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Flexible intramedullary nailing in pediatric femoral fractures, short term results at a secondary healthcare system

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Abstract
Background: Femoral fractures in children are among the most common fractures of long bones. The definitive treatment modalitiy remains controversial. Flexible intramedullary nailing has emerged as an accepted procedure for femoral fractures in school going children. We thus undertook a prospective study of paediatric femoral fractures treated with flexible titanium nailing at our centre which is a secondary health care.
Material and Methods: Our study included 18 patients having femoral fractures treated with retrograde flexible intramedullary nailing. In our study we had males and females with right side and on left side. Patients were followed up for a mean period of 10 months.
Results: Patients were followed up till their fractures healed or until the last followup visit. The mean length of follow-up was 10 months. All patients united uneventfully. Radiological union was evident in a mean time of 8.44 weeks ranging from 6 to 12 weeks. Three patients got limb lengthening of 1 – 1.5cm. Two patients got a varus angulation of less than 10º. There was no case of entry site irritation or any nerve palsy. One patient got a peculiar entry site medial localized cortical longitudinal fracture. There were 12 excellent and 6 satisfactory results using outcome criteria of Flynn *et al* for titanium elastic nail.
Conclusion: Flexible nailing in pediatric femoral fractures yields excellent and satisfactory outcome with a relatively free from major complications.

Keywords: Paediatric femoral fracture, flexible intramedullary nailing

Introduction
Femur fracture is the most common pediatric orthopedic injury that requires hospitalization [12].

In preschool children having isolated femur fracture with less than 2 cm initial shortening Early spica casting is the treatment of choice [10]. In children nearing skeletal maturity, rigid Interlocking intramedullary nail with trochantric entry point is being propounded by most Authors [3, 5, 9, 10]. In the treatment of fracture shaft of femur in school children different methods

Have been used including hip spica cast, traction, external fixator, plating and nailing [4] with Issues of patient/parent acceptance and many complications. Titanium elastic nail has emerged as a wonderful tool to address all these concerns enabling early mobilization and with drastically reduced complications. In this study we aim to share our experience with titanium elastic nail in paediatric age group in a rural setup.

Materials and Methods
Eighteen children with fracture shaft of femur presented in District Hospital Baramulla from 2014 to 2017 ranging from 6 year to 15 years with a mean age of 11.39 years. These included Thirteen males and five females. Right limb was involved in 11 cases and left limb in 7. The Mechanism of injury in our study was predominantly due to fall during sports activities i.e. in Fourteen patients and the rest of the four patients had sustained a high velocity trauma in road Traffic accidents. Thirteen fractures involved the middle third; two involved the distal third and three involved the proximal third of the shaft of femur. Eleven fractures were transverse, four were short oblique, one was long oblique and two were minimally comminuted (less than

50% cortical diameter) [20]. Five patients had associated injuries including fracture clavicle in two Epiphyseal injury distal radius in one, fracture both bones forearm in one and supracondylar fracture humerus in one patient.

All the patients were operated within four days of injury under general anesthesia on fracture Table in supine position using IITV control for reduction and proper passage of nails.

Procedure: Two longitudinal incisions were made at the level of patella on medial and lateral Side. Bone was exposed subperiosteally and an awl was used to make entry point 2-3 cm above Physis, directed obliquely proximally hitting the middle of the width of presenting cortex [10, 14].

Two equal nails of appropriate diameter (0.4× isthmic diameter) [2, 8] were chosen. Both were contoured into a bow shape in opposite directions with apex at the level of fracture and nail tip pointing to the concave side of bowed nail keeping the depth of bow approximately 3 times the

Diameter of the femoral canal [13]. The bow in each nail should be similar for balanced recoil Force. Etched line on the nail provides reference for the nail tip during insertion. They were Inserted one by one with the help of T-handle manually till opposite cortex was touched with the Curved tip directed proximally and then hammered gently up to the fracture site. Reduction was

Then confirmed with IITV and nails were passed across for which sometimes rotation of nail was needed to feed the tip into proximal fragment. Care was, however, exercised not to rotate any Nail more than 180º to avoid intertwining of nails [6]. Then they were pushed up to the proximal Metaphysis, tips facing opposite directions for optimal rotational stability. If the fracture got distracted, traction was released and patient heel impacted. Excess length of nail was cut after withdrawing it for some distance for convenience and then

Reinserted with the help of tamp leaving only 1.5 cm outside cortex for later extraction. The Exposed ends were not bent but left in close apposition to the supracondylar flare [16]. The Wounds were closed and the compression bandage was applied. The patients having stable Fractures were mobilized, without weight bearing, on crutches or walker after one week Followed by supervised progressive weight bearing after 4 weeks depending on fracture Configuration, associated injuries and callus response. Patients having unstable fracture Geometry, proximal and distal femoral fractures, the operated limb was supported with a plaster splint for initial 3 weeks, followed by toe touch weight bearing, followed by partial and later full weight bearing as per the radiological healing status. Finally cases were classified into excellent, Satisfactory and poor using criteria of Flynn *et al* [7] as detailed in Table 1

Results

The average hospital stay of our patients was 6.2 days (range 5 to 8 days). Patients were followed up till their fractures healed or until the last follow-up visit. The mean length of Follow-up was10 months (2–30). All patients united uneventfully (Figure Aa, Ab, and Ac). Radiological union was evident in a mean time of 8.44 weeks ranging from 6 to 12 weeks. All The patients were ambulatory without assistive devices by an average of 9 weeks (Range 7-12 weeks). Three patients got limb lengthening of 1 – 1.5cm. The patient with long Oblique fracture got shortening of 1.2 cm. Two patients got a varus angulation of less than 10^0. All the patients got full range of movement of hip and knee by 8 weeks. There was no case of Entry site irritation or any nerve palsy. One patient got a peculiar entry site medial cortical longitudinal fracture on to and fro movement of nail due to inadvertent lifting of nail away From cortex; this patient was given support for 4 weeks with a plaster splint and united Uneventfully (Figure B). There were 12 excellent and 6 satisfactory results using outcome criteria of Flynn *et al* for titanium elastic nail.

