

ORIGINAL RESEARCH

Does deformity following grade III B diaphyseal fractures impacts the functional outcome of the patients?

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ABSTRACT

Background: Tibial fractures are high-velocity injuries and are prone to be open fractures due to their subcutaneous nature. The study aims to compare functional outcomes following grade III B fractures of the tibia and to study the correlation between the functional outcomes of a limb following fractures of the tibia with a functional clinical score. **Methods:** This was a study involving all cases of open diaphyseal fractures of the tibia treated in the Department of Orthopaedics, Christian Medical College, Ludhiana, Punjab. The period of study was retrospective from 1 January 2000 to 31 December 2005 (6 years) and prospective from 1 January 2006 to 31 December 2006 (1 year). The total follow-up period was 1 year.

Results: Varus deformity was associated with all types of AO fracture patterns. The greatest deformation was observed in the 29-38 years age group. Valgus deformity was most common in the 29-38 years age group, most of which were associated with his AO type C3 fracture (85%). Shortening occurred primarily in associated with C3-type AO fractures (80%). Overall, knee stiffness was lower in all age groups compared to ankle and subtalar stiffness. Gait patterns changed in all age groups. Return-to-activity rates were very low in the 18-28 and 39-48 age groups.

Conclusions: External fixator remains the treatment of choice in the Indian scenario with better cost-effectiveness and early functional return. The younger age group had a better outcome than the older group. However, despite malunion and shortening, patients may have excellent/good outcomes.

Key words: Functional outcome, grade III B fractures, shaft of tibia

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INTRODUCTION

Tibial fractures are high-velocity injuries and are prone to be open fractures due to their subcutaneous nature. Gustilo Anderson in 1984 classified them depending on the severity. According to their classification, Grade III B fractures are those, which are open with periosteal stripping needing coverage. Various authors have reported a high incidence of complications such as non-union, and chronic osteomyelitis in treating these open fractures.¹⁻⁸ The demands that severe salvaged tibial fractures place on the surgeons and patients are well recognized. There tend to be prolonged periods, during which the patient is absent from work and home. These socioeconomic considerations are often given less importance than warranted, as these parameters also determine the success or failure of our treatment. The return of function of the limb and overall patient function was

regarded as a success. This study was taken up to compare functional outcomes following grade III B fractures of the tibia, also to study the correlation between the functional outcomes of a limb following fractures of the tibia with a functional clinical score.

METHODS

This study included all cases of open diaphyseal fractures of the tibia treated in the Department of Orthopaedics, Christian Medical College, Ludhiana, Punjab. The period of study was retrospective from 1 January 2000 to 31 December 2005 (6 years) and prospective from 1 January 2006 to 31 December 2006 (1 year). The total follow-up period was 1 year.

SELECTION OF PATIENTS

The open grade III B fractures of the skeletally mature

tibia 5 cm below the knee joint and 5 cm above the ankle joint were included in the study. All fractures extending into the knee and ankle joint were excluded. Fractures occurring in the age group less than 18 years and more than 70 years were excluded. The diaphyseal fracture of the tibia was classified according to the AO classification. Retrospective cases were called for follow up by writing letters or phone calls. The necessary information was obtained from the hospital records of patients as well as from the assessment of these patients at follow up. Prospective cases were followed from day one. Assessment of all the cases was done as per the proforma attached. Ethical clearance was obtained from the institutional ethics committee before embarking on the study.

STATISTICAL ANALYSIS

Data collected were entered in MS excel 2010 and analyzed using SPSS version 24.0, descriptive statistical measures like percentage, mean and standard deviation were applied.

RESULTS

Thirty-six patients were included in the study and data was analysed accordingly (N=36). The most number

(38%) of patients were in the 29-38 years age group. The mean age in this group was 33.2 years. It showed that this type of injury was common in young individuals. The study showed male predominance with 35 (97.2%) cases. Road traffic accidents (RTA) were the most common mode of injuries comprising 91% of the cases. Both sides were equally injured in the study (Table 1).

According to AO classification, C3 fractures were the most common pattern seen (50%), which signifies high- velocity injuries involved. Twenty-five (69.4%) patients were operated on within the first six hours of injury which showed an early intervention upon the majority of the patients. Only four patients had a pre-existing systemic illness and the majority didn't have any other morbid conditions. Twenty-four (66.6%) patients underwent tubular external fixation as the first choice of skeletal stabilization, Ilizarov fixator was the second most common fixation used in 10 cases (27.7%). Wound coverage was done in 20 cases in this study. Out of which, 10 (50%) were split-thickness skin grafts (STSG) and 10 (50%) were flaps. Bone grafting, solely, was carried out in three (8.3%) of the patients (Table 2).

