

Functional Outcome of Titanium Elastic Nails in Pediatric Femoral Shaft Fractures

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DOI: <https://doi.org/10.52403/ijhsr.20240434>

ABSTRACT

Introduction: Pediatric femoral shaft fracture is commonest fracture in children. Surgical management of pediatric femur fracture has widened using intramedullary nail, dynamic compression plate and external fixator which have their own merits and demerits. Flexible Intramedullary nailing in the form of titanium elastic nail is one of the best surgical modalities. This technique is considered to be ideal and effective method with least complications and has become increasingly popular in children. The aim of the study was to assess outcome of titanium elastic nail for treatment of femur fracture in children of age group 5-11 years.

MATERIALS AND METHODS: Prospective interventional study was conducted in NMCTH, Birgunj among 35 children of age group 5-11 years who presented with shaft of femur fracture at least 3 cm distal to lesser trochanter and 3cm proximal to distal physis, closed or open fracture with Gustilo Anderson type I and II. Ethical approval was obtained from institutional review committee and proper informed consent was taken. The patients were treated with titanium elastic nail and followed up at 2 weeks, 4 weeks and 6 weeks and then every month till the radiological union was achieved. Data obtained were analyzed in SPSS version 26.0. Flynn criteria was used for final functional outcome.

RESULT: Out of the total 35 cases, the mean age of the patient was 7.71 ± 1.75 years. Majority of the patients 16(45.7%) were of age group 7-9 years. Most of them 24(68.6%) were male whereas 11(21.4%) were female. The study findings showed that more than half 18(51.4%) patients sustained injury due to road traffic accident. Almost equal number of patients had fracture of left side 18(51.4%) and right side 17(48.6%). Majority of the patients 33(94.3%) had closed fracture and transverse fracture 13(37.1%). The mean time taken for surgery was 69.43 minutes \pm 14.33 and mean duration of hospital stay was 6.46 days \pm 1.01. Majority of them (85.7%) did partial weight bearing crutch walking on 2nd week and (88.6%) did full weight bearing on 6th week. The mean time for radiological union was 10.40 weeks \pm 0.81.

Flynn criteria was used to assess outcome of the treatment, according to which, majority 33(94.30%) reported excellent result and only 2(5.7%) cases reported successful result. Regarding complications, there were no major complications reported, 1(2.9%) case of nail protrusion due to long nail and in 1(2.9%) case superficial infection at nail insertion site which was treated with antibiotic.

CONCLUSION: Titanium elastic nail used for treatment of femur fracture in children of 5-11 years is an acceptable and safest option with minimal complications.

KEYWORDS: Paediatrics Shaft of femur fracture, Titanium elastic nail system (TENS), Flexible intramedullary nail, Flynn criteria.

INTRODUCTION

Femur is one of the long bones in children which is commonly fractured.¹ Femoral shaft fractures, typically caused by blunt trauma, are the most common major pediatric injuries treated by the orthopedic surgeon.² It represents 1.6% of all fractures in the pediatric populations. Boys are more commonly affected at a ratio of 2.6:1. Bimodal distribution of incidence: the first peak is from 2 to 4 years of age, and the second is in mid-adolescence. There is also a seasonal distribution, with a higher incidence during the summer months.³ Femoral shaft fracture may be an isolated injury or may be one of the multiple injuries especially with high energy trauma.⁴ Traditionally the treatment of choice has been conservative means of continuous traction or spica cast for long period of time. Conservative treatment also has good long-term result. There were only few indication of surgical management associated with head injury abdominal injury or compound fracture with extensive soft tissue involvement.⁴ Long term immobilization in spica cast resulted in a lot of psychosocial problem due to separation of the child from his/her normal environment and there were difficulties in taking care of the child in spica cast.⁵ Even after application of spica cast and proper care lots of complications such as limb length discrepancy, torsional and angular deformities were noticed.⁵ Due to these difficulties and complications of management in spica cast the indication of surgical management of paediatric femoral shaft fracture has widened.⁶

Intramedullary nailing with Kuntscher-nail, intramedullary interlocking nail, fixation with dynamic compression plate and external fixator application are some of surgical option in treatment of fracture femoral shaft in older children.^{6,7} They have their own merits and demerits. Kuntscher-nail does not prevent rotation and it can

damage growth plate. Interlocking nail damages growth plate so it is not suitable for growing child. Dynamic compression plate needs large dissection while applying and removal. External fixator is troublesome to child and there is chance of infection also. To overcome these problems in surgical management of fracture femoral shaft in child, concept of flexible nailing or titanium elastic nail came in practice.⁶

Our country is a developing country and most of parents are illiterate and farmers. So, while treating with hip spica cast, there is problem in maintaining personal hygiene and caring of child. Most of the study results show that length of hospital stays, time used for walking with and without help, angular deviation, limb length discrepancy is significantly lower with titanium elastic nail. Thus, titanium elastic nail system for femoral shaft fracture in children have good result with least complications. There are few studies performed in our population to verify that it is as effective as in other part of world.

