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Effectiveness of ender's nailing in management of diaphyseal fractures of long bones in children

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Abstract

Introduction: "Fracture of the shaft of the femur and tibia" is relatively frequent injury in children.

Majority of these fractures occur as a result of high velocity injury that leads to fracture of femur and / or tibia by tremendous force. The high velocity injury may be direct or indirect, such as that sustained in automobile accident or fall from height. Whatever the method of treatment, the goals should be to stabilize the fracture, to control length and alignment, to promote bone healing and to minimize the morbidity and complications for the child and his/her family. Recently in our institution, ender's nail fixation for diaphyseal fracture of femur and tibia is an ideal method of surgical treatment with satisfactory results with minimum complications.

Material and Method: In this age group, we have evaluated total 50 patients, out of which 30 patients have fracture of shaft femur and 20 patients have fracture of shaft tibia.

All children and adolescent patients between 5-16 years of age with diaphyseal fractures of femur and / or tibia admitted in tertiary center in government setup - meeting the inclusion and the exclusion criteria (as given below) during the study period were the subjects for the study. Patient were regularly followed up radiologically. Final outcome is measured with Flynn's criteria.

Results: 68% of the patients were boys. Fall down was the most common mode of injury accounting for 28 (56.0%) cases Average duration of stay in hospital was 5.18 days. Superficial infection was seen in 1(2.0%) case. 1(2.0%) patient had shortening. Union was achieved in <3 months in 40 (80%) of the patients with average time to union being 11.9 weeks.

Conclusion: Because of early weight bearing, rapid healing and minimal disturbance of bone growth, Ender's nail may be considered to be a physiological method of treatment.

Use of Ender's nails for definitive stabilization of femoral and tibial shaft fractures in children is a reliable, minimally invasive, and physcal-protective treatment method. Our study results provide new evidence that expands the inclusion criteria for this treatment and shows that Ender's nails can be successfully used regardless of fracture location and fracture pattern.

Keywords: Ender's nail, elastic intramedullary nails, fracture shaft of femur, fracture shaft of tibia, long bone fractures

Introduction

"Fracture of the shaft of the femur and tibia" is relatively frequent injury in children. Majority of these fractures occur as a result of high velocity injury that leads to fracture of femur and / or tibia by tremendous force. The high velocity injury may be direct or indirect, such as that sustained in automobile accident or fall from height.

Aim of the treatment in this fracture is to give an adequate reduction and alignment and carry out normal activities as early as possible in order to reduce psychological and economical burden to parents.

Whatever the method of treatment, the goals should be to stabilize the fracture, to control length and alignment, to promote bone healing and to minimize the morbidity and complications for the child and his/her family. Recently in our institution, ender's nail fixation for diaphyseal fracture of femur and tibia is an ideal method of surgical treatment with satisfactory results with minimum complications.

Materials and Methods

Aim is to evaluate the results of operative treatment - outcome, safety, efficacy of paediatric femoral and tibial diaphyseal fractures in the age group between 5 to 16 years treated by closed reduction and internal fixation with Ender's nails. In this age group, we have evaluated total 50 patients, out of which 30 patients have fracture of shaft femur and 20 patients have fracture of shaft tibia.

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On admission to ward, a detailed history was taken, relating to the age, sex, and occupation, mode of injury, past and associated medical illness. Routine investigations were done for all patients.

Patients were operated as early as possible once the general condition of the patient was stable and patient was fit for surgery

At each follow up at 6, 12 and 24 wks, patients are assessed clinically, radiologically and the complications are noted.

Clinical Assessment

1. Pain
2. Range of movements
3. Measurement of limb length – noted for shortening / lengthening
4. Time of weight bearing
5. Partial weight bearing (in weeks)
6. Complete weight bearing (in weeks)

Radiological Assessment

X-ray thigh full length with hip and knee joints – AP and LATERAL views and X-ray leg full length with knee and ankle- AP and LATERAL.

