日小整会誌 (J Jpn Ped Orthop Ass) 21(1) : 154-158, 2012.
第 21 回日本小児整形外科学会学術集会 JPOA Asian Fellows

Outcome analysis of external fixation in the treatment of high energy paediatric tibial shaft fractures

RP Lee, HS Cheng, KL Liu, KW Ng

Paediatric Orthopaedic Team, Department of Orthopaedics & Traumatology, Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, HK SAR

Abstract : Majority of the paediatric tibial fractures can be managed by non-operative method. For those due to high energy trauma, surgical treatment is more preferable because these fractures are often unstable and complicated with open wounds. Our objective is to determine the outcome of tibial fractures treated by external fixation in our centre. To identify the complications, and to correlate any risk factors associated with the complications.

There were a total of 119 tibial fractures identified. Among the 75 tibial diaphyseal fractures, 9 cases were treated surgically. 7 of the 9 operated cases were treated with external fixation. The average injury severity score was 8.25. The average operation time was 125 minutes. Patient's average hospital stay was 32.8 days. The average time for removal of the external fixator was 4.3 months. Our average FU time was 22 months. There were no significant leg length discrepancies (>10 mm), malunion(>10°), delayed union, or non-union found. We had 2 cases of minor pin tract infections.

External fixation is a useful treatment modality in high-energy tibial fracture in paediatric patient. There is a low incident rate of long term complication in our centre. Our patients did not report any significant unpleasant experience or inconvenience concerning the usage of an external fixator. It remains as a good method of treatment for our paediatric population.

Introduction

Injuries are common in children. Fracture accounts for 15% of all paediatric injuries. 10% of the fractures involve the tibial shaft. Approximately 9% of the tibial fractures are open fractures. The average injury severity score is 10. Anatomically, tibia has relatively less soft tissue coverage than other long bones, therefore it is prone to open fractures. Malunions are also more obvious than other long bone fractures[1)~3)].

Majority of the paediatric tibial fractures can be managed by non-operative method, e.g. casting or bracing. For those due to high energy trauma, surgical treatment is more preferable because these fractures are often unstable and complicated with open wounds.

Different modalities of surgical fixation are available, including internal and external fixation. Examples of internal fixation[9,10,11] are pin fixation with casting, plating, and flexible intramedullary nailing, which have been widely reported for

Key words : tibial shaft fracture, surgical treatment, external fixation
Tel : +852 26322211
Fax : +852 26377889
E-mail : peterlee@ort.cuhk.edu.hk

their usage. External fixation[4-8] is quick and simple, with the advantage of short operating time, little disturbance to the soft tissue, allow post-fixation adjustment of fracture alignment, and early mobilisation. However, there were papers published reporting various related complications of external fixation. Myers[3] in 2007 reported complications such as delayed or non-unions, mal-unions (coronal >10°, saggital >20°), lower limb shortening (>10 mm), and pin tracts, soft tissue or bone infections.

Our objective is to determine the outcome of tibial fractures treated by external fixation in our centre. To identify the complications, and to correlate any risk factors associated with the complications.

Method

This is a retrospective review of all the paediatric tibial shaft fractures, which were treated with external fixators, at the Prince of Wales Hospital, between January 2004 and July 2009. The data were collected from our central computer database system (CMS), and those children who suffered from tibial fractures treated with external fixation were identified. All the operation were performed by our unit's orthopaedic specialists, under the supervision of at least one of our paediatric orthopaedic surgeons. We have reviewed all the relevant case notes, x-rays, and called them back for an interview in our designated research clinic.

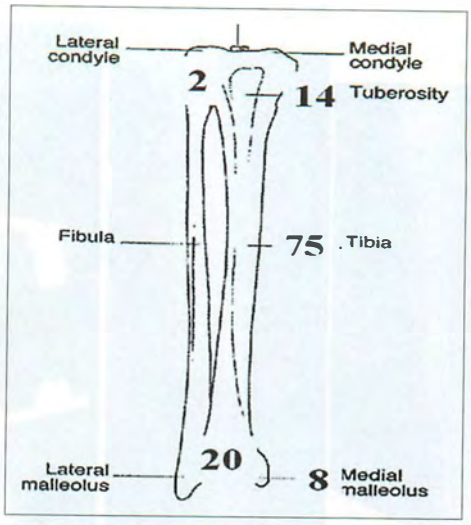

Fig. 1. Distribution of tibial fractures

All the cases with tibial fractures without an obvious history of trauma, and the fractures beyond the diaphyseal region were excluded. We also excluded patients with underlying musculoskeletal or neurological co-morbidities such as spina bifida, poliomyelitis, paraplegia, osteogenesis imperfecta, cerebral palsy.

