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Case Series

A study of outcome of diaphyseal fractures of radius and ulna in paediatric age group treated with titanium elastic nailing system

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ABSTRACT

A study of outcome of diaphyseal fractures of radius and ulna in paediatric age group treated with titanium elastic nailing system. The current study is an attempt to find out the functional outcome, radiological union, and complications of paediatric diaphyseal radius and ulna fracture treated with titanium elastic nail. This is a prospective study of twenty-five patients of age group 6 years to 16 years diagnosed with a diaphyseal fracture of radius and ulna treated with percutaneous nailing with titanium elastic nails in Department of Orthopaedics, S Nijalingappa Medical College and HSK Hospital, Bagalkot between November 2019 to April 2022. Clinical, functional and radiological outcomes were assessed with Anderson et al criteria for 6 months. In terms of union and range of motion using Anderson et al criteria 20 patients had excellent results, 2 patients had satisfactory results and one patient had an unsatisfactory result. There were no cases of poor results. Five cases had complications like Nail prominence, elbow stiffness, olecranon bursitis and super skin infection. The radiological union was achieved in a mean time of 8.24±2.62 weeks. Complications resolved after implant removal. Titanium elastic nail system showed excellent results in terms of bony union, functional outcome with minimal complications which resolve after nail exit. Therefore, titanium elastic nail system should be considered as an effective alternative of conservative management for forearm fractures in pediatric age group.

Keywords: Paediatric both bones of forearm fracture, Paediatric radius, Ulna shaft fracture

INTRODUCTION

Paediatric diaphyseal fractures of the radius and ulna, commonly referred to as both bone forearm fractures, are the third most common fracture in the paediatric population next to the distal radius and supracondylar humerus fractures and account for 13-40% of all paediatric fractures.[1,2] The primary mechanism of injury associated with radial and ulnar shaft fractures is a fall on an outstretched hand that transmits indirect force to the bones of the forearm.[1,3] Biomechanical studies have suggested that the junction of the middle and distal thirds of the radius and a substantial portion of the shaft of the ulna have an increased vulnerability to fracture.[4] Often, a significant rotational component is associated with the fall, causing the radius and ulna to fracture at different levels. If the radial and ulnar fractures are near the same level, a minimal torsional component is present. In higher-energy trauma comminution is present. Paediatric bone also is much more porous than its adult counterpart. When longitudinal forces applied slowly bend the immature bone beyond its elastic limits and into its plastic zone, resulting in traumatic bowing.

Greenstick fractures represent an intermediate step between plastic deformation and complete fractures. On anteroposterior and lateral radiographs, greenstick fractures show a cortical defect in one, two, or three of their radiographic cortices, and some bony continuity is preserved.[1] Most paediatric radial and ulnar shaft fractures

can be treated by nonoperative methods. Low-energy, displaced, and minimally displaced forearm fractures can be immediately immobilized in a properly moulded above-elbow cast following fracture reduction1. This method of treatment is associated with compartment syndrome, displacement of the fracture, refracture, synostosis, malunion and elbow stiffness.[1,5] In some patients, the reduction achieved initially may be lost due to loosening of cast and movement at the fracture site which may lead to angulation, malrotation or over-riding of the fracture fragments, necessitating operative intervention.[6]

The operative method includes percutaneous intramedullary nailing with elastic stable intramedullary nails and open reduction and internal fixation with plates and screws. The disadvantages of plate fixation include the necessity of large stripping of periosteum, increased risk of non-union, pseudoarthrosis, and infection rate. Intramedullary nailing techniques offer better advantages like short operative time, no stress risers created at the diaphyseal area that can be seen after plate or screw removal, less invasiveness, improved aesthetics because of smaller incisions, ease of application, less blood loss, less healing problems, and low rate of complications.[6]

