

ROLL OF LOCAL FLAP TECHNIQUE IN THE MANAGEMENT OF COMPOUND INJURIES OF LEG

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ABSTRACT

Objective: The objective of this study was to study the feasibility of local flaps in management of soft-tissue defects with exposed fracture bone fragments in lower extremity (particularly the leg) due to trauma.

Methods: The present study included 20 cases of traumatized lower extremity having a soft-tissue defect and an exposed bone with or without associated fractures. Study was conducted from January 1989 to August 1990. Local flaps provide a reliable single stage procedure for coverage of lower extremity soft-tissue defects. Distant flap provides good coverage but these procedures are long drawn out and tedious. Only those cases were selected in which wound was found to be preferably, in the upper 1/3rd, middle 1/3rd and the upper most part of the lower third of the leg due to easy accessibility and placement of the flaps to these areas. (As flaps can easily be transposed to these areas). All flaps, that is, Fasciocutaneous, Musculocutaneous, or local Muscle flaps were under taken as a delayed procedure after careful evaluation of traumatized limb, that is, repeated dressing, debridement and control of infection.

Results: In this study, stable wound coverage was achieved in all patients. Most of the patients were in the age group of 18 to 42 (55%), of these 90% were male. The longest duration of follow-up was 14 months and shortest was 3 months. Excellent result were obtained in Muscle and Musculocutaneous flaps while good result was obtained in 10% cases of Fasciocutaneous flap.

Conclusion: Stable coverage can be achieved by flap techniques using Fasciocutaneous Muscle of Musculocutaneous flaps. Coverage of exposed cartil bones, tendon and major vessels and adequate control of infection can be achieved by Muscle and Musculocutaneous flap in post traumatized limb. Fasciocutaneous flap (Ponten super flap) is very useful in repair of soft-tissue defect as it is a much simpler, easy to design and construct large flaps are safe due to good circulations, requires less time without any functional loss. Post-operative management is simple for both patient and staff.

Keywords: Fasciocutaneous flap, Muscle flap and musculocutaneous flap, SSG split skin graft.

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INTRODUCTION

In polytraumatized patients, compound injuries to the leg constitute a challenging problem. Inadequate soft-tissue coverage of injured limb is of prime importance otherwise may lead to necrosis of tendons, exposed bone ends and subsequent infection. Coverage of soft-tissue defect is considered to be the stepping stone toward reconstruction of deeper tissue, primarily the bone Fig. 1. The primary coverage (direct closure) of wound of leg may not be possible as: The cylindrical shape of extremity limits the amount of tissue for adequate closure and the circumference of the extremity increases with edema of trauma, tension increases in Direct closure and leads to ischemia of tissue within closed compartments. The edema limits the elasticity of the skin, primary wound closure without tension, and primary skin coverage of large soft-tissue defects of exposed bones is the essence of treatment. These are the two basic objectives of wound treatment in compound injury of leg. Infection of deeper tissues and bones is a dreadful complication which prolongs the hospital stay and thereby increasing the cost of treatment [1].

In such conditions, appropriate adequate stable skin cover is provided at the earliest to minimize the period of recumbency and hospital stay. Few techniques of primary wound closure are available: -

1. Split thickness graft (SSG) will not be accepted at avascular exposed surface, that is, bare bones tendons, across open joint.
2. Prolonged and protracted plastic reconstructive surgery in the form of distant full thickness flap is not a procedure of choice.

The local flaps in the form of Muscle, Musculocutaneous and Fasciocutaneous flaps are valuable technique that have profoundly

changed the contemporary practice of reconstructive surgery as major advancement by providing excellent single stage coverage of soft-tissue defect, with exposed bones and neurovascular structure. The donor area is grafted with SSG With more familiar with the anatomy of extremity Orthopedic surgeon is in a better position to reconstruct the soft-tissue defect, hence decreases the dependency on plastic surgeons.

METHODS

The present study included 20 cases of traumatized lower extremity having a soft-tissue defect and an exposed bone with or without associated fractures. Study was conducted from January 1989 to August 1990.

