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A Study of Functional Outcome of Retrograde Elastic Intramedullary Nail Fixation in Isolated Radial Neck Fractures in Paediatric Age Group

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ABSTRACT

Radial neck fractures in children are relatively rare injuries, accounting for 1-5% of all paediatric fractures around elbow. Most of them being non-displaced or slightly displaced can be treated conservatively. Severely displaced or angulated radial neck fractures (Judet type III and IV / O'Brien type III) require surgical intervention. To study the clinical and radiological outcomes retrograde elastic intramedullary nail (ESIN) fixation done for isolated radial neck fractures in paediatric age group. There were 7 cases with displaced radial neck fracture(Judet type II, III and IV fractures O'Brien type II, III who underwent closed/open reduction and retrograde ESIN stabilization using K-Wires/Rush Nail/TEN. Functional outcomes were evaluated based on of Mayo Elbow Performance (MEP) Score. All patients achieved complete radiographic healing at a mean of 6 weeks. The mean length of hospital stay was 3 days. Out of 7 patients, 5 patients had an excellent functional outcome and 2 had a good functional outcome. The lowest functional Score was seen in the patient having longest injury to surgery interval and the same patient had requirement to undergo open reduction for the procedure The use of retrograde ESIN fixation for treating radial neck fractures of paediatric age group shows very good functional and cosmetic results, allowing for rapid pain reduction and mobilization. It is a simple, minimally invasive and reproducible technique with a low complication rate. Owing to excellent results, surgical stabilization of radial head and neck fractures using retrograde ESIN fixation is recommended in children and adolescents.

INTRODUCTION

Radial neck fractures occur in 5-10% of all traumatic injuries of the elbow in the paediatric age group and account for 1% of all paediatric fractures[1-3]. Undisplaced radial neck fractures are treated conservatively. The outcome of these fractures is good. However, displaced radial neck fractures have fair to poor outcomes even with operative management. In most of these cases, there may be stiffness and a permanent loss of motion[4-6].

O'Brien Classification for Radial Neck Fracture

Type 1	Deviation Angle <30°
Type 2	Deviation Angle 30°-60°
Type 3	Deviation Angle >60°

Judet Classification for Radial Neck Fracture

Type I	Undisplaced
Type II	< 30 degrees
Type III	30-60 degrees
Type IVa	60-80 degrees
Type IVb	More than 80 degrees

The ossification center of the proximal radial epiphysis appears at the age of 4-6 years. The epiphysis closes at the age of 14-17 years. Fractures through the articular surface of the radial head are rare in children. The epiphysis with a metaphyseal chunk of the radial neck is the most common site of fracture[2]. Several surgical methods for treating radial neck fractures have been described, but the majority of them had poor and unsatisfactory outcomes[6]. Surgical management of paediatric radial neck fractures can be challenging. Multiple strategies exist for reduction and fixation of these fractures without clear consensus on the most appropriate approach for surgical treatment of these injuries. Concerns about elbow stiffness and avascular necrosis exist with open techniques, and while closed or percutaneous reduction options are favoured, these are often technically challenging with only a limited number of attempts recommended before resorting to open techniques due to concerns regarding increased injury, bleeding and stiffness with repeated attempts[7-9]. In our study, displaced radial neck fractures were treated with closed or open reduction methods and fixed with retrograde ESIN from the distal part of the radius. The clinical and radiological outcomes after treatment were analysed.

MATERIALS AND METHODS

A prospective study was conducted in the Department of Orthopaedics, SMIMER Hospital, Surat, Gujarat, India. The study period was from July 2022 to November 2024. There were 7 patients with radial neck fractures who were treated with closed reduction or open reduction and retrograde ESIN fixation.

Inclusion Criteria:

- All paediatric (Age≤16 years) radial neck fractures that are displaced or Judet types II, III and IV fractures or O'Brien types II and III radial neck fractures)[10,11].
- Fracture within 2 weeks of injury.
- Patient's parents who gave written consent.

Exclusion Criteria:

- Open fracture.
- Comminuted fracture.

Fig:1 Pre Operative Xray (Case no. 3)

Patients were evaluated for functional outcome upon subsequent follow ups using the Mayo Elbow Performance (MEP) Score:

Vriable	Defination	No of Points
Pain (Pain max., 45 points)	None	45
	Mild	30
	Moderate	15
	Severe	0
Range of motion (max 20 points)	Are >100°	20
	Are 50-100°	15
	Are <50°	5
Stability (max., 10 points)	stable	10
	Moderately unstable	5
	Grossly unstable	0
Function (max., 25 points)	Able to comb hair	5
	Able to feed oneself	5
	Able to perform personal hygiene tasks	5
	Able to put on shirt	5
	Able to put on shoes	5

Excellent: Score between 90 and 100.