Intramedullary fixation materials include Steinmann pins, Kirschner-wires, rush pins, and elastic titanium nails.[7] Elastic stable intramedullary nailing is primary definitive fracture care in paediatric orthopaedic practice.[8] The periosteum in children is thick as compared to adult bone. The periosteal blood supply is important for fracture healing and is rarely damaged in a child's fractured bone. Cutting or stripping the periosteum has a deleterious effect on healing in terms of callus formation, speed of healing, and bone length. Elastic stable intramedullary nails permit biological healing and callus formation in abundance. This is achieved by minimizing periosteal stripping by way of a minimally invasive approach and in most cases by a closed reduction. Even when open reduction is required, a minimal approach is used only to facilitate reduction and no more. The elasticity of the construct allows for the ideal circumstances of micro-motion for rapid fracture healing.[8] Children's fractures remodel after healing. Elastic stable intramedullary nails used to stabilize children's long bone fractures, whether made of titanium alloy or stainless steel, are adequately strong to maintain reduction for the time required for bone healing.

It is emphasized that elastic stable intramedullary nail is a successful method for treating children's fractures because they heal rapidly in less than half the time of an equivalent adult fracture. Each nail is pre-curved to achieve a three-point fixation. Once inserted into the medullary canal, the nail resists angular, compressive, and rotational forces under the elastic qualities of the material and the balanced insertion construct. Some authors do not recommend pre-contouring the nail before insertion but allow the nail to become contoured by the process of insertion. Part of the biomechanical stability of fractures stabilized by elastic stable intramedullary nails is provided by the intact muscle envelope surrounding the affected bone. Thus, an elastic stable intramedullary nail is particularly effective for closed fractures of the forearm. The choice of elastic nails of titanium alloy or stainless steel is largely a matter of surgeon preference. In the clinical setting, titanium is being used more often than stainless steel because of its elastic properties which allow for improved insertion and rotation.[7] Titanium alloy has a modular elasticity and handling characteristic very suitable to a child's diaphysis. Stainless steel is stronger with higher tensile strength and has a higher elastic limit.

All the currently available elastic nails have beaked or hooked ends to allow satisfactory sliding down on insertion along the inner surface of the diaphysis without impacting on the opposite cortex. The outer surface of these hooks is flattened like the runner of a sledge to allow easy passage of the nail down the bone. The arc of the hook is proportional to the width of the nail and facilitates passage of the nail. One nail is inserted in the radius and ulna because both bones are considered a single unit and the nail should occupy 60% of the medullary canal.[8] Titanium elastic nail is advantageous as it is a safe, simple technique, minimally invasive, and has fewer complications.

The most common functional deficit after malunited forearm fractures is particularly reduced motion of pronation and supination. Both bone fractures of the forearm particularly in the distal shaft, with residual angulation can lead to disruption of wrist joint movement.[9] This study is an attempt to find out the clinical and functional outcome and complications of fractures of the shaft of radius and ulna in the paediatric age group treated with titanium elastic nail.

CASE SERIES

This is a case series study conducted from November 2019 to April 2022 in the Department of Orthopaedics, S. Nijalingappa medical college and H.S.K Hospital and Research Centre, Bagalkot, 587102. Twenty-five patients of the paediatric age group admitted with radius and ulna shaft fracture treated with titanium elastic nails were studied for the functional outcome, radiological union and complications.

Inclusion criteria

Age group 6 years to 16 years. Simple diaphyseal fractures radius and ulna. Patient who are medically fit for surgery. Patients willing for surgery and have given informed written consent.

Exclusion criteria

Patients with comorbid medical conditions not fit for surgery. Communited diaphyseal fractures radius and ulna. Pathological fractures. Open fractures with or without

neurovascular injury. Fractures associated with proximal and distal radio-ulnar joint instability.

