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Centromedullary Metaizeau Technique for Displaced Paediatric Radial Neck Fracture: Surgical Technique and Outcomes

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ABSTRACT

Paediatric radial neck fractures accounts for 1 % of all fractures and 5-10 % of all traumatic lesions involving paediatric elbow. Close and open reduction is challenging in Judet type III and IV, paediatric radial neck fractures and if not managed accurately leads to poor outcome. Retrograde intramedullary percutaneous nail reduction known as Metaizeau technique is considered most effective technique for displaced radial neck fracture, allowing early range of motion thus achieving excellent functional outcome. Aim of this study is to evaluate anatomical and functional outcome of Metaizeau technique and surgical tips to improve stability of fixation in paediatric radial neck fractures. This prospective study includes 20 paediatric radial neck fractures of Judet type III and IV, 15 males, 5 females, which were managed with Metaizeau technique. Clinical evaluation was done using Metaizeau classification, subjective evaluation done using DASH score, radiological evaluation done using steel's classification with follow up period of 12 weeks. 20 patients were treated with this Metaizeau technique, ranging from 8-13 years, 16 patients (80%) are type III, 3 patients (15%) are type IVa and 1 patient (5%) is type IVb, according to Judet classification. 14 patients (70%) had closed reduction, in 4 patients (20%) lever arm technique was used and 2 patients (10%) had open reduction. Clinical examination revealed excellent axis in all patients, with mean DASH score of 2.72%. The ROM examination according to Metaizeau, revealed perfect in 14 patients (70%), good in 4 patients (20%), acceptable in 1 patient (5 %), and bad result in 1 patient (5%). Radiological examination according to Ursei, revealed, 15 patients (75%) healed in anatomical position with perfect result, 3 patients (15%) having good results, healed with posterior angulation of 15°, 18° and 10°, 1 patient (5%) healed with malunion and 1 patient (5%) had bad result with pseudoarthrosis. One patient that undergone open reduction had developed pseudoarthrosis having bad clinical outcome. The technique of Metaizeau is closed, minimally invasive, elastic stable intramedullary nailing technique with extraarticular manipulation, is now considered gold standard for paediatric displaced radial neck fracture, yield good to excellent results in paediatric age group in Judet type III and IV radial neck fracture with angulation. Results in our series are excellent. Increased fracture severity with open reduction is associated with poor results.

OPEN ACCESS

Key Words

Paediatric radial neck fracture, retrograde intramedullary nailing, Metaizeau technique

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INTRODUCTION

Radial neck fractures constitute 1% of all paediatric fracture and 5-10% of elbow injuries, ranking 4th after supracondylar fracture, epitrochlear fracture and external trochlear fractures[1-3]. Mechanism is by FOOSH injuries i.e., by "fallen onto an out-stretched hand[4]". Affecting children between 4-14 years of age with peak incidence between 8-10 years of age[1,5]. Immature radial head is primary cartilaginous and intraarticular fractures are rare in children and adolescents, getting its blood supply primarily from the metaphysis, this predisposes the radial head to non-union with significant displacement and avascular necrosis. Judet classification used for paediatric radial neck fracture and it helps in deciding treatment protocol[6]. Non operative treatment with cast immobilisation with early initiation of physiotherapy is considered for non-displaced or minimally displaced fractures[7]. Accepted angulation ranging between 30°-60°, for non-surgical treatment and was based on age of patients[8]. Judet type III and IV not amenable for closed reduction. Conservative treatment may result in secondary displacement, malunion and cubitus valgus deformity. ORIF (open reduction and internal fixation) may results in premature physeal closure, implant related complications, decreased range of motion, non-union, heterotopic bone formation, avascular necrosis of radial head, posterior interosseous nerve palsy. For displaced radial nerve fracture options are manipulation under anaesthesia, percutaneous k-wire leverage (PKWL), open reduction with or without internal fixation and Metaizeau technique[8]. The standard procedure for isolated paediatric radial neck fracture is centro-medullary pinning (Metaizeau technique), first described by Metaizeau in 1980 as technique of intramedullary reduction and fixation of displaced radial neck fracture using k-wire, permitting extracapsular but intramedullary reduction and fixation, allowing early mobilisation without pin removal[9]. In 1993 he further developed, method to reduce and fix displaced radial neck fracture using elastic stable intramedullary nail (ESIN) (Fig. 1)[10]. This technique respect biological bone consolidation, non-aggression of physis thus avoiding growth disorder, thus allowing early functional recovery.

