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Outcome of diaphyseal femur fractures treated with enders nail in paediatric age group

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***Abstract*---**Introduction: In children, shaft femur fracture is the most common injury sustained. Earlier these fractures were treating conservatively but with advancement of orthopaedic

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implants and surgical modalities now operative intervention is favourable for early mobilization with less complication. Inadequate reduction/fixation can lead to growth disturbances among children about to attain skeletal maturity closure. Variety of surgical options includes external fixators, plates and flexible intramedullary nails and has its own complications, but the choice of implant to be used as gold standard in the management of these fractures is still a matter of debate. Enders nailing among the Flexible Intramedullary Nails, being a minimal invasive procedure and tensile property of the nail along with the feasibility of early mobilization led to its popularity. Aim: Aim of the study was to evaluate the use of Enders nail in paediatric diaphyseal femur fractures in terms of union, complications, early mobility and minimally invasive technique. Materials and Methods: This interventional prospective study was conducted from May 2017- April 2019 with 32 paediatric patients with diaphyseal femur fracture in a 5-15 years age group. Retrograde Enders nailing was done in all diaphyseal femur fractures using traction table. Enders nail were inserted using either of the two configurations, one is two medial C and S constructs and another double or divergent C. All patients were followed up periodically for minimum 1 year and assessed using Flynn Scoring System and evaluated for clinical, functional and radiological outcomes. We also developed a protocol for implant removal in all our patients after 6 months of fracture union. Results: In our study, age group of 10-12 years was the most common with Mean age of 11.6 years with male predominance. Male to Female ratio was 4:1. Mean radiological union was8.8±1.68 weeks. Final result according to Flynn scoring system was excellent in 90.6%.Among the complications, 3 cases of knee stiffness due to immobilization which become normal after vigorous physiotherapy and 5 had nail impingement which got cured after nail removal. Conclusion: According to our study use of Ender's nail for pediatric shaft femur fracture has advantage of minimally invasive procedure, early mobilization, short hospital stay, cost effectiveness with minimal complications.

***Keywords*---**elastic stable intramedullary nail (ESIN), ender's nail, flynn scoring system, retrograde nailing, paediatric femur fracture, paediatric trauma.

Introduction

Diaphyseal femur fracture is one of the most common injury among pediatric age group. Average rate of nearly 20 per 1 lakh population per year encounters shaft femur fracture in children and boys are preponderance than girls.[1] Management of such injuries depends upon certain factors like age, level of injury, type of fracture, associated fractures, neurovascular injury and appropriate implant selection. According to the surgeon's preference the treatment options vary from conservative treatment to open reduction. Until recently all paediatric shaft femur fractures were treated conservatively with

Hip Spica and traction.[2] Accurate reduction is essential to achieve, as angular deformities cannot be corrected by growth among those children who are about to attain skeletal maturity.[3] Therefore, to reduce the chances of deformity and allow early mobilization now the trend changes from conservative to towards operative.

A variety of surgical implants such as external fixator, plates, and flexible intramedullary nails are available for paediatric diaphyseal fracture but the choice of implant to be used as gold standard in the management of paediatric diaphyseal fracture is still a matter of debate, the flexible intramedullary nails having some advantages over the former two treatment methods. The tensile property of the nail along with the feasibility of early mobilization led to its popularity.[4, 5, 6]

Materials and Methods

The study was approved by SVIEC. The interventional prospective study was conducted from May 2017- April 2019 with 32 paediatric patients with diaphyseal femur fracture in a 5-15 years age group were operated with enders nail with minimum follow-up of 1 year. All the patients were operated by single surgeon in a tertiary center.

