

Original Research Article

Outcome of shaft fractures among children treated with elastic stable intramedullary nailing

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ABSTRACT

Background: Long bone fractures are frequent occurrence among children and considered a frequent pediatric orthopedic injury requiring hospitalization. Authors aimed to retrospectively analyze the outcome of fixation of long bone fractures with elastic stable intramedullary nailing (ESIN) among children and adolescents.

Methods: From 2010 to 2018, ESIN was performed on 128 children aged 2 to 17 years having single shaft fractures of long bones. The data related to associated injuries, postoperative complications, postoperative treatment, till bony union or removal of rods, mal-union, functional deficit, need for secondary surgical intervention and subjective complaints at follow-up originated from postoperative clinical and radiological consultations carried out regularly. The primary end points were time of complete radiological union or removal of rods.

Results: The mean age at the time of accident was 9.5 years. There were 37 (28.9%) femoral fractures, 16 (12.5%) of the lower leg, 51 (39.8%) fractures of radius/ulna and 24 (18.8%) of the humerus. In 2 (2.3%) children, reoperation was necessary due to prominent ends of elastic rods and 6 (4.7%) had early removal of rods due to same reasons. End point of the study, removal of rods noted in 126 (82.8%), radiological evidence of union in 7 (5.5%) and 15 (11.7%) cases were lost at follow-up.

Conclusions: ESIN fixation of diaphyseal fractures in children and adolescents is safe. ESIN was found to be minimally invasive method, noted to produce excellent functional as well as cosmetic outcomes.

Keywords: Elastic stable intramedullary nailing, Femoral fractures, Long bone fractures, Reoperation

INTRODUCTION

Long bone shaft fractures (LBSFs) in children occur predominantly in the forearm and lower extremities.¹⁻³ LBSFs are frequent occurrence among children and considered a frequent pediatric orthopedic injury requiring hospitalization.⁴

In the past couple of decades, big shift from conservative towards surgical treatment strategies due to the development of safer and more efficient surgical stabilization techniques in children. Hence, invention of elastic stable intramedullary nailing (ESIN) technique resulted in an improvement of fracture stabilization.^{5,6}

This minimally invasive method promises early postoperative mobilization and consequently, earlier return to full weight bearing.^{5,7} Fast functional rehabilitation is associated with shorter hospital stay and lower cost.^{6,8} Furthermore, this strategy, which is highly accepted by the patient's families, is associated with fewer long-term complications (e.g. mal-rotation, mal-alignment, leg length discrepancies and growth disturbances) than other stabilization modalities.⁸⁻¹⁰ Typical complication associated with ESIN is irritation of the skin caused by protruding nail end.¹¹

Biomechanical principal of titanium elastic nails (TEN) is dependent on the symmetrical bracing action of 2 elastic

nails inserted into the metaphysis, each bearing against the inner bone at 3 points.^{12,13} This has resulted into flexural, axial, translational and rotational stability.¹² ESIN has been found to have early immediate stability to the involved bone segment, permitting early mobilization as well as return to the usual activities of the affected individual, without much complications.^{14,15}

The purpose of this retrospective study was to find out the outcome of fixation of long bone fractures (LBFs) with ESIN in children and adolescents in a secondary care hospital in Middle East.

METHODS

Authors conducted a retrospective study analysis in 128 patients (102 males and 26 females), aged 2 to 17 years, having single shaft fracture of long bones and treated with ESIN between 2010 and 2018 at the Royal Commission Medical center, Yanbu, Kingdom of Saudi Arabia. All children having open fractures and poly trauma, comminuted fractures or segmental fractures were excluded. The local ethics committee approved the study protocol before study initiation.

Fractures were classified according to initial x-ray findings as transverse fractures (fracture line crossing the longitudinal axis of the injured bone at an angle of 80-90 degrees), short oblique fracture (fracture line crossing the longitudinal axis of the injured bone at an angle of 60-79 degrees), and long oblique or spiral fracture (fracture line crossing the longitudinal axis of the injured bone at an angle of less than 59 degrees). Multi-fragmental fractures consisted of 3 or more fragments. Surgical procedure had been performed as described by Pierre et al.¹⁶ All patients underwent postoperative physiotherapy to ensure early mobilization and none of the patients were immobilized in the plaster cast. Weight bearing was allowed as tolerated by the children under the supervision of physiotherapist.

The data related to associated injuries, postoperative complications, postoperative treatment, till bony union or removal of rods, mal-union, functional deficit, need for secondary surgical intervention and subjective complaints at follow-up originated from postoperative clinical and radiological consultations carried out regularly. The primary end points were time of complete radiological union or removal of rods.

RESULTS

Overall, mean age of the study participants at the time of surgery was noted to be 9.5 years (ranging 2-17 years) and male to female ratio was 3.92:1. All surgeries were performed under general anesthesia adopting titanium nails in all cases. Commonest nail size was 2.5mm for upper limb and 3.5 mm for lower limb long bone fractures (LBFs). Mean length of hospital stay was 3.25 days for upper limb and 4.6 days for lower limb fractures.

None of the patients had cast immobilization postoperatively and physiotherapy was initiated on the 1st post-operative day.

Mean follow up 10.65 months (ranging 2.5-77 months) was noted. No major surgery related complications were observed. Overall, complications were seen among 9 (7.0%) cases, these patients had prominent ends of nails causing irritation, pain and impending perforation of the skin. Six of these patients had early removal of rods and three patients underwent readjustments of nail ends operatively. Post-operatively, no cases having loss of reduction or migration of nails were seen.