Surgical procedure

The procedure was performed under Brachial block with the patient in a supine position with the affected limb over the radiolucent arm board. A pneumatic tourniquet is applied to the arm. Intravenous antibiotics were given. The affected limb is scrubbed with 7.5% Povidone Iodine scrub solution from the elbow to the fingers. The affected limb is painted with 10% Povidone Iodine solution and draped. Under all aseptic precautions 5 mm longitudinal skin incision taken over listers tubercle, blunt dissection done. An awl is placed over the bone 5 to 10 mm proximal to the physis, the cortex is first perforated perpendicularly and then obliquely toward the elbow (Figure 1 and 2). The nail diameter chosen is between 60% and 70% of the medullary canal. The radial nail is bent to about 20 degrees to match the radial bow and to ensure restoration of the interosseous space. Nail is advanced through a radial entry point made by an awl and introduced proximally with rotatory movements, the fracture is reduced under fluoroscopic guidance and the nail is passed into the proximal metaphysis. Reductions are attempted closed in all the cases however with failed attempts pneumatic tourniquet is inflated and mini-open reduction is done at the fracture site. Nail is gently withdrawn by 1 cm and cut outside the skin and reinsert to the original position with an impactor. The incision is sutured with nylon 2.0. Ulnar nail is inserted anterogradely through the posterior surface of olecranon just distal to the physis. Under all aseptic precautions 5 mm longitudinal skin incision taken over the posterior surface olecranon, blunt dissection done. The awl is placed over the bone 5 to 10 mm proximal to the physis, the cortex is first perforated perpendicularly and then obliquely toward the wrist. The same size nail used in radius nail is chosen. Nail is advanced through ulnar entry point made by an awl and introduced distally with rotatory movements, the fracture is reduced under fluoroscopic guidance and nail is passed into the distal metaphysis. Reductions are attempted closed in all the cases however with failed attempts pneumatic tourniquet is inflated and mini-open reduction is done at the fracture site. Nail is gently withdrawn by 1 cm and cut outside the skin and reinsert to the original position with an impactor. The incision is sutured with nylon 2.0. The dressing is done and a long arm slab is applied. Standard procedures for dressing and suture removal were done.

Postoperatively, an above elbow slab is applied in all cases for 3 weeks. Active finger movements are encouraged after the surgery. Flexion and extension of elbow and wrist, Supination and pronation of forearm are allowed after removal of splint at 3 weeks. Regular post-operative follow up will be done at 3 weeks, 6 weeks, 3 months and 6 months. During the follow up the following parameters will be estimated. Functional outcome grading according to Anderson et al criteria.[10] Radiological union and complications.

Table 1: Functional outcome grading according to Anderson et al criteria.[10]

Result	Union	Flexion and extension at elbow joint and wrist joint	Supination and pronation
Excellent	Present	<10º loss	<25% loss
Satisfactory	Present	<20º loss	<50% loss
Unsatisfactory	Present	>30º loss	>50% loss
Failure	Non union	with or without loss of motion	

DISCUSSION

Diaphyseal forearm fractures in children is a common injury. The trend in the management of unstable forearm diaphyseal fractures in children is moving towards operative management and fixation using titanium elastic nails rather than closed reduction and casting as was done earlier. Closed reduction and casting tend to redisplace fracture. The most common functional deficit after malunited forearm fractures is particularly reduced motion of pronation and supination.[9] Intramedullary nailing of paediatric diaphyseal forearm fractures is a less invasive procedure, relative to standard plating. In adults, plate fixation is the standard treatment for diaphyseal forearm fractures. Operative management is beneficial to avoid repeat reductions, additional corrective surgical procedures, and functional limitations. In our study, the majority of children were in the age group of 6 years to 16 years with a mean age of 12±3 years. And 21(84%) were males and 4 (16%) were females. The functional outcome was graded according to Anderson et al criteria10 which is based on the amount of restriction of forearm rotational movements (Figure 5), flexion and extension at wrist and elbow joints (Figure 6) and radiological union. According to Anderson et al criteria10 after 6 months of follow up, the excellent result was seen in 22 cases (88%), satisfactory in 2 cases (8%) and unsatisfactory in 1 case (4%).

