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The Application of Free Muscle Flaps to Cover Compound and Complicated Tibial Fractures: A Three Years Experience

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ABSTRACT

Course and prognosis of open lower leg fractures are significantly influenced by the concomitant soft tissue injury. Selection and timing of therapeutic procedures determine the final outcome.

The strategic planning for management of such complex injuries needs collaborative effort from everyone involved in the management and convergence of their work to achieve the ultimate goal of restoring a functioning lower limb.

Free tissue transfer has become an integral part of the management of complex lower limb trauma. It widens the scope of limb salvage and helps to bring the patients back to their normal activity through accelerating form and function recovery.

In this series, we present a three years experience in the management of open tibial fractures, Gustilo types IIIB and IIIC, with the use of free muscle flaps and overlying skin graft for their soft tissue reconstruction.

In conclusion, free muscle flaps with overlying split skin graft should always be considered in salvage of traumatized lower limb with extensive and distal complex leg defects. Precise decision, proper selection and adequate perioperative management, besides good technique are the key points to success.

INTRODUCTION

The mission of treating open tibial fractures with advanced grades, Gustilo types IIIB and IIIC, requires careful planning between the reconstructive, vascular, and orthopedic surgeons. Ideally, each member of the team should have a special focus on limb salvage [1-6].

Particular anatomical conditions and the frequent coexistence of previous diseases or, of diseases connected to the trauma make it hard to choose the most appropriate surgical strategy and require a multidisciplinary approach. Timing and treatment modalities must be decided by different operators in order to ensure a lower risk of post-surgical complications and disabling outcomes. The need for plastic and reconstructive treatment is growing as a result both of the improvement in reconstructive techniques and of the increased incidence of major injuries [7-11].

There is consensus about the role of muscle flap in such defects. Muscle flaps conform well to these defects with significant dead space; provide tissues with rich blood supply required for optimum healing of all elements involved in such injuries; as well as achieving adequate stable wound coverage [12-15].

Regional muscle flaps, though technically easy, are not considered the optimum choice for distal or extensive leg defects. The presence of edema and muscle contusion, the possible interruption of their pedicles by trauma insult, in addition to the constrained postoperative positioning to avoid compression on the hinge point of flap rotation in those patients who are lacking freedom of mobility, are all factors that do not give preponderance to the use of these flaps [16,17].

The last three decades have witnessed many advances in microsurgery that have revolutionized the management of severe lower extremity soft tissue injuries and added new dimensions to the reconstructive repertoire increasing the scope of limb savage in complex lower limb injuries.

These technical advances have led to a new reconstructive paradigm. The emphasis in surgical decision making has shifted from the reconstructive ladder that stressed simplicity and selection of surgical procedures, based on their level of complexity, to another concept in which surgical options are selected on the basis of the quality of the anticipated results, regardless of the complexity of the procedure. Microsurgical free tissue transfer is no longer the last to resort when all else has failed. It is often the first choice when it will clearly yield a superior result unmatched by any other reconstructive method [18-23].

Several factors may influence the final outcome of free flap surgery. Although technical refinement in microsurgery has been the most important factor in achieving high success rate of the procedure, yet, selection criteria and perioperative management is of an equivalent importance to complete this success [24-27].

In this series, we present a three years experience in the management of open tibial fractures Gustilo types IIIB and IIIC with the use of free muscle flaps for their reconstruction.

PATIENTS AND METHODS

During the period between December, 2001 and November, 2004, twenty patients with compound tibial fractures associated with moderate to extensive defects of the leg (Gustilo types IIIB and IIIC) were included in this series. Seventeen patients were males and 3 were females with their ages ranged between 12-46 years (average age 28 years). All traumas were caused by road traffic accidents with variable expression of the mechanism of injury.

Five old trauma patients with variable durations were referred from other hospitals for further management of their compound tibial fracture. In 3 patients, the tibia was stabilized with external fixator and in 2 patients; there was a plate fixation of the tibia with a variable sized patch of gangrene affecting the overlying skin. In these conditions, urgent wound debridment, removal of plate and screws with application of an external fixation device was performed.

The other cases (15 patients) were presented in the emergency department of Kasr El Aini hospitals. In all patients with acute trauma, resuscitative measures were undertaken with management of concomitant injuries elsewhere in the body according to priorities. The local condition of the involved lower limb was thoroughly examined; the tibial fracture was evaluated with plain X-rays, the neurological status was assessed clinically, and the vascular status was evaluated clinically aided by a handy Doppler probe. The mangled extremity severity score was applied to select cases amenable to limb salvage [28].