MATERIAL AND METHODS

This prospective study includes, 20 paediatric patients with displaced radial neck fracture, who were managed surgically with Metaizeau technique, during period of February 2021 to February 2023, in Department of Orthopaedics and Trauma Centre in Jaya Arogya Group of hospital, Gwalior, Madhya Pradesh, India. Patients were selected based on some

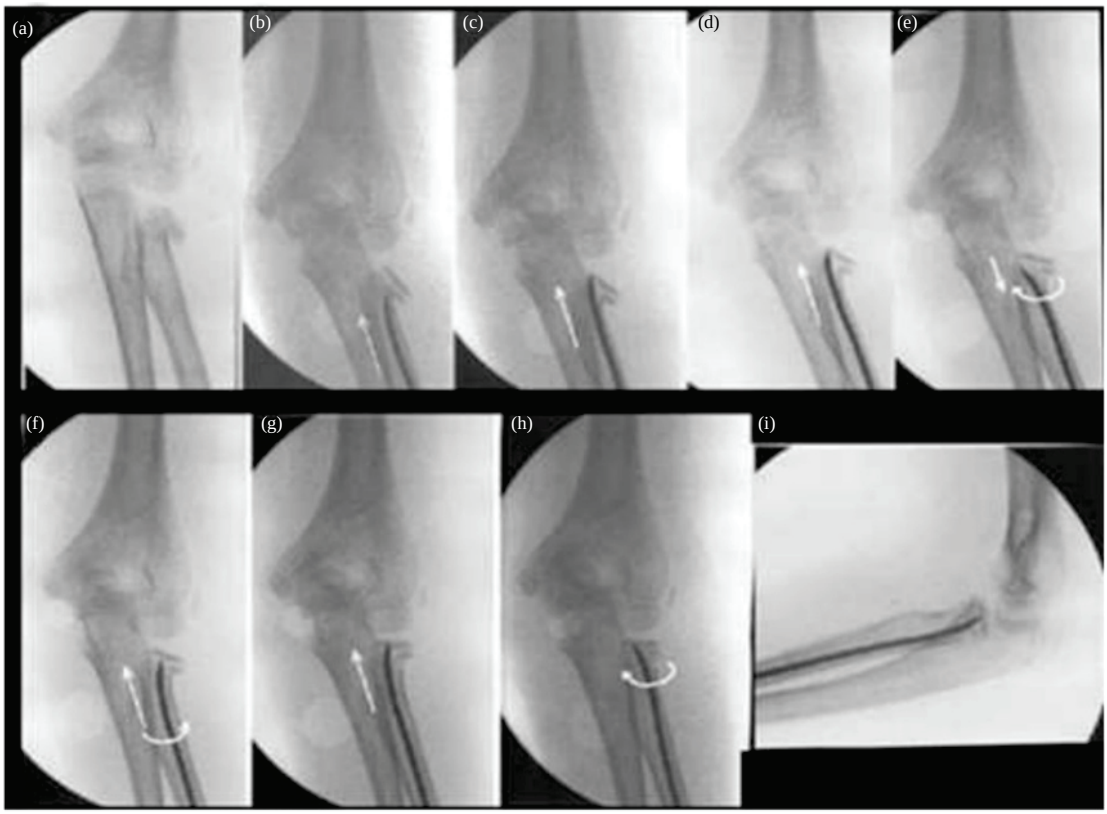

Fig. 1(a-i): Metaizeau technique

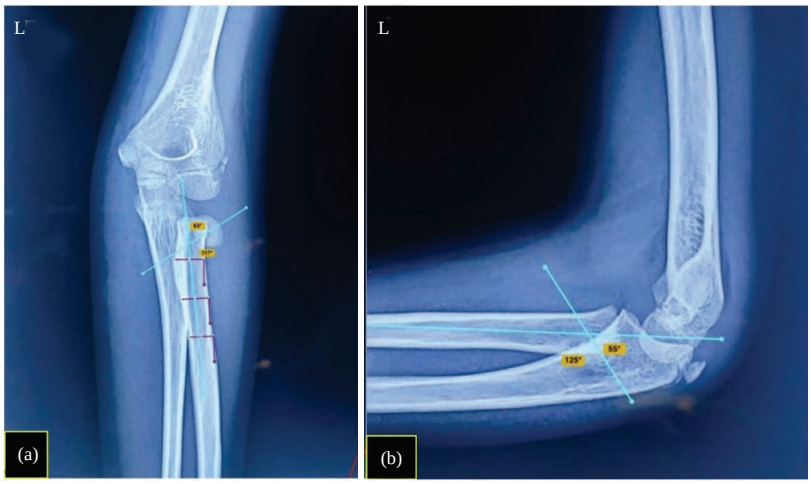

Fig. 2(a-b): Fracture angulation between lines passing through long axis of radius and fracture fragment in (a) Anteroposterior view and (b) Lateral view

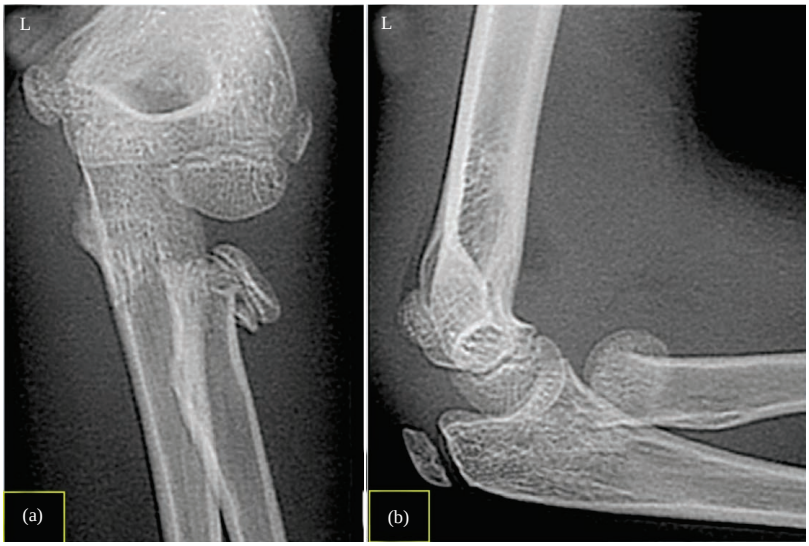

Fig. 3(a-b): Pre-operative x-ray, (a) anteroposterior and (b) Lateral view

Table 1: Patient selection criteria's

Inclusion criteria's	Exclusion criteria's
Open growth plate	Open Fractures
Fracture angulation >20°	Incomplete medical and radiographic records
	Associated head and diaphyseal fractures

inclusion and exclusion criterias (Table 1). Preoperative and 2 weeks post operative long arm slab support was given, after that slab was removed and active range of motion exercise was started. Involved elbow anteroposterior and lateral view were taken. Fracture angulation was calculated between lines passing through long axis of radius and fracture fragment, as shown in Fig. 2a and b, then fracture was classified according to Judet classification.

Steele's modification of Judet classification was used to categorise degree of translational displacement and angular deformity. Follow up was done at 2, 4, 6, 10 and 12 weeks (Fig. 3).