Table 1: Fracture pattern distribution

Parameters	N	%
Mechanism of injury		
RTA	33	91
Fall	02	5.5
Other	01	2.7
Extremity		
Right	18	50
Left	18	50
Site of fracture		
Upper 1/3	11	30.5
Middle 1/3	15	41.6
Lower 1/3	10	27.7
Site of fracture		
Transverse	08	22.2
Oblique	00	00
Spiral	01	2.7
Segmental	12	33.3
Comminuted	15	41.6

Table 2: Distribution of cases requiring secondary procedure

Parameters	N	%
Time of surgery (hrs)		
Within 6	25	69.4
6-12	03	8.3
>12	08	22.2
Pre-existing illness		
Diabetes	02	5.5
Hypertension	02	5.5
Methods of treatment		
Tubular external fixator	24	66.6
Ilizarov fixator	02	5.5

Intramedullary nailing	02	5.4
Tubular fixator followed by ring fixator	08	22.2
Secondary procedure		
Bone grafting	03	8.3
STSG	10	27.7
FLAP	10	27.7
Bone grafting and flap	03	8.3

Tubular fixator followed by Ilizarov fixator had a maximum number (five) of surgeries, which was followed by an intramedullary nail (four). The minimum number of surgeries required was three in each age group. Thirty-three percent of patients were immobilized for more than 15 weeks. With the advancing age, the average duration of immobilization

appeared to increase. The minimum duration of partial weight-bearing of 13.8 weeks was seen in the 29 to 39 years age group. However, there seems to be no definitive correlation in the duration of increase or decrease in age. The mean duration of full weight-bearing was highest, thirty-eight weeks, in the 18 to 28 years age group.

Table 3: Age groups with different parameters showing time period relation

Parameters		
Average number of surgeries according to age		
Age (years)	Patients	Number of surgeries
18-28	10	3.5
29-38	14	4.1
39-48	8	3.6
49-58	3	04
59-68	1	03
Mean duration of immobilisation		
Age (years)	Weeks (Avg)	Range
18-28	13	-
29-38	12.4	4-52
39-48	15.6	6-20
49-58	25.3	4-32
59-68	24	12-48
Mean duration of partial weight bearing		
Age (years)	Weeks (Avg)	Range
18-28	30.1	-
29-38	13.8	8-56
39-48	20.5	8-22
49-58	32	16-32
59-68	28	18-54
Mean duration of full weight bearing		
Age (years)	Weeks (Avg)	Range
18-28	38	-
29-38	23.1	16-104
39-48	24.6	10-50
49-58	37.3	20-28
59-68	32	32-58
Mean duration of union		
Age (years)	Weeks (Avg)	Non union
18-28	42.11 (18-125)	1
29-38	24.09 (18-55)	3
39-48	29 (24-42)	2
49-58	36.6 (24-54)	-
59-68	34	-
Mean duration to return to work		
Age (years)	Weeks (Avg)	Non union
18-28	45.1 (16-156)	1
29-38	21.2 (12-34)	3
39-48	26.3 (16-38)	2

49-58	34 (32-48)	-
59-68	48	-

There seems to be a slight increase in duration with an increase in age. The mean duration of the union in the 18- 28 years group was 42.22 weeks (range 18-125) with one non-union. In the age group 29-38 years, the mean duration of union was 24.09 weeks (range 18-55) with three non- unions reported. Beyond 49 years all the fractures followed up united.

The mean duration for return to work was highest with forty-five weeks, in the 18 to 28 years age group and the lowest being twenty-one weeks in the 29 to 38 years age group. Three non-unions were seen in the 29 to 38 years age group, two in the 39 to 48 years age group and one in the 18 to 28 years age group (Table 3). Varus deformity was associated with all types of AO fracture patterns. The maximum deformity was seen in the 29-38 years age group. Valgus deformity was most common in the 29-38 years group and was associated mostly with the C3 type of AO fracture (85%). Procurvatum deformity was seen in all the age groups and was mostly seen with the C3 type of AO fracture (60%). Recurvatum deformity was less commonly seen. However, it was mostly associated with the C3 type of AO fracture (71%). The rotational deformity was the least of all the deformities in all the age groups. There was only one case of recurvatum malunion. Shortening was mostly seen in the 18-28 age group and was again mostly associated with the C3 type of AO fracture (80%). Knee and ankle range of motion were better in the younger age group as compared to the older age group. However, the subtalar range of motion was better in the older age group. The number of patients in the older age group was also significantly low. Overall knee stiffness was less as compared to the ankle and subtalar in all the age groups. This could be