Gustilo grading system was used to categorize all patients [1]. Three injuries were sorted as type IIIC and seventeen as type IIIB.

The final plan of treatment was developed. Local wound management in the form of pulsed saline irrigation with adequate debridment was performed, followed by the application of an external fixator device for tibial fracture in all cases except one patient with comminuted bicondylar tibial plateau fracture extending to the shaft in whom unsatisfactory reduction and stabilization with the use of an external fixation device was expected, in this case, radical wound debridment, double tibial plating, with immediate soft tissue coverage was planned. Vascular repair in the form of saphenous interposition grafting of the posterior tibial artery for revascularization of the distal lower extremity was needed in patients with Gustilo type IIIC in whom immediate soft tissue reconstruction was indispensable.

In the absence of an urgent need for flap coverage, the decision for soft tissue reconstruction was deferred either because of the presence of other major injury elsewhere, or the need for further debridment and wound cleaning. All wounds underwent meticulous debridement of soft tissues and bone before the definitive reconstructive surgery was decided. The number of debridment depended on the condition of the wound. One to four sessions of debridment were needed with variable intervals between them. Wound culture was performed with appropriate antibiotic therapy. The time elapsed between the accident and the definitive reconstructive surgery ranged between 5 days to 4 weeks. Attention was paid to the general condition of the patient and control of concomitant medical conditions together with correction of anemia and hypoalbuminaemia. Prophylaxis against the development of deep venous thrombosis in the form of low molecular weight heparin (LMWH) in appropriate dose was started.

Preoperative evaluation of the vascular status of the lower extremity was done in all elective cases (16 patients). Arterio-venous duplex scan was performed in all elective cases with informative reports except in 2 patients in whom full examination was not amenable because of limiting factors in the form of pain, edema, and position of the external fixator. In these patients an angiogram was performed as an alternative. Cases with evidence of deep venous thrombosis were excluded from this series.

Selection of the recipient vessels according to the finding of exploration in emergency cases with arterial reconstruction, or the findings of duplex/ angiogram, with the orientation of the available vessels in relation to the defect, in elective cases. The anterior tibial artery was utilized in 9 cases, the peroneal artery in 5 cases, the posterior tibial artery in 3 cases, while the popliteal artery was utilized in 3 cases either because of the presence of a single leg vessel (1 case) or to get above the zone of injury (2 cases). The deep veins accompanying the arteries were used when the leg vessels wee selected, while in case of popliteal artery selection, the posterior tibial vein was selected for best fit in one case and the popliteal vein was selected in 2 cases. Getting outside the zone of injury was a demand which could be achieved in all cases either through dissection of an adequate healthy segment for comfortable anastomosis in leg vessel or getting higher to the popliteal vessels.

The choice between free rectus abdominis or free latissimus muscle flaps depended mainly on the extent of defects, with the latissimus flap being used in more extensive defects (6 cases). The choice of the side of the flap depended on the pedicle/flap orientation in relation to the selected recipient vessels and their orientation in relation to the defect.

Synchronous two-team approach for preparation of recipient vessels and flap harvest could be achieved in all cases of rectus flap with the patient in supine position. In only 3 cases utilizing the cotralateral latissimus flap, this approach was feasible while the patient in lateral decubitus position with the recipient vessels being the posterior tibial or popliteal.

Instructions for warm environment, adequate hydration, adequate analgesia, anxiolytic agents, and prohibition of smoking and caffeine should be strictly followed throughout the whole perioperative period to avoid hypothermia, vasospasm, and thrombotic complications.

A preclamping Heparin bolus in a dose of 40u/kg was given intravenously together with flushing of the proximal arterial stump and the flap circulation with heparinized saline solution 100u/ml.

Microvascular anastomoses were performed with the aid of magnifying loupe (5.5x) in 17 cases with the use of operating microscope in the remainder. An end-to-end (ETE) anastomosis without the need for vein graft using 9/0 interrupted Ethilon sutures was performed in all cases utilizing the leg vessels, while an end-to-side (ETS) anastomosis with the need for vein graft using 9/0 continuous Ethilon sutures was used in cases utilizing the popliteal vessels. On using the operating microscope, 10/0 instead of 9/0 Ethillon sutures were used because of the relative smaller diameter of the flap pedicle. Saphenous vein graft was harvested from the contralateral leg.

Two venous anastomoses per flap were performed in 4 cases when 2 veins could be matched both in donor and recipient veins; otherwise one venous anastomosis was performed.

