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Evaluation of the functional results of intramedullary nailing in diaphyseal both bone forearm fractures in children

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Abstract

Purpose: To evaluate the functional results of intramedullary nailing in diaphyseal both bone forearm fractures in children.

Patients and Methods: 40 patients (30 males and 10 females) with an age group of 8-14 years were included in the study. Displaced diaphyseal fractures, fractures with loss of reduction (within first week) in casting, segmental fractures, and open fractures (Gustilo & Anderson type 1 & 2) were considered for intramedullary fixation. The fractures were reduced percutaneously by manipulating the fracture fragments & were stabilised by 2-2.5 mm flexible titanium intramedullary nails. Retrograde nailing of radius was done from the dorsal entrance site. Antegrade nailing of ulna was done from the lateral cortex of the olecranon. Patients were followed at two weeks, four weeks, six weeks, eight weeks and then at monthly intervals up to 9 months. Final follow up was done at 9 months and results were assessed clinically using Daruwalla criteria with restoration of forearm rotation.

Results: In 31 (77.5%) cases, closed reduction and nailing was achieved using 2 to 2.5 mm flexible titanium nails while in 9 (22.5%) cases open reduction through limited incisions was done. In all patients fracture was united at an average of 8.1 weeks. In all patients, removal of implant was done at 6 months. Excellent results were in seen 38 (95%) patients & good results in 02 (5%) patients using Daruwalla criteria with restoration of forearm rotation. The complication reported were bursa formation in 7 (17.5%) patients, symptomatic prominent hardware in 5 (12.5%) patients, superficial radial nerve injury in 1 patient, wound related problems in 3 patients & refracture in 1 patient.

Conclusion: Elastic intramedullary nailing is a safe and reliable method for internal fixation of displaced diaphyseal unstable forearm fractures with good to excellent functional results.

Keywords: Diaphyseal forearm fractures, Intramedullary nailing, children

Introduction

Both bone diaphyseal forearm fractures are common injuries in children. Management of these injuries depends on various features including age of the child, angulation/translation of the fracture, type of the fracture and stability of the reduction. The majority of the forearm fractures can be treated with cast immobilisation because of the strong periosteum and remodelling potential [1-2]. Relative indications of surgery for these fractures in children include open injury, floating elbows, instability after reduction, and irreducibility (by closed means) [3-5].

Currently, intramedullary (IM) nails, K-wires, and plates are used for surgical treatment of pediatric forearm fractures [6-8]. Elastic stable intramedullary nailing (ESIN) has become common in the treatment of children's long bone shaft fractures [9] and has been shown to produce excellent outcomes [10-11]. Flexible titanium nails are physis sparing because they are introduced through the metaphysis avoiding the physis.

Patients and Methods

This study was a prospective study conducted at Government Hospital for Bone and Joint Surgery, Srinagar from September 2016 to September 2018, after approval of the institutional board.

Patient Selection

The study included 40 paediatric patients: 30 males and 10 females, aged between 8-14 years. Informed consent was obtained from the parents/guardians of all the cases.

Inclusion Criteria

1. Age group: 8-14 years of either sex.
2. Displaced Diaphyseal fractures.
3. Fractures with loss of reduction (within first week) in casting.
4. Segmental fractures.
5. Open fractures (Gustilo & Anderson type 1 & 2).

Exclusion Criteria

1. Age < 8 & > 14 years.
2. Undisplaced diaphyseal fractures.
3. Open fractures, Gustilo & Anderson type 3.
4. Comminuted fractures.
5. More than one week old fractures.
6. Associated neurovascular injury.

Surgical Technique

The operation was performed under general anesthesia. Blunt ended titanium elastic nails of diameter 2.0-2.5 mm were used in all the cases. After administering general anaesthesia, elbow, arm and forearm were cleaned with antiseptic solution and painted with 10% betadine solution and draped in standard manner. Closed reduction was attempted in all patients under C-arm guidance & intramedullary nailing was done. The radius was first reduced & stabilised with intramedullary nail followed by reduction of ulna & its stabilisation with intramedullary nail.

Nailing Approaches

1. Radius: Retrograde from the dorsal (Lister's tubercle) entrance site.

A 2 – 3 cm longitudinal incision was made over the palpable dorsal Lister's tubercle of the radius. Next the subcutaneous tissue was spread and the fascia was incised to expose the tubercle. After retracting the tendons, the awl was placed directly just proximal to the tubercle between second & third extensor tendon compartments approximately 1-2 cm proximal to the physis (physis sparing). Care was taken to avoid injury to the tendons. The awl was directed anteromedially as it is drilled to perforate the posterior cortex. While introducing the awl it was ensured that the opposite cortex was not breached. The nail was introduced using T-handle and advanced to the fracture site by gentle oscillating movements.

