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Closed Treatment of Displaced Fracture Neck of Radius in Children by Metaizeau Technique

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ABSTRACT

Background: Radial neck fractures in the pediatric population represent up to 1% of all pediatric fractures. Judet type III and IV radial neck fractures represent difficulties in closed and open reduction. The Metaizeau technique has been used as a tool to reduce these.

Objective: This study aimed to evaluate the clinical and radiological outcomes following Metaizeau technique for displaced radial neck fracture in children.

Patients and methods: A prospective operation clinical study of 18 patients, with fracture radial neck, who underwent closed reduction and internal fixation with Métaizeau technique. Follow up Clinical and radiological evaluation was performed and any complications were recorded.

Results: The function of elbow according to Mayo elbow performance score was excellent and good in 22.2% and 77.8% respectively. Also, the radiological results were excellent and good in 22.2% and 77.8% respectively. No complications were noted.

Conclusion: We have managed to achieve stable fixation of the reduction without any loss of position and consequently, better outcomes with no complications.

Keywords: Metaizeau technique, Radial neck, Judet classification.

INTRODUCTION

Radial neck fractures in children are rare and account for about 1% of all pediatric fractures and 5-10% of elbow fractures in children [(1)]. Radial neck fractures rarely occur at age of 2 years or less. Since radial head ossification does not occur prior to age of 5 years, these fractures are frequently seen in children aged 4-14 years [(2)]. The age group with the highest prevalence is between 8 and 12 years old. The main injury mechanism is a fall with the elbow in hyperextension, the forearm supinated and valgus force causing radial head compression against the capitulum [(3)].

Radial neck fractures are among the most common pediatric elbow fractures and they account for a disproportionate amount of bad outcomes. Thus displaced radial neck fractures represent unique treatment challenges to the orthopaedic surgeons caring for these children [(4)].

The proximal radius represents a low growth area (as compared to the distal radius) and thus it possesses limited remodeling potential at best. Symptomatic radial neck malunion have been reported along with subsequent corrective osteotomy [(5)]. Radial head fractures and true growth plate fractures of the proximal radius are both quite rare in children as this portion of the bone consistently fails through the periphyseal metaphyseal region otherwise referred to as the radial neck [(6)].

In contrast to these other fractures, true radial neck fractures are quite common as they are among the top 2-3 most frequent pediatric elbow fractures and they are quite clearly associated with a disproportionate amount of bad results [(7)]. Increasing amounts of fracture angulation and translation (uncovering of the metaphyseal fracture surface) have most commonly been associated with those bad outcomes (most frequent being significant stiffness) [(7)].

The method of closed intramedullary pinning of displaced radial neck fractures was described by **Métaizeau *et al.*** in 1980 [(8)]. They also appreciated that the prognosis for radial neck fractures was strongly dictated by 2 factors: severity of displacement and associated injuries to the elbow. It must be remembered that there is remarkably little remodeling potential in the proximal radius as it has been shown that by 8 years of age only 10% of the growth of the radius comes from this region [(9)].

Indications for surgery are primarily driven by fracture displacement, which includes angulation and translation. There are 2 frequently used displacement-focused classification schemes for pediatric radial neck fractures. O'Brien [(10)] classification is most commonly used to categorize radial neck fractures, while European authors typically apply the Judet system. Fracture angulation that meets or exceeds 30° (≥ O'Brien II or ≥ Judet III) is the chief indication for surgery [(9)]. Small series from older literature suggest that translation that meets or exceeds 3-4 mm should also trigger efforts at reduction and stabilization mainly due to concern for cross union [(11)]. Since closed reduction alone fails over 40% of the time, there has been increasing enthusiasm for internal fixation and stabilization of these fractures following reduction. In fairness, there are instances when supplemental reduction is necessary (temporary percutaneous leverage with Kirschner wire) prior to final flexible nail fixation, thus resulting in a Böhler-Metaizeau technique [(12)].

The study aimed to evaluate clinical and radiological outcomes following Metaizeau technique for displaced radial neck fracture in children.

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PATIENT AND METHODS

This operational prospective clinical study was carried out on 18 patients in Department of Orthopedics, Faculty of Medicine, Zagazig University Hospital and Sabrath Teaching Hospital, Libya through the period from March 2021to September 2021. All patients suffered from displaced fracture neck of radius with more than 30° degrees angulations.

Ethical consent:

Detailed informed consent about the study was obtained from every parent. Approval was obtained from Zagazig University Institutional Review Board (ZU-IRB). This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Children and adolescent with displaced fracture neck radius with more than 30° degrees angulations were included in the study. Patients with fracture neck radius with less than 30° angulations, patients after skeletal maturity and patient unfit for surgery were excluded.

