



To Assess Functional And Radiological Outcome in Femoral Shaft Fracture Managed by Flexible Intramedullary Nailing using RUST Score as Rehabilitational Guide

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ABSTRACT

Introduction: The definitive treatment of paediatric femoral shaft fractures remains controversial. Optimal mode of treatment may vary according to age, fracture pattern and site of impact. The purpose of this study is to show our experience with clinical, functional And radiological Outcome in Femoral Shaft Fracture Managed by Flexible Intramedullary Nailing using RUST Score as Rehabilitation Guide.

Material and method: A study was conducted in the Department of Orthopaedics Shyam Shah Medical College and associated S.G.M. Hospital, Rewa, Madhya Pradesh, From 1 Jan 2019 to 31st Dec 2020 (24 Months). Thirty children included in our study in the age group of 5 to 15 years with recent femoral shaft fractures were treated using flexible stainless steel Intramedullary Nailing. Results were evaluated according to clinical, radiological and functional outcome. We use RUST score as radiological assessment and as a guide for post-operative rehabilitation.

Results: 30 patients were managed by flexible intramedullary nailing including 20 males and 10 females. Follow up of 12 months of thirty patients were available for evaluation. Partial weight bearing initiated after a RUST score of 6 was achieved and full weight bearing initiated after a score of 8. Final functional assessment was done according to Flynn's criteria and results were excellent in 70% patients, Satisfactory in 30% patients.

Conclusion The use of flexible intramedullary nailing in properly selected patients in the pre school to early teenage population is a well-accepted and reliable option for the treatment of femur shaft fractures. Advantages are decreased length of hospital stay, early return to function, and high union rates. Care must be taken to achieve and maintain reduction, and caution is advised in older and heavier children. RUST score can be used as an effective guide for post op rehabilitation.

Keywords: Children, Fracture femur, Flexible intramedullary nailing, Flynn's criteria, Rust score, Stainless steel

INTRODUCTION

Femur shaft fractures are among the common long bone pediatric injuries¹. Femoral shaft fractures represent approximately 1.6% of all bony injuries in children². These fractures typically occur either in early childhood when weak woven bone is changing to the stronger lamellar bone or during adolescence

when children are subject to high-energy trauma from motor vehicle accidents or from sports³. The management of such paediatric fractures range from closed reduction with hip spica, traction and surgical stabilization with devices like plate and screws, external fixators, interlock nails, stainless steel

flexible nail⁴. Most pediatric fractures are treated conservatively, nonsurgical management has been the standard care of treatment, for most young children historically, because of rapid healing and spontaneous correction of angulation⁴. The expense of care is low and the outcome is generally good. In older children, conservative treatment results in loss of reduction, malunion, psychological intolerance to both the child as well as the family and complications associated with plaster, hence, in the last two decades there has been a growing tendency towards a more operative approach in children over 5 years of age⁵. Surgical methods were associated with problems and complications like pin tract infection, loss of reduction, refracture after implant removal, growth arrest and avascular necrosis of the capital femoral epiphysis⁶. For children between 5-15 years, the fracture needs an internal splint that shares load, maintains reduction and does not endanger the growth areas or blood supply of the femoral head and minimizes morbidity as well as complications^{7,30,31}. Flexible intramedullary nailing are increasingly used for fracture shaft fixation. Regarding the material used for flexible nails, the literature on the subject shows titanium is preferred to steel⁸. Wall⁹ reported the unexpected finding that the rate of malunion was almost four times higher in association with titanium nails compared to stainless steel nails. He reported that their results indicate that less costly stainless steel elastic nails are clinically superior to titanium nails for pediatric femoral shaft fracture fixation, mainly due to a much lower rate of malunion⁹. This present short term retrospective study is aimed at evaluation of our experience with stainless steel flexible nails in the treatment of femoral shaft fractures in children aged between 5 and 15 years at Shyam Shah Medical College and associated S.G.M. Hospital, Rewa, Madhya Pradesh and to evaluate that our results are comparable to those published in previous studies, even if we used a material more economical than titanium which can fulfil the same purpose and results. Aim of the study was to assess the clinical, functional and radiological outcome after closed reduction and internal fixation with flexible stainless steel nail and to assess the use of RUST score to guide the post-operative rehabilitative protocol in femoral shaft fractures between 5 to 15 years children.

