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ORIGINAL ARTICLE

Prospective Role of Uniplanar Compressible External Fixation Devices in the Management of Pathological Diaphyseal Fractures Secondary to Osteomyelitis in Children

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ABSTRACT

Introduction: Management of pathological diaphyseal fractures secondary to osteomyelitis in children still remains a nightmare for the treating orthopedic surgeon owing to the highly unpredictable clinical course and lack of certainty in achieving successful results. This study highlights the potential role of rail fixator in the management of pathological femur fracture secondary to osteomyelitis in children.

Materials and methods: A total of five children (8–13 years age group) with pathological diaphyseal fractures of femur (four cases) and tibia (one case), operated between January 2014 and December 2014, were included in the study. Chronic osteomyelitis was the underlying etiology in all the cases. The surgical management consisted of thorough debridement, lavage, freshening of fractured bone ends, opening of the bone ends, reduction and external stabilization using pediatric monorail fixator. All patients received postoperative antibiotics, based on intraoperative culture and sensitivity reports, for 6 weeks (intravenously for the initial 3 weeks, orally for the remaining 3 weeks). Weight bearing and knee range of motion were started in the early postoperative period as soon as the children were pain free.

Results: *Staphylococcus aureus* was the causative organism in all the cases. Out of five cases, four fractures united: Three femurs (between 9 and 12 weeks) and one tibia (11 weeks). There was one case of delayed union of femur (18 weeks). Septic pin tract loosening was seen in one case (femur) requiring prolonged antibiotic usage. Minimal limb length discrepancy (1–1.5 cm) was observed in all the cases.

Conclusion: Compression fixation achieved by monorail fixator can be considered as a viable option for the management of pediatric diaphyseal fractures secondary to active bony infection. It has the advantage of promoting bony union, aiding in early weight bearing, establishing successful joint mobilization, providing an option for future restoration of limb length, and improved patient comfort.

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INTRODUCTION

Chronic osteomyelitis of long bones is not uncommon in children, especially in developing countries like India. Apart from serving as a focus of infection, the chronicity of osseous infection can predispose to various complications like joint stiffness, limb length discrepancies, deformity, pathological fractures, amyloidosis, or even malignancy. The weakening of osseous architecture as a result of infection creates a focus on "stress riser" and thus serves as a harbinger for the evolution of a pathological fracture after a trivial trauma or even with physiological loading of long bones. Although an incidence of 2.7% was reported by Belthur et al,[1] the exact incidence of pathological femoral fractures secondary to chronic osteomyelitis in children is largely unknown. There is no consensus regarding the best method to treat pathological femoral fractures following osteomyelitis in children. Once infection is controlled, skeletal stabilization can be achieved by either internal or external fixation of plaster spica. This study highlights the pros and cons of the existing methods. We, also, present our experience with the use of monoaxial rail fixator in the management of pathological pediatric diaphyseal fractures secondary to osteomyelitis.

MATERIALS AND METHODS

A total of five children (8–13 years age group) with pathological diaphyseal fractures, four femur and one tibia, operated between January 2014 and December 2014 were included in the study (Table 1, and Figs 1 to 6). Chronic osteomyelitis was the underlying etiology in all

Table 1: Comprehensive summary of data of children with pathological fractures (secondary to osteomyelitis) managed with rail fixator

Case no.	Age, sex	Site	Causative organism	*Duration of post-op antibiotics (weeks)* IV	Oral	Time for union (weeks)	Pin tract infection	Knee ROM	LLD	Duration of follow-up (weeks)
1	8, f	Femur	*S. aureus*	3	6	18	+	10–80°	1.5 cm	52
2	8, f	Femur	*S. aureus*	3	3	9	–	0–90°	1 cm	60
3	12, f	Femur	*S. aureus*	3	3	10	–	10–90°	1.5 cm	56
4	10, f	Femur	*S. aureus*	3	3	12	–	0–90°	1 cm	72
5	13, f	Tibia	*S. aureus*	3	3	11	–	0–130°	1 cm	60

