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Retrograde titanium elastic nailing in management of length unstable pediatric femoral shaft fracture

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Abstract

Background: Elastic intramedullary nailing is one treatment option which is argued to be ideal stabilization method in various reports, especially in length stable fractures (transverse and short oblique) owing to its load sharing properties and minimum complications. In contrast, results in length unstable fractures are not uniform.
Objective: To study the outcome of management of length unstable femur fracture in children with titanium elastic nails.
Methods: This was a retrospective study conducted in a tertiary care teaching hospital from August 2013 to July 2015. For the study purpose we collected records of all consecutive cases of femoral shaft fractures in children from 6 years of age to 15 years. The inclusion criterion were cases of length unstable femoral shaft fracture that were managed with titanium elastic nails and having at least six months of follow up.
Results: There were 19 cases fulfilling the inclusion criterion. The mean age was 9±2.357 years. Spiral fracture was seen in 9 cases(47.40%), long oblique fracture was seen in 7 cases(36.80%) and 3 cases (15.80%) were having communition. Fracture united at average 8.42 weeks with standard deviation of 1.26 weeks. The mean follow up was 12.11±3.36 months. There were 14 cases with excellent outcome and 5 cases with satisfactory outcome based on Flynn outcome scoring. Post-operative complications were few.
Conclusion: Retrograde elastic nailing is a good option for the management of length unstable paedetric femur fracture when supplemented by slab or cast in initial few weeks.

Keywords: Elastic stable intramedullary nailing; Fracture; Femur; Children; Length unstable.

Introduction

Fracture shaft of femur is common injury in children. They represent 1-2% of all fractures in the pediatric population.(1-2) Non-operative method to treat such fracture by applying hip spica casting either primarily or after initial few days of skin traction, has been gradually replaced by operative methods due to the latter distinct advantage of rapid mobilization, especially in the age group 6 to 15 years,(3-5) head injuries(6) and cases of multiple injuries from high velocity trauma.(7) The different methods of fixation are plates and screw,(8) external fixator,(9-11) elastic intramedullary nailing(12-15) and solid antegrade intramedullary nailing.(16,17) The choice of fixation methods depends upon several factors like age, built of patient, location of fracture in diaphysis and fracture pattern. Psychosocial and economic effects of hip spica casting on patient and their families may have influence over the treatment choices.(18-20)

Elastic intramedullary nailing is one treatment option which is argued to be ideal stabilization method in various reports, especially in length stable fractures (transverse and short oblique) owing to its load sharing properties and minimum complications.(12,21) In contrast, results in length unstable fractures (long oblique, spiral, comminuted) are not uniform. Higher rates of malunion and unplanned revision surgery have been reported.(22-28) The outcome for length unstable facture has shown to be improved on postoperative adjunctive support such as brace or cast.(12,15,27)

We hypothesized that elastic titanium nailing is equally good for length unstable femoral fracture given that principle is adequately followed and routine postoperative adjunctive support such as splint or cast is given.

Methods

This was a retrospective study conducted in Orthopaedic Department of a tertiary care teaching hospital from August 2013 to July 2015. The study was approved from ethical committee of the institute. For the study purpose we collected records of all consecutive cases of displaced femoral shaft fractures in children from 6 years of age to 15 years of age. X-rays were analyzed for the selection of cases. Transverse and short oblique (fracture line angulation less than 20 degree) fracture are length stable fracture. Long oblique (fracture line angulation more than 20 degree), spiral and comminuted fracture are length unstable fracture.

The inclusion criterion were cases of length unstable femoral shaft fracture that were managed with titanium elastic nails and having at least six months of follow up, irrespective of associated injuries or multiple trauma. Cases that were managed by other methods (both operative and non-operative), inadequate follow up and having incomplete records were excluded.

There were total of 31 cases of length unstable femur fracture of which 19 were managed by titanium elastic nails, 6 cases managed by hip spica casting, 2 cases managed by external fixator and 4 cases managed by open reduction and internal fixation with plates and screws.