- Operative technique: Entry were made using awl 2 to 3 cm from epiphyseal region on both medial and lateral side of distal femur on traction table under IITV guidance after achieving reduction.
- Two types of implant configurations were used one is medial C and S constructs and another one is double or divergent C.
- Implant size was measured using Flynn's formula (Narrowest canal diameter in AP and Lat view x 0.45).[7]
- The nail tip was bent 2cm from one end at 40 degrees to aid in advancing the nail against the opposite cortex into the canal. This also prevents it to perforate the cortex.
- The medial side nail advanced till the neck and lateral side nail upto the trochanteric apophysis finally both the nails ending up in fan shaped. These two divergent nails give final reduction and stability.

All patients were immobilized with help of derotation bar for 3 weeks on affected side and rehabilitation by static quadriceps, ankle pump and knee movements facilitated early recovery and ambulation of patient. Non weight bearing walking with support started after removal of derotation bar and partial weight bearing started once the radiological evidence of callus formation is seen. We developed a protocol for implant removal in all our patients after 6 months of fracture union and further followed up for more minimum period of 6 months.

Results

Study included age group of 5 - 15 years from May 2017– April 2019. Table 1 shows age distribution and number of patients in the group. The mean age group was 11.6 years found in our study with male predominance (table 2).

Male to Female ratio was 4:1. Table 3 suggests that trauma was the commonest mode of injury then the sports activities followed by vehicular accidents. Left side was affected in majority of patients (table 4).

Majority of the patients, signs of union were found between 9 and 11 weeks with mean of 8.8±1.68 (table 5). All cases showed complete union by 12 weeks which favours early mobilisation with help of unreamed retrograde multiple Enders nail fixation rather than conservative management by hip spica. Final result according to FlynnScoring system was excellent in 90.6% as shown in table 6. In our study nail impingement occurred in 5 patients, which we removed after 6 months of union. And knee stiffness was present in 3 patients due to lack of physiotherapy and immobilization with derotation bar, which was corrected after vigorous physiotherapy. Non- union, malunion were not observed in any cases.

Discussion

Ender and Simon Weidner first developed intramedullary fixation of femur fractures with Ender's nail, which was further modified by Kuntscher later.[3]Traditionally, paediatric shaft femur fractures were treated by application of hip spica. However, prolonged immobilization produced discomfort for the patients including their parents. The results were not promising because of the complication like residual deformity and limb length discrepancy.[8]Conservative management is usually prone to longer non-ambulatory period and increasing number of absence in the school as well as bringing discomfort to child. Rigid antegrade interlocking nails provides good results but can alter vascularity of femoral head resulting in AVN (avascular necrosis) or can cause physeal damage resulting in growth disturbance at the greater trochanter leading to coxa valga.[9,10]

Closed unreamed intramedullary nailing has several advantages over conventional reamed nailing as it meets the surgical objective of stable fixation by preserving endosteal blood supply, minimal surgical trauma and thereby avoiding the exposure of fracture site.[11] Plate osteosynthesis is associated with a large surgical dissection, opening of fracture site, more operative time, relative long duration of immobilization and the complications like delayed union, infection and again a large surgical exploration is needed for implant removal.[12,13] External fixation of fracture produces pin tract infection with higher chances of non-union after removal of fixator. External fixation also produces apprehension in majority of the patients.[14, 15]

Flexible intramedullary nailing like Ender's nail or TENS need less operative time and low dose radiation exposure as compared to other operative intervention.[16] Plating, on the hand needs comparatively longer time in surgery with opening of the fracture site and major soft tissue dissection. Long scar mark over the limb is also a disadvantage especially in paediatric patients. Need for a second surgery for implant removal is essential if plating has been performed. This burdens the patient and their parents both mentally and financially.[12,13]

