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Internal fixation of pediatric shaft femur fractures by titanium elastic nails: clinical and radiological study

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ABSTRACT

Background: Management of diaphyseal femoral fractures in the pediatric age group is challenging. There has been a demand worldwide for operative fixation.
Methods: Twelve children (7 boys, five girls) aged 6-16 years with diaphyseal femoral fractures (12 fractures, one in each) was stabilized with titanium elastic nail system (TENS). Patients underwent surgery within a week days of their injury. The results were evaluated using Flynn's Scoring system. Identical two nails were used in each fracture.
Results: All 12 patients were available for evaluation and follow-up for a mean duration of 24 months (14-34 months). Radiological union in all cases was seen at a mean duration of 8 weeks. Full weight bearing was possible at a mean duration of 10 weeks (8-12 weeks). The results were excellent in 8 patients (67%) and satisfactory in 4 patients (33%). Complications that occurred were infection (2 cases), knee joint stiffness (4 cases), angulation <10 degrees (1 case), and shortening less than 10 mm (2 cases).
Conclusions: Intramedullary fixation by TENS is an effective, time-tested treatment of fracture of the femur in patients of the 6-16 years age group.

Keywords: Intramedullary fixation, Titanium elastic nail, Femoral fracture, Diaphysis

INTRODUCTION

Femoral shaft fracture is an incapacitating injury in children.[1,2] The treatment has traditionally been age related and decided by the fracture pattern and any associated fractures. The aim of treatment of any fracture is not only anatomical reduction but also restoration of soft tissue and joint function as close as possible to the normal. The aim of treatment is early mobilization by early use of the fractured limb without movement at the fracture site. Due to rapid union rates and spontaneous correction of angulations, most of the diaphyseal femoral fractures in children younger than six years of age can be treated conservatively. Above six years of age all such fractures when treated non-operatively could have loss of reduction, mal-union, intolerance, and complication associated with immobilization. When minimal growth period remains, accurate reduction is necessary as angular deformity is no longer correctable by growth

In children between 6-16 years of age, there has been an increasing trend towards internal fixation. Titanium elastic nailing system (TENS) which is variously known as elastic stable intramedullary nailing (ESIN) has become the choice of stabilization in pediatric long-bone fractures, particularly the femoral shaft fracture. Until recently skeletal traction and application of a cast were the preferred methods of treatment of femoral shaft fractures in children and young adolescent. The elastic nails would exploit a child's dense metaphyseal bone, rapid healing and ability to remodel without causing damage to the distal femur epiphysis or the blood supply to the capital femoral epiphysis.

METHODS

Twelve children (7 boys and five girls) in the age group of 6-16 years (average 10.8 years) with femoral shaft fracture were stabilized with TENS from January 2014 to December 2015. The common mode of injury was following fall from height (50%). Right-sided involvement was seen in 8 cases (66.7%) and left side in 4 cases (33.3%). Mid-diaphyseal fracture of the femur was found in 7 patients (58.3% cases) and subtrochanteric fracture (proximal 1/3 and middle 1/3 junction) in 5 patients (41.6% cases). Seven patients had closed fractures, and 5 had Gustilo- Anderson Type I & II fractures. All the patients underwent surgery within ten days of their injury in the department of orthopedics, MGMCRI, Puducherry. Nails are available in five diameters from 2.5 mm to 4.5 mm in a fixed length. Unlike TEN which are colour coded for identification, stainless steel elastic nailing does not have any colour codes. The nails shown in Figure 1 are straight except for a flat and bent tip. Special instruments include radiolucent reduction tool, nail holder, nail bender, Insertion device, nail extractor and a nail impactor were used.

Figure 1: Type of nails used in surgery.

All the patients had skin traction applied initially till the day of surgery. This is essential to minimize pain, muscle spasm and shortening. Mate the nail diameter and to develop an approach to supplement fixation and plan the incision. The patients were operated under image intensifier control with entry point of nails from caudad to cephalad direction. Nails were introduced into distal fragment after reduction of fracture with maintenance of length & rotation. Postoperatively a knee immobilizer or controlled motion brace was used for additional support. When early callus formation was observed, weight bearing was allowed. External support was discontinued when radiographic healing was complete. In all cases post- operative X-rays both anteroposterior and lateral views were taken. Patients underwent regular follow-up in the OPD for clinical and radiological evaluation in the immediate post-operative period as in Figure 3, at four weeks, eight weeks as in Figure 4, 12 weeks as in Figure 5, 24 weeks and 34 weeks.

Figure 2: Preoperative X-ray.

Figure 3: Immediate postoperative X-ray.

Figure 4: At 8 weeks postoperative X-ray.

Figure 5: Clinical photographs.

RESULTS

The mean duration of the surgery was 30 min (15-40 min). All 12 patients were available for evaluation after a mean of 24 months (14-34 months) of follow-up. All patients were encouraged for hip and knee mobilization exercises, and non-weight bearing walking from the first post-operative day. Weight bearing was allowed as per the fracture pattern and quality of fixation. By 8th week all the patients were bearing full weight. Out of 12 cases, 2 cases had pain and irritation of the skin at the entry point site, associated with the prominence of the ends of the nails.