f: Female; IV: Intravenous; (–): Absent; (+): Present; ROM: Range of motion

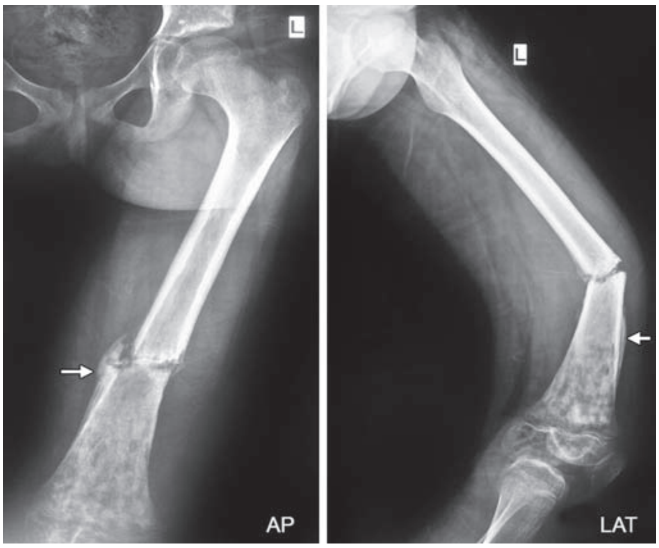

Fig. 1: Case no. 1: Preoperative radiograph showing left pathological diaphyseal femur fracture. There is evidence of periosteal reaction (arrow marks) and moth eaten appearance of distal femur secondary to osteomyelitis (AP: Anteroposterior; Lat: Lateral)

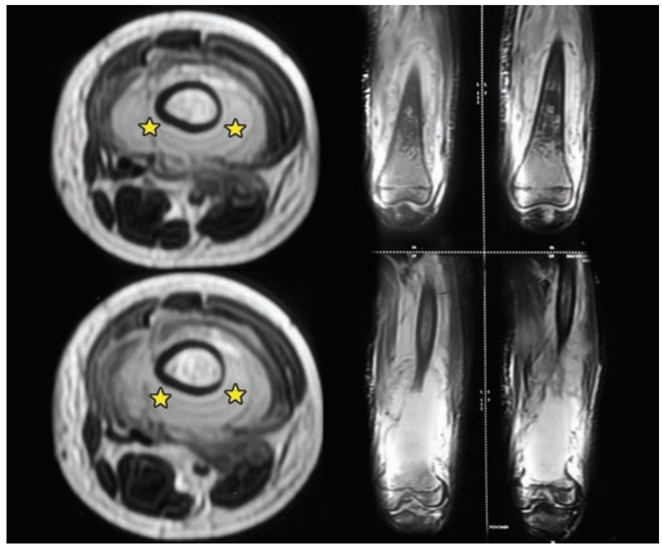

Fig. 2: Case no. 1: Axial and coronal MRI sections of left thigh showing evidence of intramedullary and subperiosteal pus collection (yellow star marks) secondary to osteomyelitis of femur

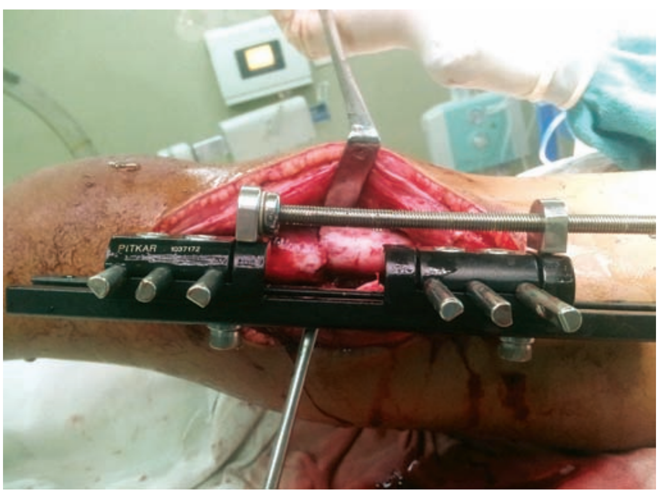

Fig. 3: Case no. 1: Intraoperative photograph after open debridement, reduction, and external fixation with uniplanar compressible rail fixator

the cases. All patients had a magnetic resonance imaging (MRI) prior to the surgery, to look for the intramedullary extent of bone marrow edema, muscle involvement, and to identify subperiosteal/extraosseous pockets of pus collections. Preoperatively, all antibiotics were stopped 48 to

