Egyptian Journal of Orthopaedic Research "EJOR"
An International peer-reviewed journal published bi-annually

Volume 3, Issue 1, July - 2022: pp: 17-22 www.ejor.sohag-univ.edu.eg

Doi: 10.21608/ejor.2022.255095

Original Article

FLEXIBLE INTRAMEDULLARY NAILS FOR FIXATION OF ADOLESCENT DIAPHYSEAL TIBIAL SHAFT FRACTURES

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Received 8/3/2022 Accepted 24/6/2022

Abstract

Background: *Diaphyseal tibial shaft fractures are the second most common fracture in hospitalized children resulting from both high and low energy trauma. Operative treatment requires implants that do not violate open physes and have less complications rate than traditional treatment methods. Flexible intramedullary nails had gained popularity for treatment of paediatric diaphyseal tibial shaft fractures.* ***Patients and Methods:*** *45 patients with diaphyseal tibial fracture were treated by flexible intramedullary nails. There were 30 male and 15 females. The youngest patient in our study was 10 years old while the oldest was 18 years old. Functional and radiological evaluations were done for all patients at the last follow up.* ***Results:*** *Most common mechanism of injury was road traffic accident followed by falling from height. 62.2 % of the cases had simple fracture (28 patient) while 26.7% of cases (12 patients) had type I open fractures and 11.1 % of the cases (5 patients) had type II open fractures. All fractures achieved full fracture union at a mean of 12 week with range from 10 to 18 week. Two cases suffered from nonunion that treated later on by bone grafting. One patient had postoperative fracture angulation.* ***Conclusion:*** *Flexible intramedullary nails can be used safely in adolescents with satisfactory results. It provides acceptable fracture redction and rapid healing with an acceptable rate of complications and return to unrestricted physical activity.*

Keywords: *Pediatric tibial fracture, Flexible intramedullary nail, Trauma, Lower extremity.*

1. Introduction

Diaphyseal tibial shaft fractures are considered the second most common fracture in hospitalized children. It results from high and low energy trauma [1]. Treatment of pediatric tibial shaft fracture includes platting, external fixation, flexible intramedullary nails and conservative treatment [2-4]. Conservative treatment was the main treatment for pediatric tibial shaft fractures twenty years ago [3,5,6,]. Closed reduction, casting and immobilization for six weeks would produce satisfactory results. However, failure to get accurate alignment, the long period of immobilization, psychological impact of long period of casting and cast complications were major drawbacks of conservative treatment. Indications for surgical intervention were failed closed treatment, associated neurovascular complications, polytrauma patients and open fractures [3]. Plate fixation and external fixation were frequently associated with infection, overgrowth, and increase of refracture rate [7]. Plate fixation has the advantages of stable fixation, direct visualization, protection of the nerve, and sparing of the adjacent joint from injury. Most importantly, plating is a more appropriate option in distal fractures compared to flexible nailing [4]. Flexible intramedullary nails have gained popularity in all pediatric fractures [8,9]. Advantages include percutaneous technique, immediate fracture stabilization, early mobilization and rapid return to school activities, limit psychological impact on the child and avoid the longtime of knee immobilization in casting [9-11]. There is a debate regarding surgical treatment of diaphyseal tibial fractures in older children (more than 10 years). Most studies assessed the outcome of flexible intramedullary nailing in young children less than 10 years [6,12]. The aim of this study, is to assess functional and radiological outcome of fixation of pediatric tibial shaft fractures with flexible intramedullary nails in adolescents (10 -18 years).

2. Patients and Methods

It is a retroospective study that was done in a tertiary level university hospital. 45 patients with tibial shaft fractures were included in our study. Their age range from 10 years to 18 years. All fractures whether simple or open fractures (Gustillo-Anderson type I, II. AO classification type A & B & C) were included. Patients with open tibial shaft fractures Gustillo-Anderson Classification type III and those with pathological fractures were excluded. Patients less than 10 years or more than 18 years were excluded. The study was approved by our local Ethical Committee of our institution. On admission, Complete demographic data as age, sex, mode of trauma, affected side, type of the fracture, soft tissue status according to Gustillo and Anderson classification, associated fractures, neurovascular deficits if present were obtained and registered. Plain radiograph including anteroposterior and lateral view of the affected limb were done. All operations were done under spinal anesthesia. Two elastic intramedullary nails of the same size were introduced in an ante grade procedure after fracture reduction under fluoroscopic guidance. Each nail diameter is should not be less than 40% of the diameter of the narrowest portion of the intramedullary canal. Prebending is essential step before nail insertion to achieve the three points contact effect. The two nails were inserted anteriorly 2 cm distal to physeal plate and within the medial and lateral metaphyseal bone cortices on each side of the tibial tuberosity. The operated side was placed in a below knee splinatage which removed at 2 weeks. All patients were followed up at 2 weeks to remove stitches, 4 weeks, 3, 6, 9 months postoperatively. At every visit, every patient was subjected to clinical and radiological evalaution to assess fracture union, knee and ankle function, walking ability, deformity and limb length discrepancy and for the presence of complications. Patients was allowed for partial weight bearing at six weeks or until a good callus appears in the follow up plain radiographs.