Surgical technique: Patient was positioned supine on operation table with affected upper limb lying on radiolucent hand table. Under general anaesthesia, close reduction was attempted by applying traction to extended elbow in supinated forearm then varus stress to the elbow was applied while applying direct pressure over the radial head (Patterson Manoeuvre). In Neher-Torch method, pressure was applied on radial aspect of radial head, while maintaining varus stress on extended elbow in supinated forearm. Israeli technique was used for difficult reduction, proximal radial fragment was stabilised with thumb's direct pressure, then pronation and flexion of supinated and extended elbow was done. Successful manual reduction suggests <30° and <30% displacement (or even radius neck shaft angle reduced to <45°). After which, an elastic intramedullary nail of diameter 0.7 times of narrowest

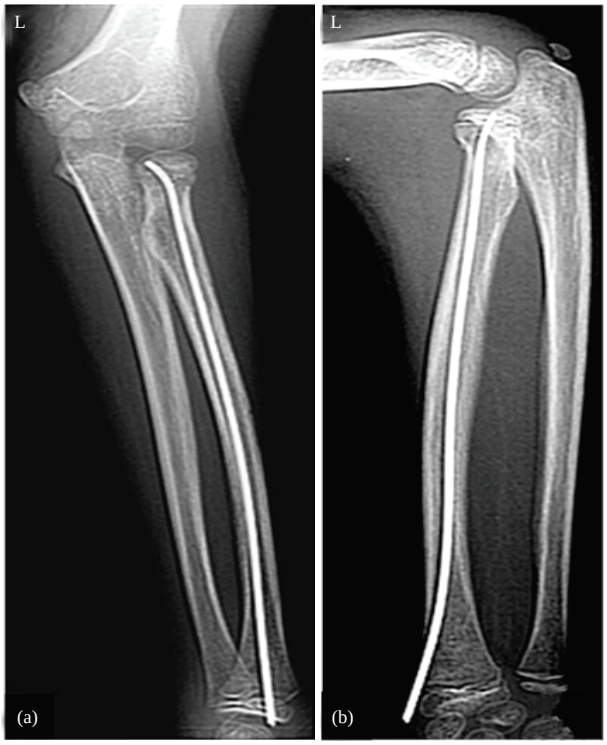

Fig. 4(a-b): Post-operative x-ray, (a) anteroposterior and (b) Lateral view

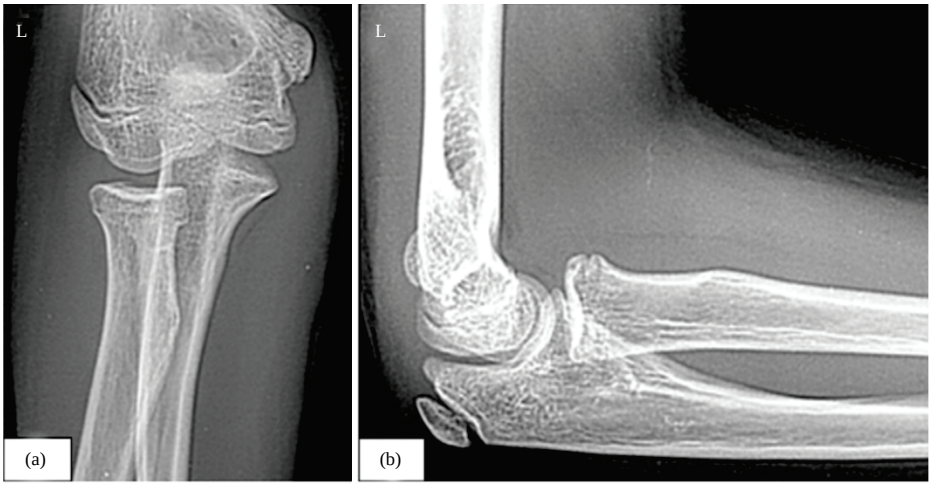

Fig. 5(a-b): Follow up x-ray after implant removal, (a) Anteroposterior and (b) lateral view

