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Observations on Intramedullary Nailing in Diaphyseal both Bone Forearm Fractures in Children

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Abstract: ***Purpose: Observations onintramedullary nailing in diaphyseal both bone forearm fractures in children aged 8-14 years.Patients and Methods: 50 patientswith an age group of 8-14 years, with 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 were included in the study. Intramedullary nailing of both bone forearm fractures was done under general anaesthesia using 2-2.5mm diameter flexible titanium nails. Patients were followed at two weeks, four weeks, six weeks, eight weeks and then at monthly intervals upto 9 months. Final follow up was done at 9 months and results were assessed clinically using Daruwalla criteria with restoration of forearm rotation.Results: Majority of patients (72%) were in the age group of 11-14 yearswith an average age of 11 years. Male children (76%) outnumbered the females (24%). Majority of the patients had involvement of left side (68%) as compared to right side (32 %).Mode of injury was sports related fall in 22 (44%)patients, fall from height in 14 (28%) patients, fall from bicycle in 7(14%) patients & road traffic accident(RTA) in 7(14%) patients. Summer was season with maximum number of patients (42%) followed by spring (26%), autumn (24%) & winter (8%). Middle third of the radius & ulna was most common site of fracture (52%), followed by distal third (38%) & least involved site was proximal third (10%) of forearm.12% of the fractures were open type (Gustillo Type1 and 2) while 88% were closed type. Fracture pattern was transverse in 34 (68%) and Oblique 16 (32%) cases.Average time from injury to intervention was 37 hours. In 38 (76%) cases, closed reduction and nailing was achieved using 2 to 2.5 mm flexible titanium nails while in 12 (24%) cases, open reduction through limited incisions was done. The average surgical time was 40 minutes. The average hospital stay was 2.3 days.The average union time was 8 weeks with a range of 6-12 weeks. In all patients, removal of implant was done at 6 months. At final follow up, excellent results were seen in 46 (92%) patients & good results in 04 (8%) patients using Daruwallacriteria with restoration of forearm rotation.Conclusion: In children aged 8-14 years, the displaced diaphyseal forearm fractures, including open fractures (Gustilo& Anderson type 1 & 2) and fractures with loss of reduction in the first week of casting can be treated by intramedullary nailing with good to excellent functional results.***

Keywords: Diaphysealforearm fractures, Intramedullary nailing,Children

1. Introduction

Injuries to the shafts of the radius and ulna are the most common reasons for children to receive orthopaedic care[1,2,3].Fractures of the radial or ulnar shaft, or both, are relatively common and account for 5% to 10% of children's fractures [3,4].Treatment of paediatric forearm shaft fractures aims to achieve and maintain acceptable reduction until bone union occurs[5]. Because of the unique feature of the forearm as a joint, and unlike other diaphyseal fractures, fractures of the radius and the ulna must be approached like other articular fractures[6]. It is not only a question of fracture healing but also of function of a broken joint and possible stiffness after injury[7]. Thus, the main purpose of treatments in the long term is to achieve full recovery of the range of motion in the forearm and minimize complications [8].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. Most of paediatric forearm shaft fractures are traditionally treated by means of closed reduction and cast immobilization[9,10,11]. Non-displaced stable fractures can always be managed by using a long arm casts[12]. Complete fractures often show bayonet shortening and they are controlled by gentle, long-lasting (5 to 10 minutes) longitudinal traction over the fracture site[13]. This diminishes muscle contraction and facilitates reduction. Traction itself may also result in spontaneous reduction of possible rotational malformation[14]. The fragments are reduced in full end-to-end contact without overriding, accepting at most slight <10 mm shortening, if any[15]. Due to potential instability, complete fractures require precise casting if treated non-operatively. Casting is aimed at neutralising deforming muscle forces around the fracture until it has healed[16]. In particular, the supinator and pronation muscles of the forearm act as deforming forces[13]. Fractures proximal to the pronator tuberosity and all fractures in the proximal third should usually be immobilized in supination position, fractures in the middle third in neutral position and those in the distal third or distally to the pronator tuberosity in pronation[15-17]. Relative indications of surgery for these fractures in children include open injury, floating elbows, instability after closed reduction, and irreducibility (by closed means)[18-20].Currently, intramedullary (IM) nails, K-wires, and plates are used for surgical treatment of pediatric forearm fractures. Elastic stable intramedullary nailing (ESIN) has become common in the treatment of children's long bone shaft fractures [21] and has been shown to produce excellent outcomes [22-23]. Flexible titanium nails are physis sparing because they are introduced through the metaphysis avoiding the physis.

2. Patients and Methods

This was a prospective study conducted on paediatric patients from September 2016 to December 2018. The study included 50 paediatric cases:38 males and 12 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.

Preoperative assessment:
Patients after admission in emergency ward were managed according to the following protocol:Resuscitation, if needed. History and general physical examination. Local Examination of the involved upper limb for swelling, tenderness, deformity, distal neurovascular status, any wound. Standard AP and lateral radiograph of the forearm to confirm the diaphyseal fracture & to see the displacement. Long arm crammer wire splint was given for immobilization of fractures.Routine investigations: Hemogram, BT/CT, Blood grouping, Blood sugar, KFT, ECG, Chest X ray were done. Single dose of cefazolin/cefuroxime 50 mg/kg BW was given pre-operatively intravenously.

Operative 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:
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.

