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Elastic nailing of tibia shaft fractures in young children up to 10 years of age

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ABSTRACT

Introduction: Although tibia shaft fractures in children usually have satisfactory results after closed reduction and casting, there are several surgical indications, including 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 nonunion are not uncommon in older children or open fractures. In the present study, we evaluated children up to 10 years of age with closed or open tibial shaft fractures treated with elastic nailing technique.

Methods: A total of 16 tibia shaft fractures treated by elastic nailing from 2001 to 2013 were reviewed. The mean patient age at operation was 7 years (range: 5–10 years). Thirteen of 16 cases were open fractures (grade I: 4, grade II: 6, grade IIIA: 3 cases); the other cases had associated fractures that necessitated operative treatments. 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 16.1 weeks after surgery (range: 11–26 weeks). No patient reported knee pain or experienced any loss of knee or ankle motion. There was a case of superficial infection in a patient with grade III open fracture. Three patients reported soft tissue discomfort due to prominent TEN tips at the proximal insertion site, which required cutting the tip before union or removing the nail after union. At the last follow-up, there were no angular or rotational deformities over 10° in either the sagittal or coronal planes. With the exception of one case with an overgrowth of 15 mm, no patient showed shortening or overgrowth exceeding 10 mm. Among final outcomes, 15 were excellent and 1 was satisfactory.

Summary: Even with open fractures or soft tissue injuries, elastic nailing can achieve satisfactory results in young children, with minimal complications of delayed bone healing, or infection.

Introduction

Tibia fractures are common in pediatric orthopedic 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, nonunions, 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

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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.

Patients and methods

After obtaining approval from the Institutional Review Board, we reviewed the medical records of 152 tibia shaft fractures in skeletally immature patients treated at our institution from 2001 to 2013. A total of 25 tibia shaft fractures were treated with elastic nailing. Patients were excluded from this study if they were older than 10 years of age, were not followed for more than one year, received surgical procedures other than elastic nailing, had been operated on at an outside institution and presented to us for postoperative care, or had pathologic fractures or metabolic disease affecting the bone. Finally, 16 cases were included in this retrospective 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 might have been 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 from a retrospective review of patient medical records and radiographs. Fracture patterns were classified based on Arbeitsgemeinschaft für Osteosynthesefragen-Orthopaedic Trauma Association (AO-OTA) classifications, and open fractures were classified based on criteria from Gustilo and Anderson [5].

Surgical procedure

All patients were operated upon under general anesthesia. 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 (Flexible Intramedullary Khai Nail, U&I, Republic of Korea) diameter was chosen using a fluoroscopic control. While taking care to avoid the proximal physis, the metaphyseal entry points were marked. Two to three centimeter 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 3.5–4.5 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 two weeks. Partial weight bearing was started 4–6 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. Radiographs were reviewed by two individuals blinded to patient details. An interrater reliability analysis using the Kappa statistic was performed to determine consistency among raters. Follow-up examinations also included assessments of knee range of motion (ROM), limb rotation and alignment, and signs of nail irritation.

Clinical outcomes (Table 1) 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.

Results

There were 9 boys and seven girls in this study, with an average age at injury of 7 years (range, 5 to 10 years). Fourteen and two patients sustained pedestrian injuries and in-car accidents, respectively. 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 one, 12, and three 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. Soft tissue injuries were further classified into two groups: minor (closed and grade I open: seven patients) and major (grade II and III: nine patients). Six patients had associated injuries or fractures, including two ipsilateral femoral fractures, three ipsilateral foot/ankle fractures or soft tissue injury, and two brain injuries.

All fractures achieved union at a mean of 16.1 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 over 10° in either sagittal or coronal planes. The mean fracture-site diaphyseal angle was 3.13° (range, 8° varus to 7° valgus) on the anteroposterior view and 2.38° (range, 0–6° of anterior angulation) on the lateral view. With the exception of one case with an overgrowth of 15 mm, no patient showed shortening or overgrowth exceeding 10 mm (mean, 5.06 mm overgrowth; range: 2–15 mm overgrowth) at the last follow-ups. The interrater reliability for the raters was found to be Kappa = 0.81.

There were four minor complications, but no major complications. A superficial wound infection in a patient with a type III open fracture resolved with oral antibiotic administration. No deep