Good: Between 75 and 89.

Fair: Between 60 and 74.

Poor: <60 points.

Surgical Technique: All children were anaesthetized, and upper limb placed in the supine position on a radiolucent operating table. The fracture was first reduced by external manoeuver in the frontal plane with fluoroscopic verification. Kirschner's wires (K-wires), Rush nails or Titanium intramedullary nails (TEN)were used in all patients for fixation. The diameter and length of the nails were selected according to the bone length and child's age. An incision was made proximally from the distal radial physic, carefully protecting the superficial branch of the radial nerve. Using an entry awl/ drill, an entry

point was made 2 cm proximal to the physis[12]. The ESIN was attached to a T-handle and using the image intensifier, advanced proximally with gentle rotational movements until it reaches the fracture. External manipulation was used to try and reduce the fracture as much as possible.

Fig. 2 : Entry into intramedullary cavity and ESIN entry

Fig. 3: Advancement and fixation with ESIN

In case of unsatisfactory results by external manipulation, few methods for closed reduction were tried: Under the guide of the C-arm image intensifier, a leverage K-wire with a 2.0mm diameter was per cutaneously inserted into the bone fragment from the displacement direction of the fractured radial neck fragment. Reduction of the fracture was achieved by leveraging the K-wire and through manual reduction. Then reduction was confirmed with an image intensifier (Fig. 1a, b, c). If the reduction failed, the proximal fracture portion moved dorsally and ventrally after several manipulations, one additional manoeuvre followed. Keeping the injured elbow flexion and neutral position, we let the assistant or surgeon himself with their thumb and index or middle finger to clamp toughly the anterior and posterior of the space between the distal fracture and capitellum to prevent movement in the proximal fracture portion (Fig. 1d and Fig. 2). Then, leverage was conducted again to achieve fracture reduction[13]. The Wallace technique for reduction of radial neck fractures is a previously described technique that employs percutaneous leverage for the reduction of radial neck fractures. A small incision is made on the dorsal subcutaneous border of the ulna at the level of the bicipital tuberosity. An elevator is then placed in the space between the radius and ulna. The elevator is then used to reduce the ulnarly deviated radial shaft to the radial head[7,14-16]. If reduction is imperfect, the Metaizeau technique is then into anatomical position[12]. The nail was advanced with gentle taps across the fracture and up to the subchondral bone, avoiding penetration of the joint. This helps to disimpact the fracture and gives better anchoring of the nail. Then, the nail was rotated 180° so that the tip pointed medially, reducing the fracture. If not successful, a second attempt was made. If the reduction was still not satisfactory, a K-wire was inserted percutaneously through the fracture from the lateral side and used as a lever arm to reduce the fracture[17].

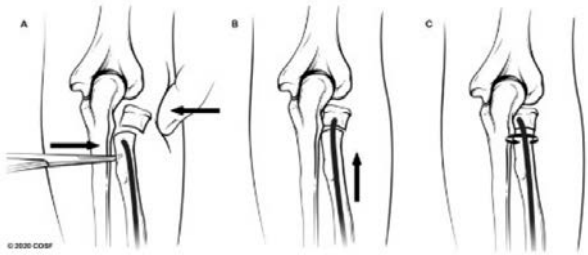

Fig. 4: Metaizeau Technique

Only if unsatisfactory reduction is obtained by closed techniques, is an open approach used for reduction. Thus, after satisfactory reduction is achieved, the fracture was fixed with ESIN.

Fig. 5: Post Operative X-Ray

Post Operative Care and Follow up: The operated limb is placed in a plaster in neutral position and patient is discharged from hospital after appropriate time, allowing for adequate antibiotic and analgesic coverage and called for regular follow-up for stitch removal at 14 days. Thereafter regular follow-up every 14 days is advised till 2 months and check X-rays are performed as required. After signs of complete clinical and radiographic union, generally around 12-16 weeks,

Table 1: Cases Under Study and Outcomes

Case No.	1	2	3	4	5	6	7
Sex	F	M	M	F	F	F	M
Age mean 10.99 years	10	14	10	8	16	9	1
Injurysurgery interval (days) mean 2.42 days	4	1	2	0	3	0	7
Judet Type	III	IVa	IVb	III	IVa	III	IVb
O'Brien type	2	2	2	2	3	2	3
Reduction method	Closed	Closed	K-wire assisted	Closed	Closed	Closed	open
Surgery to Union time (weeks) mean 6 weeks	6	8	6	4	8	4	6
Surgery to ESIN removal time (weeks) mean 13.57	12	14	13	12	16	13	15
MEPS out of 100 mean 91.42	95	90	95	100	85	95	80
Functional Outcome (based on MEPS)	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Good

the ESIN is removed and movement of limb through full range of motion is encouraged. Patient is then followed up for evaluation of restoration of function of limb by the MEP score upon full recovery, generally around 6-8 months.