Table 1: TEN outcome scoring

	Excellent	**Satisfactory**	**Poor**
Leg length inequality	**< 1cm**	**< 2cm**	**> 2cm**
Misalignment	< 5 degrees	5 to 10 degrees	> 10 degrees
Pain	None	None	Present
Complications	None	Minor and resolved	Major complications and/or lasting morbidity
No. of patients	12	6	0

Table 2: Acceptable angulation and limb length discrepancy in children with a femoral fracture

Age	**Varus/valgus(degrees)**	**Anterior/posterior(degrees)**	**Shortening(mm)**
Birth-2years	30	30	15
2-5 years	15	20	20
6-10 years	10	15	15
11years to maturity	5	10	10

Fig Aa: Femur fracture (AP View)

Fig Ab: follow up at 6 weeks (AP view and Lateral View)

Fig Ac: United fracture at 6 months Follow up

Fig Ad: At 2 years follow up after removal of hardware

Fig B: Encircled localized longitudinal fracture at medial entry site

Discussion

Fracture shaft of femur in children and adolescents have traditionally been treated conservatively By hip spica cast or traction that involved prolonged immobilization with resultant loss of School days and issues about nursing care. Residual deformity and limb length discrepancy were Also common. Because of these problems, operative approach has been more often resorted to Using external fixation or plate osteosynthesis. External fixation has lesser patient/parent
Acceptability with risk of pin traction infection and higher incidence of stiffness due to painful movements and possibility of secondary fractures through pin tract[1]. Moreover, Plate and screw fixation has the possibility of delayed union and infection and also requires as a major second Surgery for removing the plate [17, 19]. Interlocking intramedullary nails have also been used in adolescents; with complications like AVN of femoral head and coxa valga have been reported inliterature [5].
Beaty *et al* have recommended trochantric entry point avoiding piriform fossa to prevent these
Complications [3]. Rush nails and Enders pins have also been used in treatment of these fractures, However they are less stable and have higher incidence of adverse outcomes. Further Ender Nails need to be "stacked" to fill the canal to improve fixation as against balanced elastic recoil of the two opposing flexible implants in case of TENS [7].
Titanium elastic nail system, using biological surgical technique, is minimally invasive, load sharing internal splint. It endangers neither the physes nor blood supply to femoral head and avoids most complications associated with plating, external fixation or anterograde
Intramedullary nailing. It meets all requirements of Flynn *et al* "ideal device for the treatment of Most femoral fractures in children" [8]. That is why it is emerging as the most favored method of Treatment in children before skeletal maturity and above five years of age. It provides an internal three point fixation and resists deforming forces by an elastic recoil. Early mobilization is Possible and thus patient confidence and satisfaction is enhanced. Preservation of periosteum and
Fracture haematoma and also the micromotion conferred by elasticity of fixation promotes faster External bridging callus formation. Titanium elastic nail is befitting for transverse, short oblique and minimally comminuted Fractures [2, 14]. However, it does not provide adequate stability in comminuted and long oblique Fractures, in which, even if performed needs postoperative immobilization.
Most consistently reported complication with titanium elastic nail is entry site irritation and
Pain [7, 16]. This has been attributed to bending of the ends of nails. However, we did not encounter any such problem in our study. This can be explained by the fact that the extracortical nail ends were cut short (<1.5cm) and also were not bent but left along the supracondylar flare as recommended by narayanan *et al* [16]. Complications like limb length discrepancy and fracture angulations have also been reported. In our study we had limb length discrepancy in 4 patients (22.2%) and fracture angulation (Varus) in 2 patients (11.1%) and none of the patients had rotational malalignment. Since our study has less number of cases with a short follow up, we cannot comment on the exact final limb length and alignment.
Narayanan *et al* found that loss of reduction requiring operative correction or resulting in malunion were mainly due to mismatched nails or comminution of more than 25% of shaft diameter [16].
We did not get any nerve palsy in this series. Baron recorded a case of transient foot drop with Flexible intramedullary nailing[1]; Narayanan *et al* reported two cases of transient nerve palsy: First of sciatic nerve due to perforation of proximal end of one nail through posterior femoral Neck and second of pudendal nerve due to traction on perineal post [16].
Guidelines proposed by Flynn and Skaggs for acceptable alignment and limb legth discrepancy are presented in Table 2 [10]. According to these guidelines all our patients had acceptable Outcome.
Moroz *et al* reported a statistically significant incidence of poor outcome in children aged 11 years and older compared with those below this age. They also found a 5 times more
Likelihood of poor outcome in children heavier than 49 kg [15].

Conclusion

Titanium elastic nail is emerging as the most favored treatment option in femoral fractures before skeletal maturity. It is less invasive and biomechanically more stable providing internal three Point stabilization. In this study titanium elastic nails gave good results with few complications and rapid mobilization which is consistent with the findings of numerous other studies.

According to Flynn and Skaggs guidelines acceptable outcome was seen in all patients suggesting that this modality of treatment can be provided to the patients even in a rural set up.

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