3. Results

45 patients were included in our study. Most common mechanism of injury was Road traffic accident followed by falling from height. There were 30 male and 15 females. The youngest patient in our study was 10 years old while the oldest was 18 years old. The right side was affected in 28 case while the left sided was affected in 17 cases. 62.2 % of the cases had simple fracture (28 patient) while 26.7% of cases

(12 pat-ients) had type I open fractures and 11.1% of the cases (5 patients) had type II open fractures respectively. All patients were operated on the same day of admission to hospital. 5 patients had associated injuries, tab. (1). During the follow up stage, no wound complications were observed in our study our limb length discrepancy. Partial weight bearing for all patients was started at 4 weeks while complete weight bearing was allowed at 6 weeks depending on both clinical and radiological evaluation. All fractures achieved full fracture union at a mean of 12 week with a range from 10 to 18 week. Two cases suffered from nonunion. Both cases were treated using bone grafting and they had full bone union later on. One patient had post-operative fracture angulation that was less than 5 degrees in the coronal and sagittal planes and valgus ang-ulation of about 5 degrees. At the last follow up, all patients had normal knee and ankle range of motion, fig. (1-a, b, c, d)

Table (1) Demographic and fuctionas outcomes of our patients

Patient demographics and functional outcome	**Results**	
Age	Age group from 10 to 14 Age group from 15 to 18	25 patients 20 Patients
Sex	Male Female	30 male 15 female
Side	Right side Left side	28 patients 17 patients
Mode of trauma	Road traffic accident Falling from height	35 patients 10 patients
Fracture pattern	Transverse fracture Oblique fracture Segmental fracture Comminuted fracture	23 cases 16 cases 2 cases 4 cases
Soft tissue status	Simple fracture Open fracture grade 1 Open fracture grade 2	28 cases 12 cases 5 cases
Time for full weight bearing down	Average 6 weeks	-
Time of union	Average 12 weeks	-
Complications	Fracture nonunion Fracture failure (angulation)	two patients one patient

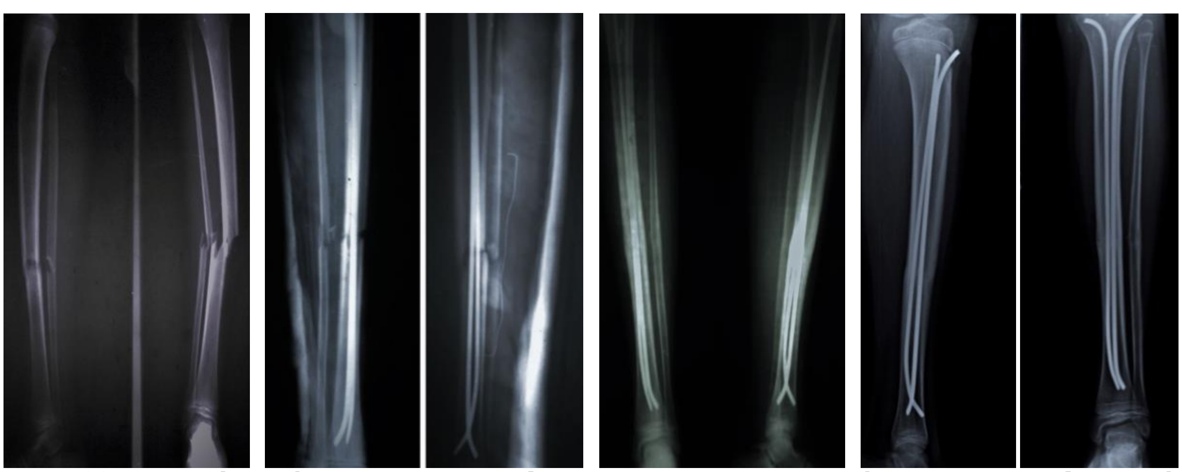

Figure (1) X-ray radiography; **a.** pre-operative, **b.** post-operative, **c.** One month post-operative, **d.** 3 month post-operative.

