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Outcome analysis of surgical management of type 2, 3a and 3b open fractures of distal 2/3rd tibial diaphysis using external fixators

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ABSTRACT

Background: There is confusion regarding ideal fixation method for intermediate grades of open fractures of tibia. In distal 2/3rd of tibia the blood supply is precarious and so it further increases the confusion. Purpose of this study is to evaluate effectiveness of external fixator as definitive treatment in these fractures.
Methods: 55 patients with type2, 3A or 3B open fractures of distal 2/3rd tibia were studied. External fixator applied at the time of debridement is removed and cast applied once wound is healed. Follow up at 1, 3, 6 and 9 months recorded. Union assessed using rust scoring system. Functional outcome assessed using Modified Functional Evaluation System by Karlstrom- Olerud after patients are mobilized.
Results: Union rate was 74.5%.Functional outcome was satisfactory in 34%, moderate function in 32% and good function in 24.4%. In 7.3% the function was poor. Only one case gave excellent function.
Among diabetic patients 71.4% developed wound infection and all developed pin tract infection showing strong association between diabetes and infection.
Conclusion: Though external fixation followed by serial casting technique gave fare outcomes, there is scope for better results and so the option of other methods of treatment should not be excluded. There is a significant association between diabetes and infection and so special care and covigilance is advised in diabetic patients.

Keywords: Open fracture, Distal tibia, External fixation, Rust score

INTRODUCTION

The tibia is a long tubular bone with a triangular cross section and is responsible for 85% of weight bearing load, whereas fibula transmits the remaining.[1] Fractures of the shaft of the tibia are one of the commonest injuries seen in orthopedic practice.[2] By its very location, tibia is exposed to frequent and wide spectrum of injuries.

An open fracture is defined as an injury where the fracture and the fracture hematoma communicate with the external environment through a traumatic defect in the surrounding soft tissues and overlying skin. It should be emphasized that the skin defect may not lie directly over the fracture site and may lie at a distant site. It may communicate with the fracture under degloved skin. Hence any fracture associated with a wound in the same region must be considered to be an open injury until proven otherwise by surgical exploration. Open fractures are often high-energy injuries and are frequently associated with life-threatening polytrauma. Apart from severe bone and soft tissue involvement, these injuries have other risk factors such as skin degloving, soft tissue crushing, contamination with dirt and debris and injury to neurovascular structures. Hence they are associated with a high risk of complications, including infection, non-union and amputation.[3]

Open fractures of shaft are more frequent in tibia than in any other long bone, because one third of its surface is

subcutaneous throughout most of its length.[4] Furthermore the blood supply to the tibia is more precarious than that of bones enclosed by heavy muscles. There is watershed area at the junction of middle and distal third where the blood supply is reduced. Open fractures damages the soft tissues around and reduces the periosteal blood supply, and so become a big concern in the treatment of fractures of distal tibia. Delayed union, non- union and infections are relatively frequent complications in open fractures of shaft of tibia. Hence, special care and expertise is necessary when treating such fractures.

The tibia being the most commonly fractured long bone and its fracture management has changed drastically from conservative to early surgical management. Treatment options for tibia fractures vary according to the type of fractures, age group, bone density, soft tissue status and associated complications. The conservative methods used are casting or bracing for stable closed fractures. Because of need for prolonged immobilization and its complications, improper anatomical alignment and associated soft tissue injuries where it leaves the wound relatively in accessible, these conservative methods have become less useful in open fractures.[5]

Operative techniques used are fixation with plates and screws, intramedullary nailing and external fixation.[5] Many studies in the recent past have shown that interlocking nails can be used to treat open fracture of the tibia quite safely. Intramedullary (IM) nailing is considered the method of choice for treatment of closed diaphyseal fractures of the tibia.[6] However, there is controversy in the literature regarding the best way of managing open fractures; tibia shaft fractures with severe soft tissue injuries or compartment syndrome, and tibia fractures in multiply injured patients. It has yet to be determined whether plate fixation, primary IM nailing, primary external fixation followed by conversion to IM nailing, or external fixation as definitive treatment is the ideal surgical management for these types of tibia shaft fractures.[5,7]

Reaming is known to damage endosteal blood supply and in conjunction with open fracture where the periosteal blood supply is already damaged by the injury, this has been thought to be associated with an unacceptable risk of deep infection and non-union. Fixation with plates and screws necessitates stripping of periosteum and so loss of blood supply and so has unacceptably high rates of infection and non-union.[5]

