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Soft Tissue Reconstruction of Open Tibial Fractures

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Abstract

Thirty patients admitted with traumatic open fractures of the tibia were reviewed with particular attention to soft tissue management over a period of 18 months. The injuries were classified according to Gustilo et al (1976,1984). Seven patients had Type II fractures and 23 had Type III fractures (8 type III a, 14 type III b, and 1 type III c). Patients had early and staged wound debridement and fracture immobilization. Various procedures were employed for reconstructing the damaged soft tissues. Primary wound closure was done in 1, delayed primary closure in 3, local myoplasty in 7, split skin grafting in 16, pedicle cross leg flap grafting in 4 and 6 patients had no intervention. No free tissue transfer was performed. There were no major complications with the procedures. All patients had successful wound reconstruction and uneventful fracture union.

Key words

Open fracture, Tibia, Soft tissue.

Introduction

Management of open fractures of the tibia, with extensive soft tissue damage, still remains a difficult challenge for the orthopaedic surgeon. A successful management of these injuries depends both on an adequate fracture stabilization and a viable soft tissue coverage. During the recent past, a better understanding of the soft tissue anatomy and physiology has led to the development of many useful soft tissue procedures for achieving the final goal of fracture union. Weiland *et. al.* (1) reported their experience of seven cases with severely injured legs with tibial fracture. They reported reconstruction of soft tissues by various techniques like split skin graft, local myocutaneous flaps, spontaneous epithelialization and microvascular free tissue transfer in these patients. Although free flap surgery is a useful concept, such techniques remain localized to very advanced centres which are highly equipped for such formidable surgeries. We have reviewed 30 patients with open tibial fractures to analyze the soft tissue management and results, in comparison with earlier reported series.

Material and Methods

Thirty patients with open tibial fractures were treated at the Hospital for Bone and Joint Surgery, Barzalla, Srinagar over a period of 18 months. There were 25 males and 5 females with age ranging from 10 to 70 years, with a mean age of 29.5 years. The nature of the trauma

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sustained by these patients is shown in Table1. Majority of the open fractures in the series were due to fire-arm and bomb-blast injuries.

Table 1 : Nature of Trauma

Nature of Trauma	No. of Patients	Percentage
Fire Arm Injury	11	36.66
Vehicular Accident	9	30.00
Bomb Blast Injury	2	6.67
Industrial Trauma	2	6.67
Miscellaneous *	6	20.00
Total	30	100

*Stone hit 4, Fall from height 2

The time lapse between the injury and hospitalization is shown in Table 2.

Table 2 : Time Since Injury

Time Since Injury	No. of Cases	Percentage
Less than 6 hours	15	50
6 - 12 hours	9	30
More than 12 hours	6	20
Total	30	100

Ten patients had associated injuries to other parts of the body caused by same or other injuring force. Two patients had cranio-cerebral trauma, 1 patient had closed and 1 patient had open (Type I) fracture of the contralateral tibia. One patient had open comminuted fractures of the medial 3 metatarsals and medial cuneiform bones. One patient had uncomplicated rib fracture.

Tibial Fracture

Four fractures were located in the proximal tibia, 18 in the middle third and 8 in the distal third. Out of these 7 were Gustilo Type II, 8 Type III a, 14 Type III b and 1 Type III c.

The soft tissue injury was assessed after initial surgical debridement using the Gustilo classification (2,3).

Primary Management

Patients were resuscitated and associated injuries were taken care of. Initial care consisted of analgesia, tetanus prophylaxis, Betadine scrub and saline lavage, splint stabilization and broad spectrum antibiotics.

Surgery was performed under general or spinal anaesthesia, as soon as the general condition of the patient permitted. Tourniquet was applied in special circumstances only, like profuse bleeding or very bad haemodynamic condition of the patient. A standard surgical protocol of examination under anaesthesia, wound debridement, bone stabilization and wound closure was adopted in all the patients.

