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A study of 50 cases of mangement of non-physeal forearm fracture in children upto the age of 12 years

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Abstract
Introduction: Injuries to the shaft of the radius-ulna are the most common reasons for children to receive orthopaedic care and are among the most challenging to the orthopaedist because of their complexity and risk of complications. Diaphyseal fracture of both bones of forearm in mature bone are now treated by open reduction and internal fixation. Diaphyseal fractures of the forearm in children are accounting for 6%-10%. Ninety percentages of them are treated conservatively i.e. closed reduction and plaster casting. The remaining of 10% are irreducible and/or unstable fractures, requiring different treatment methods i.e. closed reduction & casting under general anaesthesia, fixation with pins & plaster casting, closed reduction or mini-invasive Intra-medullary nailing, open reduction & Osteosynthesis with plates & external fixators.
Aim and Objectives: To identify the factors such as angulation at fracture site, inclination of epiphyseal plate of radius with the proximal fragments, type of fractures etc. with regards to supination & pronation in the patients treated by closed and open methods.
Materials and Methods: This is a prospective study of management of 50 patients having non-physeal fractures of radius-ulna in children upto the age of 12 years. All the patients were treated at the Department of Orthopaedics, GMERS Medical College and Hospital, Valsad, Gujarat from 20/05/2015 to 15/08/2018. The follow-up period ranged from 12 weeks to 30 months. Patients were treated with closed reduction and open reduction internal fixation by Intra-medullary nails i.e. a) Rush nail and Plates i.e. a) 3.5mm DCP b) Reconstruction plate c) 1/3rd tubular plate.
Result: At final follow-up, for closed methods, 90% patients had excellent results & 6.7% patients had good results. For operative method, 88.2% patients for IM nailing & 66.6% patients for plating had excellent results.
Conclusion: Close methods is better than operative methods.

Keywords: Non diaphyseal forearm fracture, radius, ulna, rush nail

1. Introduction
Injuries to the shaft of the radius-ulna are the most common reasons for children to receive orthopaedic care and are among the most challenging to the orthopaedic surgeon because of their complexity and risk of complications [1]. Diaphyseal fracture of both bones of forearm in mature bone are now treated by open reduction and internal fixation. Fractures of forearm in children are extremely common [2]. Diaphyseal fractures of the forearm in children are accounting for 6%-10%. Ninety percentages of them are treated conservatively i.e. closed reduction and plaster casting. The remaining of 10% are irreducible and/or unstable fractures, requiring different treatment methods i.e. closed reduction & casting under general anaesthesia, fixation with pins & plaster casting, closed reduction or mini-invasive Intra-medullary nailing, open reduction & osteosynthesis with plates & external fixators [3]. Generally, it has been accepted that children younger than 10 years of age have better remodeling capacity than children older than 10 years. Assessment of rotational mal-alignment is important because there is essentially no remodeling potential for rotational mal-alignment. Healing occurs reliably after closed treatment but malunion with resultant decreased rotation is common & associated with poor results [4]. The open surgical intervention is associated with complication like delayed union, cross union, non-union & at worst, an osteomyelitis [1]. The aim of the study was to identify the factors such as angulation at fracture site, inclination of epiphyseal plate of radius with the proximal fragments, type of fractures etc.

with regards to supination & pronation in the patients treated by closed and open methods. In addition, the study demonstrates the efficacy & complications of open method. Additionally, the study also explored the outline of the demographic data of diaphyseal forearm fractures occurring in children [5].