In our study, we tried to promote non reamed intramedullary fixation as a preferred treatment technique. The several advantages of shaft femur fracture managed surgically with Ender's nail over the conservatively managed hip spica is in accordance with k c mani et al. literature suggests complications are more common in plating, antegrade reamed nailing or even external fixators.[17] Intramedullary closed fixation preserves the periosteal blood supply, prevents the disruption of the fracture hematoma and the elasticity of the implant confers micromotion at the fracture site causing rapid bridging callus formation. A minimum of two divergent (include c & s construct) Ender's nails provide adequate fixation and stability with rapid union, early full weight bearing and low financial cost.[18,19] Three point fixation is achieved. The nail uses only small incisions, is rapid, blood loss is minimal and physeal area stands intact.[7]

Though it is advantageous in achieving fracture fixation with minimal incision and implant, Ender's nail also holds certain disadvantages. Entry site irritation, pain and impingement are some of them. In rare cases limb length discrepancy, infection, fracture angulation causing residual deformity have also been reported by various authors.[20,21]Intraoperative planning for size of the Ender's nail is very important as a smaller and mismatch nail diameter are associated with increased incidence of varus/valgus angulation.[14] Narayanan et al. reported two cases of transient nerve palsy.[14] First case was sciatic nerve palsy due to perforation of proximal end of one nail through posterior femoral neck and the second case was due to pudendal nerve injury due to traction on perineal post. In our study nail impingement was occurred in 5 patients [Figure 3], which we removed after 6 months of union. And knee stiffness was present in 3 patients due to lack of physiotherapy and immobilization with boot cast, which was corrected after vigorous physiotherapy.

All our patients had implant removal after 6months of fracture union as per our protocol and followed up further upto 6 months and all patients had good range of movements at final follow-up [Figure 4]. No clear consensus about the duration of implant removal is available in literature. Many authors suggested Implant removal can be done between 6 months to one year after fracture union. One study reported that removing of nails is possible 3 months after surgery. As mentioned in literature by 6 weeks Nails can be removed because by 6 weeks adequate union at fracture site. However, the nail should be removed only when consolidation ofFracture occurs because in early removal of nails there is more chances to get re-fracture. The most common problem encountered in this study was impingement of Nail and local infection at entry site, which was due to excess nail length protruding out and excessively bent. This problem can be prevented by keeping only 1cm of nail end outside the bone and excessive bending of nail ends and ensuring its approximation against the supracondylar flare of the femur. There was an association between the nail end impingement and skin erosion and nail pain described by similar study.[22] Near the knee, nail ends cause restriction in last 20 degrees of knee flexion in 3 patients in our study which because of nails cut too long and excessively bent at the ends noticed on further analysis, with complete relief on removal of nails post fracture union along with vigorous physiotherapy. In our study there is no incidence of complications like non-union, malunion, limb length discrepancy, osteomyelitis, physeal arrest and re-fracture.

Conclusion

The major principle of Ender's nail is fanning jamming fanning needed to achieve fracture three point fixation. As per Flynn scoring system, 29 patients (90.6%) had excellent result with 8.8 ± 1.68 weeks of union and early mobilization with full range of movement among all and only 3 patients (9.4%) had satisfactory result due to nail impingement and prolonged immobilization and lack of physiotherapy. So the present study suggests use of Ender's nail for pediatric shaft femur fracture has advantage of early mobilization, small incision, rapid and easy, cost effective, relatively fewer complications.

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Conflict of Interest

The authors declare they have no conflict of interest.