Most of the cases having a compound fracture of leg with soft-tissues defects in upper 1/3rd, middle 1/3rd leg, and the upper most part of the lower 1/3rd of leg were included in this study. Evaluation of traumatized limb for presence of neurovascular complications and the associated fracture was done. Debridement of the wound and stabilization of fracture was done before. Assessment of wound for infection, motor sensory, and vascular status was done until the wound became healthy. The was conducted with admitted patients, in the department of Orthopedics Hamidia Hospital, Bhopal, proper consents were taken before the surgery.

Definitive wound coverage was done as delayed procedure using a selected technique and at the same time split thickness skin graft was applied on the muscle pedicle flap or on the raw area created by transposition of flap.

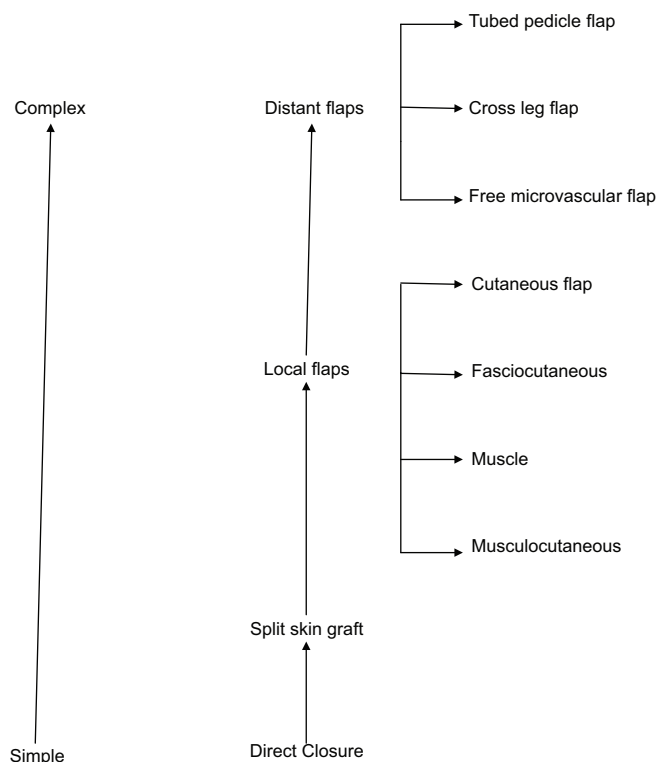


Fig. 1: Reconstructive ladder

Table 1: Aesthetic and functional consideration of Muscle flap and Musculocutaneous flap (Mathes and Nahal, 1982) [2]

Type	Muscle flap and skin graft	Musculocutaneous flap
Esthetic		
Flap	Good to fair	Excellent to fair
Donar defect	Excellent	Excellent to poor
Flap atrophy	Muscle will atrophy	Subcutaneous fat will not Atrophy
Functional		
Sensibility	No	Yes
Pliability	Fair	Excellent
Size	Limited to the size of the muscle	May be extended beyond Muscle

Procedure

The ideal flap for wound coverage was selected on the basis of the anatomical location of traumatized zone and the availability of expendable Muscle, Musculocutaneous, or Fasciocutaneous flap of suitable vascular anatomy in the adjacent healthy zone.

With all aseptic precautions under tourniquet, the wound was prepared by excising all dead tissue and scarred margins. Fixation of bone was done before applying the technique either by external/Internal fixation or by pin traction and plaster cast application.

In this series transposition of soleus muscle was done as described by Ger Muscle was fanned out to cover the raw area and at the same time the raw surface of the muscle was skin grafted (SSG).

The Fasciocutaneous flaps ("Ponten Super Flap"), along with skin subcutaneous tissue and deep fascia transposed over the wound to its distal margin without tension. Width of the distal portion of the flap should be more than the width of wound and the base of the flap should

be widened at least 3 times that of the distal end. The donor area is grafted with SSG.