At mean 10.2 weeks (ranging 4-18 weeks) of duration, all cases were found to have full radiographic healing. Routine nails removal was advised within 12 months of surgery except 14 (10.9%) cases who presented themselves for removal of nails after 1 year. Mean time of removal of nails was recorded as 11.8 months (ranging 4.5-77 months) in the lower limbs and 8.53 months (ranging 2-62 months) in the upper limb cases. No cases of delayed union, nonunion or malunion were seen. Following nails removal, all cases gained full functions whereas all complications also resolved following removal of nails. Fifty-one children (39.8%) involving, 37 males and 14 females had undergone ESIN for forearm shaft fractures. Among these, age ranged between 2-18 years while mean age was seen to be 8.14 years at the time of surgery. In this group, two patients had associated injuries (polytrauma). Authors have reported early removal of rods in five patients and two patients had undergone readjustment of nails due to problems related to prominent ends of nails. No other complications were observed.

Twenty-four children (18.8%) involving 18 males and 6 females had undergone ESIN for humeral shaft fractures. The age range was 3-18 years (mean age 11.2 years). One was open fracture and five patients had associated injuries (polytrauma). One patient had early removal of nails due to problems related to prominent ends of nails. No other complications have been noticed.

Sixteen patients (12.5%) involving all males had undergone ESIN for tibial shaft fractures. The age range was 5-17 years (mean age 10 years). Four of these patients had associated injuries (polytrauma). Closed reduction was possible in all these patients and no complications were observed.

Thirty-seven patients (28.9%) involving 31 males, 6 females had undergone ESIN for femoral shaft fractures. The age range was 3-15 years (mean age 8.78 years) at the time of index operation. Two patients had associated injuries (polytrauma). Authors have reported one patient who had undergone readjustment of nails due to problems related to prominent ends of nails. No other complications have been observed in this group.

DISCUSSION

ESIN has been considered a common choice of treatment for children with LBFs and has been noted to minimize the surgical scarring seen in the past years due to open reduction and plating.¹⁷⁻¹⁹ ESIN has been demonstrated to achieve biomechanical stability from the divergent C configuration, creating 6 points of fixation that allow the construct to act as internal splint.^{17,20} ESIN provides stable and elastic fixation and allows for controlled motion at the site of fracture resulting in healing by external callus. ESIN has been found to be safe and effective by many researchers previously.²¹⁻²³ Wrong indications or technical mistakes are usually found to cause complications, while infection, overgrowth, skin irritation at the site of entry or refractures are some of the commonest complications.^{17,19,24,25} Authors found a complication rate of 7.0% whereas irritation of the skin at the site of entry was the commonest complication. These findings in terms of complications seen were quite similar to what has been found previously by others as well.^{24,25} It is a worthy point to note that authors did not witness any serious complications among any of the cases. Weinberg AM and Colleagues among 77 children undergoing ESIN, post-surgery complications were noted in 3 cases which was superficial pin entry site infection.²⁶ Garg NK et al, reported 21 children, undergoing ESIN for displaced and unstable diaphyseal forearm fractures, noted only 1 cases of delayed union and nonunion each.²⁷ All children attained satisfactory clinical outcomes.²⁷ Although, researchers have reported complications like osteomyelitis, superficial radial nerve injury, extensor pollicis longus rupture, extensor pollicis brevis rupture, delayed healing or nonunion, authors noted 7 (5.5%) children with complications regarding prominent ends of nails.^{19,27-30}

In the present study, among children having humeral fractures, only 1 patient had early removal of nails due to problems related to prominent ends of nails. No other complications were noticed. Direct force because of direct impact, traffic accidents or crush injury commonly result in the form of fractures of humeral shaft. Fracture of the humerus are usually due to indirect force like falling on elbow or extended arm or due to strong muscular contraction. Among fractures of the humeral shaft, commonest site of the fracture is seen in between the middle to distal 3rd of humerus.^{31,32} Fernandez FF et al, among 31 children with humeral shaft fractures, noted that following surgery, all children were able to participate in sports activities like they used to do before the accidents.²⁵ Most of the children and their parents (n=30) were highly satisfied with success of the treatment while the remaining 1 children was noted to be satisfied. Complications were observed in 16.1% with ESIN of humerus shaft fractures.²⁴

Among our patients having tibial fractures, closed reduction was possible in all these patients and no complications were observed. Tibial fractures are the

commonest form involving lower limbs among children. The ESIN involving long bones among children has become popular due to excellent efficacy and less chances of complications.^{17,32} Sankar WN et al, among 19 children having tibial shaft fractures undergoing ESIN, noted that all children were seen to have full healing at a mean period of 11 weeks.¹⁷ Irritation at the entry site was noted among 5 patients but there was no case of leg length discrepancies or any other related unwanted outcome. Irritation at the entry site has been found to be the commonest form of complication after using TEN and its incidence ranges anywhere between 7 to 40%.^{17,22,31,33} Literature seem to have shown complications like osteomyelitis, angular deformity, refractures, asymptomatic proximal nail migration, delayed healing or non-union, but in this series authors did not observe any complications of this sort.^{17,3-34}

CONCLUSION

The ESIN was found to have good functional as well as cosmetic outcomes. It was found to have an early functional and cast free follow-up along with quick pain reduction. The ESIN for shaft fractures is minimally invasive, simple and well reproducible technique. Due to excellent objective and subjective results, the operative stabilization of LBFs with ESIN is recommended to the pediatric age groups.

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