Alignment sagittal/coronal angulation (in degrees - <10 or >10) rotational mal-alignment (in degrees - <10 or >10). Circumferential callus formation – good / adequate / poor. Visibility of fracture line – seen clearly / masked / not seen.

Complications

Minor complications – a) when they resolved without

additional surgery b) not resulting in long term morbidity.

Major complications – a) when further operation was required

b) long term morbidity ensued.

Minor Complications

- a. Pain at the site of nail insertion
- b. Minor angulation (< 10⁰ – sagittal/coronal; <10⁰ rotational mal-alignment) at final follow-up (24 weeks)
- c. Minor leg length discrepancy (< 2cm – shortening/lengthening) at final follow-up (24 weeks)
- d. Inflammatory reaction to nails
- e. Superficial infection at site of nail insertion
- f. Delayed union

Major Complications

1. Angulation exceeding the guidelines (>10⁰ – sagittal/coronal; or > 10⁰ rotational mal-alignment) at final follow-up
2. Leg length discrepancy exceeding the guidelines (>2cm – shortening/lengthening) at final follow-up
3. Deep infection
4. Loss of reduction requiring new reduction or surgery
5. Surgery to revise nail placement
6. Compartment syndrome requiring surgery
7. Neurological damage after nailing
8. Delayed or nonunion leading to revision

The final outcome based on the above observations is done as per Flynn’s criteria.

Flynn *et al* [1,2]

Table: Flynn *et al* criteria

Results	Excellent	Satisfactory	Poor
Variables at 24 weeks			
Limb-length inequality	< 1.0 cm	< 2.0 cm	> 2.0 cm
Mal-alignment	5 degrees	10 degrees	>10 degrees
Unresolved pain	Absent	Absent	Present
Other complications	None	Minor and	Major and
		resolved	Lasting
			Morbidity

**Additional Variables included in our study
Advanced Criteria**

Variables	Outcome		Poor	
	Excellent	Satisfactory	Moderate	– severe
Range of movements	Full range	Mild restriction	Moderate restriction	– severe
Time for union	8– 12 weeks	13– 18 weeks	>18 weeks	
Unsupported weight Bearing	8– 12 weeks	13– 18 weeks	>18 weeks	
a) Excellent : when there was anatomical or near anatomical alignment, no leg length discrepancy with no Preoperative problems.				
b) Satisfactory : when there was acceptable alignment and leg length with resolution of Preoperative problems.				

c) Poor: In the presence of unacceptable alignment or leg length with unresolved preoperative problems.

Table: Acceptable Angulation [3]

Age	Anterior / Posterior		Shortening (mm)
	Varus / Valgus (Degree)	(Degree)	
Birth to 2 years	30	30	15
2-5 years	15	20	20
6-10 years	10	15	15
11 years to Maturity	5	10	10

Treatment of tibial shaft fractures in children

Intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications. Advantages include closed insertion, preservation of the fracture hematoma, and a physal sparing entry point. [4]

Acceptable Alignment of a Pediatric Diaphyseal Tibial Fracture

Patient Age	<8 Years	>8 Years
Valgus	0	0
	5 A	5A
Varus	0	0
	10A	5A
Anterior angulation	0	0
	10A	5A
Posterior angulation	0	0
	5A	0A
Shortening	10mm	5mm
Rotation	0	0
	5A	5A

Observations and Results

Study design: An outcome of surgical study with 50 patients with Diaphyseal fractures is undertaken to study the outcome of ender’s nails fixation in Lower limb.

Distribution of patients studied

Out of 50 patients, there were 34 (68%)	male patients and	16 (32%) female patients in our study.
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Patients with shaft femur and tibia fracture had history of either RTA or fall down, with more chance of history fall down (56%) than RTA (44%).

In our study, we have found 30 patients with shaft femur fracture and 20 patients with shaft tibia fracture.

In our study, we have found that 64% patients have right side affection of limb and 36% patients have left side affection of limb.

Our study shows that there are more patients of transverse fracture than other variety, being transverse fracture 56%, oblique fracture 32% and spiral fracture 22%.

