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Evaluation of the Results of Primary Intramedullary Nailing in Gustilo III B Fracture of Tibia

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Abstract:
Best method of bone stabilization in severe open fractures of tibia is still unclear. Intramedullary nailing for Gustilo type I, II and IIIA open fractures have been prefered most traumatologists. It's the Gustilo type-IIIB open fractures for which, the optimal method of fixation is debated.This study report the outcome of 28 cases of Gustilo type III B open fractures of tibia with Primary Intramedullary nailing.

1. Introduction

"Treat the patient, not the X-ray" ~ James M. Hunter

Infection rates in these fractures are reported to be much higher than those for grade-I and grade-II fractures: Gustilo, Merkow and Templeman (1990)4 had infection rates for grades I, II and III of 0% to 2%, 2% to 7%, and 10% to 50% respectively. The same authors also found a large difference between grade-III A and grade-III B fractures, with infection rates of 4% and 52%, respectively, but these cases were not treated by early flap coverage It is universally agreed that soft tissue injury, and it's management is the most important factor in determining the outcome of open tibial fractures, but the best method of bone stabilization in severe open fractures of tibia is still unclear. The most usual method of stabilization is by external fixation, but the advent of small diameter locking intramedullary nails has lead on to many surgeons using them as the primary management. Currently, most traumatologists prefer intramedullary nailing for Gustilo type I, II and IIIA open fractures. It's the Gustilo type-IIIB open fractures for which, the optimal method of fixation is hotly debated. It is in this setting that we report the outcome of 28 cases of Gustilo type III B open fractures of tibia

2. Aims & Objectives

To study and analyze the results of Primary Intramedullary nailing in patients with severe
open fractures of tibia.To determine the effect of treatment of soft tissue injury in prevention of major complications.To evaluate all factors related to the fracture personality, surgical intervention, functional results and complications such as infection, malunion and non-union.

To promote union of bone, achieve early functional recovery of the limb, reduce morbidity
of the patient and reduce hospital stay. To compare and share the results obtained with similar works done in the field.

3. Materials & Methods

This study was conducted in the Department of Orthopaedics, and managed in collaboration with the Department of Plastic Surgery, Bankura Sammilani Medical College Hospital on a prospective basis from January 2013 to March 2015.

3.1. Study Group

All patients who presented to Bankura Medical College and Hospital with a type-IIIB open tibial fracture, between January 2013 and march 2015 were considered for the study. Out of the 79 patients admitted with fractures of the tibia, we selected 28 patients who fitted our criteria for the study.

3.2. Inclusion Criteria

1. Open fractures of tibia, falling under type III B of Gustilo-Anderson classification system.

3.3. Exclusion Criteria

The following contraindications to intramedullary nailing were recognized:

1. Gross comminution of the tibial fracture rendering the method impractical.
2. Fractures with known arterial injury (Gustilo Type III C open fractures).
3. High tibial fractures, proximal to the tibial tubercle, and those with an intra-articular extension especially those involving the knee.
4. Low tibial fractures, those within 4 cm of the ankle, those with involvement of the ankle joint.
5. Cases which presented more than forty eight hours after injury, not debrided or attended by a surgeon up until the presentation.
6. Associated with other serious injuries or co-morbid medical conditions.
7. Pathological fractures.

Twenty-four of the fractures had been caused by road-traffic accidents (85.7%); seventeen were pedestrians and seven were car or motorcycle drivers. Of the other four fractures, three were due to falls from a height and one to a sports injury. There were additional orthopaedic injuries in six patients (21.4%) and eight (28.5%), had injuries to other body systems. Fortunately, none of the injuries were severe enough to exclude any patient from the study group.

4. Method of Study

Every patient was thoroughly evaluated at the time of admission. A detailed history of the injury was taken, noting the mode of injury, severity of injury, extent and type of trauma to the adjoining soft tissue and detailed examination of the affected part.

