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Evaluation of Outcome of Paediatric Long Bone Shaft Fractures by Titanium Elastic Nailing

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ABSTRACT

Aim: To study the type of injury and clinical profile of various long bone diaphyseal fractures in children. To study the merits and demerits of Titanium Elastic nails in the management of various long bone diaphyseal fractures in children with regard to intra operative and post operative clinical and radiological characteristics (i.e., functional status, union of the fracture and post operative complications.) **Objectives:** To achieve near anatomical reduction, prevent joint stiffness & to obtain good range of motion, prevent deformity are the objectives of the treatment. **Introduction:** The incidence of paediatric trauma is highest among developing world reflecting the realities of urban violence, firearms and the dangers of highly mechanized society. Recent years have witnessed a shift towards a greater role for operative management for many children fractures. In most instances operative management produces better results than non operative treatment. **Materials and methods:** The study included 18 cases of various paediatric long bone fractures treated with flexible elastic nailing. The study was done at department of orthopaedics in Narayana Medical College and Hospital, Chintareddypalem, Nellore. The study was done over a period of two years from Oct 2012 to Apr 2014 with sequentially selected cases. **Results:** Eighteen patients of various long bone fractures of the age group between 6-12 years were treated by closed/ open reduction and Titanium Elastic nail fixation. 66.7 % fractures involved on the right side. The most common mode of injury was Road traffic accident in 61.11 % cases. 88.88 % of patients were reported to hospital within 3 days of injury. Two cases of associated fractures were seen. 90 % of patients were operated within 3 days of admission and all of the patients were operated within 5 days of injury. 50 % of the patients were operated within 50 minutes with an average operating time of 50 minutes in our study. The average blood loss was 55ml and no patient in our study required blood transfusion per operatively or post operatively. The average hospitalization time is 5 days. Most of our patients were able to do partial weight bearing with crutches by the end of 2 weeks. 77.77 % of our patients were able to do full weight bearing by the end of 9 weeks and all of the patients were able to do full weight bearing by 12 weeks post operatively one proximal migration of the nail was observed. In one patient shortening of less than 2cms was noted. Knee stiffness was observed in 4 cases. We recorded zero mortality rates. There were no cases of infection either superficial or deeply. All the fractures united within 4 months of operation and average time taken for union was 10 weeks. We were able to achieve good to excellent anatomical results in 83 % of patients whereas good to excellent functional results were obtained in 83 % patients. **Conclusion:** This method is less traumatic, gentle and one of the simplest methods known. This method is based on sound biomechanical. The intramedullary position of the implant places it more in line with the weight bearing forces thereby reducing the tendency of the fracture to settle in a deformed position. The excellent biomechanics is reflected by the absence of implant failure. No case of delayed or non union in the present study. Early ambulation is one of the advantages of the Titanium Elastic nailing.This helps to minimize the duration of hospital stay and complications of enforced bed rest like pneumonias, bed sores, UTI, thrombo embolic phenomenon, etc.

Keywords: titanium elastic nail; paediatric long bone fractures; Flexible Intramedullary Nailing (FIN)

Introduction

Paediatric trauma presents one of the largest challenges to the health of children well as great opportunity for positive impact**.** It is estimated that more than eleven million hospitalization and fifteen thousand deaths resulting from childhood injury every year[1,2]**.**

It has been estimated that 25% of children sustain an injury every year with 10% to 25% of these injuries consisting of a fracture infact on both outpatient and inpatient side musculoskeletal trauma makes up largest share of paediatric injuries. The incidence of paediatric trauma is highest among developing world reflecting the realities of urban violence, firearms and the dangers of highly mechanized society. Recent years have witnessed a shift towards a greater role for operative management for many children fractures. In most instances operative management produces better results than non operative treatment but this shift in treatment

