

# Management of Tibia Shaft Fractures Children with Titanium Elastic Nailing: A Prospective Study

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**Abstract:** ***Introduction:** Surgical indications for tibial fractures in children include associated fractures and soft tissue injuries such as open fractures. Titanium elastic nails (TENs) are often used for pediatric tibia fractures, and have the advantage of preserving the open physis. However, complications such as delayed union or non union are not uncommon in older children or open fractures. In the present study, we evaluated children with closed or open tibial shaft fractures treated with titanium elastic nailing technique. **Methods:** A total of 32 tibia shaft fractures were treated by elastic nailing from May 2016 to June 2017 at Govt Medical College and Hospital, Jammu. The mean patient age at operation was 6 years (range: 5–10 years). 26 of 32 cases were open fractures (grade I: 8, grade II: 12, grade IIIA: 6 cases). Closed antegrade intramedullary nailing was used to insert two nails through the proximal tibial metaphysis. All patients were followed up for at least one year after the injury. Outcomes were evaluated using modified Flynn's criteria, including union, alignment, leg length discrepancies, and complications. **Results:** All fractures achieved union a mean of 20.1 weeks after surgery (range: 11–26 weeks). One patient reported knee pain and two experienced restricted knee motion. There were two cases of superficial infection in patients with grade III open fracture. Six patients reported soft tissue discomfort due to prominent TEN tips at the proximal insertion site, which required removing the nail after union. At the last follow-up, there were no angular or rotational deformities in either the sagittal or coronal planes. No patient showed shortening or overgrowth exceeding 10 mm. Among final outcomes, 30 were excellent and 2 were satisfactory. **Summary:** Elastic nailing can achieve satisfactory results in young children even with open fractures or soft tissue injuries with minimal complications of delayed bone healing, or infection.*

## 1. Introduction

Tibia fractures are common in pediatric orthopaedic trauma and are generally successfully treated using closed methods and cast immobilization. Although operative treatment is uncommon in pediatric tibia fractures, operative indications include open fractures, polytrauma, associated neurovascular injuries, and unstable fractures. In contrast to adult injuries, rigid intramedullary nailing may not be possible in pediatric tibia fractures due to limitations including the proximal tibia physeal plate and small canal diameter in these patients. Although external fixation may be an option in pediatric tibia fractures with soft tissue injuries or open wounds, several complications are well known, including pin tract infections, malunions, delayed unions, non unions, and re-fractures [1,2]. Elastic nailing has been widely used in pediatric femoral and tibia shaft fractures due to its low complication rates and because it does not cross the physis [1]. This technique also has high union rates, as closed reduction may be possible without disrupting the fracture hematoma and surrounding soft tissue. Several studies have reported satisfactory results using this technique, mainly in closed pediatric tibia fractures [1,3]. However, compared to rigid interlocking nailing, its reduced stiffness may result in impaired bone healing; high complication rates have also been reported in older children [4]. Also, it is unclear whether elastic nailing of open tibia fractures in children are associated with increased incidence of deep infections or fracture healing. This study assessed the efficacy of elastic nailing of tibia shaft fractures in young children 10 years of age or less. We also investigated its safety for treatment of open fractures based on the occurrence of wound complications or infections. Our hypothesis was that elastic nailing is an effective and safe treatment method for tibia shaft fractures in young children, even those with open wounds.

## 2. Patients and Methods

A prospective study was done on 32 tibia shaft fractures in children treated at our institution from May 2016 to June 2017 with elastic nailing. Patients older than 10 years were excluded from the study. Indications for operation using elastic nailing were: (1) closed fractures with associated fractures requiring operative treatment, and (2) open fractures or fractures with soft tissue injuries, which were difficult to cast and maintain adequate reduction. Data on age at time of injury, sex, weight (kg), affected side, injury mechanism, associated injuries, the presence of open fracture, and neurovascular deficits were collected. Fracture patterns were classified based on Orthopaedic Trauma Association (AO-OTA) classifications, and open fractures were classified by Gustilo and Anderson classification [5].