In the case of musculocutaneous flaps, one head of Gastrocnemius was separated along with fascia, deep fascia subcutaneous tissue as well as skin, and whole unit transposed to the prepared wound area. Donor area grafted with SSG. Nine Fasciocutaneous flaps, seven Muscle flaps (4 Soleus and 1 Tibialis anterior), and four Musculocutaneous flaps (medial head of Gastrocnemius) were used.

In all cases, along with antibiotic, anti-inflammatory, and vasodilators were given for 5 days postoperatively.

The first post-operative inspection was done after 48 h for color discharge from stitches and position of grafted skin and the wound was inspected every 5th day till the stitches were removed.

DISCUSSION

Inappropriate management of compound injuries of the lower extremity leads to the vicious cycle described by Converg (Fig. 11). The proper approach should be to get a well-vascularized soft-tissue cover in place as soon as possible. This concept demands an aggressive initial debridement followed by aggressive wound care (Biological dressings). The timing of bone coverage must be carefully determined and must be based on sound clinical judgment. One cannot make a general statement that all compound wounds should or should not have immediate coverage with flaps. Each case must be carefully assessed in terms of the specific tissue needed and the amount of wound contamination present. Within this framework the appropriate timing of the coverage can be best determined (Maxwell and Hooper, 1979) [3].

Local flaps provide a reliable single stage procedure for the coverage of lower extremity soft-tissue defects. Distant flaps provide good coverage but these procedures are long drawn out and tedious.

Most of the patients 55% belong to the age group of 21-30 years, of these 90% were male (Table 2). Yadav (1988) described 61% in the 21-30 years age group and 92% were male. Maxwell et al. (1979) reported all 100% male in 77% 21-30 age groups. Ponten (1979) showed male predominance in 90% cases of average age of 42 years [4].

These injuries are more common in the younger age group, which was perhaps due to a more vigorous life style particularly in male.

In all cases site of injury was the crural region (Table 3) shows the different anatomical sites of injury in this series. 30% of cases reported in upper 1/3rd, 40% in middle 1/3rd and 30% cases in lower 1/3rd of leg. While in Yadav showed 30% in the upper 1/3rd, 46% in middle 1/3rd and 23% in lower 1/3rd of leg.

In this series, transposition of all flaps were undertaken as a delayed procedure after repeated dressings, debridement and controlling of infection. Yadav (1988) also delayed the procedure till the wound became healthy. Maxwell (1979) delayed the procedure till the control of infection, Mathes and Vasconez, (1982) delayed the procedure for 5-7 days. Ger (1970) suggested the use of Muscle flaps for immediate repair of traumatic defects [5].

The muscle used for achieving the soft-tissue coverage depends on the anatomical site of lesion (Arnold and Irons 1984). The Gastrocnemius muscle flap is the flap of choice in the proximal 1/3rd of leg and was used as myocutaneous flaps in four cases (Table 4). Ger and McCraw (1971) [6] and Maxwell et al. (1979) use medial head of the Gastrocnemius myocutaneous flap in compound fracture 1/3rd upper successfully in three cases [7]. Fitzgerald et al. (1985) used Gastrocnemius Muscle flap in treatment of chronic osteomyelitis. The result was satisfactory. Yadav used three Gastrocnemius Muscles for upper 1/3rd leg and 3 soleus Muscle flaps for middle 1/3rd.

Table 2: Age and sex distribution of patients

S. No	Age in years	Male	Female
1	11-20	1	--
2	21-30	10	1
3	31-40	5	1
4	41 and above	2	--
Total		18	2

Table 3: Anatomical area in the leg where flap was used

S. No	Site	No. of cases	Flaps used
1	Upper 1/3 rd of leg	6	Musculocutaneous flap Fasciocutaneous flap
2	Middle 1/3 rd of leg	8	Muscle flap Fasciocutaneous flap
3	Lower 1/3 rd of leg	6	Fasciocutaneous flap
Total		20	

Table 4: Flaps used for coverage of soft-tissue defects with exposed bone fragments

S. No.	Flap used	No. of cases
1	Musculocutaneous flap	4
2	Muscle flap with a split skin graft	7
3	Fasciocutaneous flap	9
Total		20