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has not been without some controversy. In 1979, Professor Jean Prévot and his young team of surgeons - Dr Métaizeau, Dr Ligier and Dr Lascombes of the Centre Hospitalier Universitaire of Nancy[3], France, developed and introduced a technique for the treatment of long bone fractures in children using flexible IM nailing. In 1994, Professor Prévot passed his torch of paediatric orthopaedic leadership of the University Hospital in Nancy[3] to Professor Pierre Lascombes, who has continued to improve and teach the flexible intramedullary nailing technique around the world. Titanium elastic nailing technique (TEN) is a relatively new method for internal fixation of various long bone fractures , which uses pre bent 4.0 mm (also available in 2, 2.5,3.0, 3.5 ,4.0& 4.5 mm) round, flexible, semi elastic nails and is having certain advantages over the other devices. TENS fixation is a form of multiple nail fixation, in which several nails of smaller diameter are inserted into a non reamed medullary canal of a long bone. Fracture fixation is attained by each nail which gives its *own three point fixation*. So, if two or three nails are used multiple point fixation is achieved, leading to good stability. Kuntscher developed the concept, but the extensive work had been previously worked up on nailing techniques. The alignment nailing technique widely used by Rush after World War II [6]. Actually, it was still incorporated into the idea of the Ilizarov external fixator, as Ilizarov had fully demonstrated that when traction compression forces are applied to bone with intact periosteum and blood vessels, healing occurs regardless of the circumstances[7]. In 1980s, elastic stable intramedullary nailing (ESIN) indications expanded significantly. It was first used in diaphyseal fractures [8,9]. Later then, metaphyseal fractures were also stabilized using different methods: Hackethal, Ender or also even Foucher for the 5th metacarpal [10]. ESIN has been changed to "FIN" (Flexible Intramedullary Nailing). The FIN method also termed Metaizeau technique, Nancy technique, or ESIN technique[11] (mainly in Europe). In addition, Parsch K.,(1990s), a detailed history of this method for the treatment of femoral fractures of childrens[12]. According to some authors, [13,14] it is an important to determine the factor for healing. For others, it doesn't have active role,[15] this is based on the finding that near normal healing can be achieved in hemophilic patients, and in patients of open internal fixation. Titanium and stainless steel: which of these two materials is best suited for flexible intramedullary nailing [17]. The first nails were made of stainless steel as stainless steel K-wires of all diameters. Later, a shift to the use of titanium occurs on the ground that titanium had better elastic properties. Therefore the biomechanical features of stainless steel and titanium had resistance to deformation and elastic restoring force after elastic displacement[18,19]. In supracondylar humeral fractures[20], extension lag is recurrent during the first post operative weeks and spontaneously within a few weeks it will heal. In addition, few physical therapy sittings are prescribed to perform active and active-assistive exercises, for knee inflammation and knee pain by using ice, cold therapy[21].

Material and methods

Clinical material

A Study of 18 patients who had fractures of various long bones in children were undertaken in Narayana medical college and hospital, Nellore from October 2012 to April 2014. The trauma centre of the hospital attracts the cases from Nellore. Cases were selected on the basis of a fixed inclusion and exclusion criteria which were devised in the department of Orthopedics, Narayana medical college and hospital, Nellore.

Inclusion criteria: Femoral diaphyseal fractures; Tibial diaphyseal fractures; Diaphyseal fractures of humerus; Diaphyseal fracture both bones forearm.

Exclusion criteria: Epiphyseal and metaphyseal fractures; Unmotivated patients; Compound fractures; Comminuted fractures.

Study consists of surgical management of various long bone fractures in children by flexible, multiple Titanium elastic nails. Case sheet of each patient is prepared as follows.

Examination: A thorough general physical examination was undertaken and condition of the patient assessed by noting the vital signs of pulse, blood pressure, respiration and pallor (if any). Systemic examination was performed to recognize any pre-existing medical and surgical illness esp. cardiovascular, respiratory or renal disease. Local examination was conducted to know about the deformity, extent of swelling, local tenderness, and abnormal mobility. The neurovascular status was recorded in each case. Limb length was measured and the amount of shortening was recorded in each case. Any associated injury was recorded and treatment carried out accordingly. Range of movements was also recorded in each case.

