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Original Research Article

Elastic Stable Intramedullary Nailing for Treatment of Pediatric Tibial Fractures

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ABSTRACT:

Introduction: Tibia fractures in the skeletally immature patient can usually be treated with above knee cast or patellar tendon bearing cast. The purpose of our study was to evaluate epidemiology and outcome of Elastic stable intramedullary nailing fixation of pediatric tibial shaft fractures treated at our institution. **Methods**: Over a period of one year, fifty pediatric patients of tibial shaft fractures, with average age of 9.68 yr (*SD*=2.37), were treated with elastic stable intramedullary nail. Demographic data, union and complication rate were evaluated. **Results**: There were 36 closed and 14 open fractures. The average time to union was 11.6 weeks (*SD*=2.65) for close and 14.3 weeks (*SD*=2.62) for open fracture. There were no instances of growth arrest, re-manipulations, or re-fracture. **Conclusion**: We conclude that flexible intramedullary fixation is an easy and effective method of management of both open and closed unstable fractures of the tibia in children.

Keywords: intramedullary fracture fixation • pediatrics • tibial fractures • treatment outcome

INTRODUCTIONS:

Tibial fractures are the second most common reason for orthopedic inpatient admission to children's hospitals.[1,2] Nearly all diaphyseal fractures of the tibia in children can be successfully treated using closed methods and cast immobilization. Others have proposed pins in plaster, external fixation, open reduction with internal fixation, or intramedullary stabilization for those fractures that cannot be successfully managed using closed methods.[3] Recently, titanium elastic nails have gained popularity for the stabilization of femoral shaft fractures and other long bone fractures in the pediatric population.[4-6]

Elasticity of the implants promotes callus formation by limiting stress shielding and promoting oscillation at the fracture site.[4,7] Traction forces are transformed into compression forces at the fracture site by two bent nails crossing each other and providing three-point fixation within the medullary canal. Proposed advantages of Elastic stable intramedullary nailing (ESIN) include immediate fracture stabilization, early mobilization, little soft tissue disruption, low infection and re-fracture rates, and more rapid return to daily function than conservative treatment with immobilization alone.[4,7] Current study evaluates epidemiology and outcome of ESIN fixation of pediatric tibial shaft fractures treated at our institution.

METHODS:

This was a prospective, observational study conducted in Nepalgunj Medical College Teaching Hospital (NGMCTH) from November 2013 to October 2014. There were 50 children with displaced tibial shaft fracture who underwent ESIN after closed or open reduction. Patients' demographic data, mode

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of injury, union rate, and complication rates were evaluated. Our indications for the procedure were polytrauma, open fracture, or failure to achieve a satisfactory closed reduction with informed consent.

Surgical Technique:

All patients were operated upon under general anesthesia. The affected limb was cleaned and draped. The appropriate size of nail was determined using the image intensifier. The fracture site and entry point at the level of the metaphysis were marked, taking care to avoid the physis. A two to three cm incision was made on either side of the tibia, proximal to the marked entry point. Under fluoroscopic control, the cortex was broached with a drill of larger diameter than the nail to be inserted. Two nails of equal diameter were pre-bent so that the apex of the bend would lie at the fracture site on opposite cortices. The tips of the nails were bent to 45˚ in order to facilitate passage along the opposite cortex and to aid in fracture reduction. The pre-bent nail was placed on an inserter and inserted from the side opposite the distal displacement in an ante-grade fashion. Under fluoroscopic guidance, it was slid along the opposite cortex until the fracture site was reached. A reduction was performed and the nail was advanced across the fracture site. The nail was embedded in the distal tibial metaphysis without violating the cortex or the physis. The second nail was placed from the other side in a similar fashion. The bent tip of the nails could be rotated after passing the fracture site to achieve an anatomic reduction. Care was taken not to distract the fracture site. The nail ends were then bent distally and posteriorly and cut one cm from the cortical surface so that the nail ends would sit deep to the compartment fascia but be proud enough for easy retrieval. The wounds were closed with an absorbable fascial and subcuticular stitch.

After surgery, all the patients were placed in a short-leg cast and mobilized, non-weight-bearing for four to six weeks. Weight-bearing in a walking plaster was permitted when adequate callus was seen at the fracture site. Fractures were considered to be united when tri-cortical callus was visible on the radiographs and there was no tenderness at the fracture site on clinical examination.

Final outcome was graded as excellent, satisfactory, or poor based on criteria described by Flynn and colleagues (Table 1).[4]

Table 1*: Flynn et al. (2001) criterion*

	Excellent	Satisfactory	Poor
Limb length discrepancy	<1 cm	<2 cm	>2 cm
mal-alignment	up to 5°	5-10°	>10°
pain	none	none	present
complication	none	minor	major

RESULTS:

There were 36 boys (72%) and 14 girls (28%) with tibia fractures managed with ESIN during the study period. The average age of the fifty children was 9.68 year (*SD*=2.37). Twenty four (48%) patients had tibial fracture following RTA, followed by fall from height on fourteen cases (28%), sports injury in nine cases (18%), and hit by a stone in three (6%) cases. Thirty two patients (64%) were affected on the right tibia and 18 cases (36%) on the left tibia. Thirty six (72%) children had closed fracture and fourteen (28%) had open fracture. All the open fractures were managed by open method. Of the closed 36 fractures, 32 (88.9%) were managed by closed method and the rest four (11.1%) were managed by open methods. Associated injuries were seen in ten (20%) children. Four (8%) had head trauma managed conservatively, two (4%) had blunt trauma abdomen which was also managed conservatively, two (4%) had radius fracture which was managed by intramedullary K-wire fixation, and two (4%) had ipsilateral femur fracture which was managed with ESIN. Twenty six (48%) cases which was managed with ESIN had both bone leg fracture and twenty four (48%) had isolated tibia fracture. Classification of open fractures according to Gustilo and Anderson classification is shown in Table 2.[8]