Time for union on radiological finding

In our study, most of the patients (80%) achieves union of fractures on radiological finding within 12 weeks.

Range of movements at 24 weeks

There were 80% patients started full weight bearing	within 12 weeks	and only 20% started full weight bearing
Between 12 -24 weeks.		

Outcome (according to Flynn’s criteria)

In our study, 96% patients have excellent result and only 4% patients have satisfactory result and no patients have poor result.

Outcome for additional variables in the present study

Outcome	Excellent (%)	Satisfactory (%)	Poor (%)
Variables			
Range of movements	96	4	-
Time for union	80	16	4
Unsupported weight bearing	80	16	4

Discussion

Age incidence

In the present study 17(34.0%) of the patients were 5-8 years, 22 (44.0%) were 9 to 12 years and 11(22.0%) were 13 to 16 years age group with the average age being 10.16 years.

J.M. Flynn *et al* studied children ranged from 3-16 years with a mean of 10.3 years. Wudbhav N Sankar *et al* studied children ranged from 7.2-16 years with a mean of 12.2 years.^[4] William G. Cole *et al* study of plaster casting in fracture femur mean age is 5 yr.

Sex incidence

There were 16(32%) girls and 34 (68%) boys in the present study. The sex incidence is comparable to other studies in the literature.

In their study Singh and Kumar *et al.* out of 112 cases, had 77 (69%)

Male patient and 35 (31%) female patients.

William G. Cole *et al* studied 191 patients with 113(68.58%) male and 58(30.36%) girls.

Mode of Injury

In the present study RTA was the most common mode of injury accounting for

22 (44.0%) cases and fall down accounted for 28 (56%) of the cases.

J. M. Flynn *et al.*, in their study assessing 234 cases, 136(58.1%) were following RTAs, 46(19.6%) were following self fall and remaining 43(28.8%) were as a result of fall from height.^[2]

William G. Cole *et al.*, in their study have 38(21.1%) patients with history of RTA and 131(72.7%) patients with history of fall down.

Bone affected

We studied 30(60.0%) femoral and 20(40%) tibial fractures.

In their study, Gamal El-Adl *et al.* had 48 (65.7%) femoral and 25 (34.3%) tibial fractures ^[8]

Pattern of Fracture

In our study, transverse fractures accounted for 23(46.0%) cases, oblique fractures - 16(32.0%), spiral fractures – 11(22.0%) and there were no comminuted and segmental fractures.

In their study	J. M. Flynn et	al. out of 2 2 9 femoral fractures studied 1 1 4 (48.7%) were
transverse	fractures, comminuted	fractures- 28 (12%), oblique fractures - 47(20%), spiral fractures –
29(12%)	And 14 (6%)	Were butterfly fractures.

Wudbhav N. Sankar studied 19 tibial shaft fractures out of which 9 (47.3%) were transverse, 7 (36.8%) were oblique, 2 (10.5%) were spiral and 1 (5.2%) was comminuted. ^[4]

William G. Cole *et al* studied 191 patients with femoral shaft fracture, in which 40(20.9%) had transverse fracture, 113(59.13%) had spiral fracture and 38(19.9%) patients had oblique fracture.

Fractures involving the middle 1/3rd accounted for 27 (54.0%) cases, proximal 1/3rd – 12 (24.0%) and distal 1/3rd – 11 (22.0%) of cases in our study.

In their study J. M. Flynn *et al* among 233 femoral shaft fractures, 33 fractures were in the proximal 1/3rd,

165 in the middle 1/3rd and 35 were in the distal 1/3rd. Wudbhav N. Sankar studied 19 tibial shaft fractures out of which 15 were middle 1/3rd, 2 – proximal 1/3rd and 2 were distal 1/3rd. ^[4]

Time for union

In our study union was achieved in <3 months in 40 (80%) of the patients and 3 – 4.5 months in 10 (20%). Average time to union was 11.9 weeks.

In study of Gamal El-Adl *et al.* average time to union was 85 days (12weeks), with range between 42 to 140 days for flexible intramedullary nailing.

