Comparative Study of Muscle and Fascio-cutaneous Flaps for Coverage of Exposed Tibia

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Abstract

Background- Trauma is a leading cause of tibial fractures. In salvageable lower limb trauma, morbidity can be greatly reduced with early soft tissue coverage of exposed tibia. Muscle flaps have traditionally been preferred over fascio-cutaneous flaps for coverage. With better description of the vascular supply of the lower limb, however, there is now a shift towards fascio-cutaneous flaps: pedicled or free soft tissue transfer.

Methods- 216 patients who underwent flap coverage for exposed tibia in our institute between January 2015 and December 2020 were evaluated in this retrospective, comparative study. Parameters studied were surgical complications, such as partial or complete flap necrosis, minor wound complications, venous congestion, donor-site complications; development of wound infection and osteomyelitis; duration of hospital stay; functional outcome and final aesthetic outcome

Conclusion- Fascio-cutaneous flaps were found superior to muscle flaps for coverage of exposed tibia in many respects especially for middle and lower third defects. For upper third of tibia, gastrocnemius muscle and musculocutaneous flaps provide adequate coverage. But in case of middle and lower thirds, adequate coverage can be provided by perforator-based, propeller or distal sural flaps. If adequate donor vessels are available, micro-vascular free soft tissue transfer, should be the preferred choice for large defects.

Key Words- *muscle flaps, perforator flaps, propeller flaps, exposed tibia, free flaps*

Introduction

There has been an alarming rise in the number of road traffic accidents in the modern era of motorised vehicles. Lower limb injuries are essentially on a rise. The loss of soft tissue cover over a bone or fracture, particularly when interrupted endosteal supply is combined with periosteal damage, demands coverage of the exposed bone with vascularized tissue after thorough debridement. Soft tissue coverage diminishes the rate of infection, nonunion and secondary amputation when performed early ([1]). Bony reconstruction precedes soft tissue reconstruction in a bid to provide functional lower extremity. The gold standard for coverage of severe lower extremity injuries is microvascular free tissue transfer([2]). Ideal free flaps include Latissimus dorsi, Rectus abdominis, Serratus anterior and Gracilis covered by immediate skin graft. However free fascio-cutaneous flaps such as Scapular, Antero-Lateral thigh and Radial forearm are suitable for many lower extremity applications

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and often provide excellent contour reproduction and appearance. However, this technique demands microsurgical expertise, longer operating hours, the need to sacrifice a major vessel in the tibial region and higher cost([2]).

Loco-regional flaps, which can be fascial, fascio-cutaneous, muscle or myo-cutaneous flaps, are an alternative since they were described in the 1980s. Muscle flap coverage is preferred by many surgeons because of the high vascularity. The increased vascularity provided by these flaps also brings high tolerance and resistance to infection. It also counters the development of osteomyelitis ([3,4]). In the leg, muscle flaps available are Gastrocnemius for proximal one-third of leg; Soleus, Gastrocnemius, FDL, Peroneus Longus, Tibialis Anterior, EDL for middle one-third of leg; Soleus, EDL, Tibialis Anterior, EHL, Peroneus Brevis for lower one-third of leg. Fascial and fascio-cutaneous flaps have regained popularity as excellent alternatives for coverage of lower leg defects. Sural flaps, perforator-based flaps, perforator-plus flaps, propeller flaps and adipo-fascial flaps are in wide usage now, apart from local transposition and rotation flaps ([5,6]).

The primary goal of surgical reconstruction in a lower extremity wound is to restore or maintain function. Functionality first demands a stable skeleton capable of supporting the patient's weight, with a stable surrounding soft tissue envelope. The presence or rehabilitative potential of muscles and joints along with proprioception and plantar sensibility will determine functional level. Profound detriments to a good outcome include chronic pain and development of infection, particularly osteomyelitis. Finally, the aesthetic outcome of the reconstructive options should be considered but, never at the expense of functionality and wound coverage. FAOS(Foot and Ankle Outcome Score) content is based on the Knee injury and Osteoarthritis Outcome Score(KOOS). FAOS consists of 5 subscales; Pain, other Symptoms, Function in Activities of daily living (ADL), Function in sport and recreation (Sport/Rec), and foot and ankle-related Quality of Life (QOL)([7]).This score has been modified for evaluation of leg injuries and validity confirmed by Engstrom et al in 340 patients. SCOS(Standard Cosmetic Outcome Scale) is measured using a 5-point questionnaire with scores ranging from 0-4.

Materials and Methods

The purpose of this study is to evaluate the usefulness of fascio-cutaneous flaps vis-à-vis muscle flaps for coverage of exposed tibia in the Department of Plastic and Reconstructive Surgery, SGRRIHMS and SMI Hospital, Dehradun. It is a retrospective, comparative study and includes 216 patients with exposed tibia admitted in the tertiary care hospital between January 2015 to December 2020.