Operative procedure: All the cases were done based on the principles and technique as advised by Ligier JN, Metaizeau JP et al.[13]

Under regional anesthesia or general anesthesia the patients are positioned supine on fracture table. Close reduction of the fractured femur is done by using longitudinal traction applied through a traction boot and gentle rotation. The aim of closed reduction is to obtain anatomical reduction, if not acceptable reduction. The alignment is confirmed with fluoroscopy in both the anteroposterior(AP) and lateral views. Longitudinal skin incision of 2 cm is made at 2.5-3 cm proximal to distal femur physics level over lateral and medial aspect of thigh and the entry point is made by bone awl to a 45 degree angle relative to the shaft axis. Selected pair of titanium elastic nails of equal diameter (nail diameter that is 40% of femoral medullary canal diameter) are inserted after proper contouring (pre-bent 3 times the diameter of the medullary canal) through entry points and advanced proximally to fracture site. After close reduction they are further advanced into the proximal fragment to diverge laterally towards the greater trochanter and medially within the femoral neck for proper rotational stability. Throughout the procedure position of nails and stability of fracture are checked under image intensifier control. Finally the protruding parts of the nails were cut keeping a small part outside the distal femoral entry point and wounds were closed.

Before removing the patient from fracture table, traction was loosened and the fracture reduction was checked under image. Those cases which were found to be stable without any change in reduction were immobilized on posterior slab and those cases which show any change in reduction post fixation or adolescent patient with weight greater than 40 kg were immobilized on high groin long leg cast. Sitting up in bed and static quadriceps exercise was started on first post-operative day. Non-weight bearing and crutch walking was started on second to third post-operative day. Patients were reviewed at 2 weeks, 4 weeks, 6weeks and then depending upon progression of union patient were followed up from 2 weeks to one month. Once radiological union was confirmed patients were followed after 3 months and 6 months. At 2 weeks, wound was inspected and suture removed. At 4 weeks x-ray was advised to assess any loss of reduction and to evaluate for progression of union. At 6 weeks slab/cast was removed and x-ray was done to assess progression of union, limb alignment and rotation was assessed and active and assisted active range of motion exercise for knee was started. Partial weight bearing was started at this stage. Tenderness at fracture site and lower extremity lengths were determined by clinical examination. At further follow up of 2 weeks to one month union progression, limb alignment, limb length and rotation was assessed. Progression of union at fracture site was assessed radiologically by using Anthony et al[29] scale for grading callus formation [Table 1]. Full weight bearing was allowed once union was confirmed. Final follow-up assessed for coronal or sagittal mal-alignment, limb length discrepancy and any obvious implant related complications. The final results were evaluated using criteria by Flynn et al[12] [Table 2].

Table 1: Anthony et al.[29] Grading for callus formation

Grade 0	No identifiable fracture healing
Grade 1	Primary bone healing with little or no periosteal new bone formation
Grade 2	Periosteal new bone formation on two sides of the femur
Grade 3	Periosteal new bone formation on three or four sides of the femur

Table 2: Flynn TENS outcome scoring

	Excellent	Satisfactory	Poor
Leg length discrepancy	<1cm	<2cm	>2cm
Mal-alignment	5	10	>10
Pain	None	None	Present
Complication	None	Minor and resolved	Major and/or lasting morbidity

Results

The mean age of the patients was 9±2.357 years ranging from 5 to 14 years. There were 57.9% (11 cases) male and 43.10% (8 cases) female. Thirteen cases (68.40%) were on right side and the rest 31.60% (6 cases) on left side. Fall from height especially from tree and road traffic accidents were common mode of injury each with 6(31.6%) cases followed by sports related injury in 3(15.80%) cases and slip and fall 2(10.50%) cases, the remaining two cases were due to hit over thigh by log of wood and bolder respectively.