4.1. Initial Management

In the emergency room, the patient would be resuscitated, material from the wound taken for culture and parenteral administration of antibiotics begun. Intravenous antibiotics were continued for 72 hours after the initial procedure and for 48 hours after each additional procedure. Prophylaxis for tetanus was routinely administered.

4.2. Irrigation and Debridement

Irrigation began in the emergency room itself. Whenever the patient's general condition permitted, debridement was performed as soon as possible after injury, after the patient had been resuscitated and assessed. During debridement, extension of the original wound was avoided as much as possible. Careful assessment was made of the vascularity of all remaining soft tissue and bone left in place. Bone fragments and chips with no soft-tissue attachments were usually discarded. Relaxing incisions were made posteriorly in two patients. Debridement was repeated at 48-hour intervals until the wound was clean and all devitalised tissue had been removed.

4.3. Nailing

Nailing was done within twenty-four hours of injury in nineteen patients, and four to seventeen days after injury in the remainder. Ideally the operation was performed as soon as possible after injury.The procedure had to be postponed when the patient's financial constraints or, at times, the non-availability of patient party precluded timely surgical intervention, or when the patient's associated injuries contraindicated immediate operation. Post-operatively, all but two of the patients used posterior plaster slab at night.

4.4. Soft Tissue Cover

At the primary operation all wounds were left open; re inspection was carried out by a plastic surgeon within 24 to 48 hours. If the wounds were satisfactory, soft-tissue cover was completed. The method of cover used was decided by the plastic surgeon, and this related to the extent of damage to the surrounding soft tissues. Soft-tissue cover was obtained in each case with a muscle flap or skin graft at from 3 to 10 days after the injury. The 28 patients required seventeen rotation flaps, three fasciocutaneous flaps and four split-thickness skin grafts. In only four patients was it necessary to allow some portion of the wound to heal by secondary intention.

4.5. After Care

Post operatively the limb was immobilized in extension, after assessing the distal neurovascular status on withdrawal of anaesthesia. The limb was usually kept elevated for one or two days in bed. Cast was removed as soon as the patient tolerated movements. Check dressing was done on the third post-operative day (POD) and the sutures were removed on the thirteenth day.

4.6. Secondary Procedures

A decision with regard to the method and timing of secondary bony reconstruction was made after six weeks. The methods included open bone grafting, dynamization and exchange nailing as determined by the severity of bone loss. Exchange nailing was by the technique described by Court-Brown et al in 1991. Most of our patients, even those with delayed union, refused to undergo exchange nailing, mostly due to financial constraints and the reluctance to go through the ordeal of another surgery. Exchange nailing could be done in only two of our patients. Open bone grafting with autogenous cancellous bone from the iliac crest used either an anterior or a posterolateral approach (Harmon I 945), depending on the location of the bone loss and the state of the soft tissues. Early prophylactic bone grafting at four to ten weeks (mean six) was performed for patients with severely comminuted and segmental fractures. It was not used when there was over 75% of bony apposition or definite callus formation by six to eight weeks Dynamisation was considered if the fracture gap could not be avoided during primary surgery and in cases of radiographic absence of callus. Decision making for dynamisation or bone grafting was considered within 6 to 8 weeks after nailing.

4.7. Physiotherapy

Ranges of motion exercises with a physiotherapist were started before three weeks, but patients remained non-weight-bearing. Until toe-touching at about 14 kg was allowed at three weeks and continued until callus appeared at the fracture site. Partial weight-bearing then started provided that the fracture site was painless on examination or weight bearing. Full weight-bearing was allowed when bridging callus was visible on radiographs.

4.8. Follow-up

If the general condition of the patient remained satisfactory, and the flap healthy, all patients were discharged two weeks after the soft tissue procedure. The cases were followed up on a weekly basis in the first month, fortnightly thereafter till acceptable uncomplicated range of motion was regained. Thereafter they were called every month for follow up to assess any complications which may be developing. All operative and postoperative complications were documented, and a short questionnaire was used to assess residual pain and disability. We also assessed the ranges of knee, ankle and subtalar movement, recording restriction of movement as a percentage of full joint movement.