Table 5: Fasciocutaneous flaps used in anatomical areas of leg

S. No.	Anatomical area	No. of cases
1	Upper 1/3 rd of leg	2
2	Middle 1/3 rd of leg	2
3	Lower 1/3 rd of leg (upper part)	5
Total		9

Table 6: Muscle used in local flap

S. No	Muscle used	No. of cases
1	Gastrocnemius medial head	4
2	Soleus	6
3	Anterior tibial	1
Total		11

Table 7: Technique used for stabilization of fractures

S. No	Methods	No. of cases
1	Internal fixation	6
2	External fixation	1
3	Pin traction and plaster application	13
Total		20

Table 8: Post-operative complications

S. No	Type of complications	No. of cases
1	Infection	8
2	Necrosis of fasciocutaneous flap at distal edge	2
3	Inadequate flap coverage	1
4	Functional loss due to muscle-transposed	1
5	Loss of split skin graft	1
Total		13

Table 9: Results obtained in flap study

S. No	Flap used	No. of cases	Results
1	Musculocutaneous	4	Excellent
2	Muscle flap	7	Excellent
3	Fasciocutaneous	9 {7 cases} {2 cases}	Excellent Good
Total		20	

Soleus muscle is the most useful for covering soft-tissue defect for the middle 1/3rd of leg as suggested by Mathes and Nahal (1979), (1982), Swertz and Jones (1985) [8]. The second choice for coverage of soft-tissue defect in middle 1/3rd of leg is medial head of Gastrocnemius. In this series, five flaps of soleus Muscle was used in middle 1/3rd. Total six soleus muscle flaps were used (Table 6). Fitzgerald *et al.* 1985 used 18 soleus muscles in treatment of osteomyelitis with excellent result [9].

Tibialis anterior muscle can be used with functional preservation (Robbin 1976, Moller and Peterson, 1984) to cover the upper 2/3rd of the outer surface of tibia. It was used in one case in middle 1/3rd of leg in this series (Table 6). Yadav (1988) successfully applied the tibialis anterior muscle in one case [10].

The Fasciocutaneous super flap (Ponten, 1981) described that this flap can be used from the level of knee down to foot. He successfully used these flaps is proximal middle, a lower 1/3rd of leg. He describes soft-tissue defect of lower 1/3rd of the leg is difficult area for coverage by muscle and usually, it was covered by distant flaps but the disadvantage of this is well known. Ponten (1981) [11], described Fasciocutaneous flap very useful for soft-tissue defect of the lower leg. Soleus muscle can be used to cover distal tibia (Wright and Wakins 1981, Mathes and Nahal 1982), and it was used in one case in this series for lower 1/3rd defect [12].

Lower 1/3rd of leg is difficult area for coverage by Muscle flap and usually requires coverage by distant flap.

In this series, five cases of lower 1/3rd soft-tissue defect were covered by Fasciocutaneous flaps (Table 5). There is no problem in designing a flap measuring 18 × 8 cm. It is very easy to design and construct large flaps that are safe due to good circulation. Operation time is short for an experienced surgeon. Post-operative treatment is simple for both the patient and staff (Ponten, 1981). Barclay (1982) confirmed the reliability of the Ponten's Fasciocutaneous or "super flap" in the management of lower leg injury. The result of super flap was very satisfactory. In this series of 16 cases healed primarily and two cases, there was a marginal distal skin loss. He described the damage was superficial [13].

In the present series, two cases of distal marginal necrosis of the terminal 2 cm of Fasciocutaneous flap was noted, probably due to excessive tension in the terminal part of flap. This portion was re-grafted with SSG after 5-7 days while in another case gap was filled up by granulation tissue. Vascones *et al.* (1974) showed the excessive tension on the flap was found to be one of the causes of flap failure. In this series results were found to be very satisfactory as in all cases the flaps healed. The advantage of Fasciocutaneous flap is obvious.

The Fasciocutaneous maneuver should always be considered when one is faced with the problem of covering a soft-tissue defect on lower leg.