So, the aim of this study was to evaluate the functional outcome of Titanium elastic nailing in pediatric femoral shaft fracture.

Objectives

General objective:

To assess outcome of titanium elastic nail for treatment of femoral shaft fracture in children

Specific objectives:

To know the demographic profile of the children between 5-11 years of age having femoral shaft fractures.

To determine period of operation time and period of hospital stay.

To find out complication of surgical procedure.

To evaluate period of mobilization -non weight bearing crutch walking, partial

weight bearing crutch walking, full weight bearing crutch walking.

To assess radiological union.

MATERIALS AND METHODS

A prospective interventional study was conducted in the department of orthopaedic surgery, National medical college, and teaching hospital, Birgunj, Nepal from 13th March 2023 to 12th March among 35 patients. Sample size was calculated using the formula $n = Z^2 \times p(1-p) / m^2$ and estimated prevalence of shaft of femur fracture in previous year in this institute was $p = 0.023$ (2.3%). Purposive sampling technique was used. Patients with age between 5-11 years, both sexes, body weight less than 50kg, fracture shaft of femur at least 3cm distal to lesser trochanter and 3cm proximal to distal physis. post traumatic closed or open GA Type I, II shaft of femur fractures, patient fit for surgical procedure and whose relatives/parents gave assent for study was included. Open wound like GA type III, patient age less than 5 years and greater than 11 years, Pathological fractures, late presentation (>3 weeks), Bilateral femur fracture, Previous history of fracture to either femur, Patients with associated head, chest, visceral and vascular injuries, Patients with any other fracture in addition to shaft of femur fracture in either extremity, Preoperative neurovascular injury, Patients with definite major illness like malignancy, chronic major system illness, patients not willing and medically not fit for surgical procedure was excluded from study.

Ethical approval was obtained from the institutional review committee (IRC). Radiographs were taken in appropriate views and diagnosis was established by clinical and radiological means. Fractures were diagnosed. Patients were immobilized with skin until complete pre-operative workup and fitness for surgery was obtained. Postoperatively patients were given prophylactic intravenous antibiotics 8 hourly for 72 hours followed by oral antibiotics. Patients were followed up clinically at first, third, and sixth month.

Functional outcome was assessed by Flynn's criteria. All data were processed, analyzed, and disseminated by MS office and statistical package for social sciences (SPSS) version 26.

RESULTS

In this study the age of the patient ranged from minimum of 5 years and maximum of 11 years. The mean age was 7.71 years with standard deviation of 1.76. Majority of the patients 24(68.6%) were male whereas 11(21.4 %) were female. The mechanism of injury was as such 18 (51.4%) patients sustained injury due to road traffic accident while 9(25.7%) patients due to fall from tree and 5(14.3%) due to fall from height. Others were 3(8.6%) in which different mechanism were included for example: hit by stone, sporting activity, attack of animal etc. The study resulted 18(51.4 %) patients had fracture on the left side while 17(48.6%) on the right side. Majority of the patients 33(94.3%) had closed fracture and remaining 2(5.7%) had open fracture of Gustilo and Anderson type 1. In terms of morphology of fracture, most of them were transverse fracture 13(37.1%) followed by oblique fracture 10(28.6%), spiral fracture 9(25.7%) and comminuted fracture 3(8.6%). Time taken for surgery varied from 60 to 110 minutes with mean time of 69.43 minutes and standard deviation of 14.33. The hospital stay of patient was minimum of 6 days and maximum of 10 days, mean duration was 6.46 days and standard deviation of 1.01. Majority of cases (74.3%) were discharged on 6th post operative day. Most of the patients 30 (86%) did partial weight bearing on 2nd week and remaining 5 (14%) of patients did on 4th week of post operative day. The mean and S.D. of full weight bearing crutch walking was 6.6 weeks and 0.34 respectively. Majority of the patients (88.6%) had done full weight bearing on 6th post operative week, followed by 8.6% of them on 7th week and 2.9% on 5th week.

The study results revealed, radiological union occurred in all cases with minimum

of 10 weeks to maximum of 12 weeks with mean of 10.40 weeks and standard deviation of 0.812.

Majority of the patients 33(94.3%) complained of no pain whereas only 2(5.7%) of the patients had mild pain in first follow up which subsided on analgesics. Only Two cases developed complications i.e. One case of nail protrusion in greater trochanter due to long nails and in one case insertion site got infected. The infection was superficial which was treated with antibiotic and in protruded nail careful monitoring done and nail removed after radiological union and after that the limb was protected with splint. There was rotational deformity seen in two cases, i.e. in one case, 5 degrees and in another, 6 degrees external rotation was measured. Four cases developed anteroposterior angular deformity maximum of 10 degrees. Two patients developed mediolateral angular deformity maximum of 10 degrees.