5. Outcome & Results

The patients were followed for periods ranging from seven months to two years with rates of infection, delayed union, non union , range of knee and ankle motion at union, amongst other variable.

5.1. Minor Bone Loss

Nine patients had AO type 42 B fractures with small devascularised wedge fragments (Table I); their mean age was 48.2 years (34 to 46). Five had bone loss of less than 50% of the bone circumference and four had loss of more than 50%. The mean maximal loss of length was 2.1 cm. All these fractures united at a mean time of 32.4 weeks (20 to 48). When exchange nailing was considered necessary this was performed at between 16 and 22 weeks. The single infection (Table III) was at the site of a skin graft after exchange nailing. After further debridement a flap was applied and there was union without recurrence of infection at 48 weeks. Seven patients with minor bone loss had regained full function at review; two had some impairment of function but had returned to work with modification of activities (Table III). One patient had 50% loss of subtalar movement but no others had any joint stiffness or ankle contracture.

5.2. Moderate Bone Loss

Nine patients had either devascularised wedge fragments of up to 10 cm in length or circumferential loss of up to 2.5 cm (Table I). Their mean age was 41 .7 years (18 to 78). There were seven AO type 42 B fractures, with mean maximal loss of 5. 1 cm (3 to 8) and two AO type 42 C fractures with losses of 2 and 2.5 cm respectively. These fractures united at a mean time of 42.6 weeks (35 to 56). Six required secondary bone grafting to promote union (Table II); five had this between 7 and 12 weeks after injury and three of these united without further surgery. One required further grafting at 48 weeks. The other two fractures were not bone grafted at an early stage as they were considered to have less severe wedge losses but both subsequently failed to unite, despite exchange nailing in one. Both fractures ultimately required open bone grafts between 20 and 24 weeks. In the two cases of infection in this group, split skin had been used to cover the soft-tissue defect. One patient with early infection after this showed devitalised infected bone at re-exploration. This was resected and a fasciocutaneous flap applied. The other patient became infected after exchange nailing. Re-exploration revealed a local purulent collection but the bone appeared healthy and only soft tissue debridement was needed. Both fractures subsequently united without recurrence of infection and with the nail still in position.Seven patients in this group regained full function with no disability but four were disabled (Table III). Two of these had dense ipsilateral hemiplegia, one as a result of a head injury and the other due to a cerebrovascular accident. Both patients had restriction of ankle movement by more than 50% with equinus deformities of 10 degree and 15 degree. The other two disabled patients were aged 72 and 78 years and had required walking aids before their injury. Both had residual discomfort at the ankle with reduction of ankle and subtalar movement by 50%. Two other patients also had asymptomatic restriction of knee, ankle or subtalar movement by less than 25%.

5.3. Severe Bone Loss

There were ten fractures with severe bone loss with a mean age of 36 years (18 to 72). Five of these fractures (AO type 42 C) had a mean loss of 7.3 cm (3 to 10), and one had a large solitary devascularised wedge fragment of 11 cm. All ten fractures united at a mean of 70.5 weeks (66 to 98). Bone grafting was performed at between 8 and 12 weeks in all cases, but was successful in only two fractures. Three fractures required a second bone graft. A synostosis between the tibia and fibula developed in two cases. The three infections in this group were all in patients initially treated by split-skin grafting to cover the soft tissue defect. The infection was controlled in two by early exploration and debridement, followed by the application of a fasciocutaneous flap. In the patient who eventually required amputation, infection persisted despite these measures and amputation was eventually carried out 44 weeks after the injury. Of the eight patients with nine united fractures, only two recovered full function. Four patients with impaired function were able to return to work or daily activities with some modification of their daily tasks. One disabled patient had a severe head injury and one had bilateral tibial fractures with bone loss. Full knee, ankle and subtalar movement was regained in only four limbs, but in four patients movements were restricted by less than 25%.