Soft Tissue Management

The wound was thoroughly evaluated and meticulous attention was given to all the tissues right from skin to bone and the amount of contamination and severity of damage noted. Observations at this examination determined to a large extent the subsequent management of the injury and the fracture. After a thorough Savlon and Betadine scrub, the limb was draped with sterile sheets and the wound was irrigated with 3 liters of normal saline. The mechanical irrigation itself removed most of the contaminated material from the wound. Stepwise debridement starting from skin to bone was carried out. The dead margins of the skin were excised until dermal bleeding was encountered. Muscles were debrided with particular attention to colour, consistency, contractility and capacity to bleed. The neuro-vascular structures were isolated and examined in cases where neuro-vascular status was found impaired on clinical examination. Small fragments of bone were stripped of soft tissues and any grossly contaminated bone were discarded. Attempts were made to retain major clean bone fragments contributing to fracture stability. At the end of initial debridement, the wound was again thoroughly irrigated with 3 litres of normal saline.

Following the initial debridement, the extremity was brought to length and stabilized with either unilateral or bilateral external fixator. Bilateral fixation was used in 16 patients, while as unilateral fixation was employed in 14 patients. Unilateral fixation was especially employed in cases where subsequent wound coverage by cross-leg pedicle flap was anticipated. Additional lag screw was inserted across the fracture site in certain cases for improving the stability of bone.

A 'second - look' operation was performed in operation theatre after 48-72 hours after injury. The external fixator was dis-assembled in certain cases for thorough wound inspection. The wound bed was inspected, debridement and lavage repeated and the external fixator re-assembled. At this stage, attempts were made to close the wound or cover the fracture site and exposed bone by formal myoplasty techniques (7 patients) , using axial patterned gastrocnemius or proximally based soleus flaps. In cases with extensive injury, the area was covered with Betadine soaked gauze dressing to avoid dessication..

Plastic surgeon was consulted (4 patients) at second look surgery in cases where wound coverage by plastic techniques like cross leg flap was anticipated.

Skin procedures like delayed primary closure, split skin graft and cross leg flap, were done within 1-3 weeks depending upon the behaviour of the wounds.

Bone Grafting

In cases with major bone loss, cortico-cancellous bone grafting was done to achieve union. Grafts were taken from the ileum and contralateral fibula. Bone grafting was done while the patients were still in external fixator. The external fixator was removed when the soft tissue healing was complete and the limb was amenable to plastering techniques and partial weight bearing. The extremity was fitted with a graded compression stocking after cast removal to prevent edema of the limb.

Results

Results of Type II and Type III open tibial fractures managed by staged soft tissue and bone re-construction are presented. The present series consisted of 30 patients in the age group of 10 to 70 years and of both sexes. Table 4 shows the mode of wound management in the present series.

Table 4 : Soft Tissue Management

	II	III a	III b	III c
Primary Closure	1	-	-	-
Delayed Primary Closure	2	1	-	-
Split skin graft	3	6	7	-
Cross leg flap	-	-	4	-
No intervention *	1	1	3	1

*Spontaneous epithelialization, left alone.

Out of these, 7 patients underwent local muscle flap procedures (2 proximally based soleus and 5 axial patterned gastrocnemius) prior to split skin grafting. Two patients (out of the no intervention group) were excluded from the study, one died due to the effects of poly-trauma. Another patient underwent below knee amputation as he developed gangrenous changes in the limb distal to the fracture site. Early wound healing (within 4 weeks) was observed in 22 patients (6 Type II, 16 Type III). Five patients showed delayed wound healing (4 -8 weeks: 1 Type II and 4 Type III). In one patient the wound healed very late, as he needed cross leg flap cover for which the local condition of the wound delayed the procedure. Superficial wound infection occurred in 4 patients. All responded to conservative treatment with antibiotics. Out of 28 cases, cortico-cancellous bone grafting was done in 11 (1Type II, 2 Type III a, 8 Type III b) cases while they were still in external fixator.