Limb length discrepancy was found in two cases with limb shortening of 1 cm and 2 cm reported in two patients and there was no limb length discrepancy in other cases.

The study results shows that according to Flynn criteria majority of cases 33(94.30%) show excellent result and only two cases show successful result.

Table 1: Outcome according to Flynn Scoring criteria

| Flynn criteria grading | Frequency | Percentage (%) |
|------------------------|-----------|----------------|
| Excellent | 33 | 94.3% |
| Successful | 2 | 5.7% |
| Total | 35 | 100 |

The study results shows that according to Flynn criteria majority of cases 33(94.30%) show excellent result and only two cases show successful result.

DISCUSSION

Shaft of femur fracture is the most common paediatric orthopedic problem. The treatment of femoral shaft fracture in children of age group 5-11 years is highly controversial. It can be managed both conservatively as well as surgically.

For generations, traction and hip spica were standard treatment for all femoral shaft

fractures in children. Over the past 20 years, there has been a dramatic and sustained trend towards operative stabilization of femoral shaft fractures in school aged children by using flexible intramedullary nails (titanium elastic nail), dynamic compression plating, external fixation etc. All the operative procedures have certain advantages and disadvantages.⁷

The titanium elastic nail can be easily inserted without damaging physis so growth is not disturbed and there is good purchase in bone as well as three-point fixation, so there is less chance of rotational and angular deformity and removal will be easy. Flynn criterion was used to assess the final outcome of the treatment. The study results showed that according to Flynn criteria majority of cases 33(94.30%) showed excellent result and only 2(6.70%) cases showed successful result. The study findings were consistent with study results of Gupta S et al in which 90% of patients had excellent result and 10% had satisfactory results.⁸ Similarly other studies also revealed the outcome of flexible intramedullary nail being excellent.^{9,10,11}

The study results showed that, most of the patients (45.7%) were of age group 7-9 years. The mean age of the patient was 7.71 years. Among them, 24(68.6%) were male whereas 11(21.4%) were female. The results were similar to study results of AK Mishra et. al. in which out of 33 patients, 19 were boys and 14 were girls and mean age was 7.1 years.¹⁰ Other study results also had more boys than girls.¹² In Nepalese context, boys are given more freedom to play outside their house in comparison to girls who are made confined to house, so they are supposed to get more injured than girls. Chang-wug et al treated femoral shaft fractures in 28 children in age group of 5-10 years of mean age 6.7 with retrograde titanium elastic nail. The study concluded that femoral fractures in children aged 5-10 years can be safely treated with the titanium elastic nail with minimal risk of complications.¹³

The study result revealed 18 (51.4%) patients sustained injury due to road traffic accident while nine (25.7%) patients due to fall from tree and five (14.3%) due to fall from height and remaining from other mechanisms. The study results were supported by Khazzam et al in which out of 137 patients, mechanism of injury was motor vehicle accident (76 patients), fall (18 patients), sports related activity (33 patients) followed by other mechanisms.¹² In our context, the children play outside their house and they are more prone to sustain road traffic accident.

The study results showed that out of the total 35 patients, almost equal number of the patients had fracture on the left side (18 patients) and right side (17 patients). Majority of the patients 33(94.3%) had closed fracture and remaining 2(5.7%) had open fracture of Gustilo and Anderson type 1. The side of the femur fracture was almost equal in the study by Khazzam et al.¹²

Among 35 patients, in most of them transverse fracture 13(37.1%) were seen followed by oblique fracture 10(28.6%), spiral fracture 9(25.7%) and comminuted fracture 3(8.6%). Similar results were obtained from study by Saigal A et al, there were nine transverse (50%), two short oblique (11.1%), three spiral (16.6%) and three butterfly fractures.¹⁴

Regarding time taken for surgery, time varied from 60 to 110 minutes with mean time of 69.43 minutes. The study result was consistent with findings of study conducted by Singh R et al in which the mean duration of surgery was 63 (50-70) minutes.¹⁵ The average duration of surgery was slightly less i.e. 45 minutes in the study conducted by Rasool et al.¹⁶ The time required for operative procedure was more as compared to other studies, this may be because of unavailability of expert manpower to handle the fluoroscopy or due to other operating equipment constraints.