6. Fracture Pattern
Nineteen of the fractures under study belonged to AO types 42 B, and the rest eleven fractures were of AO type 42 C category.

7. Union
The union of fracture was assessed by standard radiological and clinical criteria. In 28 cases in which union was achieved, 12 fractures united within 20 weeks, 10 cases united between 21 weeks to 30 weeks and remaining 2 fractures united after 30 weeks. The rest 4 fractures went into non-union the time to union was less in cases of fractures with minor bone loss, and delayed in cases with moderate and severe bone loss. Predictably, delayed union occurred in cases of fractures with gross soft tissue injury and extensive periosteal stripping.

Time to Union	No. of Cases	Percentage
Within 20 weeks	12	42.8
21 – 30 weeks	10	35.7
30 - 36	2	7.14
Non Union	4	14.2
Total	**28**	**100**

Figure 1

7.1. Secondary Procedures
In seven patients of fracture shaft tibia of delayed union dynamization was done along with secondary bone grafting. In one fracture plate & screw fixation with bone grafting was done due to nail breakage before fracture union. In one case of distal screw site infection-distal screw was removed after fracture union. Another case of non-union required implant removal and fixation with larger diameter reamed nail insertion. Yet another case of infected non-union was managed by implant removal with sequestrectomy and fracture was fixed later with an Illizarov fixator. In one case where the injury was located at distal third of tibia, infected non union, nail migration to ankle joint occurred. In this case implant removal and interosseous fusion (by anterior approach) by cancellous bone graft was done.

8. Result of the Study Group

8.1. Pain
Only three cases had severe knee pain. One case was of broken nail and another one a case of postoperative infection. Ten had moderate pain, which was tolerable and needed occasional analgesics. Fifteen patients had mild knee pain.

8.2. Restriction of Movement (Proximal Joint)
In none of the cases there was severe restriction of movement of proximal joint in our series. In only three cases there was moderate restriction of movement. These were infected cases in which patient was reluctant to move limb due to pain and bulky dressings.

8.3. Restriction of Movement (Distal joint)
In none of the cases there was severe restriction of joint movement. In 10 cases there was moderate restriction of distal joint movement. The restriction of movement was more in fractures with severe bone loss.

8.4. Infection
In three cases was there bone deep infection. Two cases leading to chronic osteomyelitis and in two cases there was infection at distal screw site. Superficial infection developed in only 5 cases and were controlled by proper antibiotics and dressing.

8.5. Shortening
In the twenty eight fractures, disabling shortening of >2 cm were found only in 2 cases. The shortening was found mostly in comminuted fractures.

8.6. Radiological Union
In all the twenty eight cases fracture united within 36 weeks, only 6 cases the fractures united after 30 weeks. There were no cases of non union.

8.7. Patient Satisfaction

In eleven cases patients were highly satisfied with the result. In another ten cases, patients reported their results to be satisfactory. The rest seven patients were not satisfied with their results.

8.8. Ability to Walk

Out of the twenty eight fractures, twenty one were able to walk without any aid. Five cases required single crutch for prolonged duration but ultimately were able to walk without any aid. Two patients require bilateral axillary crutches for walking till date.

8.9. Squatting

In twenty cases squatting was possible without any difficulty. But in four cases squatting was possible with mild discomfort. Only in four cases squatting was not possible.