2. Materials and methods

This is a prospective study of management of 50 patients having non-physeal fractures of radius-ulna in children upto the age of 12 years. All the patients were treated at the Department of Orthopaedic, GMERS Medical College and Hospital, Valsad, Gujarat from 20/05/2015 to 15/08/2018. The follow-up period ranged from 12 weeks to 30 months. All the patients were treated according to the merits of individual case, as decided by the treating surgeon at the Department of Orthopaedics, GMERS Medical College and Hospital, Valsad, Gujarat. On admission, general condition of patient was assessed and other associated injuries were noted and treated as per merit. Local clinical examination of injured limb was performed regarding oedema, tenderness, deformity with detail neurovascular status and movements of adjacent joints. Open fractures were graded as per Gustilo-Anderson Classification, wounds were covered with sterile dressings and above elbow plaster slab was applied. Radiographs of elbow with radius-ulna with wrist, anterior-posterior and lateral views were taken. All the close reductions were done under I.V. sedation or general anesthesia. Reduction was confirmed under I.I.T.V. guidance in both AP and lateral views. While maintaining the reduction, a well padded above-elbow cast was given in the position. While applying cast, particular care was taken to prevent crowding of fingers and plaster cast was trimmed if necessary to allow free movement of thumb and fingers. If the reduction was not acceptable in three or four attempts, an open reduction and internal fixation was done. All the operative procedures were done in supine position under anaesthesia. Closed nailing was preferred over open nailing. Approximate size of nails was taken pre-operatively. Closed nailing was done under guidance of I.I.T.V. In case of Extra-medullary implants, 3.5 DCP or 1/3rd tubular plates were used. Fixation device consisted of intramedullary nail i.e Rush Nail (Figure 1, 2) and Plates i.e. 3.5mm DCP, Reconstruction plate and 1/3rd tubular plate.

Fig 1: Rush nail

Fig 2: Trolley of rush nail insertion

Table 1: Acceptability criteria for paediatric forearm fractures [2, 6, 7]

	< 9 years		> 9 years	
	Proximal 2/3rd fractures	**Distal 1/3rd fractures**	**Proximal 2/3rd fractures**	**Distal 1/3rd fractures**
Angulation	10°-20°	20°-30°	≤ 10°	10°-20°
Translation	Complete	Complete	50%-70%	70%- 80%

Surgical Steps for closed reduction internal fixation with intra medullary nailing has been presented in Figure 3-8.

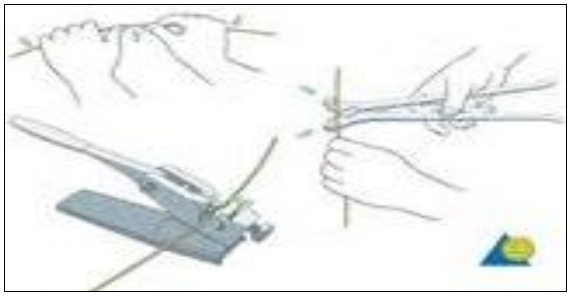

Fig 3: Surgical steps for intra medullary nailing insertion in forearm bone fracture - pre-bending of the intra-medullary nail

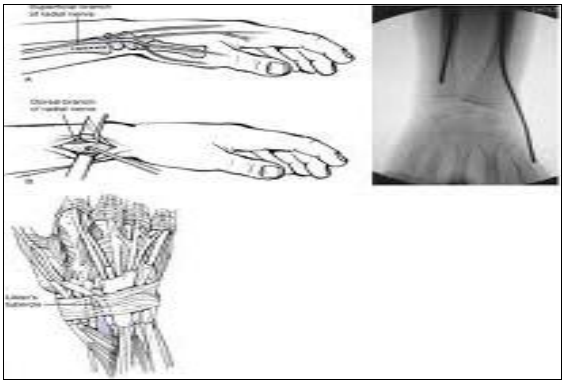

Fig 4: Entry point for rush nail insertion at radial site & Ulnar site

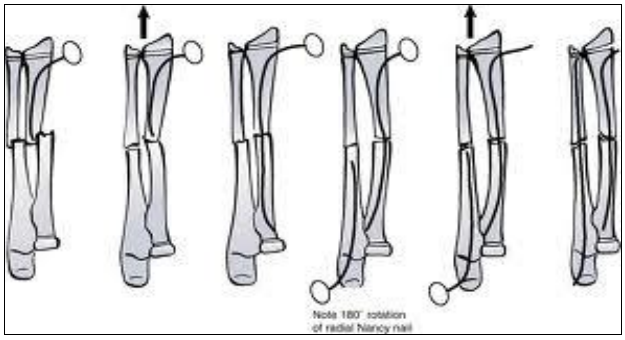

Fig 5: Insertion of the rush nail

Fig 6: Intra-operative check X-ray under IITV guidance.