width of radius was used for intramedullary fixation. Nail tip was cut in diamond/rhombus shape, which allow reduction of proximal fragment during rotational manoeuvre, and preventing nail slippage through fracture site while allow three-point fixation of radial head, that is at the proximal cut tip end of nail and on both sides of the flat proximal end of nail. Proximal to lateral side of distal radial physis, 2 cm incision was made, carefully dissecting the soft tissue, avoiding damage to cutaneous branch of radial nerve. Nail entry was made with awl under fluoroscopy guidance, then nail was advanced proximally through fracture site and nail cut end was engaged in the radial head. Following that fracture ends were distracted in combination with manual reduction then nail was rotated up-to 180°, to achieve reduction of fracture segment. In unsuccessful reduction, percutaneously 2 mm k-wire was passed in the proximal segment to use it as joystick to reduce the fracture segment by levering. After successful reduction arm was immobilised in functional position under slab for 2 weeks. Early range of motion exercise were stared. Nail removal was done 2-3 months, after radiological signs of fracture healing (Fig. 4 and 5).

Follow up: DASH (Disability of arm, shoulder and hand) scoring system was used for subjective clinical evaluation. It is a disability scoring system, consist of 30 questions, scoring from 0 as best to 5 as worse, measuring symptoms and functional status. The percentage can be calculated as follows:

$$\text{DASH} = \frac{(\text{Sum of n responses}) - 1 \times 25\text{n}}{\text{n}}$$

Where:

n = Total number of questions answered

Elbow clinical examination was done. Any axis deviation was noted. Range of motion of elbow (flexion/extension) and forearm (pronation/supination) was measured and compared with contralateral side and results was classified according to Metaizeau as follows:

- **Perfect:** If normal or full range of motion
- **Good:** If the sum of movement's limitation is <20°
- **Acceptable:**If the sum of movement's limitation is between 20° 40°
- **Bad:** If the sum of movement's limitation >40°

Radiological evaluation includes, steel's type, reduction, healing, and possible avascular necrosis. Radiological results were calculated according to Ursei as follows[9]:

- **Perfect:** If anatomical reduction was achieved
- **Good:** If translation or angulation <20°
- **Acceptable:** If angulation between 20° and 40°
- **Bad:** If angulation >40°

RESULTS

20 patients were treated with this Metaizeau technique, ranging from 8-13 years, with mean age of 9.65 years. 13 patients (65%) were males and 7 patients (35%) were females. 15 cases (75%) involved the right side, 5 cases (25%) involved the left side. 16 patients (80%) are type III, 3 patients (15%) are type IVa and 1 patient (5%) is type IVb, according to Judet classification. 14 patients (70%) had closed reduction, in 4 patients (20%) lever arm technique was used and 2 patients (10%) had open reduction. Clinical examination revealed excellent axis in all patients, with mean DASH score of 2.72%. The ROM examination according to Metaizeau, revealed perfect in 14 patients (70%), good in 4 patients (20%), acceptable in 1 patient (5%) and bad result in 1 patient (5%). Radiological examination according to Ursei, revealed, 15 patients (75%) healed in anatomical position with perfect result, 3 patients (15%) having good results, healed with posterior angulation of 15°, 18° and 10°, 1 patient (5%) healed with malunion and 1 patient (5%) had bad result with pseudoarthrosis. (Table 2) This study shows no correlation between severity of injuries or presence of other fractures and the functional outcomes as illustrated by mechanism of injuries (Table 2) and the functional outcomes (Chart 1-3). One patient that undergone open reduction had developed pseudoarthrosis having bad clinical outcome, close reduction and K-wire assisted reduction was unsuccessful in this patient, hence open reduction with arthrotomy was performed, then fracture was fixed with flexible intramedullary nail, this patient also having minimally displaced coronoid fracture, hence managed conservatively. The mean fracture angulation in male group was 52.84 and in female group it was 57.28.

Complications noted was, skin infection in 1 patient who went for open reduction, which was treated with course of intravenous antibiotics. Metal work prominence was noted in 4 patients, without any functional impairment, which doesn't require any intervention. Deep infection or neurovascular deficit was not encountered in any patients. This study shows, no joint penetration by this technique.