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References

1. Metaizeau JP. Stable elastic intramedullary nailing for fractures of the femur in children. The Journal of bone and joint surgery. British volume. 2004 Sep;86(7):954-7.
2. Hinton RY, Lincoln A, Crockett MM, Sponseller P, Smith G. Fractures of the femoral shaft in children. Incidence, mechanisms, and sociodemographic risk factors. JBJS. 1999 Apr 1;81(4):500-7.
3. Buckley SL. Current trends in the treatment of femoral shaft fractures in children and adolescents. Clinical Orthopaedics and Related Research®. 1997 May 1;338:60-73.
4. Kanlic EM, Anglen JO, Smith DG, Morgan SJ, Pesántez RF. Advantages of submuscular bridge plating for complex pediatric femur fractures. Clinical Orthopaedics and Related Research®. 2004 Sep 1;426:244-51.
5. Wright JG, Wang EE, Owen JL, Stephens D, Graham HK, Hanlon Met al.. Treatments for paediatric femoral fractures: a randomised trial. The Lancet. 2005 Mar 26;365(9465):1153-8.
6. Salem KH, Lindemann I, Keppler P. Flexible intramedullary nailing in pediatric lower limb fractures. Journal of Pediatric Orthopaedics. 2006 Jul 1;26(4):505-9.
7. Lee SS, Mahar AT, Newton PO. Ender nail fixation of pediatric femur fractures: a biomechanical analysis. Journal of Pediatric Orthopaedics. 2001 Jul 1;21(4):442-5.
8. Staheli LT, Sheridan GW. Early spica cast management of femoral shaft fractures in young children. A technique utilizing bilateral fixed skin

traction. Clinical orthopaedics and related research. 1977 Jul 1(126):162-6.
9. Beaty JH, Austin SM, Warner WC, Canale ST, Nichols L. Interlocking intramedullary nailing of femoral-shaft fractures in adolescents: preliminary results and complications. Journal of pediatric orthopedics. 1994 Mar 1;14(2):178-83.
10. Letts M, Jarvis J, Lawton L, Davidson D. Complications of rigid intramedullary rodding of femoral shaft fractures in children. Journal of Trauma and Acute Care Surgery. 2002 Mar 1;52(3):504-16.
11. Bartl V, Melichar I, Gál P. Personal experience with elastic stable intramedullary osteosynthesis in children. Rozhledy v chirurgii: mesicnik Ceskoslovenske chirurgicke spolecnosti. 1996 Oct 1;75(10):486-8.
12. Reeves RB, Ballard RI, Hughes JL. Internal fixation versus traction and casting of adolescent femoral shaft fractures. Journal of pediatric orthopedics. 1990 Sep 1;10(5):592-5.
13. Ward WT, Levy J, Kaye A. Compression plating for child and adolescent femur fractures. Journal of pediatric orthopedics. 1992 Sep 1;12(5):626-32.
14. Aronson J, Tursky EA. External fixation of femur fractures in children. Journal of pediatric orthopedics. 1992 Mar 1;12(2):157-63.
15. Krettek C, Haas N, Walker J, Tscherne H. Treatment of femoral shaft fractures in children by external fixation. Injury. 1991 Jul 1;22(4):263-6.
16. Buford Jr D, Christensen K, Weatherall P. Intramedullary nailing of femoral fractures in adolescents. Clinical orthopaedics and related research. 1998 May 1(350):85-9.
17. Mani KK, Raj RD, Parimal A. Pediatric femoral shaft fractures treated by flexible intramedullary nailing. Chinese Journal of Traumatology. 2015 Oct 1;18(5):284-7.
18. Shekhar L, Mayanger JC. A clinical study of Ender nails fixation in femoral shaft fractures in children. Indian Journal of Orthopaedics. 2006 Jan 1;40(1):35.
19. Yamaji T, Ando K, Nakamura T, Washimi O, Terada N, Yamada H. Femoral shaft fracture callus formation after intramedullary nailing: a comparison of interlocking and Ender nailing. Journal of orthopaedic science. 2002 Jul 1;7(4):472-6.
20. Boutsiadis A, Iosifidou E, Nikolaos X, Hatzokos I. Lengthening Over an Existing Intramedullary Nail In Cases of Post-traumatic Femoral Shortening. Technical Note. Case Series Study. The open orthopaedics journal. 2016;10:12.
21. Steiger CN, Lenze U, Krieg AH. A new technique for correction of leg length discrepancies in combination with complex axis deformities of the lower limb using a lengthening nail and a locking plate. Journal of children's orthopaedics. 2018 Oct 1;12(5):515-25.
22. Rudani S, Kotak A. Study of enders nailing in tibia shaft fracture in paediatric patient. International Journal of Orthopaedics. 2019;5(3):159-61.