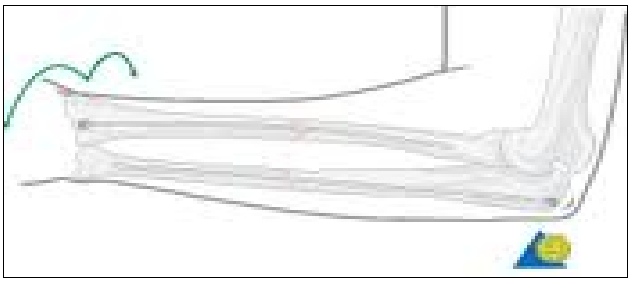

Fig 7: Final appearance of fracture

Fig 8: Final check X-ray

During each follow-up, the patient was examined clinically for Pain and tenderness at the fracture site, Status of the operative scar, Movements of the adjacent joints and forearm rotation. Radiologically, patient was assessed for Bridging callus, Angulation at fracture sites, Rotation of the fracture fragments, Orientation of the radial epiphysis. Union was judged by absence of pain and tenderness at the fracture site and bridging callus and/or obliteration of fracture line. Thereafter, patient was allowed full use of limb. Guardian were advised against massage and manipulation Implant removal was advised after one year. Lastly, the patients were assessed using the criteria of Price *et al.* & Daruwalla *et al.* [8, 9].

3. Observations & Results

The present series consists of 50 patients in the age groups of upto 12 years, having non-physeal fractures of bones of forearm, out of which 30 patients were treated conservatively & 20 patients were treated operatively, followed-up from 20\05\2015 to 15\08\2018. The follow-up period ranged from 12 weeks to 30 months. We have compared our findings with available literature. In the present series, more radii (32%) as compared to ulna (18%) were fractured in upper third region. This was due to fall on outstretched hand with maximum pronation. The maximum numbers of fractures were in M/3 region in both series.

Table 2: Shows level of fracture:

Level	Present series		Tarmuzi & Abdullah series[5]	
	Radius	Ulna	Radius	Ulna
Upper third	16(32%)	9 (18%)	8 (17%)	8 (7%)
Middle third	26(52%)	32(64%)	33(69%)	32(66%)
Lower third	8 (16%)	9 (18%)	7 (14%)	8 (17%)

In the present series, 40 percentage of patients received operative treatment which was higher than compared series[4].

Table 3: Shows type of treatment i.e. Conservative or operative treatment:

Methods	Present series	Flynn & Kristofer series[4]
Conservative method	30 (60%)	2142 (93.3%)
Operative method	20 (40%)	155 (6.7%)

Table 4: Shows type of surgical management i.e. intra-medullary nailing or Plate fixation.

	Present series	Flynn & Kristofer series
IM nailing	17 (85%)	103 (69%)
Plating	3 (15%)	44 (29.5%)
Both	None	2 (1.3%)

Table 5: Average union time of different treatment methods

Methods	Present series	Tarmuzi & Abdullah series	Flynn & Kristofer series
Closed methods	5.9 weeks	4.6 weeks	----
Open methods	7.3 weeks	----	8.6 weeks
Primary CR & IF	6.3 weeks	----	6.9 weeks
As secondary treatment	9.1 weeks	----	9.6 weeks

Table 6: Final results

Results	Conservative methods (CR & Plaster casting)	Tarmuzi & Abdullah series
Excellent	27 (90%)	40 (85%)
Good	2 (6.7%)	7 (13%)
Fair	1 (3.4%)	1 (3%)
Poor	----	----

Table 7: Results were compared using Price *et al.* & Daruwalla *et al* criteria [8, 9].

Results	Present series		Flynn & Kristofer series		Ahemad Moh. Ali & Moh. Abdelaziz series (20 Pts)	Bhasker series (23 Pts)
	IM Nailing (17)	Plating (3)	IM Nailing (103)	Plating (44)		
Excellent	15 (88.2%)	2(66.6%)	80(81%)	33 (75%)	14 (70%)	16 (70%)
Good	1(5.9%)	1(33.4%)	23(19%)	11 (25%)	5 (25%)	4 (17%)
Fair	1(5.9%)	----	----	----	1 (5%)	3 (13%)
Poor	No poor results in any series					

The final results in present series with open methods of the treatment were comparable with Flynn & Kristofer series [4], Aheman Moh, Ali & Moh. Abdelaziz series [10] and Bhasker series [11].