8.10. Cross-Legged Sitting

Only two cases were not able to sit cross-legged. In nine cases it was possible with mild discomfort but in the seventeen cases it was possible without any difficulty. Restriction of squatting and crosslegged sitting was mostly found in cases of deep infection cases where there was pre-existing knee stiffness

No.	Criteria	Grade I	Grade II	Grade III
1.	Knee pain	15	10	3
2.	Restriction of movement (Proximal joint)	25	3	0
3.	Restriction of movement (Distal joint)	18	10	0
4.	Shortening	12	14	2
5.	Infection	23	2	3
6.	Radiological Union	12	10	6
7.	Patient satisfaction	11	10	7
8.	Squatting	20	4	4
9.	Cross legged sitting	17	9	2
10.	Ability to walk	21	5	2

Figure 2

9. Final Results

There were 92.85% excellent or good results with only 7.14% poor results in this series

Result (Score)	No. of cases	*Percentage*
Excellent (30-24)	16	*57.1*
Good/Fair (23-18)	10	*35.7*
Poor (17-10)	2	*7.14*

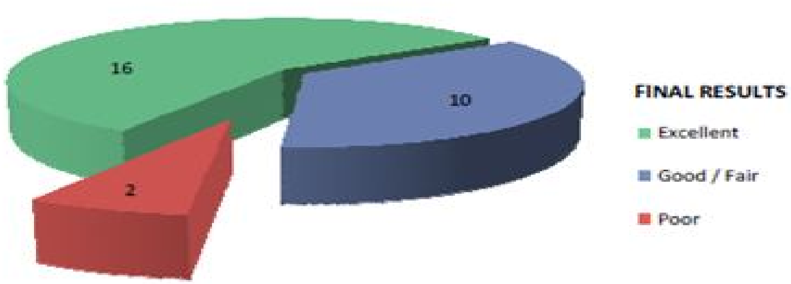

Figure 3

10. Discussion

Tibial fractures with bone loss usually result from high energy trauma which produces severe injuries to both the soft tissues and the surviving tibial fragments. Considerable delay in union must be expected with a prolonged period of treatment. In such cases the indications for limb salvage have been questioned (Hansen 1987; Heatley 1988), but improvement in techniques of bone fixation and soft-tissue cover appears to have given better results over the last 15 years. During this period primary amputations were performed for fractures with bone loss in which the limb could not be saved because of severe crush injury, severe nerve injury with loss of sensation to the foot, or irreparable vascular damage. Excluding fractures with small devitalised fragments of less than 0.5 cm in length involving less than 25% of the circumference of the tibia, there were 28 diaphyseal fractures with significant bone loss in 28 patients, with viable limbs which were suitable for intramedullary nailing.

The classification and prognosis of these severe injuries are difficult because of variation in the extent of skin degloving, muscle contusion, periosteal stripping and bone loss (Rosenthal, MacPhail and Ortiz 1977; Lange et al 1985) which are not easy to quantify. The most widely accepted classification of soft-tissue injury in open fractures is that of Gustilo and Anderson (1976), but this does not include assessment of bone loss. It has been said that Gustilo type-III B injuries with bone loss have more delay in union and require more secondary reconstructive procedures than type-III B fractures without bone loss (Court-Brown et al 1991). We have refined our classification of initial bone loss and based it on both operative and radiological findings; this has provided a more sensitive guide to the outcome.

As expected, the time to union for fractures with moderate and severe bone defects was longer than that which we have previously reported for Gustilo type-Il and type-Ill open fractures without bone loss, also treated by nailing (Court-Brown et al 1991). Union was achieved, however, in most fractures, but the time taken was directly related to the amount of bone loss. The proportion of patients who regained full function was also related to bone loss, although five of the 13 patients with impairment had either other injuries or poor function before operation. If the distal limb appears to be viable at presentation attempts at limb salvage appear to be worthwhile even in cases with severe bone loss.ISCUSSION 10