External fixation was considered as the treatment of choice by many traumatologists but has the disadvantages of bulky frames and frequent pin tract infections, malunions and non-unions. External fixation was widely used in the early part of the 20th century but fell into disregard later with advent of new internal fixation devices. Its use was popular again in the 1980s but there were still a number of questions and problems with its use.[8]

Now the controversy regarding the management of closed and type 1 open fractures of tibia is almost solved in favor of intramedullary nailing, and in higher types of open fractures (type3 C) are in favor of external fixators. However there is paucity of studies regarding the outcomes of these procedures in these intermediate grades of open fracture.[5]

In our institution most of the open fractures are currently managed by external fixation at the time of debridement, followed by external fixator removal and cast immobilization after the wound is healed, irrespective of the union status. The purpose of this study is to evaluate the results and effectiveness of this method of treatment in these intermediate grades of open fractures of the distal 2/3rd of tibia where the question of blood supply further reduces the possibility of other fixation devices.

Objectives

Aim of the study was to analyse the anatomical outcome of external fixators in type 2, 3A and 3B open fractures of distal 2/3rd tibial diaphysis in achieving bony union and to know the functional outcome in the cases of type 2, 3A and 3B open fractures of distal 2/3rd tibial diaphysis which are treated by external fixators.

METHODS

Study design

Prospective, observational study period 18 months from 18 April 2017 to 18 October 2018.

Study population

All patients undergoing external fixation surgeries for Compound diaphyseal fractures of distal 2/3rd tibia of TYPE 2, TYPE3A and TYPE 3B as classified by Gustilo-Anderson grading in the Age group of 18-60 years admitted in department of Orthopaedics, Government Medical College, Kottayam, during the study period .

Sample size

Calculated by formula,

Minimum sample size n= $Z^2_{1-\alpha/2} \times p \times q/d^2$

α=1.96 for alpha at 5% level of significance.

p= anticipated proportion of factor under study

q= 1-p

d= absolute precision

According to Bratislav Stojković, Sasa Milenković, M. Radenković, et al. Union rates is up to 83%.[9]

p=17

q=100-83=83

d=20% of

p=17×20/100= 3.4

n= (1.96×1.96×.17×.83) / (0.034 × 0.034) =468.90

Only 55 cases satisfying the inclusion criteria were treated our hospital during the study period. So, Even though a sample size 469 is needed, I will be restricting the sample size to 55.

Inclusion criteria

Compound diaphyseal fractures of distal 2/3rd tibia of TYPE 2, TYPE 3A and TYPE 3B as classified by Gustilo-Anderson grading. Patients who underwent external fixation surgery in government medical college Kottayam after April 18, 2017. Age group of 18-60 years.

Exclusion criteria

Pathological fractures. Compound tibial fractures associated with other injuries like head injury, spine fracture, other fractures in same or other lower limb etc. if mobilization is delayed due to them.

Not willing to take part in study

Statistical analysis

Data is entered in Microsoft Excel software, and analysis done using SPSS version 20.0 software. The level of significance will be $p<0.05$ and high significance $p<0.01$. The data is collected using the pro forma. The results are analyzed at the end of the study and observations were made.

Study procedure

After getting approval for thesis from institutional review board, written informed consent was taken from all patients undergoing study.

In this study, 55 patients with type ll, lllA or lllB open fractures of distal 2/3rd tibial diaphysis treated by external fixation were studied. Uniplanar external fixator is applied at the time of initial debridement. Soft tissue procedures like split skin graft and skin flap were done when found to be necessary. Wound infections and pin tract infections were treated with antibiotics, according to culture and sensitivity results. Once the skin wound was healed, the external fixator is removed irrespective of the healing status of the fracture and an above knee cast was applied maintaining the reduction. In the subsequent follow up visits, the above knee cast was converted to a patellar tendon bearing cast and a below knee walking cast and the patient is advised partial weight bearing. All the cast braces are removed and the patient is mobilized free, once the definite clinical and radiological evidence of fracture healing has appeared. Cases subjected to surgery were met during the follow up visits and analyzed for progress of treatment. Progress in treatment was noted down in the pro forma at 1 month, 3 months, 6 months and 9 months following surgery. Follow-up was stopped earlier if patient mobilized earlier or when patient is diagnosed as a case of nonunion. X-rays taken at 1 month, 3 months, 6 months and 9 months were analyzed and bony union was assessed using Rust Scoringsystem.[10] In the RUST scoring system based on the assessment of fracture healing at each of the four cortices (i.e., medial and lateral cortices on the antero-posterior X-ray, anterior and posterior cortices on the lateral X-ray), each cortex receives a score of 1 point, if presence of fracture line with no callus; 2 points, if there is callus present but a fracture line is still visible; and 3 points, if there is bridging callus with no evidence of a fracture line. The individual cortical scores are added to give a total score of 4, which being the minimum score indicating that the fracture is definitely not healed and 12 being the maximum score indicating that the fracture is definitely healed. Radiographic fracture union was defined when bony callus was evident on at least 3 cortices in standard AP and Lateral views and with rust score ≥7.