The average union time for closed fractures was 11.61 weeks (*SD*=2.65) and open fracture was 14.36 weeks (*SD*=2.62). Grade one open fracture united on 13.38 weeks (*SD*=3.11) while grade two fracture united in 15.67 weeks (*SD*=0.82). Five

Table 2*: Distribution of patients with open fracture according to Gustilo and Anderson classification.*

Mechanism of injury	Gustilo and Anderson			Total
	Grade I open	Grade II open	Grade III open	
Fall from height	3	1	0	4
RTA	5	3	0	8
Hit by a stone	0	2	0	2
Total	**8**	**6**	**0**	**14**

(10%) patient developed superficial bursitis due to prominent nail but there was no wound breakage as nail was buried beneath skin. Four (8%) patient had pain at the nail insertion site, two had limb length discrepancy of less than two cm lengthening, and two had superficial infection at the fracture site. Out of 50 patients, 46 (92%) had excellent outcome and four (8%) had satisfactory outcome according to Flynn et al. criterion.[4]

DISCUSSION:

Although cast immobilization remains the standard treatment for appropriate fractures of the tibia, pediatric orthopedic surgeons have been trying to minimize the prolonged immobilization necessary after such treatment. Fixation is particularly beneficial for children who have sustained multiple injuries from high energy trauma,those with head injuries, open fractures, compartment syndrome and for older children.[9] There have been an increasing number of reports demonstrating the effectiveness of surgical treatment of tibial shaft fractures in children. The ideal internal fixation device for such pediatric tibial fractures would be a simple load sharing device that would maintain alignment, allow mobilization until bridging callus forms, not cross the physis, and be both easy to insert and remove. The search for treatment which satisfy most of these criteria has led to an increasing number of surgeons using the elastic intramedullary nails, to treat a variety of pediatric long bone fractures including the tibial shaft.[4,6,10] There are several advantages of this technique. Three-point fixation within the medullary canal allows maintenance of both alignment and rotation for most fractures. Flexible intramedullary nails provide fixation that is stable and elastic. The elastic fixation allows for controlled repetitive motion at the fracture site. This allows for cyclic loading as well as resistance to angular and rotational deforming forces.[11] The shear forces that cause displacement are transformed into compression and traction forces.[12] The healing, as a result of this elastic stabilization, is by external callus.[13] The basic science literature supports that controlled motion at the fracture site results in improved healing in long bones fractures.[14,15]

There are few articles in the literature on the management of diaphyseal fractures of the tibia in children with intramedullary fixation.[11,16,17] O'Brien et al. reported 16 fractures of the tibia, fixed internally with intramedullary fixation, which achieved a very good functional outcome.[17] They reported one superficial infection, six coronal and seven sagittal angulations, but no functional compromise. One child had a leg-length discrepancy of over 1.5 cm. Vrsansky et al. reviewed 308 children with fractured long bones fixed with flexible intramedullary nails, of which 36 involved the tibia. An excellent functional outcome was reported, with all patients mobilizing independently by three to five months.[18] Qidawi described a retrospective review of 84 fractures of the tibia treated with intramedullary K-wires with a mean time to union of 9.5 weeks.[11] More recently, Kubiak et al. compared flexible nailing with external fixation, as a method of treating fractures of the tibia in children. This was a retrospective review of clinical and radiographical outcomes for 31 children with fractures of the tibia. Of these, 16 had Elastic Stable Intramedullary Nailing (ESIN) and 15 had external fixation. In the external fixation group there were eight children (53%) with an open fracture, compared with five (31%) in the ESIN group. The mean time to union was 18 weeks in the external fixation group but only seven weeks in the ESIN group. There were seven bony complications in the external fixation group (two delayed unions, three nonunions, and two malalignments), whilst there was one bony complication in the ESIN group.[19] The authors recommended that ESIN should be used for the treatment of fractures of the tibia in skeletally immature patients in need of surgical stabilization, including open fractures without segmental bone loss and limited comminution. Hasenhuttl reviewed 235 cases and reported good healing in 93% of closed fractures and 66% of open fractures.[20] The nonunion rate was 4.4%, as was the rate of deep infection with osteomyelitis.

It is difficult from our small sample size to draw any conclusion from this observation. In addition to the satisfactory alignment with which these fractures healed, all of our fractures healed. There were no delayed unions or malunions and there were no re-fractures, probably because these injuries heal with often-abundant callus, thereby reducing the risk of re-fracture. There were no cases of physeal arrest or proximal tibia growth disturbances.

CONCLUSIONS:

This study indicates that flexible titanium nails are an effective treatment option for the unstable tibia fracture in skeletally immature

patient. We conclude that, where indicated, flexible intramedullary nailing should be done as it is a relatively simple and effective way to stabilize open and closed fractures of the tibia in children with few complications, allowing early mobilization, and an excellent functional outcome.

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