Inclusion criteria- Presence of soft tissue defect on the leg which requires a flap; presence of palpable distal pulses; and a clean wound bed. Patients with established osteomyelitis were included in the study.

Exclusion criteria- Patients needing only skin grafts; presence of peripheral vascular disease, presence of deep bony defects or segmental bone loss; and major systemic illness.

Study Technique- History was taken using a structured questionnaire. Clinical examination for assessment of type of wound was done. Baseline investigations were carried out. These patients underwent wound debridement and dressing to prepare the wound bed. Culture and sensitivity of wound swab was done wherever indicated. Doppler study was done to delineate lower extremity vessels. Perforators can be marked using a hand-held Doppler probe([17]). After pre-anesthetic evaluation, the patients then randomly underwent fascio-cutaneous flaps or muscle flaps with immediate skin grafting for coverage of soft

tissue defects. All flaps were harvested using standard techniques described in literature. Before incision, the pedicle and perforating vessels of the local flaps were mapped by Doppler study. The study groups were segregated based on simple randomization.

Parameters studied-

(1) Surgical complications, such as partial or complete flap necrosis, minor wound complications, venous congestion, donor-site complications

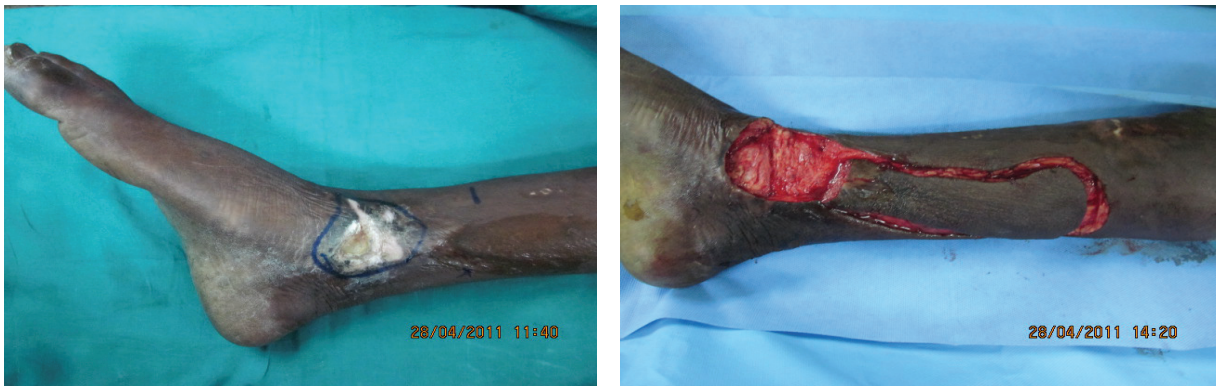
(2) Development of wound infection and osteomyelitis

(3) Duration of hospital stay

(4) Functional outcome measured by 'Modified Foot and Ankle Outcome Score'- MFAOS

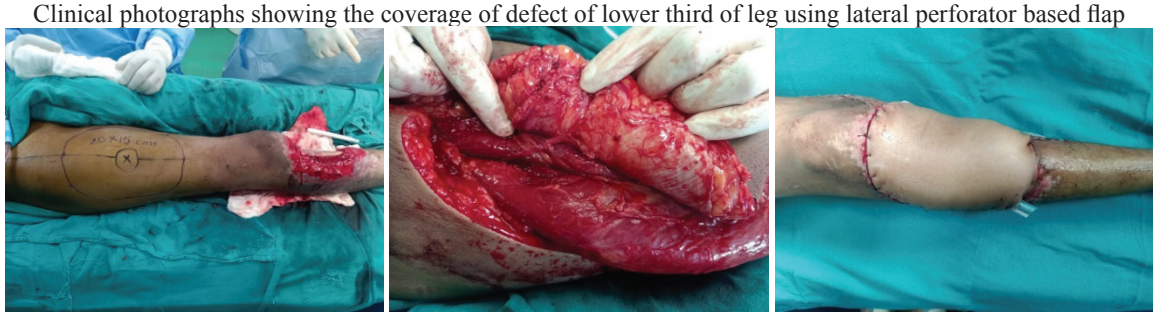
(5) Final aesthetic outcome measured by Standard Cosmetic Outcome Scale-SCOS

Clinical Photographs showing the coverage of upper 1/3 of anterior tibia using medial Gastrocnemius flap and fenestrated skin graft



Clinical Photographs showing coverage of soft tissue defect on lower third of tibia using distal medial perforator propeller flap