Figure 1: Dorsal distal (Lister) radial entry.Retrograde IM nail insertion in radius using T-handle

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

2. Ulna: Antegrade from the lateral cortex of the olecranon. 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.

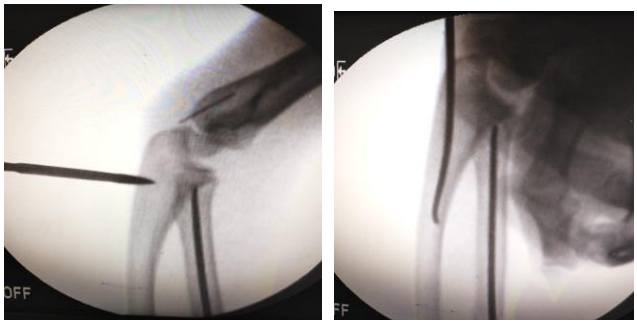

Figure 3:C-arm confirmation of Ulnar nailing, AP & Lateral views.

Since it is more often difficult to reduce radius, it was reduced first. 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 stabilization 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.

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.

3. Observations and Results

Table 1: Age Distribution

Age in years	No. of patients	Percentage
8-10	14	28
11-12	18	36
13-14	18	36

Table 2: Gender Distribution

Gender	No. of Patients	Percentage
Males	38	76
Females	12	24

Table 3: Side Distribution

Side involved	No. of patients	Percentage
Right	16	32
Left	34	68

Mode of Injury: Fall while playing sports was the most common mode of injury (44%) followed by fall from height (28%) in the form of fall from the tree, wall, windows, and stairs.

Table 4

Mode of Injury	No. of patients	Percentage
Fall while playing sports	22	44
Fall from height	14	28
Fall from bicycle	7	14
Road traffic accidents	7	14

Seasonal Distribution: Maximum cases of paediatric forearm fractures were seen during the summers (46%) followed by spring(26%).

Table5

Season	No. of patients	Percentage
Winter	4	8
Spring	13	26
Summer	21	42
Autumn	12	24

Table 6: Fracture Location

Fracture location	No. of patients	Percentage
Proximal 1/3rd	05	10
Middle 1/3rd	26	52
Distal 1/3rd	19	38

Table7: Type of Fracture

Type	No of cases	Percentage
Closed	44	88
Open Type 1	5	10
Open Type 2	1	2

Table 8: Fracture Pattern

Fracture Pattern	No. of patients	Percentage
Transverse	34	68
Oblique	16	32
Comminuted	0	0
Segmental	0	0

Time since injury to surgery: Time since injury to surgery ranged from 10 hours to 6 days. Averagetime from injury to intervention was 37 hours.

Table 9

Time since injury	No of cases	Percentage
< 24 hours	27	54
24 - 48 hours	12	24
2 - 6 days	11	22

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

Table 10

Surgical time	No. of cases	Percentage
30-40 minutes	30	60
41-50 minutes	15	30
51-60 minutes	05	10

In majority (76%) of cases, fracture reduction was achieved by closed means while 24% of the patients needed minimal open reduction through limited incisions.The average union time was 8 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 40 (80%) cases, removal of implant was done under local anaesthesia and in 10 (20%) cases, it was done under general anaesthesia. In 92% of patients in our study, there was no or negligible limitation of forearm rotations & in 8% of cases limitation of rotations was less than 20.

Table 11: Final Results Using Daruwalla's Scoring System

Clinical definition	Grade	No. of Cases	Percentage
Movements equal on both sides	Excellent	46	92%
$<20^0$ of limited rotation on injured side	Good	4	8%
$20\text{-}40^0$ of limited rotation on injured side	Fair	0	0
$> 40^0$ of limited rotation on injured side	Poor	0	0

In our case series of 40 patients, we had excellent results in 92% of the cases & good results in 8% of the cases. There were no fair or poor results in our study.

4. Discussion

In our study the age incidence was in the range of 8-14 years with the mean age of 11 years. The operative intervention usually the intramedullary nailing is preferred in older children because of high percentage of unstable fractures in older children due to more strong deforming muscular forces. The Males in our study constituted 76% of the total. This observation is attributed to more agile, sporty and outgoing nature of males, so more susceptible to sustain the trauma. In our study series, the percentage of open fractures was 12% and was comparable with other published studies[24-26]. 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. The percentage of patients who needed open reduction of fractures was 24%**.** This observation is comparable with the other published studies [24-26]. In these cases, closed reduction was not achieved after three attempts or after a '10 minute rule' of closed reduction maneuvers. Fractures were open reduced after three attempts or after '10 minute rule' because of high risk of developing compartment syndrome postoperatively. The open reduction in these patients was done 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 which is comparable to other published studies [26-28]. In our study, postoperative immobilisation was used as an adjunct to the osteosynthesis till callus formation & to prevent secondary displacement & refracture. Lascombeset. Al[29] reported secondary displacement of the fracture in 5% of the patients when post-operative immobilisation was not used. However, the necessity & duration of post-operative immobilisation is still unclear.

The union time in our study was 6-12 weeks with an average union time of 8 weeks, which was comparable to other studies[25,26,30]. In all patients fracture was united. There was no delayed union or non-union in our study.

In our case series of 40 patients, we had excellent results in 92% of the cases & good results in 8% of the cases. The results of our study were comparable to other published studies [24-27].

5. Conclusion

In children aged 8-14 years, the displaced diaphyseal forearm fractures, including open fractures (Gustilo & Anderson type 1 & 2) and fractures with loss of reduction in the first week of casting can be treated by intramedullary nailing with good to excellent functional results.

Conflict Of Interest: None.

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