attributed to the good physiotherapy compliance of younger patients. In all age groups, the majority of patients did not have any pain. However, occasional pain was most commonly seen in the 29-38 age group. The gait pattern was seen to be altered in all age groups. The significant limp was most common in the 18-28 age group, 30%. The mild limp was most commonly seen in the 39-48 years age group (61%). Return to activities was very low in the 18-28 and 39-48 age groups with only 30% and 25% respectively and maximum cases returned to their activities in 29-38 years age group (57%) (Table 4). All the age groups showed a mixed distribution of good, fair and poor results but the lower extremity functional score showed a gradual decrease with an increase in age. However, excellent results were least seen in all the age groups. There was an odd score of 65 in the 59-68 age group. The lower extremity functional score was more in the younger patients (Table 5). Pin tract infection was commonest (50%) in the 18-28 years age group. Overall, most complications occurred in the 29-38 years age group. There were fewer complications in the younger and older age group possible because of the higher severity of trauma in this age group (Table 6). The average duration of stay was 4.9 weeks and 22% of the patients were unemployed post-treatment.

DISCUSSION

EXTREMITY INVOLVED

Most tibial shaft fractures showed no predilection to any of the sides as reported in other series of studies. In the present study group, equal involvement of both sides was observed.

Table 4: Age distribution according to deformity, joint stiffness and functional disability

Parameters, N (%)									
Distribution of average deformity according to age									
Age (yrs)	Varus (DEG)	Valgus (DEG)	Procurvatum (DEG)	Recurvatum (DEG)	Shortening (MM)	Rotation (DEG)			
18-28	2.2 (3)	3.7 (4)	4.3 (5)	0.8 (2)	11.5 (5)	0			
29-38	1.2 (4)	3.9 (6)	2.3 (4)	1.2 (2)	3.9 (3)	0			
39-48	2.8 (3)	2.0 (2)	10.0 (5)	0.6 (1)	2.5 (2)	1.2 (1)			
49-58	0	4.3 (1)	6.6 (1)	0	0	0			
59-68	0	8 (1)	0	12(1)	0	0			
Distribution of joint disability according to age									
Age (yrs)	Knee			Ankle			Subtalar		
	Full	75-80%	<75%	Full	50-75%	<50%	Full	>50%	<25%
18-28 (10)	7 (70)	3 (30)	0	6 (60)	1 (10)	3 (30)	6 (60)	1 (10)	3 (30)
29-38 (14)	10 (71)	3 (21)	1 (7)	6 (64)	3 (21)	2 (14)	10 (71)	1 (7)	3 (21)
39-48 (8)	5 (62)	1 (12)	2 (25)	4 (50)	2 (25)	2 (25)	6 (75)	0	2 (25)
49-58 (3)	2 (66)	1 (33)	0	2 (66)	0	1 (33)	3 (100)	0	0
59-68 (1)	1 (100)	0	0	1 (100)	0	0	1 (100)	0	0
Distribution of functional disability according to age									
Age (yrs)	18-28 (10)		29-38 (14)		39-48 (8)		49-58 (3)		59-68 (1)

Pain					
None	7 (70)	8 (57)	5 (62)	2 (66)	1 (100)
Occasional	3 (30)	6 (42)	3 (37)	1 (33)	0
Moderate	0	0	0	0	0
Severe	0	0	0	0	0
Gait					
Normal	5 (50)	7 (50)	2 (25)	1 (33)	1 (100)
Mild limp	2 (20)	5 (35)	5 (62)	2 (66)	0
Significant limp	3 (30)	2 (14)	1 (12)	0	0
Activities					
Possible	3 (30)	8 (57)	2 (25)	0	0
Limited	5 (50)	1 (7)	3 (37)	3 (100)	1 (100)
Severely limited	1 (10)	2 (14)	1 (12)	0	0
Impossible	1 (10)	3 (21)	2 (25)	0	0