Material and method : A retrospective study was conducted in the Department of Orthopaedics Shyam Shah Medical College and associated S.G.M. Hospital, Rewa, Madhya Pradesh, From 1 Jan 2019 to 31st Dec 2020 (24 months). Thirty children included in our study in the age group of 5 to 15 years. All necessary Data and record were collected with details of the patient including -age, sex, fracture-type, location, pattern, Surgical procedure done –open or close, Presence of fracture angulation or rotational malalignment, Evaluation of fracture union with pre-op x-ray to final follow-up x-ray and rehabilitation outcome, using RUST score as radiological assessment and as guide for rehabilitation, along with any complications. Only children between the age of 5 and 15 years with a closed or a Gustillo Anderson Grade I shaft fractures of the femur were included in the study. Children <5 and >15 years, grade II and III open fractures, metaphyseal fracture, pathological fractures, children with congenital and medical co-morbidities, segmental and highly comminuted fractures were excluded from the study. Objective of treatment was to provide fast healing of the fracture in a acceptable position, near anatomic alignment, ease of home care, and early mobilization. Fracture patterns according to AO classification included 32 -A3 (16), 32-A2 (8), 32-A1 (3), 32-B1(3) type,. And according to Winquest and Hansen's classification as Grade I (18), Grade II(9) and Grade III(3). Two patients had a Grade I compound fracture shaft femur. Patients were evaluated for their routine pre-op investigation, pre anaesthetic fitness for surgery as per our institutional protocol. Fracture were operated by a retrograde nailing technique within seven days of admission. The diameter of the individual nail was selected as per Flynn et al's formula¹⁰ (Diameter of nail = Width of the narrowest point of the medullary canal on AP and Lateral view \times 0.4 mm). Two nails of equal diameter was taken so there opposing bending forces remains same¹³. Patients were treated by closed reduction and internal fixation with the flexible stainless steel retrograde nailing. S.S. Nails of 2.0–4.0 mm in diameters were used. The length of the nail was assessed intra-op by image intensifier. The patients were taken on fracture table and a reduction of the fracture was done under image intensifier. To prevent rotational mal-alignment It was checked that the patella kept facing roof and the

foot in neutral position during surgical procedure. Prebent nails that were angled at 45° about 2 cm from tip were used for smooth advancement of nail. Longitudinal skin incision of 2 cm was made at 2 cm proximal to distal femur physis level over lateral and medial aspect of thigh. An entry point was made with the help of bone awl approximately 1.5-2 cm above the distal femoral physis on the lateral side. A nail inserted with the help of T-handle through the entry point into the medullary canal and advanced up to fracture site, after proper fracture reduction nail advanced to proximal segment under guidance of image intensifier. Another nail was introduced using the same technique from the medial side. When the nails crossed the fracture site, traction released and then both nails were advanced further. The nails were put in double 'C' construct to ensure three point fixation and for proper rotational stability^{13,29}, nails were further advanced into the proximal fragment to diverge laterally towards the greater trochanter and medially within the femoral neck so that early mobilization was possible¹¹. Care was taken during nail insertion to check the nails did not cross the growth plate proximally and distally. The nail was cut at the entry site so that 1 cm of nail protrudes outside of the cortex. Post operatively IV antibiotics given for three days. Suture removal was done at two week. Postoperative splint or slab support was not provided. Patients were taught isometric exercises of straight leg elevation, strengthening exercises of the

quadriceps and hamstrings with active and passive mobility of the knee. Non weight-bearing initiated immediately after the operation as tolerated by patient with support of walker or crutches. The record of children were followed up at 1,2,3,6 and 12 month's interval until fracture union. At each followup, progression of union at fracture site was assessed radiologically by RUST score, clinical assessment at the fracture site was determined by evaluation of pain tenderness, along with limb alignment, rotation, length discrepancy, range of motion of hip and knee and any other complications. The children were evaluated functionally by Flynn's criteria¹⁰ (as Excellent, Satisfactory, Poor). The Radiographic Union Scale for Tibia fractures (RUST) score¹² was used to assess the progression of union at fracture site, callus formation and radiological union. Each femur cortex (anterior, posterior, medial and lateral) was assigned a score from 1 to 3. A cortex with a visible fracture line and no callus was given a score of one, a visible fracture line but with callus present was given a score of 2 and callus without a fracture was scored as 3. The minimum total score was 4 and the maximum was 12(healed)^{12,13}. This scoring was used to evaluate the post-operative rehabilitation in our patients at follow up. Once a total score of 6 was achieved, the patients were allowed partial weight bearing with a walker. Full weight bearing was initiated when a minimum RUST score of 8 was achieved¹³.