In our study, closed	reduction of the fracture, leading to preservation of fracture hematoma, improved
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Biomechanical stability and minimal soft tissue dissection led to rapid union of the fracture compared to compression plate fixation.

STUDIES	OUTCOME		
	Excellent (%)	Satisfactory (%)	Poor (%)
Present study	94.0	6.0	-
Gamal El Adl <i>et al.</i> ^[8]	75.8	24.2	-
J.M.Flynn <i>et al.</i> ^[11]	65	25	10
Wudbhav N. Sankar ^[4]	63.15	31.57	5.26

Summary

Thirty patients with diaphyseal fractures of the femur (30) and twenty patients with fracture tibia (20) were treated with ender's nailing in tertiary center at government setup.

Children and adolescents aged between 5 to 16 years were included.

Transverse fractures	Accounted for 23(46.0%) cases, oblique fractures 16(32.0%)	and spiral fractures –
11(22.0%).		
Fractures involving the middle 1/3rd accounted for 27 (54.0%) cases. All the patients		were prepared and
operated as	early as	Possible once the general condition was stable and the patient was fit for surgery.

The average duration between trauma and surgery was 1.86 days with 34 (68%) patients undergoing surgery within 2 days and between 3 to 7 days (32%).

43 (86.0%) cases were immobilized (with long leg cast for femur fracture / above knee POP cast for tibia fracture) postoperatively for 6-8 weeks and such immobilization was for 9 weeks in rest of the 7 (14.0%) of the cases.

Average duration of stay in hospital was 5.18 days.

Union was achieved in <3 months in 40 (80%) of the patients with average time to union being 11.9 weeks.

Unsupported full weight bearing walking was started in < 3 months for 40 (80%) of the patients.

All patients had full range of hip and ankle motion in the present study and 2 (6.66%) patients had mild restriction in knee flexion at 12 weeks

8(16.0%) had developed pain at site of nail insertion during follow up evaluation, all of which resolved by the end of 12 weeks follow up.

Superficial infection was seen in 1(2.0%) case. 1(2.0%) patient had shortening

No patient in our study had major limb length discrepancy (i.e. > ± 2cm). Nail back out was not seen in any of the

Cases. 1(2.0%) patient presented with varus (4⁰) angulation, no patient presented with valgus angulation and no patients had antero-posterior angulation or rotational mal-alignment^[10]

The development of the Ender's nail fixation method has put an end to criticism of the surgical treatment of paediatric long bone fractures, as it avoids any growth disturbance by preserving the epiphyseal growth plate, it avoids bone damage or weakening through the elasticity of the construct, which provides a load sharing, biocompatible internal splint, and finally it entails a minimal risk of bone infection^[11].

ded in the study. 34.0% of patients were between 5-8 years, 44.0% of patients in between 9-12 years and 22.0% of patients in between 13 to 16 years age group with the average age being 10.16 years. 68% of the patients were boys. Fall down was the most common mode of injury accounting for 28 (56.0%) cases followed by RTA - 22 (44.0%)^[9]

Conclusion

Based on our experience and results, we conclude that ENDER'S NAILING technique is an ideal method for treatment of pediatric femoral and tibial diaphyseal fractures. It gives elastic mobility promoting rapid union at fractures site and stability which is ideal for early mobilization. It gives lower complication rate, good outcome when compared with other methods of treatment.

It is a simple, easy, rapid, reliable and effective method for management of paediatric femoral and tibial fractures between the age of 5 to 16 years, with shorter operative time, lesser blood loss, lesser radiation exposure, shorter hospital stay, and reasonable time to bone healing.

Because of early weight bearing, rapid healing and minimal disturbance of bone growth, Ender's nail may be considered to be a physiological method of treatment.

Use of Ender's nails for definitive stabilization of femoral and tibial shaft fractures in children is a reliable, minimally invasive, and physeal-protective treatment method. Our study results provide new evidence that expands the inclusion criteria for this treatment and shows that Ender's nails can be successfully used regardless of fracture location and fracture pattern.

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