Fig. 6: After removal of ESIN at 13 weeks Post Op and 6 months Post Op

Fig. 7: Clinical Outcome at 6 months Post Op (carrying angle, flexion, extension, pronation and supination)

RESULTS AND DISCUSSIONS

All patients achieved complete radiographic healing at a mean of 6 weeks. The nails were removed at a mean of 13.57 weeks. The mean age at the time of the surgery was 10.99 years. There seems to be nearly equal distribution of radial neck fracture among male and female patients (3 and 4). Lower number of fractures was found in adolescents and higher in elementary school aged children (2 and 5). The mean total operative time was 32.8 minutes. The mean length of hospital stay was 3 days. In 15 (57.7%) of the patients, the fracture was treated with closed reduction. Owing to difficulty in reduction and soft tissue interposition, the fracture was reduced with percutaneous K-wire assistance in 1 patient and with an open reduction in 1 patient. There was no instance of nail migration during the postoperative period and complications such as radial head necrosis, posterior angulation of >15° and dislocation of the radial head were not seen in any cases. Out of 7 patients, 5 patients had an excellent functional outcome and 2 had a good functional outcome. The lowest functional Score was seen in the patient having longest injury to surgery interval and the same patient had requirement to undergo open reduction for the procedure. There are several treatment possibilities for Judet type III and IV fractures including: percutaneous pinning[18,19], ESIN technique proposed by Metaizeau[20,21] and open reduction with or without internal fixation[22]. It is widely reported in the literature that open reduction leads to worse outcomes instead of a good reduction of the fracture[19,23-25]. In fact, after open reduction, the incidence of avascular necrosis, proximal synostosis, heterotopic ossification, infection, premature physeal closure and loss of ROM is higher than after closed reduction[26,23,25,27]. Therefore, percutaneous methods of reduction have been developed in an effort to avoid the higher incidence of complications associated with open reduction. However, some radial neck fractures, in particular severely displaced, are impossible to reduce with closed methods, requiring open reduction[22,28,29]. We observed good to excellent functional results without affecting the elbow range of motion or patients' activities of daily life, which goes to support the statement that this approach can also be an alternative surgical procedure in the treatment of displaced radial neck fractures in adults. The advantages of this minimally-invasive technique are found in the avoidance of implant-related complications like screw dislocation or perforation affecting the proximal radio-ulnar joint[30]. In addition, the ORIF is associated with a higher rate of avascular necrosis[31,32], proximal synostosis[33], heterotopic ossifications[34], infection and loss of ROM[35], especially in those cases where the plate has to be positioned out of the safe zone due to fracture pattern[36]. A disadvantage to our method is the need for a second surgery for hardware removal, requiring good patient education, motivation and follow up. Additionally, not all paediatric radial neck fractures may be amenable to

this method of fixation. In our series, the median age at time of injury was 10.99 years old, but it is certainly possible that in very young children with Salter-Harris type I fractures, intramedullary fixation may instead result in pushing the fragment further away, which may be further complicated by percutaneous reduction manouvers. We also realized the concern for immobilization of the elbow postoperatively after stabilization of the radial neck fracture. We have not observed any long-term complications resulting from this period of immobilization, however and we do feel that this relatively brief period is necessary and allows for a balance between fragment control while the fracture heals and a short enough duration to prevent undesired permanent loss of movement of the elbow. A final drawback to our study is that this is from a single institution with limited follow-up.

CONCLUSION

Surgical treatment of radial head fractures in children with flexible intramedullary nail provided good functional outcome, being a good option for treating this injury. The use of retrograde ESIN fixation for treating radial neck fractures of paediatric age group shows very good functional and cosmetic results, allowing for rapid pain reduction and mobilization. It is a simple, minimally invasive and reproducible technique with a low complication rate Compared to ORIF, this surgical technique has a minor complication rate, though crucial care has to be taken to avoid any harm to the superficial radial nerve during the approach. Owing to excellent results, surgical stabilization of radial head and neck fractures using retrograde ESIN fixation is recommended in children and adolescents Further research into various methods and variables needs to be done to aid in treatment of this relatively rare type of injury.

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