Observation table-

Table 1- Characteristics of patients-

Parameters	No. of Patients (sample size 30)
Gender	
Male	20
Femalr	10
Age in Years	
5-8	15
9-12	12
13-15	03
Injured Femoral Side	
Right	18

Left	12
Mode of Trauma	
Road Traffic Accidents	17
Fall on Ground	10
Fall From Hight	03
Involved Femoral Shaft	
Proximal Third	18
Middle Third	08
Distal Third	04
Fracture Pattern	
Transverse	18
Oblique	09
Spiral	03
Communitted	00

Table 2: Flynn's Criteria

Variables at 12 months	Excellent Result in 70% (21 cases)	Satisfactory Results in 30% (9 cases)	Poor Result 0%
Limb Length Descrepency	< 1 cm	<2 cm	>2 cm
Malalignment	5 degrees	5-10 degrees	>10 degrees
Pain	No	No	Yes
Complication	None	Minor and Solved	Major or Residual Deformity

Table 3: Fracture Classification and Follow up Evaluation:

Winquest and Hansen's Fracture Classification	No. of Cases (30)	Follow up in Months	Radiological Assessment by RUST score of 8 in Weeks(full weight bearing)
I	18	12	10
II	09	12	9.8
III	03	12	10.2
IV	-		-

RESULTS: A total of 30 patients were included in our study. There were twenty male and ten female, with an average age of 9.2 years at the time of injury. Age distribution-15(50%) of the patients were 5-8 years, 12(40%) were 9 to 12 years and 3(10%) were 13 to 15 years age group. The youngest child in the study was 5 years and 6 months old and the oldest was 14 years and 2 months at the time of their admission. The most common mode of injury was road traffic accident 17(56.7%) followed by fall on ground 10(33.3%) fall from height 3(10%). 18 fractures were in the middle third followed by, 8 proximal one-third and 4 distal-third fractures in which 18 right sided fractures (60%) and 12(40%) left sided fractures. most common fracture pattern was transverse fracture type. The average time for anesthesia and the operative procedure was 45–60 min. No significant blood loss, infection, or wound complications were encountered, and no compartment syndrome or neurovascular injury complicated the nailing process. The average duration of hospital stay was 10 days. Smaller diameter nail size used was 2.5mm while larger diameter nail size used was 4mm according to Flynn's formula. Clinical evaluation revealed full range of motion of hip, knee and ankle in all patients at final follow-up. The average time of attaining a RUST score of 6 was 7 weeks and a score of 8 at 10 weeks. When classified as per Winquest and Hansen's Fracture Classification patient with fracture type I achieved a RUST score of 6 at 7 weeks and a score of 8 at 10 weeks. Patient with fractures type II achieved score of 6 at 6.8 weeks and 8 at 9.8 weeks. Patient with fractures type III achieved RUST score of 6 at 7.2weeks and 8 at 10.2 weeks. Radiological evaluation was done by RUST Score criteria. There was no nonunion or delayed union in our study. The functional outcome was evaluated at the final follow up at 1 year using the Flynn's criteria. The results were excellent in 21 children (70%) and satisfactory in 9 children (30%). No child had poor result. The most common problem encountered in our study was skin irritation, and entry site wound in 6 children (20%) which was managed by dressing and oral antibiotics. Out of 30 cases, 1 cases had limb length shortening of less than 5 mm which was not significant. 1 case had limb lengthening of 9 mm. Angular malalignment was defined as an angulation of > 10 degree in the coronal plane or >15 degree in

sagittal plane¹⁴. In our study we had Varus malunion of <10 degree in coronal plane in 3 children(10%). Rotational malalignment was termed as "excessive" if it was more than 10 degree⁹. We did not have any child with rotational malalignment. In general nail removal was performed at the end of one year after good fracture union. No complications were associated with the nail removal procedure and no refracture was observed after the nail removal.

DISCUSSION: The ideal treatment for pediatric femoral shaft fractures depends upon the age of child, location and type of fracture, availability of facilities, knowledge of surgeon, and financial conditions to some extent^{15,32}. Non-operative management results in complication such as malunion, joint stiffness and delay in functional recovery in older children and also results in prolonged hospitalization causing financial loss to the family as well as increased hospital bed occupancy ratio has led to the emergence of operative fixation for these kind of fractures^{16,17}. Over the past few decades, management of pediatric femoral fractures has shifted more towards operative intervention because of quicker recovery, shorter rehabilitation period, less immobilization, and less psychological impact to the children¹⁸. Flexible intramedullary nails act as internal splint, can be easily applied, act on the principle of symmetric bracing action of two nails with same modulus of elasticity which gives three point fixation, rotational, axial, transitional and bending stability by counteracting the distraction and compression forces working at the fracture site, require no exposure of fracture site, and cause few complications^{13,29,30,31}. During insertion of nails, reaming is not done, and nutrient vessels are preserved, so there is a theoretical advantage of early healing of fractures^{19,20}. Flexible nail treatment facilitates alignment and opposes fracture fragments, which allows certain controlled movement over the fracture site and helps the formation of external callus. External callus then helps to bridge the fracture fragments early, and gives strength to the bone¹⁵. Regarding the material alloy for flexible nails, no conclusive evidence is provided in the literature that supports the superiority of titanium over steel. Differences between these two materials have been observed in laboratory tests, and, it is generally accepted that steel is stronger, yet less flexible^{8,21}. In

developing country like india, titanium osteosynthesis material is expensive; therefore stainless steel nails provides an effective, more economical substitute in the treatment of femoral shaft fractures.