Case 1 (Fig. 1,2,3)

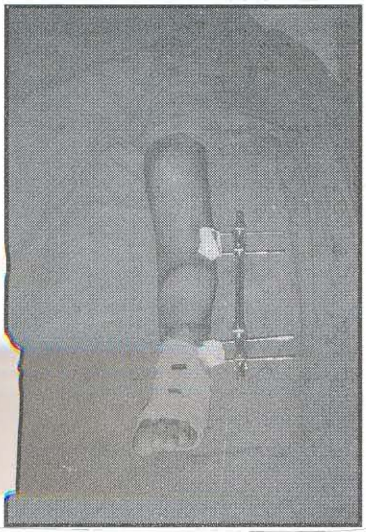

Fig. 1. Showing cross leg pedicle flap in a fire arm injury

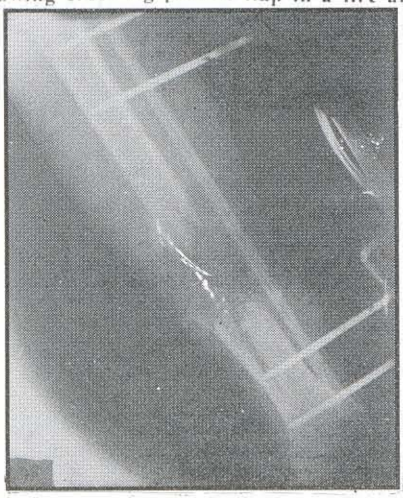

Fig. 2. Same patient with diaphyseal bone loss

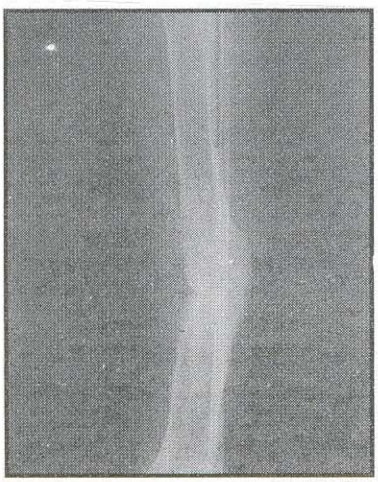

Fig. 3. Fracture united

Case 2 (Fig. 4,5,6)

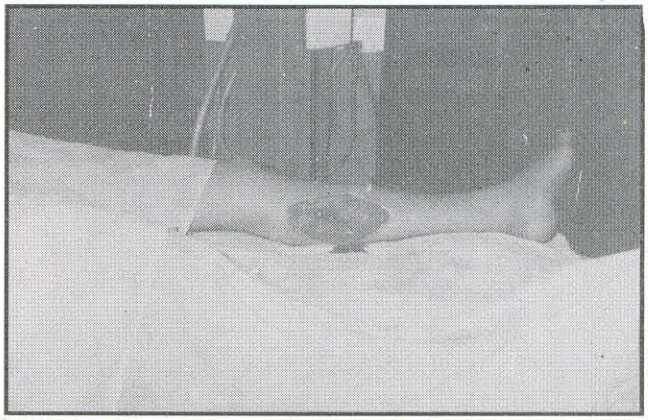

Fig. 4. Showing fire arm injury

Fig. 5. Showing comminuted fracture tibia fixed with external fixator

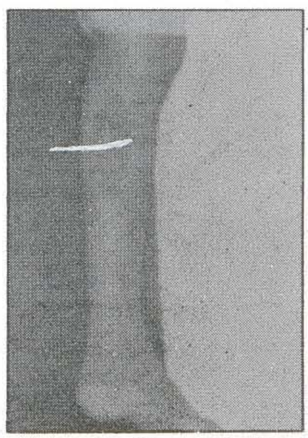

Fig. 6. Showing split skin graft. Wound healing

Complications

Complications related to the use of local muscle flaps were uncommon. Two patients developed partial necrosis of the transferred muscle which needed partial debridement. There were 2 cases of incomplete split skin graft take at the donor site. They healed satisfactorily after a re-do procedure. There were no complications related to cross leg flaps.