All fractures were closed fracture. Most of the cases had fracture in middle third (14 cases, 73.70%) followed by 15.80% cases in upper third and 10.50% cases in lower third. Spiral fracture was seen in 9 cases (47.40%), long oblique fracture was seen in 7 cases (36.80%) and 3 cases (15.80%) were having comminution.

In all cases closed reduction was successful to achieve either anatomical reduction 16(84.20%) cases or non-anatomical but acceptable reduction 3(15.80%) cases. Most of the spiral fracture reduced beautifully over the fracture table (Fig. 1). One each case of Long oblique fracture, spiral and comminuted fractures could not reduced anatomically, but the reduction was acceptable for the age, so decided to continue with the procedure without going for open reduction(Fig. 2). All cases were immobilized postoperatively with either long leg posterior slab or high groin long leg cast. In one cases, after fixation of fracture when traction was loosened, fracture reduction showed varus angulation and so cast was applied with valgus moulding at fracture site(Fig. 3). In other two cases, cast was applied due to weight of the patient. There were no complications noted intraoperatively.

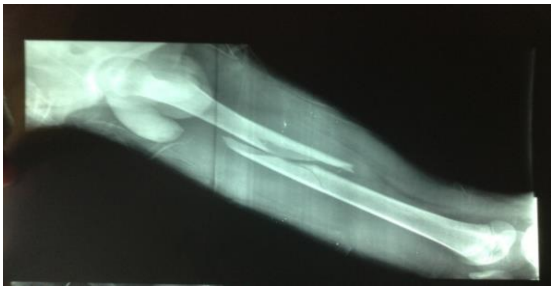

Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1: Case number 4, 14 year male. 1A: Anteroposterior view of right thigh, spiral fracture middle third; 1B: Lateral view of right thigh, spiral fracture middle third; 1C: anatomical reduction and fixation with 4mm titanium elastic nails, postoperative immobilization with long leg posterior slab

Fig. 2a

Fig. 2b

Fig. 2: Case number 7, 8 year boy. 2A: Anteroposterior and lateral view of right thigh, spiral fracture upper third; 2B: nonanatomical but acceptable reduction and fixation with 3.5mm elastic titanium nail, postoperative immobilization with long leg slab

Fig. 3a

Fig. 3b

Fig. 3: Case number 19, 13 year old boy. 3A: spiral fracture with medial cortex communition; 3B: Closed reduction and fixation with 3.5 mm elastic nail. After removing traction, there was varus angulation at fracture site, high groin cast with valgus moulding done

Table 3: Details of cases

Case no.	Age	Sex	Laterality	Mode of injury	Fracture pattern	Location	Quality of reduction	Union	Flynn outcome score	Final follow up	Complication
1	9	F	L	FFH	Oblique	MT	A	7	E	9	None
2	7	F	L	OTH	Spiral	MT	A	8	E	10	None
3	5	F	L	SAF	Oblique	MT	A	9	E	11	None
4	14	M	R	RTA	Spiral	MT	A	9	S	7	Flexion loss 15 degree
5	7	F	R	FFH	Oblique	LT	F	8	S	15	1.5cm shortening
6	11	F	R	SI	Spiral	MT	A	9	E	11	None
7	8	M	R	RTA	Spiral	UT	F	8	E	8	None
8	8	F	R	FFH	Spiral	MT	A	10	E	12	None
9	7	F	R	OTH	Communited	UT	A	9	E	13	None
10	11	F	R	RTA	Oblique	MT	A	8	E	16	None
11	12	M	R	SI	Spiral	MT	A	8	E	20	None
12	8	M	R	FFH	Oblique	MT	A	9	E	12	None
13	8	M	R	RTA	Spiral	MT	A	7	E	14	None
14	7	M	L	FFH	Communited	MT	A	6	E	9	None
15	9	M	L	FFH	Spiral	LT	A	12	S	14	1.5cm shortening with distal nail migration requiring early nail removal
16	10	M	R	SAF	Oblique	MT	A	8	E	12	None
17	10	M	R	RTA	Spiral	MT	A	8	S	8	Flexion loss 30 degree*
18	7	M	L	SI	Oblique	UT	A	8	E	17	None
19	13	M	R	RTA	Communited	MT	F	9	S	12	Varus angulation 10 degree

