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Study of functional outcome of management by external fixation followed by definitive internal fixation in compound tibial fractures

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Abstract
Aim: To study the functional outcome of compound tibial fractures managed by external fixation followed by definitive internal fixation.
Methodology: This prospective study was done from November 2016 to November 2018, for a period of 24 months, in Department of Orthopaedics & Traumatology, Osmania General Hospital, Hyderabad. Patient with compound tibial fractures meeting all the inclusion criteria were treated by external fixation followed by definitive internal fixation, later followed up regularly to check for functional outcome of the fracture in terms of fracture union both clinically and radiologically, improvement in leg motion, ability to walk.
Results: In our series, Male predominated with the ratio of 9:1. In our series, RTA was the predominant cause of injury. In RTA, 2-wheeler Vs. 4- wheeler was the most common (10 cases). In our series, 23% of the patients had Associated Injuries. Most of the fractures were in middle half of the tibia. average time to admission after injury was 9 hours (Minimum of 1½ hours to 45 hours). In cases referred from outside Hyderabad average time to admission after injury was 15½ hours. In our series, average time from admission to surgery (External fixation) was 6½ hours (minimum of 1 hour to 14 hours). Union was observed in 11 of the 13 patients. The mean time to union was 27 weeks (range 20 weeks to 40 weeks). The timing of secondary intramedullary nailing in our study shows that Grade II open fractures were undergone nailing with average of 11.8 days with the range of 6 -20 days. Grade III A fractures have undergone nailing with average of 30 days with the range of 14 – 48 days. For grade III B fractures nailing was done with the average of 32.5 days ranging from 28– 45 days. The final outcome mainly depends on the age of the patient, time of admission since injury, type of injury. Good result is favoured by the debridement technique, appropriate selection of timing for external fixation and intramedullary nailing.
Conclusion: Early intervention and aggressive soft tissue management in open tibial fractures result in decreased number of procedures, minimal hospital stay and early return to their daily routine.

Keywords: tibial fracture, soft tissue management, associated injuries, intramedullary nailing, functional outcome

Introduction
An open fracture is a fracture that involves a break in the skin with soft tissues communicating with the fracture or its hematoma, or both. The tibial shaft is one of the most common sites of an open fracture. Due to high prevalence of complications associated with these fractures, management often is difficult, and the optimum method of treatment remains a subject of controversy. Most of them are due to road traffic accidents followed by fall, sports activities, blow / assault, gunshot injuries and other rare injuries like blasts [1-5].
Open injuries of tibia are associated with twice the amount of contamination than other open fractures. Good results have been achieved with better understanding of the importance of serial wound debridement and early soft tissue cover for open fracture. Secondary reconstructive procedures are difficult due to subcutaneous nature of the tibia. Reliable cover of traumatic musculocutaneous defects can be achieved with free flaps and advancement made in the micro-vascular techniques.
Progressive refinements in the fixation of fractures and early bone grafting have resulted in a shorter time to union.

The combined treatment of both the soft-tissue and skeletal components of severe open tibial fractures by dedicated teams commonly the orthopaedic surgeon plastic surgeon has further improved outcomes and reduced morbidity [6].

Open fractures have a higher infection rate and it increases with increasing severity of soft tissue injury. The risks of delayed union and non-union increases with increasing comminution. The treatment, prognosis and outcome are mainly determined by the mechanism of injury, degree of comminution, soft tissue injury and displacement [7-9].

Our study is to highlight the important role of external fixation followed by a definitive internal fixation in compound tibial fractures. external fixation is a method of immobilizing fractures by means of pins fast through the skin and bone. In external fixation, a minimum of metals exist inside the tissue. The fracture elements maybe realigned, distracted or compressed while the wound area is well exposed due to which local lavage, flushing, dressing and other wound managements are easy and convenient causing minimal discomfort to the patient. Since external fixator system provides micro motion at facture site it helps achieve stable fixation of limb permits healing of fracture and famous fracture union. After healing of external wound or wound management by grafting or flapping and the skin condition is healthy, the patient can be taken for definitive internal fixation by plating, nailing or screwing. In this scenario my discussion focuses on evaluating the functional outcome of compound tibial fractures managed by external fixation followed by a definitive internal fixation.