All patients were subjected to full history taking including age and gender and mechanism and side of injury. Radiological examination including elbow joint plain X-ray (Antero- posterior and lateral view – radial head capitular view – oblique views to evaluate degree of displacement) was done. Angulation of the fracture was calculated between two lines passing through the radial axis and the fracture fragment on the radiograph. Additionally, clinical examination including edema, limitation of motion and associated injuries was performed. Patients were then classified according to the Judet classification of radial neck fractures as mentioned in Table (2) and patients were planned for operative management [(13)].

Surgical technique:

Under general anesthesia, the upper limb was prepared and draped from the axillary fold to the hand and was placed on a hand table, using an image intensifier, an attempt for closed reduction was made by pulling the extended elbow in a varus direction and applying pressure on the lateral side of the elbow and performing repetitive supination-pronation of the elbow. Trial for close reduction of the radial neck fracture by traction and varus manipulation, then identification of the lateral side of distal radial physis and a 2 cm incision proximal to the physis was made. The soft tissues were dissected carefully, avoiding injury to the delicate cutaneous branch of the radial nerve. The cortex was perforated with a drill. A 1.5-2.0 mm Nancy nail, guided by a handle, was introduced into the medullary canal and then hammered upward until its tip reached the displaced epiphysis. The Nancy nail was then pushed in order to elevate the epiphysis and then turned 180 degrees around its axis to relocate the radial head so the tip points medially reducing the fracture. If the reduction was still not satisfactory, a Kirschner wire was inserted percutaneously, through the fracture from the lateral side and used as a lever arm to reduce the fracture. Finally, the fracture was stabilized with one nail. We used post-operative immobilization in a long-arm cast for 3-4 weeks.

Postoperative care and follow up:

Radiological evaluation:

Standardized anteroposterior and lateral elbow radiographs done at the time of the initial management, after 4 weeks (time of consolidation) and at time of the most recent follow-up (final follow-up), were available for every patient. MRI (magnetic resonance imaging) was performed when avascular necrosis of the radial head was suspected. Any residual angulation was measured on radiographs. Results were considered as follows: excellent if the reduction was anatomic, good if a simple shift or inclination not exceeding 20° persisted, fair if the tilt was between 20° and 40° and poor if it was beyond 40° or there was bone changes such as avascular necrosis and non-union [(14)].

Clinical evaluation:

Early dressing of wound every 3 days (cast evaluation, presence of compartment syndrome and state of the wound). Late evaluation; the range of motion (ROM) of the elbow (flexion, extension) and forearm (supination, pronation) was measured and compared to the contralateral side.

Assessment of Complications: including infections, neurologic (radial nerve injury) complications, non-union and avascular necrosis of the radial head or radio-ulnar synostosis.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc., Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test (χ^2) was used to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean ± SD. Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value < 0.05 was considered significant.

RESULTS

This study was carried on 18 patients, their age ranged from 8 to 14 years with the mean of 11.3 ± 0.48 years, 77.8% were more than 8 years, 67% were males and 33% were female (Table 1).

Table (1): Demographic data of the studied patients.

Variable	Patients (n=18)
Age	
Mean ± SD	11.3 ± 0.48
(Min-Max)	(8-14)
≤8 years	4 (22.2%)
> 8 years	14 (77.8%)
Sex	
Male	12 (67%)
Female	6 (33%)

There were 12 left sided fracture cases (67%) and 8 cases (33%) were right sided displaced fracture neck radius. There were 5 patients had Judet type 3, 10 patients had Judet type 4a and 3 patients had Judet type 4b. Regarding to the angle of radial neck fractures, 55.6% of patients had 60-80 degree angulation, 27.8% had 30-60 degree angulation and 16.6% had > 80 degree angulation (table 2).

Table (2): Affected side, Judet classification and angles of radial neck fractures among the studied patients

Variable	Patients (n=18)
Side	
Left	12 (67%)
Right	6 (33%)
Judet classification	
Type 2	5 (27.8%)
Type 3	10 (55.6%)
Type 4a	3 (16.6%)
Angle	
< 30 Degree Angulation	0 (0%)
30–60 Degree Angulation	5 (27.8%)
60–80 Degree Angulation	10 (55.6%)
>80 Degree Angulation	3 (16.6%)

Regarding characteristics of trauma, all patients had high energy trauma and they fall on out stretched hand, 67% had left side lesion, 33% had right side lesion with no associated injuries. The interval time between trauma and surgery ranged from 2 to 7 days with the mean of 4.2 ± 0.44 days (Table 3).