Investigations: Investigations included haemoglobin, bleeding time, clotting time, complete blood count, urine examination, blood urea, blood sugar, and electrocardiogram. X- rays of the affected limb were taken. X-ray chest was also done to diagnose any pre-existing chest disease.

Management:B/K skin traction upto 2kgs weight for femur, A/K POP slab immobilization for diaphysis tibia or 'U' slab immobilization for humerus applied according to the fracture. Any associated injury or medical or surgical illness was treated accordingly. Patients were operated as early as possible after obtaining anaesthetic fitness.

Apparatus and instruments: Titanium Elastic nails; Nail introducer cum rotator; Nail impactor; Nail bender and Nail Extractor; Bone awl and Mallet; Image intensifier is mandatory.

Surgical approaches: Patients with cardiopulmonary, renal and liver diseases having high anaesthetic risk. Patients with fractures in flourosis, osteogenesis imperfect, tumors of bonecongenital deformity. Children with fracture shaft of femur above 6 years old in order to prevent the shortening and deformity. Children with fracture shaft of tibia above 6 years old in order to prevent the shortening and deformity. Compound fractures of tibia, segmental fractures of tibia in children. Children with fracture shaft of Humerus above 6 years old in order to prevent the shortening and deformity.

General anaesthesia or spinal anaesthesia was used depending upon the fitness of the patient. Local anaesthesia supplemented by sedation was in those cases that were not fit for major anaesthesia. Patient is placed on the operating table and closed reduction of the fracture was obtained by giving simultaneous traction and counter traction in longitudinal direction. The reduction was checked radiologically with image intensifier. Every attempt was made to reduce the fracture by closed means. If closed reduction failed, a small incision was given at the fracture site and reduction achieved. Injectable antibiotic was given pre-operatively. Entire segment of the involved limb on the injured side was thoroughly scrubbed with savlon and then painted with betadine and draped so that only the involved segment of the limb and with 2 nearby joints are exposed. A skin incision approximately 3cms long was made at the nail insertion site. Subcutaneous tissues are cleared with artery forceps. Periosteum is stripped with periosteal elevator and bone is exposed. An oval window of size 1cm was made in the bone with acurved awl with the long axis in the vertical direction.

Entry portals

Femur-RETROGRADE FIXATION: Use a 4- to 4.5-mm drill bit with a tissue protector to make a hole in the cortex on the medial and lateral distal femoral metaphysis at a point approximately 3 cm proximal to the physis. Antegrade fixation: Drill a 4- to 4.5-mm hole in the cortex at the metaphyseal-diaphyseal junction.

Tibia-Antegrade nailing: The starting point for the nail entry hole is approximately 1.5 to 2 cm distal to the physis. Retrograde nailing: Entry point is approximately 1.5 to 2 cm proximal to the physis .

Humerus: The starting point for the nail entry hole can use Antegrad or retrograde nailing. Titanium elastic nail of the appropriate size was taken and inserted into the hole that was made and gradually advanced with the help of the introducer and mallet blows across the fracture. The first nail was inserted and advanced it for some distance. The next nail was inserted lateral to the first. In some cases second nail was inserted from the opposite cortex. The nails were inserted after bending them with bender in such a way that they fanned out in the femoral head. Position of the nails was checked radiologically. After achieving haemostasis subcutaneous tissues and skin were closed layer by layer and antiseptic dressing was given. Postoperatively, radiographs of the affected limb were taken.

Radius and ulna: Radial & ulnar nails were identical. The nail diameters should be between 2.0 mm and 3.0 mm, depending upon patient's anatomy. The nail can be placed in the radius from a distal approach and the nail be placed in the ulna from a proximal approach. The entry point in the radius is either just proximal to the radial styloid or through Lister's tubercle for diaphyseal fractures. The nail is inserted retrograde allowing the nail tip to capture the proximal fragment for head fractures of radius. Reduction can be completed using rotation of the curved tip of the nail. The antegrade entry point in the ulna can be either at the posterior aspect of the olecranon or a lateral approach through the proximal metaphysis. The retrograde entry point in the ulna is through the distal metaphysis.