Table 1: Modified functional evaluation system by Karlstrom-Olerurd- scores.[11,12]

S. no	Measures	3 Points	2 Points	1 Point
1	Pain	No	little	Severe
2	Difficulty in walking	No	moderate	unable
3	Difficulty in stairs	No	supported	Unable
4	Difficulty in previous sports	No	some sports	unable
5	Limitation at work	No	moderate	Unable
6	Status of skin	normal	various colours	ulcers/ fistula
7	Deformity	No	little up to 7%	remarkable, >7%
8	Muscle atropy	<1 cm	1-2 cm	>2cm
9	Shorter lower extrimity	<1cm	1-2cm	>2cm
10	Loss of motion at knee joint	<100	0^0-20^0	$>20^0$
11	Loss of subtalar motion	<100	0^0-20^0	$>20^0$

Patients are clinically assessed for functional outcome using modified functional evaluation system by Karlstrom-Olerud [11,12] after mobilizing without the help of a functional cast brace.

Table 2: Final scoring system (modified functional evaluation system by Karlstrom-Olerud).[11,12]

Excellent	3SI 3 Points
Good	32-30
Satisfactory	29-27
Moderate	26-24
Poor	23-21

Collected data which was recorded on a pro forma was analyzed. During every phase of the study the personal details of the patients participating in the study was kept confidential & the patient had every right to withdraw at any phase of the study without affecting his future treatment.

RESULTS

Fractures studied 41 out of 55 (74.5%) united. 14 (25.5%) fractures were subsequently diagnosed as non-union and treated by further fixation procedures.

Table 3: Union status after treatment with external fixation followed by cast immobilization.

Union status in treatment	Number of patients	Percentage (%)
Non union	14	25.5
united	41	74.5
total	55	100

Table 4: Timing of union.

Timing of union (Month)	Number of patients	Percentage (%)
1	1	1.8
3	8	14.5
6	29	52.7
9	3	5.5
Non union	14	25.5
Total	55	100.0

By 6 months, 38 cases showed radiological union with a rust score ≥7. 14 out of total 17 cases which were not united at 6 months were diagnosed as non-union at 9 months. The mean time of union in the united cases of fracture in this study was 165± 51 days (5.5±1.7 months).

Among the cases which obtained fracture union, maximum number (n=14) of cases gave a satisfactory function, followed by moderate function in 13 cases and good function in 10 cases. In 3 cases the function was poor. Only one case gave excellent function.

71.4% of diabetic patients had infection and it was found to be statistically highly significant with a Chi-square value of 17.77 at p<0.001.

Table 5: Modified functional evaluation system score.

Function	Score	Number of patients	Percentage (%)
Excellent	33	1	2.4
Good	32-30	10	24.4
Satisfactory	29-27	14	34.1
Moderate	26-24	13	31.7
Poor	23-21	3	7.3
Total		41	100

Table 6: Comparison of study population based on diabetes and Wound Infection.

Diabetic	Infection		Total
	Yes N (%)	No N (%)	
Yes	5 (71.4)	2 (28.6)	7 (100)
No	4 (8.3)	44 (91.7)	48 (100)
Total	9 (16.4)	46 (83.6)	55 (100)

Table 7: Distribution of study population based on diabetes and pin tract Infection.