Management protocols have to be flexible because of the wide variation in the extent and severity of injury. They should provide effective guidelines for treatment during the immediate phase (6 to 8 hours after injury), the early phase (first week) and the delayed phase (after the first week). It is generally agreed that the early treatment of soft tissues and bone includes thorough excision of all contaminated and devitalised tissue and 'therapeutic' levels of antibiotics for 48 hours to prevent infection, which is the major cause of failure (Damholt 1982; Swiontkowski 1989). Although there is evidence in favour of the use of intramedullary nailing in the early treatment of uncomplicated open tibial fractures (Court-Brown et al 1991; Tornefla et al 1994), its use in fractures with bone loss has not previously been described. Most authors favour the use of an external fixator for the stabilisation of these injuries (Karlstm and Olerud 1983; Velazco and Fleming 1983; Edwards et al 1988; Buck et al 1989; Christian et al 1989).

We consider that nailing offers considerable practical advantages over external fixation. The gains include earlier weight-bearing, easier access for secondary soft-tissue and bony procedures, a reduced malunion rate and better patient tolerance. Furthermore, it avoids the risks of pin-track infection, which is seen in up to 80% of cases during prolonged external fixation (Velazco and Fleming 1983) and of late refracture.

Direct comparison with previous reports of the use of external fixation for such cases is impossible, because fractures with bone loss are usually included in the whole spectrum of open fractures. The rates of infection and of failure of treatment reported in such series, however, appear to be similar to those which we report using intramedullary nailing (Table IV).

In our series the overall average union time was 32 weeks (ranging from 20-36weeks).

Average times of union in other series were:

11. Incidence of Infection and Delayed Union in Interlocking of Tibia

	Author	Open Fractures	Deep infection		Delayed union %	Non union %	Mal union %
			Acute (%)	Osteomyelitis (%)			
1.	Zucman, Maurer	149	8	6	-	1	1
2.	Rubinstein et al	6	0	0	3	-	-
3.	Sanders (Ao-nails)	64	9	3	31	2	1
4.	Bone et al	29	7	0	4.8	-	-

Figure 4

The occurrence of Infection is considered to be the most important factor determining the ultimate prognosis (Urist, Mazet and McLean 1954; Carpenter 1966). In our series there were no early infections after early flap cover; all six infections appeared to be related to deficiencies in the early phase of soft-tissue management. Five of the six infections were controlled by further debridement and the application of fasciocutaneous flaps. The importance of the soft-tissue blood supply for both fracture healing and the survival of bone grafts has been shown experimentally (Stringa 1957; Holden 1972) and the advantages of flap cover over local skin cover have been demonstrated (Richards et al 1991). We now consider that flap cover should be the routine I treatment for soft-tissue defects in open fractures with bone loss. Theoretical arguments based on blood supply to the fracture favour external fixation, but Rhinelander in 1974 found that intramedullary nails interrupted the blood supply only temporarily and then only when there was direct contact with the cortex. Small diameter non-reamed locking nails do not require a tight interference fit, and need very little cortical contact for stability. It is also probable that early flap coverage will improve the blood supply to the fracture site regardless of the type of fixation. Other factors in the choice of method of stabilisation include ease of application, alignment, local complications, ease of secondary procedures, and available salvage procedures. Patient acceptance and ease of nursing care also matter. The use of non-reamed nails is easily learned and requires fluoroscopic control only for distal locking. In our series nailing seemed better than external fixation in providing excellent, lasting alignment, making soft-tissue procedures and secondary reamed nailing easier and improving patient compliance. External fixation is bulky, requires meticulous pin care and has been reported to have an incidence of pin-track infections as high as 80%. It also has an unacceptably high rate of infection with secondary intramedullary nailing (McGraw and Lim 1988). On the basis of our study, we recommend the use of non-reamed locked intramedullary nails for the stabilization of grade-III B open tibial fractures. The secondary bony procedures required during the delayed phase of treatment were determined by the extent of initial bone loss. Patients with minor bone loss were initially managed expectantly, although further treatment was required for delayed union in nearly half of them. It is useful to make a careful clinical and radiological reassessment of fracture healing at between 16 and 20 weeks after injury. Lack of advanced signs of union at this stage was treated successfully by exchange nailing.