Fig. 4: Case no. 1: Postoperative radiograph at 18 weeks showing complete union

Fig. 5: Case no. 2: Immediate postoperative radiograph after open reduction and external fixation of left femur

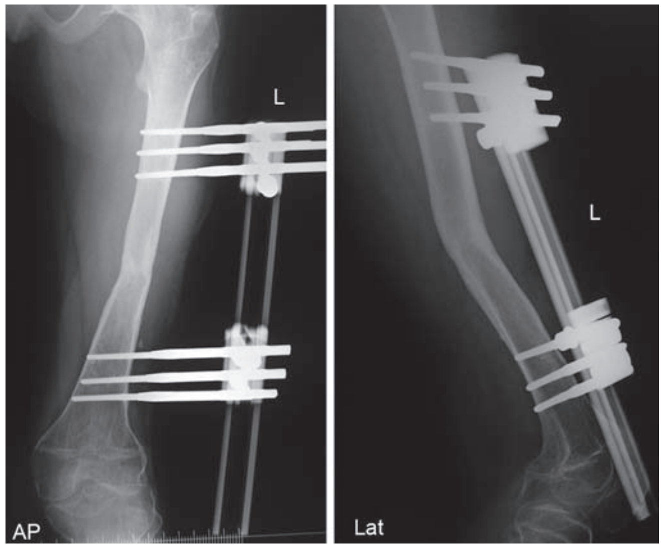

Fig. 6: Case no. 2: Postoperative radiograph at 9 weeks showing complete bony union. Even though there is evidence of anterior angulation, patient did not have any functional limitation (AP: Anteroposterior; Lat: Lateral)

72 hours before the planned surgical procedure, depending on the half life of the antibiotic. Routine blood investigations including total white blood cell (WBC) count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and blood cultures were sent in all the cases.

Surgical Procedure

Standard surgical approaches were used—lateral approach for femur and anterior approach for tibia. Thorough debridement of bone and soft tissue was done. Devitalized tissue was meticulously removed. Any localized collection of purulent material, if present, was thoroughly drained. The fracture site was adequately exposed. Keeping in mind to avoid further iatrogenic damage to the already brittle bones, the bone fragments were gently held with bone clamps and both their ends were freshened with a bone rongeur until fresh bleeding (viable bone ends) were seen. The medullary canals were opened up, clearing off all the intramedullary infected and necrotic tissue, both proximally and distally with the help of Volkman's curette and Kerrison punch. Material (soft tissue, bone, intramedullary curettings) was collected for culture and histopathological analysis. Meticulous hemostasis was achieved. High-volume low-pressure lavage was done with 10 to 12 L of normal saline. Once debridement was completed, reduction was achieved and maintained by external fixation. Two monorail clamps with three pins each on either side of the fracture site were employed, following the standard principles of monorail fixator application. Compression-distraction (CD) clamp was applied, and fracture site was compressed adequately. Closure was done by standard fashion over a negative suction drain.

Postoperatively, a combination of second-generation cephalosporin and aminoglycoside was started after ensuring adequate renal function. These empirical antibiotics were replaced by organism-specific antibiotics, once the culture and sensitivity reports were available. Immediate range of motion exercises were started in all the patients. Weight bearing was delayed till there was radiological evidence of callus formation.