FFH-fall from height,RTA-road traffic accident,SI-sports injury, SAF-slip and fall, OTH-others
UT-upper third, MT-middle third, LT-lower third
A-anatomical, F-Non anatomical but acceptable(functional)
E-excellent, S-satisfactory
*case of cerebral palsy with bilateral femur fracture
M-male, F-female
L-left, R-right

Fracture united at average 8.42 weeks with standard deviation of 1.26weeks. Minimum period of fracture union was seen at 6 weeks and maximum of 12 weeks was seen. The final follow up ranges from 7 months to 20 months with mean follow up of 12.11±3.36 months. There were 14 cases with excellent outcome and 5 cases with satisfactory outcome based on Flynn TENS outcome scoring. No case show poor outcome (Fig. 4-6).

Fig. 4a

Fig. 4b

Fig. 4c

Fig. 4: Case number 4, 14 year male. 4A: united fracture; 4B and 4C: clinical outcome. Terminal loss of flexion of 15 degree

Fig. 5a

Fig. 5b

Fig. 5c

Fig. 5: Case number 7, 8 year boy. 5A: United fracture; 5B and 5C: excellent clinical outcome

Fig. 6a

Fig. 6b

Fig. 6c

Fig. 6: Case number 19, 13 year old boy. 6A: united fracture, varus malunion of 10 degree; 6B and 6C: satisfactory outcome

Post-operative complications were few. Limb shortening of 1.5 cm was noted in one case and terminal loss of knee flexion by 15- 30 degree was seen in other cases. The details of the cases are illustrated in Table 3.

Discussion

The management of femoral shaft fracture in children has undergone considerable change in last few decades. The first evolution leads to acceptance of operative treatment over non-operative treatment especially in children greater than 6 years of age, on the grounds of rapid mobilization better patient care and increasing economic and psychosocial effects on patient and care taker.[3-5]

In 1988, Ligier JN, Metaizeau JP et al[13] gave the idea of elastic intramedullary nailing especially for length stable fracture. Since then multiple reports have supported this technique with excellent results and argued as gold standarad treatment in length unstable femoral diaphysis fracture.[12,21] Elastic nailing system acting as an "internal splint" shares loads, maintains length and alignment while permits enough fracture site motion for callus formation. Early mobilization of knee with lesser need of immobilization is added advantage in length stable fracture. Moreover, the procedure being closed there is no disturbance of periosteum or fracture hematoma hence less risk of infection, delayed union or non-union.[12]

Secondary hip spica casing after few days of traction, open reduction with plates and screw, submuscular bridge blating, external fixator and elastic nailing are the options in the management of length unstable femoral shaft fracture. Hip spica casting is gradually over taken by the operative methods. Closed reduction and external fixation methods continues to be widely used method owing to its biology preserving nature. Pin tract infections, joint stiffness and cumbersome implant are the major disadvantages. Traditionally done open reduction and internal fixation with plates and screws in length unstable fracture yields poor result due to massive soft tissue stripping, usually required in such fractures. Increased risk of infection is added disadvantage.[3-5,30] Submuscular bridge plating is relatively noble method and results are encouraging in such fracture pattern. Biology preservation, relative stability at the fracture site allowing secondary healing, early knee mobilization and lesser need of immobilization are the noted advantages over other methods of fixation and so this method has been argued to be ideal method in length unstable femoral shaft fracture. Long term results and wider acceptance of the technique is still far away.[31,32]