Out of 12 cases, 10 mm (1 cm) shortening was observed in 2 cases. These both patients had comminuted fractures. Only one patient had less than 10-degree angulations in the lateral plane. No broken nails were observed. No re-fracture was observed. Infection was seen in 2 cases, knee joint stiffness in 4 cases, shortening less than 10 mm in 2 cases. All the cases were advised implant removal at eight months.

Table 1: Tabulation of critical parameters like age and sex of the patients, nature and mode of injury, specifications of nail used, follow-up results and intra-op blood loss and post-op ROM and union rate.

Sl No	Age in years	Sex	Mode of Injury	Type of fracture	Side of fracture	Closed /open Injury	Blood loss	Nail diameter	ROM	Time for union (in weeks)			
										4	8	12	24
1	10	M	Height	MD	L	Closed	<100 ml	2.5 mm	FR	+	++	+++	+++
2	12	F	RTA	ST	R	Open	<300 ml	2.5 mm	0-100º	-	+	++	++
3	14	M	Height	MD	R	Closed	<100 ml	3 mm	FR	+	++	+++	+++
4	9	M	Height	MD	L	Closed	<100 ml	2.5 mm	FR	+	+	++	+++
5	6	M	Height	MD	R	Open	<300 ml	2.5 mm	FR	+	++	+++	+++
6	14	F	Height	ST	L	Open	<200 ml	3 mm	0-120º	+	++	+++	+++
7	12	M	RTA	MD	R	Closed	<150 ml	2.5 mm	FR	-	+	+	++
8	7	M	Height	MD	R	Closed	<100 ml	3 mm	FR	+	++	+++	+++
9	10	F	RTA	ST	L	Closed	<200 ml	2.5 mm	FR	+	++	+++	+++
10	8	F	RTA	MD	R	Open	<300 ml	2.5 mm	0-120º	+	++	++	+++
11	11	M	RTA	MD	R	Closed	<100 ml	2.5 mm	FR	++	+++	+++	+++
12	16	F	RTA	ST	R	Open	<300 ml	3 mm	FR	+	++	+++	+++

M = Male; F = Female; RTA = Road Traffic Accident; MD = Mid diaphyseal; ST = Subtrochanteric; R = Right; L= Left; ROM = Range of Motion; FR = Full Range; + = Little amount callus seen; ++ = Fair amount callus seen; +++ = Good amount of callus seen; - = No visible callus seen.

DISCUSSION

Heinrich et al in their study observed that 22% of their patients had a limb lengthening greater than 5 mm, and 11% had a limb shortening greater than 5 mm.[3] In another similar study comparing several methods including elastic nails the maximum shortening was observed in the conservative group followed by external fixator group whereas lengthening was observed only in the external fixator group. In our study, only 2 cases showed 1 cm shortening which was clinically indiscernible. Herndon et al reported that malunion developed in 7 patients out of 24, treated with traction while no malunion was observed in 21 children, treated using elastic nails.[4]

In a study comparing anterograde versus retrograde elastic nails by Galpin et al it was reported that 35 patients out of 37 had excellent improvement regarding angular deformity.[5] In our series, we had angulation less than 10 degrees in the anteroposterior plane in one patient (8.3%). In our series, progress of union was satisfactory in all 12 cases. At the end of 8 weeks, 6 cases showed excellent callus formation while 6 cases had inadequate callus formation. No supplemental bone grafting was required in any of the cases. No significant malunion was observed in any of the 12 patients.

Flynn et al found elastic nail advantageous over hip-spica in the treatment of femoral shaft fractures in children.[6] Buechsenschuetz et al documented elastic nails to be superior regarding union, scar formation and overall patient satisfaction when compared to nonoperative management.[7] Ligier et al treated 123 pediatric diaphyseal femoral fractures with elastic nails.[8] All fractures united with an excellent long-term outcome. Similarly Narayanan et al found elastic nails to be a very promising modality of fracture management in children.[9] In our series, by suture removal all 12 cases could do straight leg raising exercises. At the end of study period nine patients (75%) could do a full range of motion at the knee joint.

Flynn et al used a knee fixating device for pain control, for support of quadriceps and prevention soft tissue irritation in the knee by the ends of the nail until the callus appears (4-6 weeks).[6] The patients were able to walk on day nine on an average with the help of equipment and at eight weeks on average without

equipment. In our series patients were made ambulatory on crutches after 1st postoperative week. Partial weight-bearing was allowed at six weeks (range 4-8 weeks), and full weight-bearing was allowed at ten weeks (range 8-12 weeks).

Advantages of elastic nail fixation are early union due to repeated micro-motion at fracture site, early mobilization, early weight bearing, scar acceptance, and high patient satisfaction rate. Besides these, unlike other implants Elastic Nails does not endanger either the epiphysis or the blood supply to the femoral head. The excellent biocompatibility and elasticity of titanium have further enhanced the virtues of Elastic Nails. More importantly, elasticity promotes callus formation by limiting stress shielding.

CONCLUSION

The intramedullary fixation by TEN is a method of choice due to its distinct advantages over other conventional modalities. Easy manoeuvring, excellent outcome, lower incidence of complications and easier postoperative care have made TEN the most prudent, practical and successful intervention in the management of femoral shaft fractures in patients between 6 and 16 years of age.

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