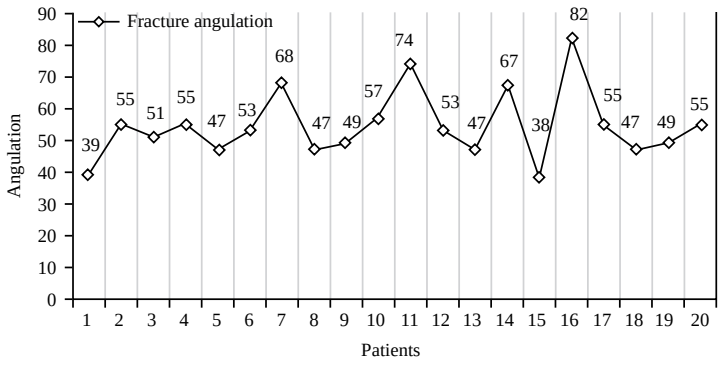

Chart 1: Fracture angulation

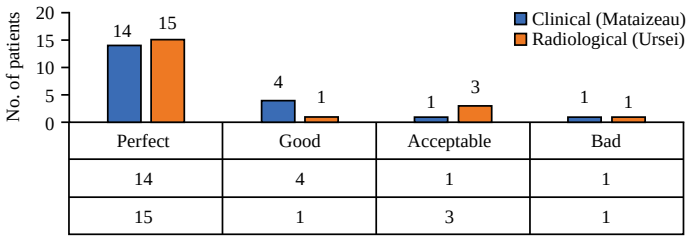

Chart 2: Clinical (Metaizeau) and radiological (Ursei) outcome

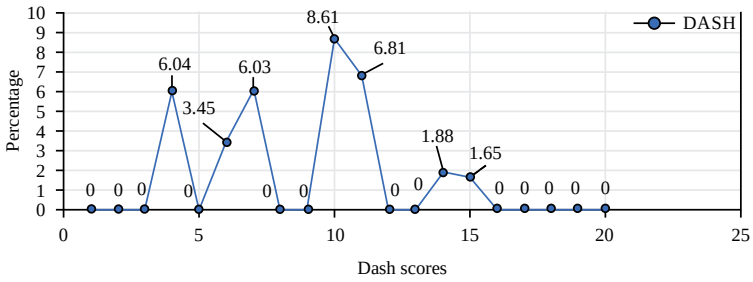

Chart 3: DASH score

Table 2: Patient demographic data's, fracture properties with reduction technique

Age (years)	No.	Percentage
8	8	40
9	3	15
10	3	15
11	2	10
12	2	10
13	2	10
Gender		
Male	13	65
Female	7	35
Side		
Right	15	75
Left	5	25
Injury types		
Fall at the same level	17	85
Fall from tree	1	5
Fall on stairs	1	5
Fall from bicycle	1	5
Associated fractures		
None	13	65
Lateral epicondyle	1	5
Distal radius	2	10
Olecranon	2	10
Coronoid	1	5
Proximal ulna	1	5
Judet types		
III	16	80
IVa	3	15
IVb	1	5
Steele's (grade)		
2	16	80
3	4	20
Techniques		
Metaizeau	14	70
Metaizeau+leverage	4	20
Metaizeau+open surgery	2	10

DISCUSSIONS

Paediatric radial neck fractures are uncommon, accounting for less than 1% of all paediatric fractures and less than 5% of elbow fractures[11]. Literature demonstrating age interval between 4-14 years and peak between 8-10 years of age for paediatric radial neck fracture, this is due to significant fragility before complete ossification of conjugal cartilage of epiphysis (14-17 years old)[1,5,12]. Children radial neck fracture are more common than radial head fracture, due to high chondral ratio in radial head during growth and the narrow neck, which makes is more prone to fracture, usually involving proximal radial physis, producing Salter and Harris Type I or II fracture. There are several options for management of paediatric radial neck fracture, close reduction is difficult with increased fracture angulation, also it can lead to loss of reduction in due course of time[10]. Open reduction allows anatomical reduction but ORIF (open reduction and internal fixation) having its own complications, leading to worse outcome[9,13]. Judet-IV fracture having more worse outcome than Judet-III fracture[14].