11.1. Exchange Nailing

Exchange nailing for the treatment of an ununited long-bone fracture includes removal of the current intramedullary nail, reaming of the medullary canal, and placement of an intramedullary nail that is larger in diameter than the removed nail.

11.2. Effects of Exchange Nailing

Exchange nailing provides biological and mechanical effects that promote osseous healing. The biological effects result from reaming of the medullary canal, and the mechanical effects result from the use of a larger-diameter intramedullary nail.

11.3. Biological Effects

Reaming of the medullary canal increases periosteal blood flow and stimulates periosteal new-bone formation. A large portion of the cortex loses perfusion immediately after reaming because the endosteal circulation is destroyed and bone marrow blocks the intercortical canals. In response to these effects, periosteal blood flow increases in order to maintain circulation in the cortical bed. Blood flow in the cortex returns to normal or supranormal levels within days after medullary reaming. The periosteum reacts to the increased blood flow by forming new bone, which in turn aids in healing of the nonunion. Several authors have suggested that the products of reaming, which contain osteoblasts and multipotent stem cells, serve as local bone graft that stimulates medullary healing at the nonunion site. In a study of a cadaver sheep model, Frolke et al. reported that a substantial amount of reaming debris was extruded through a femoral osteotomy site during reaming of the medullary canal. In contrast, in a report on twenty-five patients with aseptic femoral nonunion, Furlong et al. stated that, in their opinion, it is unlikely that the products of intramedullary reaming can penetrate the fibrous tissue at a nonunion site to serve as bone graft in the periosteal region; however, they did not directly measure extruded reaming products. At the present time, there is no consensus in the literature regarding whether reaming products act as local bone graft in cases of nonunion. Other possible mechanisms by which reaming stimulate healing at a nonunion site includes activation of growth factors, induction of an inflammatory response and attenuation of immune system reactivity.

11.4. Mechanical Effects

A nail that has a larger diameter than the intramedullary nail that was removed provides greater bending rigidity and strength than the original nail. Reaming also widens and lengthens the isthmic portion of the medullary canal. This increases the cortical contact area of the nail, which can be improved either by enhancing mechanical stability. Mechanical stability can also be improved by increasing the length of the nail when the original nail was too short in one of the fragments. Furthermore, mechanical stability, increasing the number of interlocking screws or by using a nail that allows placement of interlocking screws that are not purely parallel to one another.

11.5. Bone Grafts

Fractures with circumferential bone loss of greater than 2.5 cm require early bone grafting (Blick et al 1989; Sledge et al 1989; Court-Brown et al 1991); this applied to all the fractures in our series with moderate or severe losses of bone. The early elective use of bone grafting at between 8 and 12 weeks for moderate bone loss appears to be justified; fractures with severe bone loss may require repeated grafting. This method of treatment is not as technically demanding as some of the more specialized alternatives such as vascularised or free segmental bone transfers (Weiland 1981; Ito, Kohno and Kojima 1984; Salibian, Anzel and Salyer 1987), bone transport (Ilizarov l989; Dagher and Roukoz 1991) or segmental bone transport over an unreamed nail (Raschke et al 1992).

The major concern with this procedure was whether internal fixation can safely be used in open tibial fractures on the day of injury with plates and rigid intramedullary nails have stressed the high rate of infection. The theoretical arguments against the use of intramedullary nailing as a method of primary bone stabilization in open tibial fractures have not been borne out in practice and the use of this technique offers considerable advantages over external fixation. The strict wound care and the relatively a traumatic insertion, with the unreamed technique, of small diameter nail crossing the fracture site makes this a feasible procedure in open fractures. In this series, the extent of soft tissue damage was not a contraindication excluding an appropriate fracture from treatment by this technique.