Tables

Table 1: Age Distribution

AGE GROUP (IN YEARS)	NUMBER OF PATIENTS
5-9	4(12.5%)
10-12	19(59.37%)
13-15	9(28.3%)
Total	32(100%)

Table 2: Sex Distribution

SEX	NUMBER OF PATIENTS
Male	28(87.5%)
Female	4(12.5%)
Total	32(100%)

Table 3: Mode of Injury

MODE OF INJURY	NUMBER OF PATIENTS
Trauma by Sports activities	17(53.1%)
Vehicular Accident	15(46.8%)
Total	32(100%)

Table 4: Side Affected

SIDE AFFECTED	NUMBER OF PATIENTS
LEFT	19(59.3%)
RIGHT	13(40.6%)
TOTAL	32(100%)

Table 5: Fracture Union

NUMBER OF WEEKS	NUMBER OF PATIENTS
6 to 8	12 (37.5%)
9 to 11	18 (56.25%)
12 to 14	2(6.25%)
Total	32 (100%)

Table 6: Final Result According To Flynn Scoring System

FINAL RESULT	NUMBER OF PATIENTS
EXCELLENT	29(90.6%)
SATISFACTORY	3(9.4%)
POOR	0
TOTAL	32(100%)

Figures

Figures 1-6: X-rays of 5 years old patient operated with enders nail and implant removed after 1 year

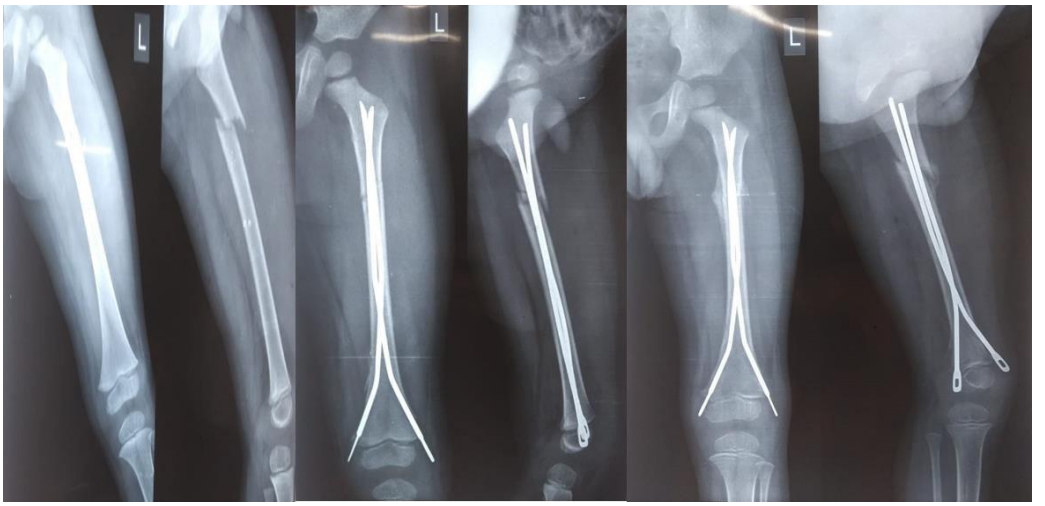

Figure 1: 1.1.Pre op x-ray 1.2. Post op x-ray 1.3: 3 months follow-up x-ray

Figure 2: 2.1 six months follow-up 2.2. Final follow-up 2.3. Implant removal at the end of 7½months

Figure 3: A 7 year old boy after 6 months operated with Ender's Nail for left shaft femur fracture having impingement of Ender's Nail mildly limiting activities of daily life

Figure 4: A 5 year old boy doing activities of daily living at final follow-up after Ender's Nail removal for left shaft of femur fracture.