Elastic nailing is well established technique with excellent results in most reported series. It works on the principle of balanced nailing and three point fixation and it applies well in transverse and short oblique fractures.[13,33] For the bone like femur which is eccentrically loaded, any comminution in any of the cortex or the fracture pattern like long oblique or spiral, fixation done with elastic nailing theoretically should not resist shearing, axial or bending force. Biomechanical studies done with bone model have shown poor stability using elastic nails in comparison to other methods like paedetric locking nail. Though some comparable stability is seen in deforming force other than rotation.[34]

Clinical results for such types of fracture pattern when fixed by elastic nailing varies. In a comparative study by Mahesh DV et al[22] they had poor results in length unstable fracture and they recommend for other methods of fixation, though they didn't mention about any use of postoperative splits or cast. Sink EL et al[24,25] and Flynn JM[12] have also shown higher incidence of malunion, leg length discrepancy and nail end irritation with length unstable fracture pattern.

In our study we didn't get any poor result as per Flynn scoring. Few cases where we had satisfactory result, varus maluion was seen in only patient and in few cases there were shortening and loss of terminal knee flexion. We believe our better results are owing to following exact principles of elastic nailing and use of immobilization (either slab or cast) in every case. Use of immobilization avoids any deforming force at fracture site for initial few weeks till callus is form. After that, both nail and callus starts sharing load as well as movement at fracture site has seized so that effect of deforming force is minimized. Aggressive mobilization of the knee after removal of slab or cast and isometric strengthening of quadriceps and hamstring is very important. Even after aggressive rehabilitation, we had loss of terminal knee flexion in few patient. Visibility of callus does not always resist axial loading. We had few cases of shortening of less than 1.5cm.

One method to improve stability in length unstable fracture without losing freedom of mobilization is using end caps, which prevent nail from sliding back through the insertion site and therefore increases the axial stability in length unstable femur fractures and may prevent soft tissue irritation and shortening,[35,36] though the results are not supported in a biomechanical study by Kaiser et al.[37] Use of four nails on the principles of canal filling as advised by Ender HG[38] has also shown to improve the results[39] or three nails construct as shown by Kaiser et al.[40] Recent findings of better stability and clinical outcome by paedetric locked nailing or submuscular bridge plating seems to be better option for unstable fracture pattern but this has to be verified under larger clinical trials.[31,32]

Most authors have reported nail migration and associated problems like skin breakdown, superficial or deep infection, effusion at the adjacent joint and stiffness due to soft-tissue irritation, bursitis, reoperation to perform nail trimming or nail advancement, and early implant removal with the subsequent risk of refracture to be more common especially when the nail ends were bend.[12,24-28] We had one case with nail migration causing painful bursitis. We removed the nail at three and half months. At final follow up, he had 1.5cm of shortening. Ligier JN et al[13] have recommended postoperative immobilization to minimize the nail related complications. In our study by the virtue of fracture pattern we immobilized every case for six weeks and have regularly kept the nail end unbend flushed with the metaphysis, which may be reasons for low number of this type of complication. However, Luhmann et al.[27] have shown that irritation by the nail tip is not associated with early knee motion.

Our study has severe potential limitations. Being retrospective study, not all cases of length unstable pattern were included during the study period. Some cases were managed by other methods and this selection bias in management may have excluded cases that were poorly suited for elasting nailing. Also being an observational study of single method fixation statistical significance of the results could not be obtained. A better study would be either prospective comparative study comparing different methods of fixation or randomized controlled trial. Small number of cases in our study is another limiting factor. Large sample size in single center or multicentric studies with larger sample size would give more convincing results. But even with high trauma load centres, it will take very long duration to have adequate sample with adequate follow up. Evolvement of newer methods like paedetric locking nail or submuscular plating will also diminish the cases for elastic nailing.

Retrograde elastic nailing is a good option for the management of length unstable paedetric femur fracture when supplemented by slab or cast in initial few weeks post operatively. Initial few weeks of knee immobilization post operatively, prevent from loss of reduction and probably nail tip related complication.

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