Aim of the study

To study the functional outcome of compound tibial fractures managed by external fixation followed by definitive internal fixation.

Materials and Methods

This prospective study was done from November 2016 to November 2018, for a period of 24 months, in Department of Orthopaedics & Traumatology, Osmania General Hospital, Hyderabad. Patient with compound tibial fractures meeting all the inclusion criteria were treated by external fixation followed by definitive internal fixation, later followed up regularly to check for functional outcome of the fracture in terms of fracture union both clinically and radiologically, improvement in leg motion, ability to walk. The goal of surgical treatment includes the restoration of the functional integrity and strength of leg along with preservation of tibial anatomy and functional restoration.

Inclusion criteria

- Age 18-60 years, both males and females.
- Compound tibial fractures (proximal, middle, distal).
- Compound tibial fractures of any duration.
- Gustilo and Anderson Grade II, III A and III B compound tibial fractures presenting to our hospital.

Exclusion criteria

- Grade I and Grade III C open tibial fractures.
- Patients with co-morbidities, who are not fit for surgery.
- Patients managed by Plating, LRS, Ilizarov.
- Age below 18 years.

Results

Age incidence

Patients' age ranged from 15 to 60 years. Average: 37

Table 1: Age Incidence

Age in yrs	No. of Patients
18 – 30	15
31 – 40	4
41 – 50	8
51 – 60	1
61 – 70	3

Sex incidence

In our series, Male predominated with the ratio of 9:1.

Table 2: Sex incidence

Sex	No. of Patients
Male	28
Female	3

Mode of injury

In our series, RTA was the predominant cause of injury. In RTA, 2-wheeler Vs. 4- wheeler was the most common (10 cases).

Table 3: Mode of injury

Mode	No. of Patients
RTA	25
Fall of heavy weight	2
Assault	1
Industrial	1
Buffalo stampede	1
Wood cutter injury	1

Place

In our series, nearly half (45%) of the patients were referred from other hospitals.

Table 4: Place of injury

Place	No. of Patients
Hyderabad	17
Referred from outside Hyderabad	14

Referral time: Minimum of 1½ hour to the maximum of 45 hours.

Side

In our series, Right side was more common

Table 5: Side involvement

Side	No. of Patients
Right	18
Left	13

In our series, Right side was more common.

Associated injuries / fractures

In our series, 23% of the patients had Associated Injuries

Table 6: Associated injuries / fractures

Fractures	Injuries No. of Patients
Head Injury	2
Posterior dislocation hip	1
Tibial plateau	1
Metatarsal fracture	1
Distal radius fractures	1

Time delay to surgery

In our series, average time to admission after injury was 9 hours (Minimum of 1½ hours to 45 hours). In cases referred from outside Hyderabad average time to admission after injury was 15½ hours. In our series, average time from admission to surgery (External fixation) was 6½ hours (minimum of 1 hour to 14 hours). In our series, total time delay from injury to surgery (Ext Fix) was 15½ hours. For the patients referred from outside it was 23 hours.

Classification of soft tissue injury

We classified the open fractures of tibia according to the Gustilo and Anderson *et al*. classification. Among 31 patients:

Table 7: Classification of soft tissue injury

Grade	No. of patients
II	15
IIIA	12
IIIB	4
Total	31

Table 8: Anatomy of fracture

Type of Fractures	No. of Fractures
Transverse	8
Oblique	9
Comminuted	12
Segmental	1

In our series, nearly 40% of fractures were comminuted.

Location of fracture

Tibia was divided into 4 quarters from A to D.

Table 9: Location of fracture

Location	No. of Patients
A (Proximal ¼)	1
B (Upper middle ¼)	14
C (Lower middle ¼)	11
D (Distal ¼)	4

In our series, most of the fractures were in middle half of the tibia.

Treatment protocol

On receiving the patients, we resuscitated them according to advanced Trauma life support guide lines in our Trauma ward. Patients were specifically examined for other associated injuries. Patients were hemodynamically stabilized. Injection Tetanus Toxoid was given to all of the patients. All the patients were given 2g of Cefotaxime at admission. Inj. Diclofenac and Inj. Pentazocine were used for pain relief.