4. Discussion

Tibial shaft fractures are reported ton be the third most commnon long bone fracture in adolescent age group [13,14]. The main goal in treatment of adolescent tibial shaft fractute is to have a healed fractue within adequate alignment parameters and to avoid associated complications such as refracture, compartment syndrome, malunion and infection. In this age group, acceptable reduction is up to 5 degrees of coronal and sagittal angulation,10 mm of shortening and 50% translation [15]. Accurate rotational reduction to within 5 degrees is essential as malrotation will not remodel with subsequent skeletal growth [16]. Closed reduction and casting was the standared for treatment for adolescent tibia shaft fractures. Advantages are cost effective, avidance of permanent scars and to prevent implant related complications as pain, infection and implant removal after healing. Disadvantages are long period of immoblization and joint stiffness [17]. Tibial platting can achieve perfect anatomical reduction but the associated soft tissue damage, periosteal stripping would delay fracture healing with high incidence of wound infection and nonunion rate [18]. Flexible intramedullary nails were first used by Nancy, France by Ligier et al [19]. The principle of elastic stable nailing differs from the use of other fl exible rods as Ender's rods, which are stacked to fi ll the medullary canal. ESIN technique requires balancing forces between two opposing fl exible nails of the same diameter. Therefore, it is important to select nails 40% of the narrowest diaphyseal diameter; contour the nails with a similar gentle curvature, and use medial and lateral starting points that are at the same level in the metaphysis [8,11,20]. External fixation is one of avaiable choice for treatment of tibia shaft fractures. The advantages of extenral fixation are allowing excellent access to the limb for the management of complex wounds, it provides relative fracture stability,and it facilitates access to the soft tissue envelope and allow more immobilization of the limb. Disadvantages include refracture, prolonged time of treatment, pin tract infections, limb overgrowth, joint stiffness, malunion, delayed union, and loss of redcution [17,21]. Flexible intramedullary nails have a lower risk of complication than traditional methods. It allows a certain amount of movement at the fracture site thus ensuring optimal development of the external callus by reducing shear and converting it into compression and traction forces. Else, it placed percutaneosly through the proximal tibial metaphysis with no danger to the physis [10,22]. Kubiak compared the results of both external fixation and elastic intramedullary nailing [23]. The mean time to union was 18 weeks and 7 week respectively. Complications like nonunion, malunion and delayed union were more prominent in external fixation group compared to the elastic intramedullary nail group. In the current study, mean time for fracture union was 12 week with no difference between closed or open fractures. There is some controversy regarding criteria for time of fracture union. Some authors had used the radiological criteria while other authors had used radiological and clinical criteria. In the current study, clinical union is usually preceding radiological union despite there was a weak callus formation at the fracture site. Clinical union was judged by the absence of pain at fracture site and weight bearing. In some studies, the average time to union was 20.7 weeks [24]. in another study, the average time for union was 16.1 weeks [6]. In another one by Sankar, it was 11 week [25]. Older children and adolescents have a high rate of delayed union or nonunion with this technique [26,27]. However we did not encounter this complication in our study. We had two cases aged 12 years and 13 years who experienced non union. We had allowed partial weight bearing for all our cases at 6 weeks. Early weight bearing before 6 weeks is not allowed to avoid complicationas malunion and fracture angulation.

5. Conclusion

Flexible intramedullary nails can be used safely in adolescents with satisfactory results. It provides accepted fracture redction and rapid fracture healing. Complications rate is low with rapid retun to unrestricted physical activity.

References

[1] Galano, G., Vitale, M., Kessler, M., et al. (2005). The most frequent traumatic orthopaedic injuries from a national pediatric inpatient population. ***J. of Pediatric Orthopaedics***. 25 (1): 39-44.

[2] Flynn, J., Skaggs, D., Sponseller, P., et al. (2002).The operative management of pediatric fractures of the lower extremity. ***J Bone Joint Surg Am***. 84 (12): 2288-2300.

[3] Shannak, A. (1988). Tibial fractures in children: Follow-up study. ***J. of Pediatric*** Orthopaedics. 8 (3): 306-310.

[4] Bingshu, H., WAng, J. (2012). Plate fixation of paediatric fractures of the distal tibia and fibula. A***cta Orthopœdica Belgica***. 78: 660-662.

[5] Thompson, G., Wilber, J. & Marcus R. (1984). Internal fixation of fractures in children and adolescents. ***Clinical Orthopaedics and Related Research***. 188: 10-20.