Normal saline solution irrigation was used throughout the whole phase of anastomosis, while heparinized saline solution in a concentration of 100u/ml was instilled around anastomoses just prior to declamping. Also instillation of papaverine around the recipient pedicle just proximal to the anastomosis might help in elimination of vasospasm.

The muscle flap was sutured to the defect with split skin graft applied primarily in 14 cases, while deferred as a secondary procedure, within the first postoperative week, in 6 cases.

Detection of arterial and venous Doppler signals on the surface of the flap using a handy Doppler probe, with the point of maximum intensity being marked on the surface with a blue prolene stitch for postoperative monitoring through a window in the dressing to avoid disturbing the whole dressing. Postoperatively, the flap was monitored every 2 hours for the first 48 hours then every 4 hours for the completion of 7 days. Weak or absent signal heralded urgent re-exploration in 5 cases. Arterial spasm was found in one case, venous thrombosis was found in 2 cases, and haematoma compressing the pedicle was found in 2 cases. In case with arterial spasm, anastomosis was dismantled, a fogerty catheter was introduced proximally till satisfactory flow was achieved followed by revision of anastomosis with instillation of papaverine around the anastomotic site. In case of venous thrombosis, anastomosis was dismantled, venous thrombectomy, copious heparinized saline irrigation and revision of anastomosis was performed. In both arterial and venous revisions, full therapeutic dose of LMWH was started. In cases with compressing hematoma, evacuation and wound irrigation was performed, a small vein in the field was found to be the source of bleeding in one case with no definite source in the other.

Postoperative positioning was fashioned in order to avoid compression on the flap or the site of anastomosis.

Routine postoperative prophylactic anticoagulant therapy in the form of LMWH was administered for 7 days. Administration of prophylactic broad spectrum antibiotic for an average duration of 10 days postoperatively.

Further orthopedic management was required in 12 patients. One patient for the surgical treatment of osteomyelitis and the remainder 11 patient for non-union or malunion of their tibial fracture. Internal fixation in the form of interlocking nail with bone graft was performed in 4 cases, plate and screw in 2 cases, and bone transport with Ilizarov technique in 5 cases.

RESULTS

Case presentation (Figs. 1-6), patient summery (Tables 1-3) free rectus abdominis muscle flap was used more frequently than latissimus dorsi muscle flap (14 cases, 70%) because it fits more with the longitudinally oriented leg defects. Latissimus flap was reserved only for cases with more extensive defects.

External fixation of the tibial fracture was the role in all cases, except one, in whom double plating of a comminuted bicondylar tibial plateau fracture extending to the shaft was performed.

Urgent flap coverage was needed in 4 patients (20%), one for coverage of plated tibia and 3 for coverage of vascular repair. The strategic plan in such cases required radical debridment of both soft tissue and bone followed by operative exploration of the leg vessels in ischemic cases with limb revascularization by saphenous interposition grafting of the posterior tibial artery. The anterior tibial or peroneal vessels were utilized as recipient vessels for microanastomoses.

Delayed soft tissue coverage was planned in the remainder of cases (16 cases, 80%) within a period ranged from 5 days to 4 weeks. All cases planned for delayed coverage underwent a preoperative vascular study. The non-invasive Duplex scan was tried in all cases with failure to demonstrate the required information in 2 cases in whom angiographic study was done.

The leg vessels were utilized as recipient vessels in all cases except three. ETE anastomosis was the role when leg vessels were utilized, while ETS anastomosis was performed when popliteal vessels were utilized.

The inferior epigastric pedicle of the rectus flap was found to have 2 veins collected together in one stump, with variable length, before draining into the external iliac vein. The stump was found to be too short in 4 cases in which case, 2 venous anastomoses were performed.

Satisfactory magnification was achieved with 5.5x loupe glasses in 36 anastomoses in 17 flaps while microscope was reserved for higher magnifications in relatively smaller diameter vessels of the remaining 3 flaps.

The total operative time was 6-8 hours. Synchronous two-team approach was feasible in 17 cases (85%) which effectively reduce the total operative time by 2 hours (25%).

Skin graft was delayed in the initial 3 cases at the start of free flap experience. Following that, the role was to apply the skin graft immediately except over 3 flaps. In 2 cases, operative revision of arterial anastomosis with uncertainty about the outcome of the flap deferred the decision of immediate grafting, while in the other case, the copious blood oozing from the operative field alarmed further loss from the donor site of the graft, hence delaying it.