RESULTS

Laboratory Analysis

Preoperatively, leukocytosis was present in all the cases. An average WBC count was 15,000 cells/mm^3 with a range between 13,000 and 19,000 cells/mm^3. The leukocyte counts returned to normal (4,000–11,000 cells/mm^3) within 5 to 7 days after the surgery. Elevated ESR (average: 34 mm/hour, range: 28–44 mm/hour) and CRP were found in all the cases, which took an average of 12 weeks (10–14 weeks) to return to normal.

Causative Organism

Staphylococcus aureus was the causative organism in all the cases, as evident by gram staining and microbial culture. Blood cultures were sterile in all the cases.

Time for Union

Out of five cases, four fractures united uneventfully—three femurs (at 9, 10, and 12 weeks respectively) and one tibia (11 weeks). There was one case of delayed union of femur (18 weeks). Septic pin tract loosening was seen in one case (femur) requiring prolonged antibiotic usage.

Pin Tract Loosening

Delayed pin tract infection and septic loosening of the pin tract was observed in one case involving femur at 12 weeks postoperatively. The subsequent management included prolonged antibiotic usage till 16 weeks, removal of loose pins and the external fixator, debridement, and closure of pin tracts. The child was placed on spica plaster immobilization for weeks with a window cut over the surgical site for wound care. The infection subsided and the fracture eventually united at 18 weeks.

Limb Length Discrepancy

Minimal limb length discrepancy (LLD; average: 1.25 cm shortening, range: 1–1.5 cm) was observed in all the femoral cases. Limb shortening of 1 cm was seen in the tibial case. All the five cases required an appropriate shoe raise for weight bearing and ambulation.

Range of Motion

Hip

There was no limitation of hip movements in any of the femoral cases.

Knee

In spite of restriction of knee movements, range of motion was within the functional range in all the femoral cases. The maximal range of knee flexion achieved was 90°, for the cases involving femur. Limitation of terminal extension was present in two cases (femur). Limitation of flexion beyond 90° was present in all the four femoral cases. There was no limitation of knee flexion in the case involving tibia. The range of motion was between 0 and 130°.

Ankle

Range of ankle motion was unaffected and was within the normal range in the tibial case.

Follow-up

The average duration of follow-up is 60 weeks with a range between 52 and 72 weeks. There was neither recurrence of infection nor refracture.

DISCUSSION

Treatment of pathological diaphyseal fractures secondary to osteomyelitis in children should be targeted at minimizing the rates of reported complications—persistence of infection, nonunion, angular deformity, and growth arrest.[1] Nevertheless, the primary goal of surgery, in such cases, is efficient control of infection. This can be achieved by thorough excision of sinus tracts, drainage of abscesses (if any), meticulous debridement of nonviable, or infected granulation tissue, obtaining tissue for microbiological and histopathological analysis, freshening of bone ends until fresh punctuate bleeding is seen (Paprika sign), curettage of the medullary canal, and, last but not the least, voluminous lavage. Stabilization of bone can be done as a part of the same surgical procedure (one-step) or as a two-step procedure. In the two-step procedure, the child is put on traction (skin or skeletal); wound is allowed to heal with antibiotics or repeated debridements if necessary; once infection has completely settled down, bony stabilization is done. The benefits of a two-stage procedure may be prematurely curtailed by the potential limitations of prolonged skin/skeletal traction in children—skin irritation, loosening of traction, circulatory problems, decubitus ulcers, pin tract infection, knee stiffness, and growth disturbance.[2]

Mechanical stabilization of pathological femur fracture in children can be achieved by any one of the following methods—casting, external, or internal fixation. Hip spica with or without K-wire incorporation can be beneficial in small statured children and pathological femoral fractures in the metadiaphyseal junctions, where application of an external fixator may be technically difficult.[2,3] The disadvantages of hip spica must be kept in mind—joint stiffness, restriction of mobility, plaster sores, spica syndrome, and the inability to detect the spread of infection under the plaster cast. Internal fixation in the background of infection is controversial. Elastic intramedullary nailing and antegrade trochanteric intramedullary nailing have been documented.[1] However, any implant used for internal fixation may favor the formation of a biofilm by pathogenic microorganisms which can lead to persistence of infection.