The evidence of bridging callus along three cortices of the diaphyseal bones fracture in both anteroposterior and lateral radiograph was considered proof of radiological bony union (Figure 3 and 4). The radiological union was achieved in a mean time of 8.24±2.62 weeks, the range being 6 weeks to 16weeks. Radiological union of fracture was observed in about 96% of patients before 13 weeks

and more than half of the patients achieved radiological union before 8 weeks.

In our study, there were no Intraoperative complications. No complications were seen in 20 cases [80%]. Complications were seen in 5 cases like elbow stiffness, nail prominence, olecranon bursitis and superficial skin infections at the incision site. In Yalcinkaya et al study complications was seen in 17 patients like radial nerve injury secondary to tourniquet use, decreased sensation resulting from irritation of the superficial radial nerve by the wire on the radial side, superficial skin infections at the incision site, olecranon bursitis, wire migration.

In Parajuli et al study complications were seen in 8 patients like skin irritation over prominent ulnar hardware in four, backing out of ulnar pin requiring early removal in one, superficial skin break down with exposed hardware and delayed union. In Kapoor et al study complications were seen 10 patients like delayed union, nail prominence which required early removal and one of these cases developed refracture, post-operative compartment syndrome.[11-13]

Figure 1: Intra operative images. (A) Fracture reduction, (B) Nail insertion with T handle, (C) Nail punched with tamp, (D) Nail buried under skin.

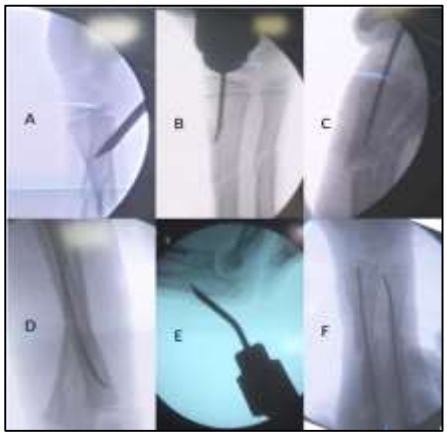

Figure 2: C ARM images. (A) opening of canal of Radius with awl, (B) nail insertion into radius, (C) advancing nail in radius canal and fracture, (D) advancing nail till proximal metaphysis of radius, (E) opening of canal of ulna with awl, (F) advancing nail till distal metaphysis of ulna.

Figure 3: Radiological images. (A) pre-operative X-ray, (B) post-operative X-ray, (C) 6 weeks follow up, (D) 6 months follow up.

Figure 4: Radiological images. (A) Pre-operative X-ray, (B) Post-operative Xray, (C) 3 weeks follow up, D) 6 months follow up.

Figure 5: Clinical images with forearm range of movements. (A) Midprone, (B) Pronation, (C) Supination.

Figure 6: Clinical images range of movements. (A) elbow flexion, (B) elbow extension, (C) palmar flexion, D) wrist dorsiflexion.

Figure 7: Nail prominence.

Figure 8: Skin breakdown after nail prominence.

Figure 9: Superficial skin infection.

In our study, complications like compartment syndrome, nerve injury, delayed union, malunion, non-union, mechanical block to wrist movement, refracture, nail migration, vascular and tendon injury were not seen. In our study, 2 cases of nail prominence (Figure 7 and 8) further led to superficial skin breakdown after 4 to 6 months after surgery and 1 case of elbow stiffness was due to mechanical block by ulnar nail, these complications were resolved after implant removal.

One case of Superficial skin infection at incision site (Figure 9) was controlled with higher intravenous antibiotics and delayed suture removal. In most of the patients implant removal was done after 6 to 12 months of primary surgery. Our study had certain limitations like small sample size, single centred study and lack of comparison group.

CONCLUSION

Titanium elastic nail system showed excellent results in terms of bony union, functional outcome with minimal complications which resolve after nail exit. Therefore, Titanium elastic nail system should be considered as an effective alternative of conservative management for forearm fractures in pediatric age group.

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