12. Conclusion

We consider that the successful treatment of tibial fractures with bone loss depends on maintaining a satisfactory infection-free environment for bone healing. This implies immediate wound toilet with excision of all tissue of doubtful viability, fracture stabilisation, early reconstruction of the soft-tissue envelope with a well vascularised flap, and secondary bony reconstruction according to the severity of bone loss.

The paramount principle of treatment of open tibial fractures is the creation of a suitable environment for healing, for which reconstruction of the soft-tissue envelope and stabilisation of the fracture are crucial. Although the general principles of aggressive debridement, stabilisation, antibiotics, early soft-tissue cover, and early prophylactic bone grafting are accepted, it is not yet clear which the best method is for stabilising type-IIIB fractures. The factors which are prejudicial to union are the initial displacement, comminution, associated wounds of soft tissue, and infection, the last being the most potent cause of delayed union and non-union. It is the purpose of this paper to report on a series of open fractures of the tibia caused by high-energy trauma and thus help in a small way in refining the management of fractures of this kind. One of the major problems we faced in the management of our series of open tibial fractures, was infection. The explanation offered for the higher rates of infection in our study is the delay in initiating the primary procedure before the infection sets in the contaminated wound. All cases of infection were noted in cases which had a delayed presentation (more than 12 hours after injury), or a delay in management (more than 24 hours). Early cover not only reduces infection, but also improves the blood supply to the healing bone. Early stabilization of the fracture greatly facilitates the care of the soft-tissue wound and prevented pressure on devitalized areas of skin by angulation of displaced bone ends.

It has been our experience that intramedullary nails are of benefit in the primary stabilization of a tibial fracture, especially in multiple and complicated injuries such as encountered after traffic accidents. In this series, the use of intramedullary nails for internal fixation did not lead to an increased incidence of infection. On the contrary, primary osteosynthesis with nails offers a certain security against serious infection, as it provides adequate immobilization of unstable fracture fragments. Meticulous primary wound care by sharp excision and the wound is the crucial part of the initial treatment and is responsible for the success of primary healing in the majority of the fractures. Based on this series, it can be stated firmly that this procedure is a safe method for stabilizing unstable tibial fractures. It does not require complicated instrumentation and it can be learned easily by any orthopaedic surgeon.

We conclude that the protocol produces satisfactory results in the management of these difficult fractures, and that intramedullary nailing offers considerable practical advantages over other methods of primary bone stabilization.

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Annexure

Clinical Photograph

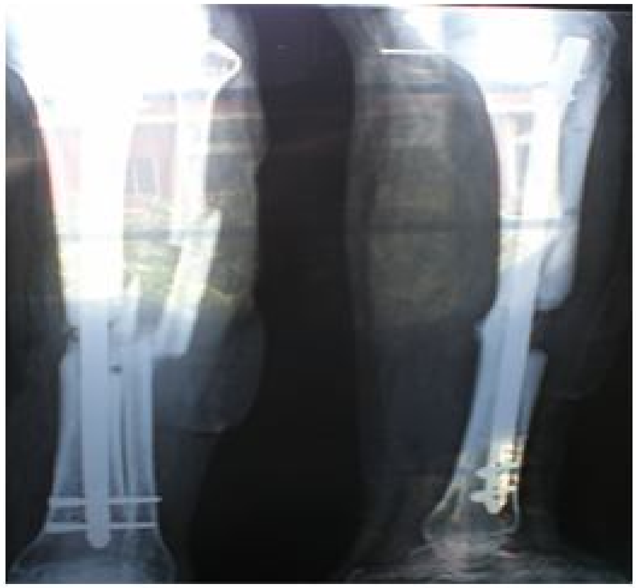

Figure 1: Post operative x-ray of a patient having Gustilo type IIIB wound

Figure 2: Clinical photograph of the same patient after healing of the wound

Figure 3: Clinical photograph of the same patient showing full flexion

Figure 4: Clinical photograph of the same patient showing full extention