provides a good cosmetic result. It can cover large defects when the epimysium is cut, and allows an epidural block to be performed for sympathectomy effect and pain control in the affected extremity during the immediate postoperative period.

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Patients and Methods

The entire gracilis muscle free flap transfer experience for traumatic extremity wounds from 1988 through 1995 at the Naval Medical Center Portsmouth was reviewed. Twenty-six such flaps were performed in 24 men and 1 woman. All records were reviewed to determine mechanism of injury, size of the defect, indication for flap coverage, complications, and outcome. Patients ranged in age from 20 to 71 years, with an average age of 29.7 years. Tobacco use was reported for only 2 patients. The two oldest patients (60 and 71 years respectively) had significant comorbid diseases consisting of chronic obstructive pulmonary disease, hypertension, peripheral vascular disease, and diabetes mellitus.

Results

The mechanism of injury was varied, with vehicular accidents accounting for 17 (68%) injuries: eight motorcycle (32%), eight automobile (32%), and one pedestrian (4%). Fall from a height was the second largest category, causing three injuries (12%). Other categories were crush injuries, two (8%); and penetrating injuries, one (4%). The mechanism of injury was not recorded for 2 patients (8%). The wound defect size was recorded for 17 wounds in 16 patients and ranged from 3 × 3 cm (9 cm^2) to 13 × 18 cm (234 cm^2). The average-size defect was 75.5 cm^2 (Table).

There were three major indications for flap coverage. Open fracture with exposed bone was present in 21 patients (84%), 7 patients (28%) had gross tissue infection and/or tissue necrosis that required aggressive debridement prior to flap

Patient Age and Defect Size

Patient	Age (yr)	Size of Defect (cm^2)
DG	29	32
JG	26	100
MA	21	180
NR	35	120
AK	44	—
NB	25	—
TC	23	73
EI	25	9
LB	21	15
RB	21	—
EG	30	—
MG	60	10
DF	23	—
DM	20	—
DD	23	—
RM	21	25
SF	21	36
MS	33	—
CO	71	100
WF	33	60
MJ	37	75
JE	26	—
SH	28	234
TL	23	80
		65
BP	23	70

coverage, and 5 patients (20%) had significant tissue loss without infection or necrosis. No injuries required neurovascular repair. Sixty-four percent of patients experienced no postoperative morbidity. Nine patients (36%) had a total of 11 complications (Fig).

Our criteria for complications were very strict. Four patients (16%) developed minor flap wound edge separations that healed readily with local wound care. Three patients (12%) developed clinical postoperative infections. One abscess occurred at the donor site and responded to incision, drainage, and local wound care. The other two infections occurred at the recipient site. One elderly diabetic patient developed a wound infection with resultant complete loss of the split-thickness skin graft, requiring repeat grafting. The third patient developed infected orthopedic hardware, necessitating hardware removal. Two patients (8%) had partial or complete loss of the split-thickness skin graft. One patient (4%) developed a thrombus in the flap, which required exploration and revision of the anastomosis, which was successful. One patient (4%) experienced a nonunion of an underlying tibial fracture. When comparing indication for flap closure to complications, 71% of patients with gross infection or tissue necrosis in the wound developed a complication, representing 56% of all complications.

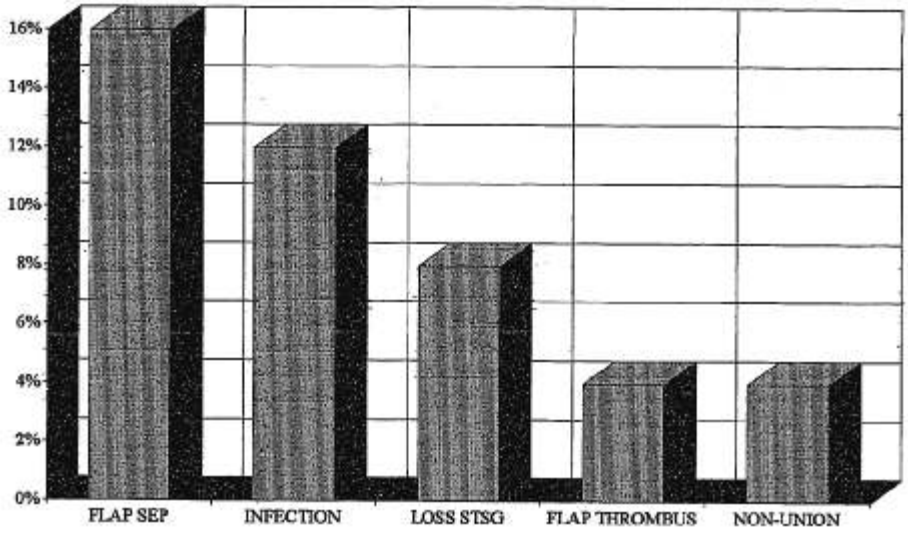
All 26 flaps survived and healed, yielding a 100% success rate for gracilis muscle transfer. Three patients required debulking of the flap 3 to 6 months after initial transfer.