Post-operative care: Plaster of Paris immobilisation was given for a period of 3 or more weeks in unstable fractures. Immobilisation with brace was given for stable fractures. Injectable antibiotics were given for three days followed by oral broad spectrum antibiotics for seven days. Sutures were removed on 10^{th}or 14^{th} postoperative day.

Physical therapy-Stable fractures: Static muscle strengthening exercises were started from the first postoperative day. Patients were allowed to walk with crutches after suture removal or after 2 weeks and gradually full weight bearing was allowed at 4 to 6 weeks after surgery. For humerus fractures patients were allowed to take shoulder and elbow mobilisation exercises after 2 weeks.

Unstable fractures: Static muscle strengthening exercises were started from the next day of surgery.

Patients were allowed non weight bearing crutch walking for 4 to 6 weeks and then gradually full weight bearing was allowed depending upon the patient and tolerance.

Follow up: Patients were followed at regular intervals for at least 10 to 12 months and all the patients were examined clinically for any evidence of wound infection, deformity and range of movements at two nearby joints, limb length discrepancy, malalignment, knee and shoulder stiffness and ability to squat. Radiological examination was carried out for evidence of union and migration of nails.

Post operative status: X rays of the bone and 2 nearby joints**;** Physiotherapy started on; Movements of the joints started on; Partial weight bearing started on; Full weight bearing started on.

Evaluation of results: Results were evaluated both anatomically and functionally according to the following criteria (Flynns scoring criteria)[22].

Results

During the period october 2012 – April 2014, 18 patients of age between 6– 12 years of age group with various diaphyseal long bone fractures in children's were treated by closed /open reduction and Titanium Elastic nail fixation. Diaphyseal long bone fractures in the age group 6-9 years comprising of 6 cases and age group 10-12 years comprising of 12 cases in the present study. In the present study sex distribution is equal. Twelve cases involved on right side and six cases involved on left side. The common mode of injury was Road Traffic Accident in 61.11 %; 39 %of the patients due to fall in the present study. Most of the patients reported to the hospital within 3 days of injury (88.8 %). 44.44 % patients reported on the day of injury. 2 cases only, one with opposite distal femur fracture and another with ipsilateral both bones forearm fracture. **i.e., 11.11%.** 90 % of the cases were operated within 3 days of injury whereas only 10 % of the patients could be operated 5 days of injury. 61% of the lower limb fractures were operated under General anaesthesia, 33% under spinal anaesthesia. Upper limb fractures were operated under brachial block (5.5 %). Out of 18 patients majority had a hospital stay between 0-5 days (77.77 %). 72.22 %of the patients had less than 50 ml blood loss during operation. Average blood loss was 55 ml. 22.22 %of the patients were able bear full weight by the end of 6 weeks where as 78%of the patients were able to bear full weight by the end of 12 weeks post operatively. Almost all the fractures united within 4 months after operation. (Figure 1 & 2)

Anatomical results

Excellent results were obtained in 66.66 % cases whereas 16.66 % patients had good anatomical results.16.66% patients had fair results.(Table 1)

Functional results

Good to excellent results were obtained in 83 % of patients and 16.66 % patients had fair result (Table 2) The complications observed were shortening which was seen in 1case. Migration of nails was seen in 1 case. Slight to Considerable limitation of joint movements were seen in 4 patients. One patient required re-operation. In the present study there were no cases of infection. No patient died during the post operative period.(Table 3)

Table – 1: Anatomical Results

Anatomical results	No of cases	% age
Excellent	12	66.66
Good	3	16.66
Fair	3	16.66
Poor	0	0
Total	18	100

Table –2: Functional Results

Functional results	No of cases	%age
Excellent	12	66.66
Good	3	16.66
Fair	3	16.66
Poor	0	0
Total	18	100