Table 5: LEFS score and Johner Wruhs relationship table

Results (using the criteria of Johner and Wruhs)					
Age (yrs)	Excellent	Good	Fair	Poor	Average lower extremity functional score
18-28 (10)	1 (10)	3 (30)	0	6 (60)	61.1
29-38 (14)	1 (7)	4 (28)	4 (28)	5 (35)	56.6
39-48 (8)	1 (12)	1 (12)	3 (37)	3 (37)	53
49-58 (3)	0	1 (33)	1 (33)	1 (33)	54
59-68 (1)	0	0	1 (100)	0	65

Table 6: List of complications noted in the study

Age (yrs)	Pin tract infection	Stiff knee	Stiff ankle	Stiff knee & ankle
18-28 (10)	5 (50)	2 (20)	1 (10)	2 (20)
29-38 (14)	6 (42)	5 (35)	1 (7)	2 (14)
39-48 (8)	2 (25)	5 (62)	1 (12)	0
49-58 (3)	2 (66)	0	1 (33)	0
59-68 (1)	1 (100)	0	0	0

SITE OF FRACTURE

Most tibial shaft fractures are at the level of middle or distal 1/3rd. Proximal fractures are often less encountered. The rates of fractures in the three-segment of the tibia are similar between the series of other workers. In the present study, there was a higher incidence of fractures in the proximal 1/3rd of the tibia compared to other studies. Minor variations were presumably due to differences in the mode and velocity of injuries.

AO CLASSIFICATION

The present study showed that the most common fracture pattern was of C type (63.8%), this was similar to the study done by Keating *et al.* However, interobserver variance can be present while classifying the fracture pattern.

FRACTURE PATTERN

Majority of the fractures (41.6%) in our study were comminuted as seen in other studies too. This could be attributed to the higher velocity of injury-causing these fractures.

TIME OF SURGERY

All patients were surgically intervened within 24 hours of trauma in our study. This was similar to the series of other workers and our study. This shows early intervention in all cases to minimize the chances of complications.

METHODS OF TREATMENT

Studies done by Gershuniet *al.*, Gustilo *et al.*, Thakur *et al.* showed that tubular external fixation was the choice of fixation.²⁻⁴ However, later series by Kun *et al.* and Keating *et al.* showed drift in the trend of fixation with intramedullary rods.^{1,5} The present study reflects both patterns of fixation as per the choice of the surgeon with tubular fixation in 66% of cases, Ilizarov fixation in 27.7% and intramedullary nailing in 5.4% of cases.

CASES REQUIRING SECONDARY PROCEDURE

The series reported by Thakur *et al.* showed that 60% of cases required skin grafting, 6.3% requiring flap coverage and 60% bone grafting. Tornetta *et al.* reported that 86.2% of cases required skin grafting, 79.3% flap coverage and 75.8% required bone grafting.²⁻⁶ The present study also shows the use of

all three modalities. 27.7% needed skin grafting, 36% flap coverage and 16.6% bone grafting.

MEAN DURATION OF IMMOBILISATION, PARTIAL AND FULL WEIGHT BEARING

Thakur *et al.* series used tubular fixation as skeletal stabilization in which the duration of partial weight-bearing was one week, and full weight-bearing was 3.8 weeks.⁴ The present study showed similar variation as shown in the above series. However, using tubular fixation the duration was 12.8 weeks of immobilization, 19.6 weeks to partial weight-bearing and 25.6 weeks to full weight-bearing. Using intramedullary nailing and Ilizarov fixator as a method of stabilization, the duration of immobilization was 19.5 weeks, 29.2 weeks to partial weight-bearing and 39.2 weeks to full weight-bearing. The above observation clearly showed that the duration depended upon the nature of fixation used and the fracture pattern.

MEAN DURATION TO UNION AND RETURN TO WORK

Hamza *et al.* reported 12 weeks to union and 18 weeks to return to work using tubular fixation.⁷ The present study was like the above-reported series showing bony union in 26.2 weeks using tubular fixation and time to return to work by 25.4 weeks.

COMPLICATIONS

Thakur *et al.* in their study showed varus malunion in 5.4% cases and shortening in 2.8% cases with tubular fixators.⁴ A study by Tornetta *et al.* reported valgus deformity in 14.2% of cases using a tubular fixator, however, there was no other malalignment.⁶ Cases treated with intramedullary nailing showed no malunion or shortening. Keating *et al.* in their series had 1.7% cases with varus and 5.2% cases with valgus deformity using an intramedullary nail.¹ However, there was no documentation regarding other malalignments.