Clinical photographs showing the coverage of defect of lower third of leg using lateral perforator based flap



Clinical photographs showing the coverage of defect of anterior upper third of tibia using free ALT flap

Observations and Results

Trauma due to road-side accidents was the most important cause of soft tissue defects of leg (93.7%). Most soft tissue defects had associated tibial or both bone fractures of leg (81%) which were stabilized with external or internal fixation before flap coverage. Degloving injuries accounted for 13% of the patients who did not have skeletal injury. Non-traumatic causes of leg ulcers(6%) include venous ulcers, ulcers formed after necrotizing soft tissue infections, diabetic ulcers, ischemic ulcers. Following table shows the distribution of cases based on etiology:

Location	Total	Trauma with fractures	Trauma without fractures	Others
Upper third	36	31	4	1
Middle third	90	75	9	6
Lower third	78	62	16	0
Middle & Lower third	12	6	0	6

Complication rates were as follows-

1)Partial Necrosis- Out of 54 muscle flaps, 12 fllaps(22.2%) showed necrosis involving only margins. This was managed by regular dressings. No additional surgical procedure was required. Out of 162 fascio-cutaneous flaps, 42 flaps(25.9%) showed partial necrosis. The difference is not significant.

2)Complete Necrosis- Out of 54 muscle flaps, 2 flaps(3.7%) and out of 162 fascio-cutaneous flaps, 6 flaps(3.7%) underwent complete necrosis. 'p' value is 0.1 which can be considered insignificant. They were managed by debridement and wound coverage by an alternative procedure. In 1 case pedicled osteo-fascio-cutaneous fibula transfer was done for reconstruction of tibial defect. In 1 case LD free flap reconstruction was done. In 6 cases, lateral distal perforator-based flaps were used for coverage.

3)Venous Congestion- No venous congestion was observed in any of the muscle flaps. Out of 216 fascio-cutaneous flaps, 24 flaps(14.8%) showed some venous congestion, all in islanded distal sural flaps. 'p' value is 0.04 which is significant. These flaps

showed only marginal necrosis which required no revision procedures. Only regular dressing changes were required.

4)Donor Site Complications(Skin Graft loss or Wound Dehiscence)- Out of 54 muscle flaps, 6 flaps(11.1%) showed donor site complication in the form of wound dehiscence. This was re-sutured after debridement. Out of 216 fascio-cutaneous flaps, 30 flaps(18.5%) showed some graft loss at the donor site. 'p' value is 0.525 which is not significant. The donor site complications were minor and were mostly managed with regular dressing changes

5)Wound Infection- Out of 54 muscle flaps, 33 flaps(66.7%) showed postoperative wound infection at the recipient site as evidenced by wound swab analysis. This was due to partial necrosis, complete necrosis, wound dehiscence or osteomyelitis. Out of 216 fascio-cutaneous flaps, 42 flaps(25.9%) showed wound infection due to partial necrosis of flaps. They were managed by thorough debridement and regular dressings. 'p' value of this distribution is 0.022 which is statistically significant.

6) Osteomyelitis- Out of 54 muscle flaps 6 flaps(11.1%) had evidence of osteomyelitis in the form of persistent wound discharge, discharge of bone spicules and radiographic features. Out of 216 fascio-cutaneous flaps, 24 flaps(14.8%) showed osteomyelitis. 'p' value is 0.633 which is not significant.

7)Duration of Hospital Stay-The length of hospital stay of patients ranged from 8-42 days with a mean value of 17.03 days There was no significant difference in the length of hospital stay between the two groups of patients.

8) Modified Foot and Ankle Outcome Score (MFAOS)- The various subsets of MFAOS i.e. pain, symptoms/stiffness, activities of daily living, sports and recreation and quality of life were evaluated individually. Out of the 5 parameters, only ADL (Activities of Daily Living) showed significant statistical difference between muscle and fascio-cutaneous flaps. The score in this subset was significantly better for fascio-cutaneous flaps.

9) Standard Cosmetic Outcome Score (SCOS)- Fascio-cutaneous flaps demonstrated a significantly better SCOS than muscle flaps. SCOS was evaluated using unpaired student t as it is a continuous variable.

10) Preferred Flap Type in Various Sites- Out of a total of 216 cases, 36 patients had soft tissue deficit over upper third of tibia (16.7%), 90 had defects involving middle third (41.7%), 78 had lower third defects (36.1%) and 12 had soft tissue deficit over middle and lower thirds of tibia (5.6%).

Only 16.7% of defects in the upper third of leg were covered by fascio-cutaneous flaps. In contrast, 80% defects in middle third and 93.3% defects in lower third were covered by fascio-cutaneous flaps. Muscle and myo-cutaneous flaps were the preferred modality in upper third of leg (83.3%). The difference was significant with a 'p' value of 0.002.