Discussion

The science of microvascular free tissue transfer began in 1972 with the report of transfer of omentum for a scalp wound.[1] The field has expanded rapidly in the interim and now free tissue transfer, including muscle flaps, musculocutaneous flaps, intestinal flaps, and fasciocutaneous flaps, is a recognized standard of care. We report 25 injured patients with significant distal leg, foot, and forearm wounds treated with free gracilis muscle transfer in a military hospital setting. This represents the largest series that we could find in the English literature to date.

Heckler[2] identified criteria that must be met for a tissue to serve as an ideal donor. The vascular pedicle should be consistent in size and location, the transfer should result in minimal functional deficit, and the resulting scar should be well concealed. The gracilis muscle lies superficially in the medial thigh and is supplied by two to three vascular pedicles. The dominant proximal pedicle originates from the profunda femoris or medial femoral circumflex artery. This artery has a diameter of 1.2 to 1.5 mm, enters the posterior surface of the muscle 10 ± 2 cm from its origin from the symphysis pubis, and is usually accompanied by two venae comitantes. The gracilis functions as an accessory thigh adductor and knee flexor, and is a totally expendable muscle.[3] Its removal results in no reported functional deficit, and the scar can be concealed easily and limited to the side of the primary injury.[2,4–6] The gracilis therefore represents an exceptionally good donor muscle.

Because of its size, the gracilis free flap is usually recommended for small- to moderate-size wounds no larger than 20 to 25 cm^2.[2,7] This



Complications. STSG = split-thickness skin graft.

makes it particularly suited for distal extremity trauma. However, by cutting the epimysium and splaying out the muscle, the gracilis can be used in much larger wounds, such as that covering a 13 × 18-cm (234 cm^2) defect as in 1 patient in our series. Careful physical examination will give an approximate muscle width, which is reported in the literature as 4.5 to 5.0 cm in the proximal thigh.[4] We can usually increase the width of the muscle by a minimum of 30% to 50% by splitting the investing epimysium. Scott and colleagues[8] demonstrated that the concomitant use of epidural anesthesia with general anesthesia for free flaps to the lower extremity resulted in a lower rate of microvascular complications, presumably secondary to lower extremity vasodilatation and prevention of vasospasm. Another appealing advantage of the gracilis flap over other flaps is that by utilizing epidural anesthesia, excellent postoperative analgesia is imparted for both the donor and recipient sites, thereby limiting overall narcotic requirements.

The gracilis can also be used as a musculocutaneous free flap to offer skin and subcutaneous tissue in addition to muscle bulk.[2,4,6] However, when dealing with distal extremity trauma, the additional bulk of the skin and subcutaneous tissue often makes this inadvisable. Even without the added tissue, muscle flaps with split-thickness skin grafts often require later debulking, as illustrated in our series.[9]

A particular advantage of free flaps in the patient with high-energy distal extremity trauma, even in small wounds, is their ability to aid in healing wounds with contamination, frank infection, or necrotic tissue.[2] Asaadi and associates[10] demonstrated in a dog model that free muscle flaps significantly improved healing in severely contaminated or infected wounds with exposed bone. Despite increased minor morbidity, all patients in our series with infected or necrotic tissue healed their wounds with the free gracilis flap.

While our series focuses primarily on young trauma patients, we did treat two older patients successfully with gracilis flaps. Others have reported success in elderly patients and note that despite slightly increased morbidity and mortality due to comorbid factors, free flaps should play a significant role in elderly patients with extremity wounds.[11,12]

The gracilis muscle has also been used for nontraumatic wounds. Lai and coworkers[13] demonstrated successful use of the gracilis flap in a series of 9 diabetic patients with infected foot ulcers. This group of patients has traditionally been considered poor candidates for free grafts due to suspected atherosclerotic and/or microvascular angiopathy. Others have demonstrated successful use of the free gracilis flap in patients requiring concomitant vascular reconstruction to supply adequate inflow for limb salvage, however no such injuries were demonstrated by this series.[14,15]

The gracilis muscle provides consistent anatomic and donor characteristics, good size to cover large wounds, and predictable results even in the face of infection. We conclude that the

gracilis free muscle flap should be considered as a first-line option for tissue coverage in the traumatized extremity and is the approach we use in our extremity algorithm. It can be used with low morbidity and high success, resulting in negligible functional defect, good cosmesis, and may be used to perform an epidural block during the immediate postoperative period.

The opinions or assertions expressed herein are those of the authors and are not to be construed as official or as reflecting the views of the Department of the Navy or the Department of Defense.

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