External stabilization can be achieved using a simple or modular external fixator, monoaxial rail fixator, or a circular frame Ilizarov fixator. The advantages of external fixators, in this context, are: Immediate skeletal stabilization, better wound care, and absence of any risk of biofilm formation, and hence, persistence of infection. Simple or modular fixator does not provide axial compression across the fracture site. Hence, they are not optimal in promoting bony union. Additionally, weight bearing cannot be instituted. Ilizarov method of external fixation has been successfully used in three adult patients with pathological femoral fractures secondary to osteomyelitis by Fenton et al.[4] The limitations of a circular ring fixator include pin/wire tract related (pain, sepsis, breakage), patient discomfort, and technical difficulty associated with surgery in children.[5]

To the best of our knowledge, the usage of monoaxial rail fixator for the management of pathological diaphyseal fractures secondary to osteomyelitis in children has not been reported. Its advantages are manifold. First, the monorail fixator allows for axial compression across the fracture site, thus promoting bone union. As evident from our series, all the cases united uneventfully except one case of delayed union. Second, early mobilization of the adjacent weight bearing joints is possible, thus preventing disabling joint stiffness. Third, the patient can be made to bear weight on the affected side with the fixator *in situ*, thus preventing morbidity associated with prolonged recumbency. Fourth, the same fixator can be used for correction of limb length discrepancies once bony union is achieved.[6,7] However, an additional corticotomy and supplementary pin placement or pin readjustments may be required. Fifth, being less bulky than a circular ring fixator, which circumferentially encompasses the entire thigh, the level of patient as well as parent satisfaction is better with a rail fixator, especially with regards to day-to-day activities like toileting and nursing care.

The main limitations of a rail fixator in our series included pin tract infection and pin loosening. According to our experience with rail fixator, pin tract infections generally subside with a longer duration of antibiotic treatment. Generally, in our institute, we prescribe intravenous antibiotics (based on the intraoperative culture and sensitivity reports) for the initial 3 weeks, followed by, oral antibiotics for the subsequent 3 weeks. In the pretext of pin tract infection, oral antibiotics are usually continued as long as the pin tract discharge is present. The value of regular meticulous pin tract care should not be forgotten. We generally advice the parents to hygienically clean the pin tracts with normal saline or sterile water, remove crusts (if any), and apply antibiotic (ciprofloxacin) eye drops thrice a day. The problem of pin loosening can be tackled by the use of hydroxyapatite-coated pins.[6]

Restriction of knee range of movements, as seen in our series, might be secondary to the scarring and fibrosis of the pin tract, leading to the tethering of muscle to the bone. This problem can be effectively prevented by following certain simple intraoperative and postoperative measures. Intraoperatively, utmost care is to be taken for keeping the knee flexed to beyond 90° prior to passage of drill and subsequent pin insertion. This method ensures that both the quadriceps and the iliotibial band are transfixed in flexion.[6] Additionally, release of the iliotibial band intervening the pin tracts also helps in preventing postoperative restriction of range of motion. Postoperatively, early aggressive physiotherapy emphasizing on isometric quadriceps strengthening exercises and joint mobilization exercises should be instituted with adequate analgesic cover.

Some amount of LLD is inevitable in pathological long bone fractures. This might be attributable to bone loss secondary to infection and/or surgical treatment. The latter is due to iatrogenic nibbling of bone ends in the process of freshening them during surgery. Nevertheless, the maximum shortening seen in our series is only 1.5 cm, which requires only a shoe raise for weight bearing and ambulation.

CONCLUSION

Compression fixation achieved by monorail fixator is a viable option for the management of pediatric diaphyseal fractures secondary to active bony infection. It has the advantage of promoting bony union, aiding in early weight bearing, establishing successful joint mobility, improving patient comfort, and providing an option for future restoration of limb length.

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