In the presence of infection, the use of a Muscle or Musculocutaneous flap has certain advantages over Fasciocutaneous and random cutaneous flaps (Chang and Mathes 1982 and Russell and Graham 1988) [14]. Posts traumatic infection results were satisfactory as in all cases infection were controlled. Role of Muscle flap in treatment of chronic Osteomyelitis has been emphasized by Stark (1946), Chang

and Mathes (1982), Fitzgerald et al (1985) in different series. They demonstrated that muscle provided greater oxygen delivery in cellular and non-cellular environment at the site of infection and increase of concentration of antibiotics in a fibrotic cavity in an experimental animal, Russell and Graham (1988) [15].

In almost all cases, fracture was present. These fractures were stabilized, that is, by nail, external fixator, or pin traction and plaster application. Yadav (1988) used external fixator and plaster application. Maxwell et al. (1979) used Hoffman's double frame external fixation system. He showed that Hydrotherapy, biological dressing's skin grafting and flap coverage have been made easier by its use [16].

In eight cases, there was flaring of the infection (Table 8) necessitating prolonged use of suction drain system and daily dressing until complete healing was achieved. Delayed loss in split skin graft was noted and second skin grafting procedure was done.

Kojima and Kohno (1979) pointed out disadvantage of primary grafting that oozing from the Muscle flap interferes with grafted skin, leading to necrosis and may require re-grafting. Fitzgerald et al (1985) used SSG after 48 h [17].

Functional loss due to muscle transposition was reported in one case of the Soleus muscle. Tobin (1985) used a Hemi soleus flap either proximally based or distally (reversed) transfer. It prevents plantar flexion power by Hemi soleus belly left in situ. In this series functional loss was little and the Gastrocnemius muscle overcame the function of Soleus [18].

1. In this study, stable wound coverage was achieved in all patients; the longest duration of follow-up was 14 months and the shortest 4 months. Yadav (1988) showed the longest follow-up of 10 months and shortest 4 months [19].
2. High rate of success (98%) was due to:
 - Proper selection of cases
 - Proper selection of extendable muscle and
 - Proper planning of flaps, better knowledge of the vascular pattern of muscle and skin, and meticulous aseptic technique used.

The early physiotherapy is of immense help in preventing the functional loss by strengthening synergistic muscle. Adequate aggressive debridement, fixation of fracture, proper positioning of limbs to prevent pressure on flap or pedicle was of profound importance for the success of flaps in this study.

Although the present study comprises only a small number of patients, the Fasciocutaneous, Muscle and Musculocutaneous flaps provided a single stage procedure for coverage of the soft-tissue defects of the traumatized leg. Stable wound coverage was possible with control of infection and soft-tissue coverage was possible in those cases where bone, tendon or major neurovascular structures were exposed. The results found in this study are in agreement with several other studies (Ponten, 1981, Barclay et al., 1982, Maxwell et al. (1979), Barford and Pers (1970) and Kroll et al. (1987) and Yadav (1988) [4].

RESULTS

The present study includes 20 cases. Most of the patients were in the age group of 18 to 42 years. There were only two females.

The study includes 20 cases of traumatized lower extremities (particularly the leg) which required local flap coverage for soft-tissue defects with exposed fractured bone fragments.

Most of the patients were male in the age group of 18–42 years. There were only two females. Maximum number of flap coverage was done in middle 1/3rd of leg. Fasciocutaneous flap was done in 45% cases in this series.

Excellent results were obtained in Muscle and Musculocutaneous and Fasciocutaneous flaps, while good results obtained only in 10% of cases of Fasciocutaneous flaps.

CONCLUSION

1. The most common site of soft-tissue defect in the lower extremity is leg. Stable wound coverage to exposed cortical bone, tendons and major vessels could be achieved using Fasciocutaneous, Muscle or Musculocutaneous flaps technique.
2. Fasciocutaneous flap maneuver should always be considered when facing difficulty in covering the soft tissue on the lower leg. This flap is simpler, easy to design, and can construct large flaps, that are safe due to good circulation. These flaps (Fasciocutaneous) require less time and involve less risk to the patient without any functional loss. Post-operative management is simple for both the patient and the staff.
3. Adequate control of infection was achieved using Muscle and Musculocutaneous flaps.
4. Fixation of bony fragments provided easy access to the wound by providing stability.
5. No functional deficit was noted in cases where complete reconstructions of limb were possible during the study period. The total period of hospital stay of the patient was reduced.