Table (3): Characteristics of trauma and the lesion of the studied patients

Variable	Patients (n=18)
Trauma (high energy)	
Fall on out stretched hand	18 (100%)
Side	
Left	12 (67%)
Right	6 (33%)
Associated injuries	
NAD	18 (100%)
Interval trauma - surgery (days)	
Mean ± SD	4.2 ± 0.44
(Min-Max)	(2-7)

Regarding Mayo elbow score, 66.7% and 33.3% of patients had good and excellent Mayo elbow score respectively (Table 4).

Table (4): Mayo elbow score of the studied group

Mayo elbow score	Patient n (%)
Excellent 90-100	6 (33.3%)
Good 75-89	12 (66.7%)
Fair 60-74	0 (0%)
Poor 0-59	0 (0%)

The function of elbow according to Mayo elbow performance score was excellent and good in 22.2% and 77.8% respectively, also the radiological results were excellent and good in 22.2% and 77.8% respectively (Table 5).

Table (5): Outcome of the studied patients

Variable		Patients (n=18)
Clinical results (Mayo elbow performance score)	**Excellent** **Good**	4 (22.2%) 14 (77.8%)
Radiological results	**Excellent** **Good**	4 (22.2%) 14 (77.8%)

Figure (1): X-ray of 7 years old girl showing radial neck fracture type 4b Judet classification.

Figure (2): Reduction of a radial neck fracture by Nancy nail in a 7 years old girl.

DISCUSSION

Radial neck fractures are relatively rare in children, accounting for 1% of all fractures in children and 5% to 14% of traumatic elbow injuries. They result from a fall on the outstretched arm, with the elbow extended and the forearm supinated. They typically affect children between 4 and 14 years of age with a peak of incidence ranging between 8 and 10 years of age [15]. The peculiar vascular anatomy of the radial head and neck makes it a zone with a precarious blood supply. The radial head is covered by articular cartilage and vessels enter at level of periosteal attachment. These get damaged at the time of injury and open manipulation. Complications range from stiffness, malunion, osteonecrosis and nerve injury [16].

Various surgical techniques have been used to treat radial neck fractures in children, such as percutaneous joystick reduction with Kirschner wires (KW) and open reduction with or without internal fixation, but the technique of stabilization by elastic stable intramedullary pinning, first described by Metaizeau in 1980 and subsequently developed in 1993, significantly improved the results of surgery [17]. The surgical option used is one of the determining elements of the final functional result. It is clear that the Metaizeau technique reduced the need for open reduction and internal fixation [18].

Both internal fixation technique with closed reduction and open reduction of displaced radial neck fractures have advantages and disadvantages that warrant consideration. First, internal fixation technique with closed reduction does not damage the blood supply. Second, the Metaizeau technique was attempted in all cases, so the elastic stable intramedullary nailing (ESIN) was already placed in the distal radial medullary cavity. The radial neck fracture could easily be fixed by softly tapping the ESIN through the fracture ends. Third, as compared KW fixation, there is no need to drill the radius and no risk of pin-tract infection during internal fixation with closed reduction by ESIN fixation. In contrast, percutaneous KW fixation has the advantages of a simple operation, low costs, and avoidance of secondary surgery to remove internal fixation [19, 20]. **Tollet *et al.*** [21] believe that closed surgery may be indicated even in the case of a large displacement fracture. The open surgery allows an anatomical reduction of the fracture, but it compromises the epiphyseal vascularization which generates a high incidence of complications (radial head necrosis) and a rate of bad result in 40% of the cases [22].

Metaizeau *et al.* [18] proposed a technique of closed reduction and intramedullary pinning for radial neck fractures. A Kirschner wire is inserted from the posterolateral aspect of the radial neck with the forearm pronated to avoid injury to the posterior interosseous nerve. Reduction is achieved by turning around the nail 180°. Percutaneous leverage reduction is used for severely displaced fracture. The principles of this technique are the respect of the biology of the bone consolidation by a percutaneous intramedullary fixation, the non-aggression of the physis thus avoiding the growth disorders, and the early functional recovery.

Because of the good results of this method, it is now accepted worldwide and its benefits being widely recognized [23].

Trabelsi *et al.* [24] reported that displaced fractures neck of radius are frequent around 9-10 years. This is explained by the significant fragility before complete ossification of the conjugal cartilage of the epiphysis (14-17 years old). In **Stiefel *et al.*** [25] study, the average age was 8 years and 4 months. This comes in agreement with our study that was carried on 18 patients, their age ranged from 8 to 14 years with the mean 11.3 ± 0.48.