Fig 1. (a): Dorsal distal (Lister) radial entry using an awl. (b): Retrograde IM nail insertion in radius using T-handle.

Fig 2: C-arm confirmation of radial nailing, AP & Lateral views.

2. Ulna: Antegrade from the lateral cortex of the olecranon (Proximal lateral/Anconeus ulnar entry):

The skin was incised 1.5 to 2 cm longitudinally over the proximal lateral aspect of the olecranon, approximately 3 cm distal to the apophysis. The lateral cortex of the olecranon was perforated with the awl directed obliquely in a distal direction, 3 cm distal to olecranon apophysis & just anterior to the posterior border or about 4 mm lateral to the posterior crest (physis sparing). The nail was inserted using T-handle and advanced distally to the fracture site by gentle oscillating movements.

Fig 3: Skin incision for Proximal Lateral (Anconeus) ulnar entry.

Fig 4: C-arm confirmation of Ulnar nailing AP & Lateral views.

Since it is more often difficult to reduce radius, it was reduced first. Attempt to bring the fracture planes in contact indirectly by percutaneously manipulating the fracture fragments was first done under C-arm guidance & fracture stabilisation was achieved by completing the intramedullary nailing using 2-2.5 mm flexible titanium nail. After successful radial fracture reduction & stabilisation, ulna was reduced indirectly by percutaneously manipulating the fracture fragments & fracture stabilisation was achieved by completing the intramedullary nailing under C-arm guidance using 2-2.5 mm flexible titanium nail.

The fractures where closed reduction was not achievable after

2-3 closed reduction attempts or following a 10 minute rule of closed reduction maneuvers, a limited incision approximately 2-3 cms in length was given directly over the fracture sites for both radius & ulna and an open reduction was done after proper soft tissue dissection followed by fracture stabilisation by intramedullary nailing using 2-2.5 mm flexible titanium nails.

The nails were bend, cut and their ends were placed deep in the subcutaneous tissue. Before cutting, the nail was withdrawn by 1 to 2 cms, bent such that the distal end lies flush with the bone and re-impacted into the bone. The incisions were then closed with single sutures.

Fig 5: Wound closure with subcutaneous burial of nail ends.

Post-Operative Period: A long arm posterior plaster slab was given in all the patients and the forearm was immobilised for a period of 4 weeks. Patients were followed-up at two weeks, four weeks, six weeks, eight weeks and then monthly with a final follow up at 9 months postoperatively. Removal of implant was done under local anaesthesia or under general anaesthesia after complete bony union.

Results

Table 1: Type of Fracture

Fracture Type	No of cases	Percentage
Closed	36	90
Open Type 1	04	10
Open Type 2	0	0

Table 2: Fracture Location

Fracture location	No. of patients	Percentage
Proximal 1/3rd	05	12.5
Middle 1/3rd	20	50
Distal 1/3rd	15	37.5

Table 3: Fracture Pattern

Fracture Pattern	No. of patients	Percentage
Transverse	29	72.5
Oblique	11	27.5
Comminuted	0	0
Segmental	0	0

Time since injury to surgery: Time since injury to surgery ranged from 10 hours to 6 days. Average time from injury to intervention was 37.3 hours. Majority of cases (57.5%) were intervened within 24 hours.

Table 4: Show time since injury percentage

Time since injury	No of cases	Percentage
< 24 hours	23	57.5
24 - 48 hours	09	22.5
2 - 6 days	08	20

Surgical Time: In our study, the average surgical time was 39.7 minutes with majority of cases done within 30-40 minutes.

Table 5: The surgical time and percentage

Surgical time	No. of cases	Percentage
30-40 minutes	26	65
41-50 minutes	10	25
51-60 minutes	04	10

In majority (77.5%) of cases fracture reduction was achieved by closed means while 22.5% of the patients needed open reduction through limited incisions.

The an average union time was 8.1 weeks with a range of 6-12 weeks. In all patients fracture was united. There was no

delayed union or non-union in our study.

Removal of implant was done in all cases at 6 months postoperatively. In 33 (82.5%) cases, removal of implant was done under local anaesthesia and in 07 (17.5%) cases, it was done under general anaesthesia.

In 95% of patients in our study, there was no or negligible limitation of forearm rotations & in 5% of cases limitation of rotations was less than 20. In our case series of 40 patients, we had excellent results in 95% of the cases & good results in 5% of the cases. There were no fair or poor results in our study.