Table – 3: Complications

Complications	No of cases	%age
1. migration of nails	1	5.55
2. Infection		
a) Superficial	0	0
b) Deep	0	0
3. Bed sores	0	0
4. Implant failure	1	5.55
6. Shortening < 2 cms	1	5.55
7. Mal union with rotational deformity	1	5.55
8. Limitation of joint movements (total)	4	22.22
a) Slight (10-20%)	3	16.66
b) Considerable (20-50%)	1	5.55
c) more than 50%	0	0
9.Reoperation	1	5.55

Figure.1. X-ray findings of various cases before and after surgry (Follow-up)

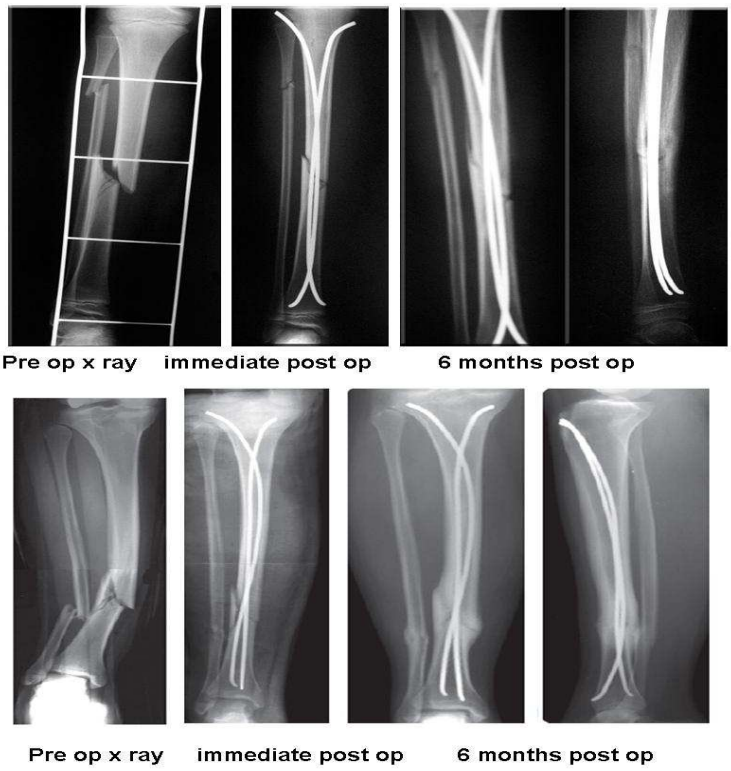
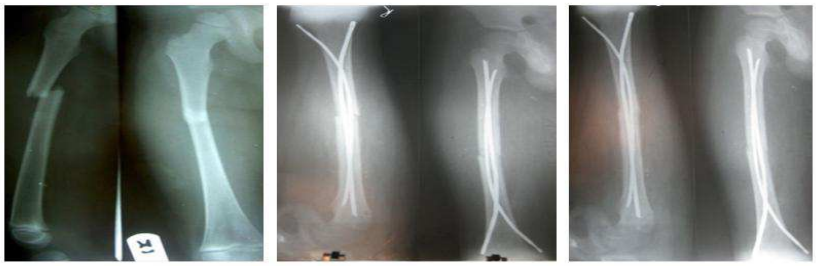
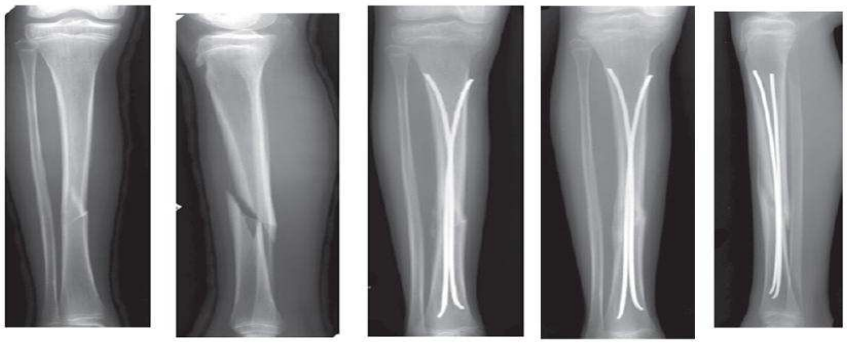