As per the study results, the duration of hospital stay varied from 6 to 10 days, mean duration was 6.46 days. The average duration of hospital stay was slightly more

in the study conducted by Sayed et al which was 9-17 (average of 12 days) days.¹⁷ Similarly, Shekhar L, Mayanger JC et al studied 24 children with 24 femoral shaft fractures in age group 6-14 year (average 9.67 years), they had hospital stay of 10.4 days.⁶ Similarly, a study conducted by Gaid M et al for-cost analysis of children treated with titanium nail reduced hospital stay by 75% in comparison to conservative method. This resulted in cutting the overall cost by approximately one third in comparison to treatment using traction.¹⁸ Thus, the present study result shows shorter hospital in comparison to other studies, this may be because the patient was operated as soon as possible. This signifies that the patient can be discharged early with this modality of treatment. Thus, the patient can return to their home early which cuts the cost of the treatment reducing financial burden and also children can join their school soon.

Majority of the patients (85.7%) did Partial weight bearing crutch walking (PWBCW) on 2nd week and remaining 14.3% of patients did PWBCW on 4th week after post operative day. Mean duration of full weight bearing crutch walking was 6.6 weeks. Majority of the patients (88.6%) had done full weight bearing on 6th post operative week, followed by 8.6% of them on 7th week and 2.9% on 5th week. The study findings was similar to study of Bhaskar A et al in which out of 60 children, majority of the children were able to partial weight bear by 3- 4 weeks and full weight bearing on average of six weeks.¹⁹ Similarly, study by Shekhar et al found that full weight bearing was on 6.6 weeks (5 to 12 week) ⁶whereas study by Mishra AK et al revealed mean time of full weight bearing crutch walking was 10 weeks.¹⁰ Thus, the study findings were consistent with other study results.

Majority of the patients 33(94.3%) complained of no pain whereas only two patients (5.7%) had mild pain in first follow up. The study results revealed, radiological union occurred in all cases with range of 10 weeks to 12 weeks with mean of 10.40

weeks. The study result was consistent with study result of Park SS et al., risk factors for overgrowth after flexible nailing for fractures of the femoral shaft in children in which the mean time to radiological union was 10.7 weeks.²⁰ similar finding were reported by study of Chang-wug oh et al, the mean time was 10.5 weeks.²¹

Regarding complications from the treatment, the study revealed, one case of nail protrusion and one case insertion site got infected. The infection was superficial which was treated with antibiotic and in protruded nail careful monitoring done with nail removed after radiological union and after that the limb was protected with splint. There was rotational deformity seen in 2 cases, in one case, 5 degrees and in another, 6 degrees external rotation was measured. Four cases developed angular deformity maximum of 10 degree. None of the cases developed lengthening and two cases developed shortening maximum of 2cm. Similar to our study findings, a study by Bhasker A et al, two cases developed infection which resolved with antibiotics. Insignificant limb length discrepancy was seen in 3 children.¹⁹ Findings from study by Gupta S et al revealed majority, 70% of patients had no complications, only 20% had irritation at entry site, 5% had infection and proximal nail migration. There were no delayed union, non-union or re-fracture.⁸ Another study by Lohiya et al flexible intramedullary nailing (Titanium elastic Nail) in paediatric femoral fractures in 73 cases Limb Length Discrepancy ranged from -3 cm to 1.5 cm. Other complications included superficial infection⁹, proximal migration of nails¹⁰, irritation at nail insertion site²² and penetration of femoral neck with nail tip.⁸

Multicenter center study conducted by Flynn et al showed flexible intramedullary nail (Titanium elastic nail) to be an ideal and effective method. This technique has become increasingly popular in children. Overall, surgery allowed rapid mobilization with few complications. Irritation of the soft tissue near the knee by the nail tip

occurred in four patients, leading to a deeper infection in two cases.²³ Similar results were obtained from the study conducted by Jubel et al, which showed painful skin irritation was seen in 3.8% due to the protruding end of the nail. There was no rotational or angular deformity of more than 5 degrees.²⁴ Similar complications was reported by Anastasopoulos et al such as pain/irritation at insertion site, superficial wound breakdown and one case of delayed union. No major complication was recorded.²⁵ The present study was conducted in small group of children and follow up period was also small. The study findings showed, titanium elastic nail is reliable and safe for treating paediatric femoral shaft fractures with relatively free of serious complications.

Conclusion

We conclude that the titanium elastic nail is the safest and most ideal option for the femoral fracture in children of age group 5 to 11 years. It is simple technique and minimum invasive method for stabilizing pediatric femoral shaft fracture. It has got minimal complications and the overall outcome is excellent.

Declaration by Authors

Ethical Approval: Approved

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Gaurav Gupta, Rabins Kumar Sah, Prashant Thakur, Robin Yadav. Functional outcome of titanium elastic nails in pediatric femoral shaft fractures. *Int J Health Sci Res*. 2024; 14(4):236-242. DOI: <https://doi.org/10.52403/ijhsr.20240434>