Wound inspection & Classification

After temporary stabilization, wound was inspected and preliminary typing according to Gustilo and Anderson was made. Plastic Surgeon's opinion was obtained in all patients, in the initial wound examination itself. If the wound is clean, wash with saline and betadine was done. Then sterile dressing and above knee slab was given. If the wound is contaminated with external dirt, preliminary wound wash was given.

FLOW study

(Fluid Lavage of Open Wounds) standardize the minimum amount of soap or saline solution based upon the severity of open fracture wound according to the Gustilo- Anderson Classification

- Type I - 3 Litres
- Types II and III - 6 Litres.

Sterile dressing and Thomas splint were applied. Inj. Tetanus antiglobulin 500 I U was given in patients with gross contamination. All patients were shifted for investigations after resuscitation and preliminary examinations. Good quality antero-posterior (AP) and lateral (Lat) X-Rays including knee and ankle were taken for the involved limb and other necessary X-Rays were taken to rule out associated fractures. CT-Brain and Ultra-sound was taken in necessary patients.

External fixation

Patients were taken to operation theatre after preliminary anesthesiological assessment. At the time of starting anaesthesia second dose of Inj. Cefotaxime was given to all of the patients. Dressing was opened in the theatre. Limb was prepared for surgery. Thorough wound debridement was done layer by layer after adequate extension of the wound. Fracture ends were debrided and freshened.

Loose fragments which were smaller and without soft tissue attachments were removed. Fragments with soft tissue attachments were retained as much as possible. Adequate irrigation was done with normal saline. After thorough debridement the wound grading was done as per Gustilo and Anderson method. Plastic Surgeon's opinion was sought in five cases during external fixation.

After ensuring thorough debridement, fracture was stabilized with external fixation to aid the wound healing and infection control. All Grade II wounds were closed primarily.

All Grade III A wounds were closed primarily or split skin grafting was done. For Grade III B wounds flap cover [46] was done. 2 muscle flaps and 2 fasciocutaneous flaps were done with the help of plastic surgeons after third and fourth weeks of injury respectively.

Post operative protocol for external fixation

All patients were started on injection Cefotaxime and Amikacin depending on the age and renal parameters. For Grade II and Grade III patients, appropriate antibiotics by culture and sensitivity were continued for 3weeks with ESR and CRP monitoring. For Grade III B fractures, same antibiotics with Metronidazole were continued for 2 weeks. During dressing wound was inspected for signs of infection on every alternate day. Culture and sensitivity was done when there was any sign of infection and repeated every week when there was infection. Antibiotics were changed accordingly and were given for extended period of 3 - 4 weeks. Post-operative antero- posterior and lateral X-Rays were taken to analyse the fragment alignment and their ends. Once the wound got settled from infection clinically, microbiologically and by serial monitoring of CRP & ESR, then patient is assessed for secondary intramedullary nailing. Weight bearing was delayed for comminuted fractures and type III compound wounds for stable statically locked fractures weight bearing was started as soon as the patient tolerates. All uncomplicated Grade II, Grade III A fractures & all Grade III B fractures were retained till adequate healing occurs. If the wound is healing and healthy with good alignment, external fixation was removed and patellar tendon bearing cast was given to ensure adequate knee mobilization for three weeks. Then planned for internal fixation with interlocking nailing.

Internal fixation with intramedullary nailing

Careful patient selection was done with

- Clinically healed wound
- No growth in culture & sensitivity
- Normal ESR & CRP

Fracture pattern was carefully studied. Length of the nail was decided with Tibial tubercle – medial malleolar distance (TMD). The TMD is determined by measuring the length between the highest points on the medial malleolus and Tibial tubercle. Diameter of the nail was determined with lateral X-Ray and according to the comminution & segmentations.

Patients were taken to operation theatre after preliminary Anesthesiological assessment. Prophylactic antibiotic Inj Cefotaxime 1gm intravenous was given to all of the patients 30 min before surgery. Limb was prepared for surgery. Fracture ends were debrided and loose fragments were removed. Adequate irrigation was done with normal saline.

We used either split Patellar or medial para patellar approach (3cases) for entry point identification. We reamed the medullary canal up to the measured nail size. Proximal locking was done with the help of Jig. Distal locking was done with either distal locking Jig or freehand technique under C-arm. Most of the cases distal locking is done with the jig and confirmed by the guide wire. Out of 31 cases, 11 were open nailing and the rest 20 were closed nailing. Those which crossed 3 weeks of external fixation, had difficulty in closed nailing.