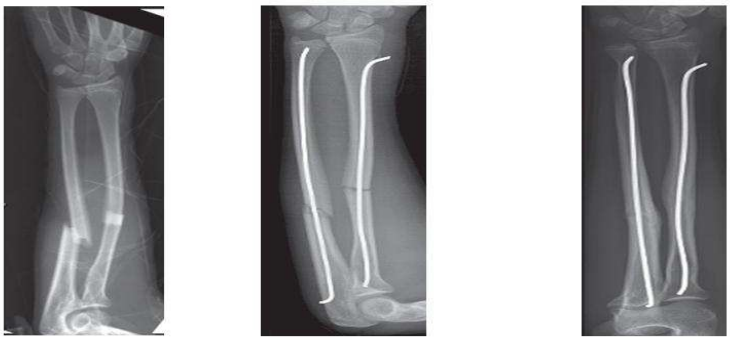
Figure.2. X-ray findings of various cases before and after surgry (Follow-up)



Pre o.p x ray Immediate post 6 months post op



Pre opxray postop xray 6 months post op



preop x ray immideate post op 6 months post op

Discussion

The present study consisted of 18 cases of various long bone diaphyseal fractures (Femur, Tibia & Humerus) in children; treated in the department of Orthopaedics, NARAYANA MEDICAL COLLEGE HOSPITAL, NELLORE during the year Oct2012-Apr2014. The results obtained have been compared with the results obtained by other works using the same technique.

In the present study, there were 9 males (50%) and 9 females (50%). Road traffic accident was responsible for 61.11 % of the patients and accidental fall was responsible for 38.88 % patients. Most of the patients reported within 3 days of injury (88.88%).Concomitant systemic diseases were found in only one patient (Rickets). In this series, 11.11% cases of associated fractures were found whereas Todd and Schein reported 2.6 % incidence of associated fractures in their series. The average operating time in the present study was 50min. Iwegbu and Patel reported the average

operating time of 40 minutes whereas Paust off and Schein reported average operating time of 100 minutes. This is marked contrast to the other types of fixation like interlocking nailing and plating techniques. No patient in the current study required blood transfusion. The average blood loss was 55ml. Iwegbu & Patel reported an average blood loss of 180ml. Passoff and Schein reported an average blood loss of 100ml and Pankovich and Tarabishy reported a blood loss of 120ml. This is also more contrast to other types of fixation devices where blood transfusion is necessary. The average hospitalization time in the present study is 5ays.Majority of the patients had operation within first week period. In our study mortality rate is zero. Atul Bhaskar[30] took into consideration 60 patients with various long bone fractures underwent operative treatment with elastic intra-medullary nails. The mean age was 10 years.

In our study, 18 paediatric age group patients with various long bone fractures were treated with flexible intramedullary nails. In the present study, the mean age group was 10.33 yrs. Roop Singh *et al*.,[31] studied 35 number of pediatric patients in age group 6-14 years with diaphyseal femoral fractures. Patients were followed-up clinically and radiologically for two years. Overall, the results observed were excellent in 25, satisfactory in 8 and poor in 2 patients. Hospital stay time averaged for 12.30 days in series. All the fractures healed with an average time to union of 9.6 weeks (6-14.4 weeks). In present study follow up was done clinically and radiologically for a period of 6 months .Average hospital time was 5 days. All fractures in our study showed evidence of union on average of 4 months. P. Berger encountered complications in three hydrops of the knee, four low-grade infections and one delayed union. Leg length discrepancy was only seen in five patients (18%) and was less than 2 cm[32-33].