This study was done to evaluate the result of management of displaced radial neck fracture by technique described by Metaizeau, which is elastic stable intramedullary nailing technique with extraarticular manipulation.

In the Stiefel *et al*.[15] series, average age is 8 years, 4 months, which is closed to our study mean age of 9.65 years. Predominant mechanism of paediatric radial neck fracture is indirect, caused by fall onto an outstretched hand with elbow extended or slightly flexed with valgus force to the elbow joint[16], which is predominant mechanism of injury in our study. Around 50 % radial neck fracture, can be associated with other elbow related fracture, in our series 25 % having elbow related fractures that is olecranon fracture, coronoid fracture, proximal ulna fracture, lateral epicondyle fracture. Collateral ligament rupture is responsible for elbow instability[15].

In general, conservative management is considered for children <5 years of age, presenting with full pronation and supination, with radial neck shaft angle <50°-60° and with minimum displacement or translation (<2-3 mm)[5,17]. Fracture displacement >50% (or >4 mm) with angulation >30°, should undergo an attempt of close reduction[14,18].

Conservative treatment for minimally displaced radial neck fracture has good results[9,10]. According to Vocke and Laer[19] in children <10 years, angulation up to 50°, can remodel and give good functional results. Al-Aubaidi *et al*.[20] used surgical reduction and fixation in radial neck fracture with angulation >30° with excellent results. However, it believed that, conservative treatment for moderate and severe displaced radial neck fracture with angulation >30°, can lead to decreased ROM with increased risk of avascular necrosis[9,13,15]. Close reduction and plaster immobilisation was done in a series of 28 patients by Steinberg, including those with severe displacement (60-90°), re displacement occurred in 60% of this patient, open reduction was done to maintain reduction but outcome was poor. In our study 2 patients treated with ORIF, despite all methods of close reduction was attempted, one patient having acceptable outcome, other having bad outcome. Comminuted fracture, completely displaced fracture dislocation, interposition of capsule or annular ligament between radial head and neck necessitate, open reduction. Poor outcome in radial neck fracture attributed to higher fracture angulation, improper reduction and complication of open reduction. Metaizeau centro-medullary reduction technique, has diminished the need of open reduction and other fixation technique.

Technique of close reduction and intramedullary pinning for radial neck fracture was proposed by Metaizeau[21], where a Kirschner wire is inserted from posterolateral aspect of radial neck with forearm in pronation to avoid injury to posterior interosseous nerve, fracture reduction achieved by turning the elastic intramedullary nail 180°, this percutaneous leverage technique used for severely displaced radial neck fracture. Fasol, and Schedl[23] and Ugutmen *et al*.[24] reported risk of damage to motor branch of radial nerve, by percutaneous leverage reduction technique and it could damage the physis[24]. How ever our study doesn't show any difference between close reduction or lever arm technique of fracture reduction. 4 patients were managed by this technique in our study having perfect outcome in 1 and good outcome in 3 patients.

Forearm functional arc of motion is pronation of 50° and supination of 50°. Klitscher found that after Metaizeau technique, functional arc is well restored. Functional arc of motion is well achieved in all our patients.

In our study we found that, results were excellent when close reduction method and Metaizeau technique was used. Open reduction results in inferior outcome.

With initial fracture angulation <80°, reduction was stable and gives good to excellent results. Metaizeau *et al*.[10] stated that when initial reduction >80°, there was good outcome in 75% cases, remaining required open reduction. In our study angulation >70° seen in 2 patients (10%), not easily allowing close reduction, hence open reduction was done, affecting the final ROM.

Study done by Zaid *et al*.[20] in a series of 19 children, having mean DASH score of 3.06, being comparable to our study mean DASH score of 2.72.

CONCLUSION

The technique of Metaizeau is closed, minimally invasive, elastic stable intramedullary nailing technique with extraarticular manipulation, is now considered gold standard for paediatric displaced radial neck fracture, yield good to excellent results in paediatric age group in Judet type III and IV radial neck fracture with angulation. Results in our series are excellent. Increased fracture severity with open reduction is associated with poor results.

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