The distribution of flap types is as follows:

Flap Type	Upper third	Middle Third	Lower third	Total
Fascio-cutaneous Flaps	6	72	84	162
Muscle Flaps	30	18	6	54
Total	36	90	90	216

Free microvascular tissue transfer is increasingly becoming the preferred method of coverage as the reconstructive surgeon opts for the reconstructive elevator instead of the ladder. Out of the 54 muscle flaps done 19 were free LD transfers; and of the 162 Fascio-cutaneous flaps 13 were Free ALT transfers. Despite the intricacies of micro-vascular anastomosis, there outcome was on par with the pedicled flaps.

Discussion

No significant advantage of muscle flaps over fascio-cutaneous flaps was found. In fact, the rate of complete necrosis and wound infection was found to be significantly higher in muscle flaps. This is in contrast to the established belief that muscle flaps are superior to fascio-cutaneous flaps in eradicating established infection. Flap necrosis probably reflects compromised blood supply due to previous trauma. Distally based hemisoleus flap has been known to have a dubious blood supply and has an unfavourable prognosis ([8]). Proximally based soleus and gastrocnemius flaps have better vascularity, but can be insufficient for coverage of middle third defects ([9]).

Venous congestion was not a major problem in muscle flaps. It was not seen in any of the 54 cases that underwent muscle or myocutaneous flaps. This is probably because of the rich network of venules and veins present in the substance of gastrocnemius([10]). Venous drainage is further aided by the contraction and relaxation of muscle. In contrast, 24 out of 162 fascio-cutaneous flaps showed significant venous congestion. 18 of these were distal sural island flaps and 6 were distal lateral perforator-based flap.

Partial graft loss at the donor site is a known complication and has been reported in many publications ([1,11]). This is probably due to compromised blood supply secondary to trauma and crush injury. Graft revascularization requires a highly vascular wound bed which can support the nutrition requirements of the skin graft. Wound infection was mostly associated with partial or complete necrosis of the flap or the development of osteomyelitis. It has been proved in various studies that fascio-cutaneous flaps, whether perforator based, propeller or perforator plus, have an excellent blood supply of their own and compare handsomely with muscle flaps in wound coverage as well as control of infection. They are also usually available for providing adequate wound coverage in lower leg wounds. Hence, the lower wound infection rates ([5,12,13,14]).

Osteomyelitis is not a contraindication to flap coverage. 26% of leg wounds with exposed bone go on to develop osteomyelitis([4]). The percentage increases with delay in wound coverage by definitive surgery. This is possibly due to decreased blood supply to the bone due to periosteal stripping and avulsion of the nutrient pedicle. This, coupled with wound bed contamination increases the propensity to osteomyelitis. By providing coverage with vascularized tissue like fascia or muscle, risk of development of osteomyelitis can be reduced.

Perforator-based, especially perforator plus flaps deserve a special mention due to their low complication rates and robust coverage especially for defects of middle and lower thirds of tibia. The simplicity of technique and ease of harvest are an added benefit leading to reduced operative time ([12,15,16]). It is no wonder that they are now being used so extensively.

In our study, there was a significant difference in the ADL scores of muscle and fasciocutaneous flaps with fasciocutaneous flaps scoring better. This is important as there is some loss of leg function due to use of gastrocnemius for wound coverage ([2,7]). Fascio-cutaneous flaps were cosmetically superior to muscle flaps. Propeller flaps and to some extent perforator-based flaps yielded the highest cosmetic outcome scores. This was because of the decreased requirement

of skin graft and reduced stepping in the donor area when compared with muscle and musculocutaneous flaps.

Conclusion

Fascio-cutaneous flaps were found superior to muscle flaps for coverage of exposed tibia in many respects especially for middle and lower third defects. For upper third of tibia, gastrocnemius muscle and musculocutaneous flaps provide adequate coverage and are better than fascio-cutaneous flaps for filling up of any defect created in the bone due to trauma. But in case of middle and lower thirds, adequate coverage can be provided by perforator-based, propeller or distal sural flaps. The rate of complications was also found to be less in fascio-cutaneous flaps, significantly with respect to wound infection and necrosis (complete or partial) in middle and lower thirds of tibia. Contrary to the widely held belief that muscle flaps are superior in controlling osteomyelitis. in this study no such correlation was found. Muscle flaps were marginally better but no statistically significant difference was seen. In functional terms, fascio-cutaneous flaps showed better ADL (activities of daily living) scores and thus better quality of life. Cosmetic outcome scores were also better for fascio-cutaneous flaps.

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Conflict of Interest- None

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