Post operative protocol for interlocking nailing

All patients were started on Inj Cefotaxime and Amikacin depending on the age and the renal parameters. Same antibiotics were continued till suture removal. Post-operative antero-posterior and later X-Rays were taken and analysed for nail length, locking and stability of the fixation. First look dressings were done on 3rd post- operative day. Dressings were changed frequently whenever there was soakage. After that dressings were changed on alternative days. During dressing wound was inspected for signs of infection like warmth, swelling, skin induration, and bulging of the sutured ends. Culture and sensitivity were done when there was any sign of infection. Culture and sensitivity were repeated every week when there was infection. Antibiotics were changed accordingly and were given for 4 – 6 weeks.

We started static quadriceps exercise and toe movements on the second post- operative day. Knee mobilization with quadriceps exercise started as soon as the pain subsides.

Weight bearing was delayed for comminuted fractures and type III compound wounds for stable statically locked fractures weight bearing was started as soon as the patient tolerates. Partial weight bearing was started for Grade III and comminuted fractures once the callus formation was seen.

All uncomplicated Grade II and Grade III A, fractures were discharged after second look dressing (POD - 5) of the wound. All complicated and Grade III B fractures were retained till adequate healing occurs and the wound is inspected on every day.

Follow-Up we advised

- Static/ Dynamic quadriceps exercise & knee mobilisation - started as soon as pain is tolerated
- Suture removal on 10th day.
- Monthly follow-up for first 3 months.
- Every 3 months up to union and every six months afterwards.
- Weight bearing - not allowed since radiological and clinical evidence of union is achieved

Observations

Type II Fractures

Union was observed in 11 of the 13 patients. The mean time to union was 27 weeks (range 20 weeks to 40 weeks). Dynamization alone was done in one patient. Dynamization followed by bone grafting was done in another patient. For infective non- union seen in one patient, posterolateral bone grafting was done and for non-union in other patient bone grafting was done. Results of these patients were awaited. No patients had undergone implant exit and LRS, Ilizarov after nailing.

Type III A Fractures

Union was observed in 7 of the 10 patients. The mean time to union was 31 weeks (23-37 weeks). Prophylactic bone grafting was done in 1 patient. Aseptic non- union was seen in one patient in whom bone grafting [10] was done. Infective non-union was seen in two patients, for which antibiotic exchange nailing has been planned.

Type III B Fractures

Two of the four type III B fractures united in average time of 47 weeks. Out of the 4 patients muscle flaps was done in 2 patients and fasciocutaneous flaps in 2 patients. 3 patients developed infection, for which appropriated antibiotics were given. One patient required wound debridement. Dynamisation was done in 1 patient. Union achieved in 1 infected patient following posterolateral bone grafting. Wound debridement and bone grafting were done in 1 patient and wound debridement, antibiotic coated exchange nailing with bone grafting in 1 patient. Results are awaited for the 2 patients.

Table 10: We assessed the outcome with Karistorm-Olerud criteria

Grade	No. of Cases	Union	Dynamisation	Bone Graft	Time (Wks) Avg.	Deep Infection	Non Union	Aseptic Non Union
II	13	11	2	3	27	1	1	1
IIIA	10	7	1	1	31	2	2	1
IIIB	4	2	1	3	47	3	2	-
Total	27	20	4	7	35	6	5	2

Complications

Early

- Alcoholic delirium developed in three patients. They were treated with i.v. fluids, diazepam and Thiamine.
- Superficial infection was seen in five patients
- Fasciocutaneous flap necrosis occurred in two patients
- Split skin graft necrosis occurred in one Grade IIIA patient and one Grade IIIB patient which were allowed to granulate because of superficial infection.

Late

- Deep infection developed in six patients (Grade II-1, Grade IIIA – 2, Grade IIIB – 3) and all developed Non-union.
- Aseptic Non-union in two patients.

