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Evaluation of surgical fixation of paediatric diaphyseal long bone fractures in lower limb with elastic stable intramedullary nailing (Esin)

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Abstract
Femoral shaft fractures account for 1.6% of all paediatric injuries. The best treatment for children between five to sixteen years of age is still questioned. patients in this transitional age group have high risk of shortening and mal union when conservative measures are used Fixation with flexible intramedullary nails have become a trendy technique, for stabilizing femoral fractures in school aged children. The present study consisted of 25 cases with diaphyseal lower limb fractures of either gender within age group 5-16 years, admitted in Orthopaedics Department of a tertiary care hospital of Punjab and were treated with elastic stable intramedullary nail. RTA accounted for 92% cases. Isolated femur fracture was seen in 40% cases. 8% cases also had ipsilateral tibial fracture with it & 52% had only tibial shaft fractures. Transverse fracture was observed in 56% cases. All cases were fixed with elastic titanium nail. Minor complications, as per Flynn's criteria were seen in 12% cases. No case developed any major complication. Excellent results were obtained in 76% cases and satisfactory results were obtained in the remaining 24% cases.

Keywords: Femoral, tibial, intramedullary, Flynn, elastic, titanium

Introduction
Femoral shaft fractures account for 1.6% of all paediatric injuries. In children 5 years or younger, closed reduction & spica cast application for fracture femur is a commonly followed treatment for most of diaphyseal fractures. In skeletally mature adolescents, use of intramedullary rod is now model treatment for long bone fractures; but the best treatment for children between five to sixteen years of age is still questioned. Compared with younger children, patients in this transitional age group have high risk of shortening and malunion when conservative measures are used [1, 2, 3].

Surgical stabilisation of paediatric femoral and tibial fractures dramatically changed in 1982. Metaizeau and the team from Nancy, France, developed the technique of flexible stable intramedullary pinning (FSIMP) using titanium pins [4, 5]. In the last twenty years, the surgical treatment of paediatrics fractures has increased many folds, although debate still persist over its indications [6]. Surgical treatment of long bones fractures in children must first consider the fact that excellent results can be achieved with non-operative care, with reported union rates of more than 90%, and 100% full functional recovery [7]. Sporadically, reduction cannot be maintained due to excessive shortening, angulation, or malrotation at the fracture site, making operative intervention necessary [8].

Children managed with traction and spica cast as a treatment modality have to undergo various adverse physical, social, psychological penalties of prolonged immobilization. Different other treatment options include external fixation, plate osteosynthesis, intramedullary nailing. However, there is a risk of certain complications, particularly pintract infection and refracture after external fixation or osteonecrosis with solid nails [1, 2, 3, 9].

In the past eight years fixation with flexible intramedullary nails have become a trendy technique, for stabilizing femoral fractures in school aged children [2, 3]. It gives stable fixation with rapid healing and prompt return of child to normal activity [9, 10, 11].

Elastic stable intramedullary nailing of long bone fractures in the skeletally immature patients has gained extensive attractiveness because of its irrefutable effectiveness and truncated risk of complications.

Many studies have armoured the use of this technique, quoting advantages that include closed insertion, preservation of the fracture hematoma, and a physeal sparing entry point [12, 13, 14].

Material and Methods

The present study consisted of 25 cases with diaphyseal lower limb fractures of either gender within age group 5-16 years, admitted in Orthopaedics Department of a tertiary care hospital of Punjab and were treated with elastic stable intramedullary nail. An informed consent was taken from the parents/guardians of each and every patient before the research study.

Inclusion criteria

- Children and adolescent patients from 5 to 16 years of both sexes with only closed diaphyseal lower limb fracture otherwise fit for surgery.

Exclusion criteria

- Patients less than 5 years of age and more than 16 years of age, with open fractures, unfit for surgery medically or otherwise.

Under c-arm image intensifier, using spica table the patient was fixed with two titanium elastic nailsfor femoral fractures while tibialdiaphyseal fractures were fixed with the patient in supine position only. The nails were prebent slightly to facilitate reduction and three point fixation was achieved. For femoral fractures, a 2.0 cm longitudinal skin incision was made over the medial and lateral surface of the distal femur starting 2 cm proximal to the distal femoral epiphyseal plate, soft tissue was split down to the bone. Bone entry was made with the help of awl. Likewise, for tibial diaphyseal fractures, entry points for nails were made at the proximal end of tibia on medial and lateral side using 2 cm incisions.