In **Trabelsi *et al.*** [24] twenty-two patients (11 males, 11 females) were included. While in our study 67% of them were males and 33% were females

Slabaugh *et al.* [26] reported that the mechanism of fractures neck of radius is essentially indirect, which are caused by having "fallen onto an out-stretched hand". In **Trabelsi *et al.*** [24] study, the left elbow was the most often affected (12 of 22 fractures). The mechanism of radial neck fractures in their series was indirect in 14 cases (it was a valgus forced elbow following a fall on the outstretched hand with the elbow extended and the forearm supinated). A direct trauma following a fall with reception on the bending elbow was observed in 8 cases. Their series included a metaphyseal fracture of the radial neck in 8 cases and an epiphyseal separation fracture type II of Salter and Harris in 14 cases. This comes in agreement with our study, which found that all patients had high energy trauma and they fall on out stretched hand.

There is controversy regarding in which angle radial neck fracture can be managed conservatively or how much angulation should be operated. Most of the authors agree that more than 30° angulation require reduction and surgical treatment for children under the age of 10 and more than 15° at the end of growth. However, the treatment strategy is up to surgeon and it is clear that younger patients have more chance to remodel [27]. **Vocke *et al.*** [28] reported that radial neck fractures with an angulation up to 50° in children under the age of 10 had good results with conservative treatment whereas **Al-Aubaidi *et al.*** [18] used surgical reduction and fixation in patients who had radial neck fractures with an angulation over 30° with excellent results. Regarding the angle of radial neck fractures of our cases, 55.6% of patients had 60-80 degree angulation, 27.8% had 30-60 degree angulation and 16.6% had >80 degree angulation.

As regards Mayo elbow performance score, **Klitscher *et al.*** [29] evaluated 24 cases of radial neck fractures that were managed with the Metaizeau technique. The cases were followed up for 32 weeks. Outcomes showed that 82% reported excellent and the remaining had good outcomes. **Kansay *et al.*** [30] study had 76% excellent outcomes amongst seventeen

patients. They reported no complications. In **Trabelsi *et al.*** [24] study based on the MEPS score, they had 15 excellent, 2 good, 4 fair and 1 poor result. **Ursei *et al.*** [14] demonstrated that based on the clinical evaluation criteria presented, they had 14 (70%) excellent, 3 (15%) good, 1 (5%) fair and 2 (10%) poor results. **Yallapragada and Maripuri** [11] recorded at final follow-up that there were 19 (90.5%) excellent or good results, and 2 (9.5%) fair results. In our study, the function of elbow according to Mayo elbow performance score was excellent and good in 22.2% and 77.8% respectively, also the radiological results were excellent and good in 22.2% and 77.8% of patients respectively. In our study the result according to Mayo elbow performance score compared to other studies was low due to that most of the cases had radial neck fracture with angle more than 60 degree Judet classification type 4a.

Regarding complications, no complications were reported in our study. This comes in agreement with **Kansay *et al.*** [30] who reported no complications. Also, **Ursei *et al.*** [14] demonstrated that there was no instance of neurovascular deficit, heterotopic bone formation and radioulnar synostosis or infectious complications during their study. While **Yallapragada and Maripuri** [11] recorded at final follow-up that complications noted were superficial skin infection at the entry site in one patient, which was treated with a course of oral antibiotics. **Klitscher *et al.*** [29] evaluated 28 radial neck fractures and found that three patients reported malunion, in the form of angulation of more than 20 degrees. No other major complications were noted. In a study by **Bither *et al.*** [31] where fourteen children were treated with modified Metaizeau technique. The average follow-up was 39 months. Heterotrophic ossification and transient posterior interosseous nerve palsy were the only complication seen in two patients who had to undergone open reduction. In **Trabelsi *et al.*** [24] study different complications have been noted such as radial head necrosis in 1 case, pseudarthrosis in 1 case and peri-articular calcification in 2 cases. It was noted that epiphyseal fractures had a poor functional outcome in 4 cases whereas only 1 case of poor outcome in metaphyseal fractures.

CONCLUSION

The technique of closed reduction and distal intramedullary nail fixation of the radial neck fractures in children described by Metaizeau in 1980 changed the prognosis of radius neck fracture in children and has given better functional and anatomical results with no complications. We believe that flexible intramedullary nailing using the Metaizeau technique is a good option for displaced radial neck fractures in children.

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