In our study, all fractures were united within 16-18 weeks of fixation with no non-union or delayed union. Children with transverse fracture pattern had a shorter union time. In our study average age being 9.2 years. Flynn JM et al in their study of 49 cases of children ranged from 6-16 years with a mean age of 10.2 years²². Saikia et al studied children from 6-16 years with a mean of 10.8 years²³. Santosha et al²⁹ studied 30 children from 5-16 year with a mean age of 9 years. There were 10 (33.3%) girls and 20 (66.7%) boys in our study. The most common mode of injury was road traffic accident 17(56.7%) followed by fall on ground 10(33.3%) fall from height 3(10). Flynn et al in their study included 234 cases, out of which 136(58.1%) were due to RTAs, 46 (19.6%) were due to fall on ground and other 43 (28.8%) were due to fall from height⁴. Bandyopadhyay et al included 70 patients in their study, mode of injury in 42 patients (60%) was RTA, fall from height in 22 (31.42%) and other 4 (8.58%) was due to sports injury²⁴. The average time of surgery in our study was 45-60 minutes. In study by Singh et al, the average time of surgery was 63 minutes²⁵. In a study by Saikia et al the average time of surgery ranged from 50 – 120 minutes with a median of 70 minutes²³. The average duration of hospital stay in our study was 10 days. Gross et al conducted a study on cast spica management of the femoral shaft fractures in children and young adults²⁶. The average duration of hospital stay in their study was 18.7 days. The average hospital stay was 10 days in Singh et al study²⁷. There was no pre set protocol to guide the post operative rehabilitation. In our study, we used the RUST score as a guide to rehabilitative care to define a specific time at which we allowed for partial and full weight bearing¹³. We believe that in near time this method could be standardized and used as a definitive guide for rehabilitation in such patients. The RUST score is a method to assess the maturity and completeness of callus formation and thus function as a guide to rehabilitative decisions. Partial weight bearing was allowed after achieving a score of 6 and full weight bearing after a minimum score of 8 as per the RUST

score¹³. The average time to allow for partial weight bearing was 7 weeks and full weight bearing at 10 weeks. Ekansh et al¹³ used RUST score for grading callus formation and guiding rehabilitation. They reported partial weight bearing at an average of 6.27 weeks and full weight bearing at 9.74 weeks. Singh et al in their study allowed full weight bearing depending on the clinical and radiologic progress of fracture union with an average time of 8.3 weeks²⁵. The use of RUST score help us to determine a specific time for initiation of weight bearing. This helps to avoid early weight bearing which leads to an increased risk of angulation at the fracture site. In the present study, 6 (20%) patients had developed pain and wound at site of nail insertion during initial follow up evaluation which resolved completely after dressing and oral antibiotics. it could have been avoided with proper selection of entry site and proper advancement of the nail to lie against the supracondylar flare^{29,31}. Flynn et al reported 38 (16.2%) cases of pain at site of nail insertion out of 234 fractures treated with titanium elastic nails⁴. This is the most common complication after femoral shaft fractures in children. In our study, 1 cases had limb length shortening of 8 mm which was not significant. 1 case had limb lengthening of 1 cm, This is due to the increased vascularity at the growth plate during the process of fracture healing⁷. In our study we had Varus malunion of <10 degree in coronal plane in 3 children(10%), which would have been avoided with adequate bracing²⁹. We did not have any child with rotational malalignment. In our study, the final outcome was excellent in 21 (70%) cases, satisfactory in 9 (30%) cases and no patient had poor outcome. Flynn et al¹⁰ treated 234 femoral shaft fractures and the outcome was excellent in 150 (65%) cases, satisfactory in 57 (25%) cases and poor in 23 (10%) of the cases. Singh et al²⁷ treated 112 patients of femoral fractures, 86 had excellent results, 24 had satisfactory results, and 2 had poor results.

Conclusion: The preliminary experience with flexible intramedullary nailing in the 5- 15 year old age group suggests that it is a safe and effective method of treatment of pediatric femoral fractures that controls the length and alignment, lessens the risk of malunion, speeds the rate of rehabilitation, and is associated with less financial and emotional cost to the families involved. This study had certain limitations as it was single centered, so the result

should be generalized with caution. did not have a control group .We didn't compare other modalities of fixation with S.S. nail. Long term results of the treatment were not analyzed. The minor complications and problems encountered in our series could have been easily avoided by strictly following the basic surgical principles.

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