[6] Heo, J., Oh, C-W., Park, K-H., et al. (2016). Elastic nailing of tibia shaft fractures in young children up to 10 years of age. ***Injury***.;47(4):832-836.

[7] Bar-On, E., Sagiv, S. & Porat S. (1997). External fixation or flexible intramedullary nailing for femoral shaft fractures in children. ***J Bone Joint Surg Br***. 79 (6): 975-978.

[8] Barry, M., Paterson, J. (2004). Flexible intramedullary nails for fractures in children. ***J. of Bone and Joint Srgery-British***. 86: 947-953.

[9] Goodwin, R., Gaynor, T., Mahar, A., et al. (2005). Intramedullary flexible nail fixation of unstable pediatric tibial diaphyseal fractures. ***J. of Pediatric Orthopaedics***. 25 (5): 570-576.

[10] Flynn, J., Hresko, T., Reynolds, R., et al. (2001). Titanium elastic nails for pediatric femur fractures: A multicenter study of early results with analysis of complications. ***J. of Pediatric Orthopaedics***. 21 (1): 4-8.

[11] Kenawey, M., Hosny, H. (2017). Evidence-based treatment for paediatric diaphyseal femoral fractures. ***Paediatric Orthopaedics***. 2017: 91-106.

[12] Griffet, J., Leroux, J., Boudjouraf, N., et al. (2011). Elastic stable intramedullary nailing of tibial shaft fractures in children. ***J. of Children's Orthopaedics***. 5(4):297-304.

[13] Santili, C., de Oliveira Gomes, C., Akkari, M., et al. (2010). Fraturas da diáfise da tíbia em crianças. ***Acta Ortopédica Brasileira***. 18 (1): 44-48.

[14] Ward, W., Rihn, J. (2006). The impact of trauma in an urban pediatric orthopaedic practice. ***JBJS***. 88 (12): 2759-2764.

[15] Mashru, R., Herman, M. & Pizzutillo, P. (2005). Tibial shaft fractures in children and adolescents. ***J. of the American Academy of Orthopaedic Surgeons***. 13 (5): 345-352.

[16] Waters, P., Skaggs, D. & Flynn J. (2019). ***Rockwood and wilkins fractures in children***, 9th ed. : Lippincott Williams & Wilkins, USA.

[17] Martus, J. (2021). Operative fixation versus cast immobilization: Tibial shaft fractures in adolescents. ***J. of Pediatric Orthopaedics***. 41: S33-S38.

[18] Shen, K., Cai, H., Wang, Z., et al. (2016). Elastic stable intramedullary nailing for severely displaced distal tibial fractures in children. ***Medicine***. 95 (39): e4980-

[19] Ligier, J., Metaizeau, J., Prévot, J., et al. (1988). Elastic stable intramedullary nailing of femoral shaft fractures in children. ***Bone & Joint Journal***. 70 (1): 74-77.

[20] Vallamshetla, V., De Silva, U., Bache, C., et al. (2006). Flexible intramedullary nails for unstable fractures of the tibia in children. ***Bone & Joint Journal***. 88 (4): 536-540.

[21] Bartlett III, C., Weiner, L. & Yang, E. (1997). Treatment of type II and type III open tibia fractures in children. ***J. of Orthopaedic Trauma***. 11(5): 357-362.

[22] Firica, A., Popescu, R., Scarlet, M., et al. (1981). Lostéosynthèse stable élastique, nouveau concept biomécanique. Etude expérimentale. ***Rev Chir Orthop***. 67 (Suppl 2): 82-91.

[23] Kubiak, E., Egol, K., Scher, D., et al. (2005). Operative treatment of tibial fractures in children: are elastic stable intramedullary nails an improvement over external fixation? ***J Bone Joint Surg Am***. 87 (8): 1761-1768.

[24] Srivastava, A., Mehlman, C., Wall, E., et al. (2008). Elastic stable intramedullary nailing of tibial shaft fractures in children. ***J. of Pediatric Orthopaedics***. 28 (2): 152-158.

[25] Sankar, W., Jones, K., Horn, B., et al. (2007). Titanium elastic nails for pediatric tibial shaft fractures. ***J. of Children's Orthopaedics***. 1 (5):281-286.

[26] Gordon, J., Gregush, R., Schoenecker, P., et al. (2007). Complications after titanium elastic nailing of pediatric tibial fractures. ***J. of Pediatric Orthopaedics***. 27 (4): 442-446.

[27] Lascombes, P., Haumont, T. & Journeau, P. (2006). Use and abuse of flexible intramedullary nailing in children and adolescents. ***J. of Pediatric Orthopaedics***. 26 (6): 827-834.