Complications in the present series were mainly infection [osteomyelitis at fracture site in 6 (21.4 %) and pin tract infection in 8 (28.6 %)] . This could be attributed to the fact that most of these patients reported late after being mismanaged by unqualified local medical practitioners. Pin tract infection was mostly observed in patients who were fixed with bi-lateral external fixator. There were no cases of non-union in the series.

Discussion

One of the most difficult problems in traumatology is open fracture of the leg with additional severe soft tissue damage. Tibia, because of its location, structural anatomy and sparse anterior coverage of soft tissues is particularly prone to severe open fractures.

Primary aim in the management of open tibial fractures is to return the patient to his pre-fracture activity, as soon as possible. However, because of the precarious blood supply and limited soft tissue envelope, healing of tibial fracture is quite unpredictable. Rhinelander (4,5) Gothman (6) and Whiteside and Lesker (7) have shown that bone and the surrounding soft tissues may share micro-vascular anastamoses and function in mutual symbiosis. The proliferation of vessels supplying the muscles and the periosteum accommodates the fracture callus response and leads to revascularization of the bony fragments thus leading to fracture union. Hence, a healthy and viable fracture bed is essential in achieving the ultimate goal of fracture union.

Meticulous debridement of necrotic tissue and attentive wound care have been shown to be effective therapy for open tibial fractures. Rapid reconstruction of soft tissue damage seems interesting but good efforts at rapid reconstruction following especially high energy tibial trauma may lead to undesirable and catastrophic results. The higher risk involved in rapid wound coverage may be related to the response of local tissue injury. as also to the possibility that the necrotic and infected bone may be inadvertently covered.

The aim in the management of such injuries is to obtain a live and healthy soft-tissue bed by serial debridement thus allowing maximum recovery of local vascularity and then attempting a definitive wound coverage. This protocol of management helped us in obtaining an infection free fracture environment for incorporation of a bone graft. Such protocol is beneficial especially in high energy tibial trauma (Table 1, present series), which causes massive soft tissue contusion and devitalization from energy dissipation.

The Gustilo classification (2,3) provides a useful guide to trauma severity and treatment. The distribution of injury types in our series is consistent with the observations made in other series (Table 3). Among the 23 Type III fractures, 8 were Type III a, 14 Type III b and 1 Type III c wounds.

Table 3 : Types of Wounds

Type of Wound	Goran Karlstrom[8] (1975)	Chabda P.S.[9] (1990)	Present Series
Type II	35.7%	21.1%	23.3%
Type III	64.3%	78.9%	76.7%

On a comparative analysis of the nature of trauma sustained by patients of different series it was found that open fractures are caused by major trauma, the nature of which is fire-arm injury, bomb blast injury, vehicular accidents, industrial trauma and fall from height. However, contrary to other reports the majority of open fractures in our series were due to fire-arm and bomb-blasts. The effects of such injuries on the soft tissues are more severe compared to other modes of trauma. Missile injuries lead to dissipation of tremendous amounts of energy and cavitation phenomenon in the target organ. During the passage of a missile through the tissues, it gives up energy which can be calculated from the formula $KE = \frac{1}{2} M (V_1 - V_2)$ where M is the mass, V1 is missile velocity at entry and V2 the missile velocity at exit. A rifle bullet travelling at 1000 meters per second or a bomb shell at 2000 meters per second causes severe soft tissue damage many centimeters around the missile track. In addition fragments of bone act as secondary missiles due to absorption of energy from the primary missile. Devitalization of soft tissues around the missile track provides a culture medium for the bacteria which are sucked in from the skin wound due to negative pressure created by the temporary cavity. As such these wounds behave differently from other wounds, hence the need for staged wound debridement and delayed coverage. A comparison of the nature of trauma is shown in Table 5.