Results

There were a total of 119 tibial fractures identified, with 65% of them were diaphyseal

Table 1. Summary of patients managed by external fixation

Age/ Sex	Cause	Open wound	Injury severity score	Gustilo-Anderson Classification	AO classification	OT time (mins)	Hospital Stay (days)	Final malalignment (post ex-fix removal)		
								Coronal (degrees)	Sagittal (degrees)	LLD (mm)
11/F	Vehicle	Yes	9	3b	42B2.3	130	37	4	8	2
11/M	Vehicle	Yes	18	2	42A3.1	90	31	1	2	5
9/M	Bicycle	Yes	9	1	42A2.3	60	17	2	5.5	n/a
13/F	Vehicle	No	9		42B3.2	270	32	2	3	6
10/M	Bicycle	No	4		42A1.3	65	71	2	7.5	n/a
6/F	Vehicle	No	9		42A2.1	60	15	2	3.5	7
8/F	Bicycle	No	4		41A2.2	180	27	1	2	10

A|B|C

Fig. 2.
A : 9 years old boy with tibial and fibular shaft open fracture
B : Post-operative x-ray
C : Final alignment after removal of external fixator

fractures. Their average age was 8.5 years old. There were 2 cases of proximal tibial physeal fractures, 14 tibial tuberosity avulsion fractures, 75 tibial diaphyseal fractures, 20 distal tibial physeal fractures, and 8 malleolar fractures (Fig. 1).

Among the 75 tibial diaphyseal fractures, 9 cases were treated surgically. The mechanisms of the injury include vehicle or bicycle collision, and falling off from a bicycle. 6 of them were close and 3 were open fractures. 7 of the 9 operated cases were treated with external fixation by the Hoffmann II® system. The average injury severity score was 8.25 (ranged from 4-18) (Table 1).

The average operation time was 125 minutes (ranged from 60 to 270 minutes). There was one patient who also suffered from humeral open fracture and radial nerve palsy, therefore the total operation time was longer, which lasted for 4.5 hrs. Post-operatively, we allowed them to mobilise and walk from post-operative day 2-5. The average time for removal of the external fixator was 4.3 months (ranged from 3-5 months).

Our average follow up time was 22 months. Patient's average hospital stay was 32.8 days. All the X-rays films were traced back and reviewed (Fig. 2-a~c). All 7 cases achieved complete fracture healing. The alignment and lower limb length were measured on the x-ray films. There were no significant leg length discrepancies (>10 mm), malunion (>10°), delayed union, or non-union found (Table 1). We had 2 cases of minor pin tract infections, which were treated with a course of oral antibiotics.

Discussion

In the past, surgical fixation of paediatric tibial fractures was once thought to be a rarity. In the 1980s and early 1990s, series of papers have been published describing successful treatment of paediatric tibial shaft fractures using external fixation[4)6)7]. Indications included mainly in cases with polytrauma or severe soft tissue injuries. However in the late 1990s onwards, there were more authors starting to describe on the complications related to external fixation[4)~6)11)], such as pin track infection, delayed union, malunion, and leg length discrepancy. Since then more surgeons shifted to the use of intramedullary flexible

Fig. 3. External appearance of external fixator

Fig. 4.
Daily wound and pin tracts dressing by nursing staff

nailing as an alternative for surgical fixation of these fractures.

Myers et al reported their experience in using external fixator and their related complications. Their average time to union was 4.8 months. There were 27% of pin tract infection, 10% of leg length discrepancy, 10% of malunion, 13% of delayed union, and 6% of non-union.

We had a total of 7 patients who suffered from tibial shaft fracture, which were treated with external fixation during the period from January 2004 to July 2009. It represented 5.9% of all the tibial fractures during that period. All 7 cases were high energy trauma which involved bicycle or vehicle injuries, with an average injury severity score of 8.25.

The time for our patient's fracture union, which allowed us to remove the external fixator was on average 4.3 months. There was no case of re-fracture after the removal of implant. None of our patient experienced non-union. Some had mild degree of angulation after healing of the fracture, but not more than 4 degrees (range 1-4°) on coronal plane, and less than 8 degrees (range 2-8°) on sagittal plane. The maximum lower limb shortening was 10 mm (range 2-10 mm). Clinically there were no obvious lower limb shortening. No revision surgery was needed among this group of patients.