In our series, complications encountered were knee stiffness in 4 cases (22.22%), no infections or nonunions, malunion in 1 case (5.55%), shortening less than 2 cm in 1 case (5.55%). knee stiffnes cases improved on physiotherapy. Also the nails were rigid and difficult to insert through the metaphyses of children bones[23]. Enders nails were devised to overcome this problem but usually multiple Enders nail was required to achieve fracture stability. The titanium flexible nail with newer design has an advantage over the older Enders nail. Because of the inherent stiffness of titanium even 2 mm nails have sufficient strength and elasticity compared to K-wire or stainless steel pin of the same diameter [24]. As reported by Vrsansky, 308 fractures were treated by flexible nailing technique for children. However, the previous studies cautioned that these nails should not be used in children under 5 years. Recently, Barry and Paterson have described the role of titanium nails in paediatric fractures, with emphasis on technique in various long bones[26]. In our study, most of the cases the fracture can be manipulated and the nails inserted by closed technique and we encountered difficulty in six cases. A small incision was made near the fracture site to negotiate the nail into the intramedullary cavity. There was no wound infections observed in this study.

Rohde RS1, Mendelson SA *et al*.[27] observed complications such as malunions, nonunions and 2 cases of acute synovitis of knee joint following intra articular penetration of knee by migration of a flexible nail. In our series there were no cases of nonunion, acute synovitis 1(5.55%) case developed malunion, 1(5.55%) case of flexible nail migration. In the humerus fractures, the pins inserted from the lateral side in 3 number of cases and both medial and lateral in 3 number of cases. It was felt that the exposure to locate the ulnar nerve would offset any advantages of closed nailing technique. We kept at least 1.5 cms overlap between fracture ends to prevent overgrowth. With end-to-end alignment with these nails, over growth remains a potential problem[28,29]. These patients were followed up until skeletal maturity.

Routine metal removal of these implants have been done, the metal work was removed after nine months. We did not have a control group nor did we compare other methods of treatment. However, we feel that flexible nailing can have a place in the management of paediatric long bone fractures, which fail skilled conservative treatment. There are distinct advantages in terms of duration of hospital stay, fracture stability and early return to function. Shortening less than 2cms was found in 5.5 % of patients in the current study where as 11 % rate reported by Chan *et al*. Knee stiffness was encountered in 22.22 % cases in the present study can be compared with those of Iwegbu & Patel, Pankovich and Tarabishy who reported a range of 26 to 41. We conclude that the results shown by our study compares favourably with that shown by reporters using the same technique. However, this method must be used with caution in unstable fractures where few weeks' protection is necessary post operatively. This method is ideally suited for the paediatrics patients groups and patients with anaesthesia risk also.

Conclusion

The following conclusions have been arrived at after comparing the overall results of this study with that obtained by other works. Titanium elastic nailing is ideally suited not only for the children and younger age groups but also in biologically old, fragile, high anaesthesia risk and osteoporotic patients. Hence it can

aptly be called as "A friendly to paediatric, geriatric and younger age groups. This method is less traumatic, gentle and one of the simplest methods known. This method is based on sound biomechanical. The intramedullary position of the implant places it more in line with the weight bearing forces thereby reducing the tendency of the fracture to settle in a deformed position. The excellent biomechanics is reflected by the absence of implant failure. No case of delayed or non union in the present study. Early ambulation is one of the advantages of the Titanium Elastic nailing. This helps to minimize the duration of hospital stay and complications of enforced bed rest like pneumonias, bed sores, UTI, thrombo embolic phenomenon, etc. The risk of infection is negligible as the incision is far away from the fracture and it is a closed technique. The high incidence of complications in unstable fractures necessitates a certain degree of caution to be exercised. Few weeks protection often required post operatively. There is a high incidence of knee stiffness with this procedure which can be minimized by proper placement of entry portal and rigorous physiotherapy in the postoperative phase. Operative time is also less. This is also very useful in over population countries. Patients are more comfortable from 1st post operative day onwards because of least traumatic in nature. In segmental fractures Titanium Elastic nailing eliminates the torsion of the middle segment, so chances of necrosis of the middle segment is minimised. Titanium Elastic technique can be carried out by an average Orthopaedic surgeon. Finally, we were convinced by the versatility of the Titanium Elastic nailing as it provides a solution to many fractures that would have been difficult for internal fixation by any other methods including poly trauma cases, with less operative time, less infection rate, less bleeding and improved rehabilitation programme.

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