Diabetic	Pin tract Infection		Total
	Yes n (%)	No n (%)	
Yes	7(100)	0(0)	7(100)
No	2(4.2)	46(95.8)	48(100)
Total	9(16.4)	46(83.6)	55(100)

100% of diabetic patients had pin tract infection and it was found to be statistically highly significant with a Chi-Square value of 40.995 at p<0.001.

DISCUSSION

Nonunion and delayed union still represents one of the major complications in the treatment of open fractures. Loss of fracture hematoma and wound infection makes the open fractures more prone to these complications.

Break down of the tissue barrier between the fracture zone and the environment leaves the underlying bone prone to direct contact with contaminating agents. Subsequent chronic osteitis and/or non-union still represent today a major source of disability and decreased quality of life for the individual patient as well as a socio-economic problem for public health systems.

55 patients with type ll, type lllA or type lllB open fractures of distal 2/3 rd diaphyseal tibia fracture, satisfying the inclusion criteria were admitted and treated by external fixation, in department of Orthopedics, Government medical college, Kottayam for treatment, between April 18th of 2017 to October 18th of 2018.

Only the patients of age between 18 and 60 years were included in the study. Among the study population 81.8% were men, with a male: female ratio of 4.5:1. This is in agreement with studies conducted by Fakoor and Pipelzadeh.[13] The male predominance in our study may be due to various social and demographic factors.

The leading cause of open fracture was found to be road traffic accidents (76.4%). Similar findings have been reported by Azam, et al.[14] Rest of the injuries was caused by fall from height (16.4%), fall of an object to leg (3.6%) and assault (3.6%).

In the study population 12.7% (7 out of 55) were diabetic. This is in agreement with the overall prevalence of diabetes in India as per study conducted by Ramachandran et al.[15]

Among the diabetic patients 71.4% developed wound infection, and 100% developed pin tract infection which means diabetes is a strong precursor for infection.

In the study population 16.4% (9 out of 55) suffered significant wound infection. The incidence of pin tract infection was also similar (16.4%). Gopal, et al reported deep infection in 6.1% patients in his study.[16] In study conducted by Tornetta, et al out of 14 patients treated by external fixation one deep infection and two pin-track infections were reported. [17] In study conducted by karl, et al out of thirty-one patients managed by external fixation, three deep and two superficial infections developed[18]; eleven patients had severe pin track infections. McGraw, et al reported deep infection in 44% of patients in his study.[19]

1 case (1.8%) achieved union at 1 month, 14.5% of patients achieved bone union at 3 months, 52.7% at 6 months and 5.5% at 9 months. The total rate of union in these fractures treated by external fixation was 74.5%. 25.5% of fractures were finally diagnosed as nonunion and underwent other procedures.

Gopal et al reported that 34% of patients required a further surgery to achieve union; where as in our study the nonunion rate was 25.5%.[16] In study conducted by McGraw the nonunion rate was 50% in open tibial fractures. [19]

Different factors related to wound debridement, time of wound debridement and fixation, fracture fixation and follow up treatment might have an effect in the union rate and function.

The mean time of union in the united cases of fracture in this study was 165± 51 days (5.5±1.7 months). Byrd et al reported a mean time of union of 6.4 months in open fractures in which soft tissue coverage was delayed from 8 to 30 days. [20] In the study conducted by Gopal et al the mean time for union was 41 weeks. 16 Only 3 out of 17 fractures which were not united at 6th month united at 9 months.

Of the total 41 fractures united, 26 fractures (63.4%) united in alignment and 15(36.6%) fractures malunited.

The functional outcome at mobilization was found to be satisfactory in 14 cases (34%), followed by moderate function in 13 cases (32%) and good function in 10 cases (24.4%). In 3 cases (7.3%) the function was poor. Only one case (2.4%) gave excellent function. A subsequent increase in functional status is logical after a course of physiotherapy.

CONCLUSION

The total rate of union in these fractures treated by external fixation was 74.5%, with a mean time of union 165±51 days (5.5±1.7 months). 25.5% of fractures were finally diagnosed as non-union and underwent other procedures. The functional outcome at mobilization was found to be satisfactory in 34%, followed by moderate function in 32% and good function in 24.4%. In 7.3% the function was poor. Only one case (2.4%) gave excellent function.

With the development of new operative and aseptic techniques as well as a deeper understanding of the pathophysiology of fractures with soft tissue compromise the results can be improved.

There is a significant association between diabetes and infection and so special care and vigilance is advised in diabetic patients.

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