All the patients were permitted static quadriceps exercises within 48 hours. Active knee, hip and ankle movements bring into being after 4 days post-operatively. Segmental or long spiral fractures were given supplementary support with thigh lacer. Partial weight bearing was commenced at 6 weeks after radiological sign of early union but was delayed in segmental fractures. Full weight bearing was permitted by 8-12 weeks contingent on the fracture configuration and consolidation of fracture union.

Follow-up, assessment was done at 6, 12 and 24 weeks clinically, radio logically and for any complication.

Minor complications included

1. Pain at the site of nail insertion
2. Minor angulation (< 10 degree – saggital/coronal)
3. <10 degree rotational mal allignment at final follow-up (24 weeks)
4. Minor leg length discrepancy(< 2cm – shortening/lengthening) at final follow-up (24 weeks)
5. Superficial infection at site of nail insertion

Major complications included

1. Angulation exceeding the guidelines (>10 degree – saggital/coronal; or > 10 degree rotational malalignment) at final follow-up
2. Leg length discrepancy exceeding the guidelines (>2cm – shortening/lengthening) at final follow-up
3. Deep infection
4. Loss of reduction requiring repeat surgery
5. Surgery to revise nail placement
6. Compartment syndrome requiring surgery
7. Neurological damage after nailing
8. Delayed or nonunion leading to revision

The final outcome based on the above observations is done as per Flynn's criteria (given below) [16].

TENS outcome score

Table 1

Results at 24 weeks Variables	Excellent	Satisfactory	Poor
Limb-length inequality	<1.0 cm	<2.0 cm	>2.0 cm
Malalignment	5º	10º	>10º
Unresolved pain	Absent	Absent	Present
Other complications	None	Minor and resolved	Major and lasting morbidity

Case 1: Pre and Post Operative Roentgenograms (Femur Fracture)

Case 2: Pre and Post Operative Roentgenograms (Tibial Fracture)

Observations and Results

In our study, 80% of patients were within 5-8yrs age, 12 % within 9-12yrs and 8% within 13-16 yrs age. 88% of the

patients were male and 12% females. There were 15 patients with tibial diaphyseal fractures and 10 patients with femoral diaphyseal fractures. Most common mode of injury in our study was RTA which accounted for 92% cases, the remaining 08% being due to fall from height or stairs. In 52% cases on the left side and on right side in 48% cases. Transverse fracture was observed in 56% cases, oblique in 20% cases, spiral in 24% cases. 32% cases had fracture in proximal 1/3rd region, 64% in middle 1/3rd and 4% in distal 1/3rd. Time interval between trauma and surgery was <2days in 80% cases, 3-5 days in 12% cases,>5 days in 8% cases. Isolated femur fracture was seen in 40% cases. 8% cases also had ipsilateral tibial fracture with it & 52% had only tibial shaft fractures. Duration of surgery was <30 minutes in 12% cases, 30-60 minutes in76 % cases, >60 minutes in 12% cases. Duration of hospital stay was <7 days in 72% cases and 8-12 days in 28% cases. Time for radiological union was 8-12 weeks in 76% cases, 13-18 weeks in 20% cases and 19-24 weeks in 4% cases. At 24 weeks, 80% cases had full range of motion and mild restriction was seen in 20% cases. There were no cases with moderate and severe restriction of movements. 80% cases started partial weight bearing in 6-7 weeks, 12% in 8-9 weeks and >9 weeks in 8%. Time of full weight bearing was <12 weeks in 76% cases, 13-18 weeks in 16% cases and >18 weeks in 8% cases. Minor complications, as per Flynn's criteria were seen in 12% cases. No case developed any major complication. 28% of the cases complained of pain at initial follow up which was resolved in all cases at 16 weeks. Superficial infection was seen in 4% cases. Limb shortening of 1.5cm was seen in 8% cases. Varus angulation of 5 degree was seen in only one case.

In our study, excellent results were obtained in 76% cases and satisfactory results were obtained in the remaining 24% cases.

Age distribution of patients

In our study, 25 children with femoral and tibial diaphyseal fractures between the age 15-16 years were included. All were fresh cases. The oldest patients in our study was 14 years of age and the youngest being 5 years. 72% of the cases were <10 years of age and 28% were above 10 years age (as shown in Table 2).