## 3. Surgical Procedure

All patients were operated upon under general anaesthesia. The affected limbs were cleaned and draped. Adequate debridement and cleansing procedure were performed for open fractures or fractures with associated soft tissue injury. The appropriate nail diameter was chosen using a fluoroscopic control. While taking care to avoid the proximal physis, the metaphyseal entry points were marked. Two to three centimetre incisions were made on the medial and lateral sides of the tibia, proximal to the marked entry points. A cortical hole was made with a drill bit 3.2–4.5 mm in diameter. After adequate bending, two nails of the same diameter were inserted. The nails were advanced adjacent to the fracture line, and one nail was further advanced, while closed reduction of the fracture was performed, under fluoroscopic guidance. The second nail was similarly passed through the fracture. The nail positions and fracture alignment were checked. The nail tips were cut 1.0–1.5 cm away from the bone surface.

### Post-operative management and assessment

Postoperatively, long leg splints were applied for three weeks. Partial weight bearing was started 6 weeks later, when there was radiographic evidence of a bridging callus. Full weight bearing was postponed until complete union. Callus formation on 3/4 cortices and fading of fracture lines on radiographs were considered signs of complete union. The nails were routinely removed during a second surgical procedure after the fractures were deemed to be clinically and radiographically healed. Frontal and sagittal plane angulations were assessed on anteroposterior and lateral plain radiographs obtained immediately postoperatively and at the last follow-ups. At the last follow-up, long-standing films were used to assess leg-length discrepancies (LLDs) between the injured and uninjured sides. Follow-up examinations also included assessments of knee range of motion (ROM), limb rotation and alignment, and signs of nail irritation. Clinical outcomes were evaluated using modified criteria described by Flynn et al. [6] Complications were defined as follows: (1) delayed union: union over 24 weeks, (2) nonunion: union after 9 months or union with an additional procedure, (3) malunion: malalignment of over 10 degrees in any plane, and (4) LLD: shortening or overgrowth of over 20 mm. Major and minor complications were classified as follows: (1) minor complications: delayed union, skin-tissue irritation by nails, transient superficial infection, and any other complication that did not disturb walking; and (2) major complications: nonunion, deep infection, LLD, and any other complication not classified as minor.

### 4. Results

There were 18 boys and 14 girls in this study, with an average age at injury of 6 years (range, 5 to 10 years). All injuries were acute traumatic fractures fixed primarily with elastic nailing. The nail diameter included, 3.5, 3.0, and 2.5 mm nails used in 2, 24, and 6 patients, respectively. The mean time from injury to operation was 0.4 days (range: 0–2 days). Among open fractures, one of three grade III open fractures were treated using negative pressure wound therapy (NPWT), while the others were closed primarily with or without wound-suction drainage (Fig. 1). Fractures involved the middle and distal third of the tibia in two and fourteen patients, respectively. According to AO-OTA classification, there were 13 type A, and three type B fractures. The mean follow-up period was 2.2 years, and the longest was 4.5 years. Thirteen patients had open fractures: 4 were grade I, 6 were grade II, and 3 IIIa based on the Gustilo and Anderson classification. 10 patients had associated injuries or fractures, including 3 ipsilateral femoral fractures, 4 ipsilateral foot/ ankle fractures or soft tissue injury, and 3 head injuries. All fractures achieved union at a mean of 20.1 weeks after surgery (range, 11–26 weeks), including a case of delayed union that united at 26 weeks. At the last follow-up, there were no angular or rotational deformities in either sagittal or coronal planes. No patient showed shortening or overgrowth exceeding 10 mm at the last follow-ups. There were 8 minor complications, but no major complications. Two cases of superficial wound infection in patients with a type III open fracture resolved with oral antibiotic administration. No deep infections or osteomyelitis were reported. The other six patients

experienced soft tissue irritation due to prominent nail tips at the proximal/medial entries. All six required additional procedures. One patient reported knee pain or two experienced loss of knee motion. Assessment of final outcomes using modified Flynn criteria revealed 30 excellent and 2 satisfactory outcome. The severity of soft tissue injury also did not influence the fracture angulation or development of complications. Age and AO-OTA classification also did not affect final outcomes or complications.