The present study showed a high number of deformities in both groups. This could be attributed to the fracture pattern and interobserver variance while recording the malalignment. The outcome of treatment depends upon the union achieved and mobility gained post-treatment. Thakur *et al.* in their study showed 100% union in patients treated with tubular fixation and 10.9% ankle stiffness.⁴ Their study also had 35.6% pin tract infection.

Tornetta *et al.* compared tubular and internal fixation in his series and showed 100% union with both.⁶ However, their study also had 21.4% pin tract infection and 14.2% superficial infection. Keating *et al.* in their study showed 42% non-union in cases treated with intramedullary nails.¹ The study also reported 17.5% superficial infection, knee stiffness and ankle stiffness in 16% of cases respectively. The present study observed 19.4% non-union and a higher incidence of pin tract infection, and knee and ankle

stiffness in cases treated with a tubular fixator. However, the other group had no non-union but again a high incidence of stiffness of the knee and ankle. This could be due to poor care of tubular fixators and lack of appropriate physiotherapy at home by the patients.

FUNCTIONAL OUTCOME

Quality of life score (QOL); SF36-Short form 36 Fairhurst *et al.* reviewed the function of salvaged grade III tibial fractures in which 25% had shortening and 50% had stiffness of the ankle and subtalar joint.⁸ His analysis was done using the Quality-of-Life Score. Yokoyama *et al.* reported a shortening of 66.6% of cases in his study.⁹

In the present study out of the treated patients, 36% had knee, 38.8% ankle and 27.7% subtalar stiffness which were comparable to the other reported series. Fifty-four percent of cases also had shortening of the injured limb and 22% were unemployed after treatment. Only 8.3% of patients achieved excellent, 25% good, 25% fair and 41% poor results using Johner *et al.* criteria.^{9,10} This again was comparable to an analysis done using the Quality-of-life score.

The excellent results in Johner *et al.* criteria meant a good union with no evidence of infection, no deformities and good joint mobility which simultaneously assessed with lower extremity functional score reflected no pain or limp and no restriction of activities of daily living in an individual.¹⁰ It also showed a higher lower extremity functional score for an excellent result. As the results deteriorated, the scores also went down and the poor result showed lower scores. It showed a significant relationship with $p < 0.01$. While assessing the malunion, it was found that more than 6.3 degrees of varus, 10-degree rotation and 20.5 mm shortening significantly altered the outcome and scores. It had a significant relationship ($p < 0.01$) whereas valgus up to 9.2 degrees, procurvatum up to 11.7 degrees and recurvatum up to 5.07 degrees did not have any impact on the lower extremity functional score. It means that varus, rotation & shortening had more impact and affected the results and scores more than the valgus, procurvatum and recurvatum malunion.

The valgus, procurvatum and recurvatum deformity did not have significant relation when evaluated statistically ($p > 0.01$). The critical analysis of results of treatment of tibial shaft fractures by Puno *et al.* described varus or valgus deformity greater than 10 degrees and anterior- posterior angulation greater than 20 degrees or shortening of more than 2 cm as malunion. Based on the analysis done, a relationship can be predicted with Johner and Wruhs criteria and lower extremity functional score. The Johner *et al.* criteria were specially meant for lower limb fractures. The Lower Extremity Functional Score was found superior to the much-used Short Form 36. The poor results had a score of less than 24, fair results had a score between 25 and 68, good results had a score

between 69 and 77 and excellent results had score more than 77. Statistically, this showed a significant relationship with a $p < 0.01$. In the analysis, the tubular external fixator was a satisfactory modality for treating grade III B open fractures of the tibia. However, care must be taken to avoid shortening valgus and rotational deformities.

LIMITATIONS

This was a single centric retrospective study and the number of cases matching the criteria were limited. The number of such fracture cases are on the rise due to high velocity motor vehicular accidents, hence a multicentric study with more study population would have yielded better inference.

CONCLUSION

Non-union and infection gave poor results and poor functional outcomes. In spite of malunion and shortening, patients may have excellent/good outcomes. The younger age group had a better outcome than the older group. In our opinion, the tubular external fixator remains the treatment of choice in the Indian scenario with better cost-effectiveness and early functional return.

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ETHICAL APPROVAL:The study was approved by the Institutional Ethics Committee.

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