Regular postoperative flap monitoring with a handy Doppler probe effectively reduced the overall rate of flap failure through early detection of vascular compromise of the flap with subsequent urgent intervention. In this way, three out of five vulnerable flaps were successfully salvaged. Although there was no actual vascular problem in cases with hematoma, yet the reduced signal intensity, as detected by the Doppler probe, pointed out to the compressive nature of hematoma that would ultimately induce vascular compromise. The flaps that suffered venous thrombosis, though venous thrombectomy and full therapeutic dose of low molecular weight heparin was administered, proceeded to progressive venous failure and flap loss. In such cases, the flap left in place using the Crane principle that succeeded to develop underlying granulation tissue sufficient to accept skin graft, following debridment of the necrotic flap, in one case; while in the other case, severe infection entailed flap debridment with the exposed tibia being covered at a later stage with a cross leg flap with utilization of the external fixator to adjoin a cross leg fixator.

Although free flap survival is considered all or non phenomenon, yet there was a distal necrosis in one case of rectus abdominis flap reflecting inadequate supply of the distal territory of the flap from the inferior epigastric vessels; as in such case there was no change in the Doppler signal throughout the monitoring phase.

There was no total loss of the graft over the flap, however 4 cases showed partial breakdown of the graft which healed spontaneously by repeated dressings without the need for further interventions.

Wound infection has occurred in 3 cases with concomitant partial loss of the graft over the flap. Two cases responded well to local dressing and systemic antibiotics, while a sinus discharging pus persisted in one patient that aroused attention to the diagnosis of underlying osteomyelitis. Flap edema was observed in the early postoperative period in 5 flaps which might reflect a temporary haemodynamic instability of the flap following its transfer. It responded completely to leg elevation in 3 flaps and partially in 2 flaps with minimal residual edema. Late development of flap edema occurred in 2 other cases, one after 3 months and the other after 8 months which could be attributed to lymphatic obstruction. Cases with persistent edema were treated with appropriate pressure garments after removal of the external bone devices together with prophylaxis against recurring lymphangitis.

Donor site complications in the from of hematoma, seroma or wound infection were diagnosed in 5 patients. The rectus flap donor site was less subject to complications when compared to that of the latissimus flap [one out of 14 rectus flaps (7%) in comparison to 4 out of 6 latissimus flaps (67%)]. This might be attributed to the enormous dead space left behind the latissimus muscle harvest.

No major bleeding complications occurred as a side effect of the proposed anticoagulant regimen (Fig. 7). Yet there was still minor bleeding complication in the form of hematoma formation in 2 patients (10%), with one patient developed hematoma both in donor and recipient sites.

Orthopedic complications of union was diagnosed in 11 patients with the need for further orthopedic management (55%). Stiff ankle or knee joints following the period of immobilization was found in 4 patients that responded partially to physiotherapy.

Table (1): Case study.

Case no.	Sex & Age (year)	Site of defect	Size of defect (cm)	Tibial fracture (Gustilo)	Vascular injury (with ischemia)	Nerve injury
1	M, 27	Distal 2/3	21X9	IIIC	Present	Absent
2	M, 34	Distal 2/3	15X9	IIIB	Absent	Absent
3	F, 28	Distal 1/3	12X8	IIIB	Absent	Absent
4	M, 12	Distal 1/3	10X6	IIIB	Absent	Absent
5	M, 41	Distal 1/3	13X9	IIIB	Absent	Absent
6	M, 25	Proximal 2/3	20X6	IIIB	Absent	Absent
7	M, 22	Distal 1/3	12X7	IIIB	Absent	Absent
8	F, 36	Middle 2/3	19X10	IIIB	Absent	Absent
9	M, 18	Distal 1/3	13X8	IIIB	Absent	Absent
10	M, 16	Distal 1/3	11X6	IIIB	Absent	Absent
11	M, 28	Distal 2/3	20X9	IIIB	Absent	Absent
12	M, 46	Distal 1/3	11X6	IIIC	Present	Present
13	M, 30	Middle 1/3	13X9	IIIB	Absent	Absent
14	M, 16	Distal 1/3	11X7	IIIB	Absent	Absent
15	M, 43	Distal 2/3	18X8	IIIC	Present	Present
16	M, 24	Middle 2/3	18X10	IIIB	Absent	Absent
17	M, 29	Distal 1/3	12X6	IIIB	Absent	Absent
18	M, 24	Distal 2/3	18X9	IIIB	Absent	Absent
19	M, 19	Distal 1/3	11X7	IIIB	Absent	Absent
20	M, 33	Distal 1/3	11X8	IIIB	Absent	Absent