Table 2: Age Distribution of Patients

Age in years	No. of patients	Percentage (%)
5-8	20	80.00
9-12	3	12.00
13-16	2	08.00
Total	25	100.00

Table 3: Sex Distribution of Patients

Sex	No. of patients	Percentage (%)
Male	22	88.0
Female	3	12.0
Total	25	100.0

Discussion

In the present study conducted at tertiary care hospital in Punjab, 25 patients with diaphyseal lower limb fractures within age group 5-16years were surgically fixed with elastic stable intramedullary nail (ESIN). Final outcome of surgical intervention was evaluated in agreement with the Flynn's criteria. The duration of stay in the hospital was <7 days in 18 (72%) cases and 8-12 days in the remaining 7(28%) cases. The average duration of stay in hospital was 7.5 days. The mean hospital stay was 12 days in Kalenderer O *et al.* study [15]. Average hospitalization time was 11.4 days in the study conducted by Mann DC *et al.* [18]. Compared to the above studies conducted on conservative methods and cast bracing, the average duration of hospital stay was less in our study i.e. 7.5 days. The shorter hospital stay in present series is because of proper selection of patients, stable fixation and lesser incidence of complications.

In our study, closed reduction of the fracture, leading to preservation of fracture hematoma, improved biomechanical stability and minimal soft tissue dissection led to rapid union of the fracture compared to compression plate fixation.

In the present study, unsupported full weight bearing was started in <12 weeks for 19 (76%) of the patients, between 13 and 18 weeks in 16 (20%) and at 20 weeks in 2 (8%) patient. The average time of full weight bearing was 10.6 weeks. The average time of full weight bearing in Flynn *et al.* (2002) study was 8.5 weeks [16].

19(76%) patients had full range of hip and knee motion in the present study and 6 (24%) patients had mild restriction in knee flexion at 12 weeks, but normal range of knee flexion was achieved at 8 months. J.M. Flynn *et al.* reported 2 (0.9%) cases of knee stiffness out of 234 fractures treated with titanium elastic nails [16].

In our study, 5 (20%) patients had developed pain at site of nail insertion during initial follow up evaluation which resolved completely in all of them by the end of 16 weeks. J.M. Flynn *et al.* reported 38 (16.2%) cases of pain at site of nail insertion out of 234 fractures treated with titanium elastic nails [16].

Superficial infection was seen in 1 (4%) case in our study which was controlled by antibiotics. J.M. Flynn *et al.* reported 4 (1.7%) cases of superficial infection at the site of nail insertion out of 234 fractures treated with titanium elastic nails [16].

In our study union was achieved in 18 (72%) cases in less than 12 weeks, in 6(24%) cases within 13-18 weeks and >18 weeks in 1 case. Average time of union was 10.9 weeks. Oh C.W *et al.* reported average time for union as 10.5 weeks [17]. Aksoy C *et al.* compared the results of compression plate fixation and flexible intramedullary nail insertion. Average time to union was 7.7 (4 to 10) months in the plating group and 4 (3 to 7) months for flexible intramedullary nailing [19].

Leg length discrepancy is the most common sequele after femoral shaft fractures in children and adolescents. No patient in our study had major limb length discrepancy (i.e. > ± 2cm). Only 2 patients had shortening of 1.5cm. Ozturkman Y. *et al.* observed mean leg lengthening of 7mm in 4 (5%) patients and mean shortening of 6mm in 2 (2.5%) children [20]. Clinically significant limb discrepancy (> 2cm) did not occur in any patient in their study. John Ferguson *et al.* noted more than 2cm shortening in 4 children after spica treatment of pediatric femoral shaft fracture [21]. In the present study, limb lengthening of more than 10mm was present in 2 (10%) cases. Comparing to limb length discrepancy in conservative methods, limb length discrepancy in our study was within the acceptable limits.

No patient in our study had significant rotational deformity. Heinrich SD *et al.* out of 183 fractures studied, reported 8 degree out toeing in 4 children and two children with 5 degree in toeing following flexible intramedulary nailing [22].

Conclusion

Going through the observations results, it is crystal clear that Elastic Stable Intramedullary Nailing (ESIN) is a better method for treatment of paediatric long bone fractures as it is

a minimally invasive, simple and well reproducible technique with less surgical time, lesser stay in the hospital, early union, lesser chances of limb length discrepancy & superficial or deep infection with a steep learning curve. This technique allows early full weight bearing and return to the normal activities. Hence the fixation of long bones fractures with ESIN should be recommended to the pediatrics patients. This technique has many merits over a traditional plating.

It is a simple, effective, reliable and minimally invasive method with less morbidity for management of pediatric femoral and tibial fractures between the age of 5 to 16 years.

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