4. Discussion

The present series consists of "A prospective study of 50 cases of nonphyseal forearm fractures in children upto the age of 12 years" treated at department of Orthopaedics, GMERS

Medical College and Hospital, Valsad, Gujarat between 20/05/2015 to 15/11/2018. All 50 cases were included for assessment of final results. In the present series, the average age was 9.3 yrs, this is probably due to the fact that this age group is more active and playful, hence more prone to sustain injury. As most paediatric forearm fractures occur due to low velocity injury i.e. a simple fall, open injuries are uncommon. Forearm bones are surrounded by a number of muscles, thus after a forearm fracture, these muscles exert different kinds of forces in different directions, as a result the chances of displacement of the fracture fragments are very high. In the present series 42 (84%) radii and 44 (88%) ulna had type-1 displacement (according to Sarmiento classification) which was related to the mode of injury i.e. simple fall (low velocity trauma).

In the present series, more radii (32%) as compared to ulna (18%) were fractured in the upper third region. This was due to fall on outstretched hand with maximum pronation. The maximum numbers of fractures were in M/3 region in both the series.

Closed reduction and cast immobilization remains the current gold standard for treating paediatric forearm fractures. In the present series, 30 (60%) patients were treated with closed reduction and cast immobilization. In the present series, main indications for surgeries were, Unacceptable alignment, open fractures, Failure to achieve close reduction after three to four attempts, Patient with delayed presentation, Refracture of the previously treated fractures. In the present series, Redisplacement in plaster cast occurs in 7-13 % 0f cases, usually within two weeks of the injury. It shows the importance of check X-ray with cast at 7-10 days interval upto 3 weeks [12] in the present series, 3 (6%) patients had redisplacement of the fracture fragments in the check X-ray. Out of 3 patients, 2 patients were treated with osteoclasis and re-reduction and alignment was acceptable. Low energy trauma and excellent healing potential in children, non union is very rare. None of the patients had non union in the present series; our result is comparable with the literatures.

Children, as compared to adults, have thick periosteum. Thus, direct trauma to the forearm leads to either green stick variety of fractures or transverse fractures. Comminuted fractures are suggestive of high velocity trauma. In the present series, 21 (42%) radii and 22 (44%) ulna had transverse fractures, 17 (34%) radii and 15 (30%) ulna had green stick variety of fractures and 3 (6%) radii and 1 (2%) ulna had comminuted fractures, which was comparable with the literature. Average duration of immobilization in the present series was 4.32 weeks. In all the series [11, 10, 12, 6, 13, 5] it is mentioned that the fractures treated conservatively will unite earlier than those treated operatively. If we are opening the fracture site, then we will remove the fracture hematoma which has many osteogenic factors and we will also interfere with periosteal blood supply of the bone and detach the surrounding soft tissue envelope. Fractures of the forearm in early childhood & young adults do not pose a problem as per the best mode of management. In early childhood (<10 yrs), more of the malalignment is compensated by remodeling [4] & the adults are treated by open reduction & internal fixation. Gradual correction of angular deformity can occur in children. However our opinion is that one should aim at anatomical or near anatomical reduction, rather than depending on nature to take care for the angulation deformity.

5. Conclusions

Though the series is relatively small & period of follow up is short, to draw the definitive conclusions however it appears that A detailed history regarding mechanism and duration of injury is very important. Complete physical examination with Possibility of associated injury must be kept in mind, particularly in high velocity trauma. Early adequate debridement and judicious use of broad spectrum antibiotics and good post-operative care will reduce the chance of infection in open injuries. Check-X ray to diagnose displacement in plaster cast is important. Closed reduction and casting yield excellent to good results and if satisfactory alignment is not achieved, surgeon should proceed for operative treatment.IM nailing fixation of an unstable forearm fractures in skeletally immature patients is safe, child friendly, minimally invasive technique that allows early functional treatment with an excellent functional and cosmetic outcome in comparison to plate osteosynthesis. Care should be taken to avoid injury to EPL (extensor pollicis longus) tendon for nail insertion in radius. Extra physeal insertion for ulna nail will avoid irritation at the tip of olecrenon. Surgeon should aim at anatomical or near anatomical reduction, rather than depending on nature to take care for the angulation deformity.

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