Table 6: Final Results Using Daruwalla's Scoring System

Clinical definition	Grade	No. of Cases	Percentage
Movements equal on both sides	Excellent	38	95%
< 20° of limited rotation on injured side	Good	02	05%
20-40° of limited rotation on injured side	Fair	0	0
> 40° of limited rotation on injured side	Poor	0	0

Chart 1: Range of alteration of forearm rotation

Fig 6: A 13-year-old male with proximal third both bone complete forearm fracture. A: AP and lateral injury radiographs. B: Immediate postoperative radiographs. C: 6-month follow-up radiographs. 9-month follow-up radiograph (Implant removed). D: Pronation. E: Supination.

Fig 7: 11-year-old male with proximal third both bone complete forearm fracture. A: AP and lateral injury radiographs. B: Immediate postoperative radiographs. C: 6-month follow-up radiographs. 9-month follow-up radiograph (Implant removed). D: Pronation. E: Supination.

Discussion

Both bone forearm diaphyseal fractures are increasingly being treated by operative methods. Operative treatment was performed in 13.3% of cases in 2000–2001 and 52.7% in 2008–2009. Non-operative treatment decreased from 87% to 47% in the same time period ($P=0.015$)^[14].

The increase in operation activity was mostly due to the increasing incidence of elastic stable intramedullary nailing: it increased from 10% in 1998–2000 to 30% in 2007–2009 ($P=0.043$)^[14]. There is a growing trend towards flexible or titanium elastic intramedullary nailing for fixation of forearm fractures in children^[11, 15, 16]. This surgery offers stable fixation without disturbance of the periosteal blood supply or removal of the hematoma, which contributes to fracture healing. This method also allows for micromotion to stimulate the callus to bridge the fracture gaps. Intramedullary nailing of forearm bone fractures in children offers an alternative form of stable fixation with few reported complications^[17-19]. Most forearm shaft fractures continue to be successfully treated with closed methods. Our indications for surgical treatment of these injuries were displaced unstable diaphyseal forearm fractures, including the segmental and open fractures (Gustilo & Anderson type 1 & 2) and fractures with loss of reduction in the first week of casting. Currently, intramedullary fixation of children's forearm fractures is preferred over plate fixation because of reduced soft tissue disruption.

In our study, the percentage of open fractures was 10%. The low percentage of open fractures in children was because the mode of injury was of moderate severity in the majority of patients including fall while playing. The study included only

30% of the cases with fall from significant height or due to RTA.

In 22.5% cases, closed reduction was not achieved after three attempts or after a '10 minute rule' of closed reduction maneuvers. The cases required open reduction through a small (2-3cm) incisions directly at the fracture level. All these patients had soft tissue interposed between the fracture ends making the fracture irreducible through closed means.

In our study, the period of immobilisation was 4 weeks. The postoperative immobilisation was used as an adjunct to the osteosynthesis till callus formation & to prevent secondary displacement & refracture. Lascombes *et al.*^[11] reported secondary displacement of the fracture in 5% of the patients when post-operative immobilisation was not used.

The union time in our study was 6-12 weeks with an average union time of 8.1 weeks. In all patients fracture was united. There was no delayed union or non-union in our study.

The removal of implant was done at 6 months post-operatively. The implant was removed late to prevent risk of refracture as has been reported in the literature with early implant removal. Lascombes *et al.*^[11] in their series of eighty-five forearm fractures treated with ESIN, the nails were removed at 4.25 months after the initial surgery in the first fifty patients, but because three cases of refracture occurred, they recommended nail removal between ten months and one year after the initial surgery. Similarly, Gorter *et al.*^[13] reported forearm refractures in patients who had elastic nails removed between two and four months after injury. Also there was low risk of infection as the implant was buried subcutaneously.

Complications

Bursa formation was the most common complication seen in our study group. Bursa formation was seen in 7 (17.5%) cases. Prominent exposed nail end & hypertrophic scar formation was seen in 3 cases each. Two patients had symptomatic prominent nail irritation & one patient had superficial infection where nail end was exposed outside the skin. One patient had decreased sensations over dorsal radial nerve distribution. One patient had a refracture during the study & 2 patients had decreased forearm rotations.

Table 7: Complications

	No of cases	Percentage
Bursa formation over hardware prominence	07	17.5
Prominent exposed nail end	03	7.5
Hypertrophic scar (minimally open)	03	7.5
Limitation of forearm Rotation	02	5
Infection at hardware entry site	01	2.5
Injury to dorsal cutaneous branch of radial nerve	01	2.5
Refracture	01	2.5
Prominent irritating nail end	02	5

Conclusion

Elastic intramedullary nailing is a safe and reliable method for internal fixation of displaced diaphyseal unstable forearm fractures with good to excellent functional results.

Conflict of Interest: None.

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