We had 28.5% of the cases with pin tract infection (2 out of 7 cases), which were only minor infection, and were treated by a week's course of oral antibiotics. It is inevitable to have bacterial colonization of the pin tracks. Careful skin incision and soft tissue protection during pin insertion remains important to lower the rate of infection. Pin tract infection did not alter our patient's length of hospital stay. JB Hull et al reported up to 60% of the 44 cases(48 fractures) had pin tract infection, but only 1 case required to remove part of the external fixation early.

Upon our interview of the patients in the out-patient clinic, none of them reported inconvenience in taking care of the external fixator. They did not have bad experience from the injury, and both patient and the parents were all satisfied with the final outcome.

Some studies suggested that the time for removal of the implant can be earlier in paediatric patients[6]. Traditionally we assess the patient's bone healing by clinical examination and x-ray or CT scan. On average we removed our external fixator in 4.3 months. Joslin et al[12] suggested some other scientific method in more accurately assessing the bone healing in tibial fractures. They used electronic devices to measure fracture stiffness and the percentage of weight bearing. They showed a linear correlation between fracture site stiffness and weight bearing ratio. Therefore the percentage of weight bearing over the injured limb could be used to aid us in assessing the fracture healing and the timing for removal of the external fixation. Other measurements such as fracture site stiffness and bone

marrow density can also be used. In our unit, we are assessing the patient's healing status by measuring the BMD at the fractured site, and clinical assessment. Physical examination, radiographs, weight bearing ratio between the normal and the injured lower limb are used.

Conclusion

External fixation is a useful treatment modality in high-energy tibial fracture in paediatric patient. There is a low incident rate of long term complication in our centre, which is compatible with other internationally published papers by different centres. Various reasons including good post-operative reduction alignment, stable fixation by a rigid fixation system, and good wound care by the nursing staffs all take a very important role (Fig. 3, 4). Nowadays a better out-patient wound nursing care is available in our locality, which allows better pin tract care, therefore less pin tract infection and loosening, and a better healing alignment.

There have been numbers of analytical reviews of papers in using external as well as internal fixation. The majority of the studies were retrospective studies. Controversies persist in choosing the type of fixation, and there is still lacking a randomized prospective controlled trial in the current literature. Currently there is no clear management guideline for managing paediatric open fracture. In our experience, external fixation can provide very good results with minimal complication, together with the advantage of short operative time and easy removal of the implants after fracture healing. Our patients did not report any significant unpleasant experience or inconvenience concerning the usage of an external fixator. It remains as a good method of treatment for our paediatric population.

References

1) Canale ST, Beaty JH : Fractures and Dislocations in Children. Campbell's Operative Orthopaedics. 11th Edition, p. 1675-1693, 2008.
2) Heinrich SD, Mooney JF. Fractures of the shaft of the tibia and fibula. Rockwood and Wilkins' Fractures in Children. 7th Edition.
3) Cheng JCY, Shen WY : Limb Fracture Pattern in Different Pediatric Age Groups : A Study of 3,350 Children. J Orthop Trauma **7**(1) : 15-22, 1993.
4) Setter KJ, Palomino KE : Pediatric tibia fractures : current concepts. Current Opinion in Pediatrics **18**(1) : 30-35, 2006.
5) Myers SH, Spiegel D, Flynn JM : External fixation of High-Energy Tibia Fractures. J Pediatr Orthop **27**(5) : 537-539, 2007.
6) Hull JB, Bell MJ : Modern Trends for External Fixation of Fractures in Children : A Critical Review. J Pediatr Orthop B **6**(2) : 103-109, 1997.
7) Schranz PJ, Gultekin C, Colton CL : External fixation of fractures in children. Injury **23**(2) : 80-82, 1992.
8) Gougoulias N, Khanna A, Maffulli N : Open tibial fractures in the paediatric population : a systematic review of the literature. Br Med Bull **91**(1) : 75-85, 2009.
9) Yusof NM, Oh CW, OH JK et al : Percutaneous plating in paediatric tibial fractures. Injury **40**(12) : 1286-1291, 2009.
10) Swindells MG, Rajan RA : Elastic intramedullary nailing in unstable fractures of the paediatric tibial diaphysis : a systematic review. J Child Orthop **4**(1) : 45-54, 2010.
11) Yip WH, Lee KB, Shen WY : Early Experience of Metaphyseal Plating by the Minimally Invasive Plate Osteosynthesis Technique for Closed Distal Tibial Fractures. Hong Kong J Orthop Surg **10**(1) : 22-27, 2006.
12) Joslin CC, Eastaugh-Waring SJ, Hardy JRW et al : Weight bearing after tibial fracture as a guide to healing. Clinical Biomechanics **23**(3) : 329-333, 2008.