### 5. Discussion

Our results found that elastic nailing achieved a satisfactory outcome. Union rate was very high, even when open fractures were associated. Major complications, including impaired bone healing, mal-union, or deep infection, were very uncommon. Although cast immobilization has been the standard treatment for tibia fractures in children, operative treatment is particularly beneficial for children with open fractures, fractures with soft tissue injuries, and associated fractures or injuries necessitating surgical procedures. Elastic nailing is one of the most commonly used fixation techniques for long bone fractures in children [7]. However, this technique may result in non union in older children. This technique may also be less effective for open fractures when the surrounding soft tissue is injured. However, the effects of age or open fracture status on tibia fracture healing after elastic nailing has yet to be fully elucidated. The objective of this study was to assess the outcome of elastic nailing of diaphyseal tibial fractures in young children. We also investigated adverse effects associated with its use in open fractures. Although external fixation had been used for treatment of long bone fractures in children, its use is declining due to high rates of complications such as delayed union, nonunion, or re-fractures [8]. Elastic nailing may be an ideal method to treat pediatric tibia fractures, with the advantage of being a simple load-sharing device and protecting the proximal physis. It has recently become a popular method for fixation of displaced tibia fractures in skeletally immature children, offering faster and better bone healing compared to external fixation [1,9]. Compared to other long bones, elastic nailing of tibia fractures is challenging because of the eccentric surrounding musculature and triangularly-shaped bone cross-section [10]. Older children and adolescents reportedly have higher rates of delayed tibia fracture union or nonunion with this technique [4,11]. Similar to pediatric femoral fractures, this technique has a risk of impaired fracture healing in children over 11 years or heavy-weighted children [12]. 30 of 32 cases healed uneventfully within an acceptable period. For this reason, we believe that elastic nailing may achieve consistent and satisfactory fracture healing in tibia fractures of young children, in contrast to older children. Open fractures or associated soft tissue injuries in the pediatric tibia fractures were the main reasons to choose the operative treatment in this study. However, open tibial shaft fractures treated by elastic nailing have higher rates of bone healing problems compared to closed fractures [13,14]. Economedes et al. [15] also reported a longer time to union in over 50% of open tibia fractures in children who received elastic nailing. They also experienced three non-unions which required a change in the instruments

and removal of the elastic nails. Baldwin [16] reported that grade II and III open fractures might have a higher risk of complications than grade I fractures. However, those studies included older children or adolescents [15,17]. There was only one case of delayed union in this study, and no cases of nonunion among all open fractures, regardless of grade. This is a major difference from other studies that reported increased rate of delayed unions in grade 2 and 3 open fractures [13]. However, the treated patients in this study were younger (7 years-old), with all patients 10 years of age or less, compared to these previous studies. The biology of these fractures in young children might result in increased healing potential, perhaps due to a thick periosteum, better vascularity, and better healing ability. From this viewpoint, elastic nailing is a safe method in open tibia fractures of young children, with minimal complication rates. A recent systemic literature review [16], reported an overall infection rate for open tibia fractures in children ranging from 3.6 to 30.4%. Severe wounds from grade III open fractures may have a higher incidence of infection compared to lower-grade injuries. However, recent reports [13,15] showed that immediate or early elastic nailing of open pediatric tibia shaft fractures could be safely performed with minimal risk of wound or infectious complications. Similarly, the current study of 26 open fractures also had a minimal infection rates, with only two cases of superficial infection in a patient with a grade III open fracture. Because elastic nails are inserted at a distant position from the traumatic wound, this technique may result in minimal damage to the initial open wound at the fracture site. This favorable result may also be due to advances in care of open fractures, such as antibiotics, debridement, wound irrigation, and negative pressure wound therapy. Similar to femur fractures, elastic nailing has been associated with skin or soft tissue irritation at the nail entry point in up to 26% of cases [18]. In our series, 6 of 32 cases experienced this complication. This observation may be explained by differences in subcutaneous anatomy of the medial tibia compared to the femur. Although surgeons may cut the nail tips during the procedure to prevent this complication, it may become symptomatic or aggravated after starting joint motion exercises and with decreased leg swelling. As all of the cases in this study that developed this complication also required an additional and unexpected operation, this should be avoided. It is important to minimize the prominence of nails protruding from the cortex. This study had several limitations. First, the small number of patients may underpower the significance of this study. Open tibia fractures are uncommon injuries in the pediatric population, and we also confined cases to those occurring in patients 10 years of age or less. The decision to use elastic nails may be skewed, as it was based on surgeons' preferences. Additional prospective studies are necessary to compare TENs to other methods.

In summary, elastic nailing of tibia fractures is a safe and effective treatment in young children. Compared to older children, this technique may achieve consistent bone healing in young children, even when combined with soft tissue injuries.

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