AUTHORS' CONTRIBUTIONS

The author Dr. R. Sadh, was principal investigator of the study, and involved in the design, conduct, and analysis, and Dr. V Pal, contributed in applying anatomical concepts, report writing, editing, and review of the manuscript.

CONFLICTS OF INTEREST

The author declares that they have no conflicts of interest

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REFERENCES

1. Arnald PG, Irons GB. Lower extremity muscle flaps. *Orthop Clin North Am.* 1984;15(3):441-9.
2. Mathes SJ, Nahal F. Selection of muscle and musculocutaneous flap in reconstructive surgery.
3. Ponten B. The fasciocutaneous flap: Its use in soft tissue defects of the lower leg. *Br J Plast Surg.* 1981;34:215-20.
4. Yadav A. Role of Local Muscle Flaps in Traumatized Lower Extremity. Thesis, Submitted for the Degree of M.S.(Ortho.), University, Delhi; 1988.
5. Ger R. The operative treatment of the advanced stasis ulcer. A preliminary communication. *Am J Surg.* 1966;111:659-63.
6. Ger R, McCraw JB. Closure of defects of the lower extremity by muscle and myocutaneous flaps in Reconstructive Surgery of lower extremity. In: Converse JM, editor. *Reconstructive Plastic Surgery: Principles and Procedures in Correction Reconstruction and Transplantation.* Vol. 7., Ch. 86. Philadelphia, PA: W.B. Saunders Company; 1977.
7. Mathes SJ, McCraw JB, Vasconez L. Muscle transposition flaps for coverage of lower extremity defects: Anatomic considerations. *Surg Clin North Am.* 1974;54:1337-54.
8. Amarante J, Costa H, Reis J, Soares R. A new distally based fasciocutaneous flap of the leg. *Br J Plast Surg.* 1986;39:338-40.
9. Nahal HW, Stern PJ, Kreilein JG, Gregory RO, Webster KL. Complications of muscle-flaps transposition for traumatic defects of the leg. *Plast Reconstr Surg.* 1983;72:512-7.
10. Robbins TH. Use of fasci-muscle flaps to repair defects in the leg. *Plast Reconstr Surg.* 1976;57:460-2.
11. Barclay TL, Cardoso E, Sharpe DT, Crockett DJ. Repair of lower leg injuries with fasciocutaneous flaps. *Br J Plast Surg.* 1982;35:127-32.
12. Barford T, Pers M. Gastrocnemius-plasty for primary closure of compound injuries of knees. *J Bone Joint Surg.* 1970;52:124-7.
13. Donski PK. Distally based fasciocutaneous flap from the sural region. A preliminary report. *Scand J Plast Res Surg.* 1983;17:191-6.
14. James ET, Gruss JS. Closure of osteomyelitis and traumatic defects of the leg by muscle and musculocutaneous flaps. *J Trauma.* 1983;23:411-9.
15. Riegels-Nielsen P, Krag C, Medgyesi S, Pers M. The repair of soft tissue defects in the lower leg. A comparison of different flap techniques. *Acta Orthop Scand.* 1983;54:772-6.

16. Tobbin GR. Hemisoleus and reversed hemisoleus flaps. *Plast Reconstr Surg.* 1985;76:87-96.
17. Kojima T, Kohno T, Ito T. Muscle flap with simultaneous mesh skin graft for skin defects of the lower leg. *J Trauma.* 1979;19:724-9.
18. Woods JF, Irons GB Jr., Masson JK. Use of muscular, musculocutaneous and omental flaps to reconstruct difficult defects. *Plast Reconstr Surg.* 1977;59:191-9.
19. Vasconez LO, Bostwick J 3rd, McCraw J. Coverage of exposed bone by muscle transposition and skin grafting. *Plast Reconstr Surg.* 1974;53:526-30.