- Ankle stiffness in 1 patient and movement restriction was noted in 3 patients.
- Anterior knee pain was observed in 4 patients.
- Hyper pigmentation of flap was noted in 2 patients

Discussions

External skeletal fixation has become the treatment for severe open tibial fractures despite the problems of malunion and pin-tract sepsis associated with its use. In early years intramedullary nailing using unreamed unlocked nails had produced good results in type III open tibial fractures but the method did not adequately stabilize comminuted or segment fractures. Then reamed interlocking nailing have become the answer for this without increasing the rate of infection. Recently treatment for open tibial fractures has evolved into a stage where primary nailing and early soft tissue cover [49] became the prime method of treatment.

In our hospital immediate wound debridement with or without external fixation and cast immobilization followed by elective interlocking nailing is the routine for grade I and grade II open tibial fracture. Wound debridement and External fixation followed by repeat wound debridement after 72 hours and elective delayed primary cover followed by internal fixation is the method of treatment for grade III fractures.

The timing of secondary intramedullary nailing in our study shows that Grade II open fractures were undergone nailing with average of 11.8 days with the range of 6 -20 days. Grade III A fractures have undergone nailing with average of 30 days with the range of 14 – 48 days. For grade III B fractures nailing was done with the average of 32.5 days ranging from 28– 45 days.

We have done 31 cases out of which we have lost the follow up of 4 patients. We have analysed union, infection and functional outcome in the remaining 27 patients. In our study average time to union was 35 weeks (grade II – 27 wks, grade IIIA – 31 wks, grade IIIB - 47 wks). Grade II fractures results were comparable with the previous studies (Averaging 23.5 wks in Court-Brown *et al*). One required dynamization and another required dynamization and bone grafting. Grade III fractures union time is comparable with the previous studies.

One Gr III A and one Gr III B patient had bone grafting. Dynamisation was done in one Gr III B patient.

Our union rate was on par with other studies. Infection was noted in 6 patients, 5 were early infections (Gr II- 1, GrIII A-2 and GrIII B-3) and one (GrIII A) being late. Three of them were (Gr II-1, GrIII A- 1, GrIII B-1) taken up for external fixation after twenty-four hours and all of them were referred from places outside Hyderabad. Probably this delay in initiating the treatment could have been the reason for infection. Two of the three Gr III compound fractures developed infection following flap necrosis.

Comparing the other studies, the infection rate following sequential nailing was comparable or better. Non-union developed in 7 patients out of which 2 being aseptic nonunion. These two aseptic nonunion were diagnosed to have delayed union for which bone grafting was advised but the patients were not willing to undergo any procedure at that time. Bone grafting was done in these two patients later after a trial of dynamization [11].

In our study non-union rate was similar to the external fixation group but morbidity associated with external fixator was there. On comparing with other studies, high rate of non-union was due to delay in secondary intervention. In 5 out of the 7 cases secondary intervention has been done and results are awaited. Though there is high rate of non- union, functional outcome assessment by Karlstrom & Olerud score was excellent to satisfactory in 25 patients and poor in only two patients.

Anterior knee pain [12] was noticed in four patients but all of them were done through medial Para-patellar approach.

Fig 1: Case No.1, 34-year-old male, Grade III b

Fig 2: Intramedullary nailing

Conclusion

Primary interlocking and primary closure produce excellent results in Gr I and Gr II fractures as compared to any other modality of treatment.

Primary interlocking nailing and primary closure as a single staged procedure required fewer number of secondary procedures as compared to external fixation and secondary nailing.

Due to various reasons like delayed referral, heavy contamination with road traffic accidents, emergence of multi resistant organisms, the compound wound requires thorough wound debridement, multiple liberal and repetitive wound wash with skeletal stabilization by external fixation.

Functional outcome of secondary intra medullary nailing after external fixation was far better than in primary interlocking with primary closure in our institution.

The average days for secondary intramedullary tibial nailing after external fixation for Grade II, Grade III A and Grade III B were 11.8, 30, 32.5 days respectively.

Although the superficial infection is there and there is delay in definitive procedure in the management of compound fractures, this can be improved by early surgical intervention, timely secondary procedures and accurate assessment of soft tissue injury. The final outcome mainly depends on the age of the patient, time of admission since injury, type of injury. Good result is favoured by the debridement technique, appropriate selection of timing for external fixation and intramedullary nailing. Early intervention and aggressive soft tissue management in open tibial fractures result in decreased number of procedures, minimal hospital stay and early return to their daily routine.

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