Table 5 : Comparative analysis of the Nature of Trauma

	Chacha PB.[10] (1974)	Karlstrom G.[5] (1975)	Rezaian S.M.[11] (1977)	Court CM Brown EF[12] (1990)	Present Series
No to Patients	10	28	10	51	30
FAI *	1	-	1	-	11
Bomb Blast	1	-	1	-	2
Vehicular Trauma	5	24	9	46	9
Industrial Trauma	4	-	-	-	2
Miscell. #	-	4	-	5	6

*Fire Arm Injury

#Stone hit, fall from height etc.

In the present series, 71.5 percent of the patients required plastic surgical intervention in the from of local myoplasty (7), split skin graft (16), cross leg pedicle flap (4). Rest of the patients had primary or delayed primary closure or were left for spontaneous epithelialization.

Pedicle flaps offer the best solution to the problem of soft tissue coverage of Type II and Type III open fracture wounds. Such flaps consist of a strip of skin, a strip of muscle or a strip of muscle and its surface skin.

Stark (1946) first described the use of local muscle flaps (13). However, Ger (14-16) , popularized and refined the method and local muscle flap technique became widespread. The most useful and dependable donors for the lower extremity have been the medial gastrocnemius and soleus flaps. Both are based on a proximal arterial supply from the popliteal artery. Transposition muscle flap accomplishes coverage of exposed bone, management of dead space while at the same time introducing a richly vascularized soft - tissue envelope to the fracture site. Such an envelope promotes accelerated healing of the bone because it bypasses the usual lag phase required for the initiation of the healing response (17). Muscle flap is placed in the wound using only loose retention sutures and then subsequently skin grafted. This approach, we feel, is better than one stage coverage obtained by the composite mycocutaneous flap technique. In our series, utilization of this technique significantly shortened hospitalization time, involved only one or two surgical procedures and at the same time provided a stable wound coverage. Full thickness cross-leg pedicle flap was taken in 4 (14.28%) patients in our series. All these patients had severe Type III injury of the leg and all were fixed with unilateral external fixators, which proved to be of definite advantage in these patients. This is due to the fact that adjustment of the fixator for placement of the flap and consequent loss of the fracture reduction was not required. Cross-leg pedicle flaps are useful when the open fracture wound is caused by circumferential crush or blast injury or when there is associated proximal arterial injury. In these situations, the local muscle has poor or marginal blood supply and thus cannot be transposed (18).

Split thickness skin grafts have been associated with fewer problems than any of the other coverage techniques. Even in such severe injuries, as in the present series, with significant soft tissue loss, satisfactory coverage with split skin grafts alone was obtained in 53.5% of cases. This compares well with the series presented by Charles C. Edwards (19).

Even after optimal reconstruction of the soft-tissue injury, the time to union in Type III tibial fractures is often prolonged. In our series of 28 patients, 11 (39.3%) required corticocancellous bone grafting to achieve union. This observation is close to that of Goran Karlstrom (8) who reported an incidence of 42.8% in his series. Court CM *et. al.* (12) and Chabda *et. al.* (9) had an incidence of 68.6% and 68.4% of bone grafting, respectively in our series. 9.09 % of the patients who were bone grafted belonged to Type II, 19.18% to Type III a , and 72.8% to Type III b group. There were no cases of non-union at the final follow-up.

In summary, we have reviewed the soft tissue management of open tibial fractures. Local muscle flaps with subsequent split skin grafting and cross leg pedicle flaps have provided a reliable means of soft-tissue cover for Type III injuries. A clean and well vascularized soft-tissue envelope is essential in achieving an early and uneventful fracture union. It is rarely desirable to proceed with fixation and bone grafting procedures to reconstruct bony defects, until there is a healthy soft-tissue bed.

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