Intramedullary devices in the management of Judet III and IV paediatric radial neck fractures

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Abstract

Purpose: The aim of this study is to discuss the results of different intramedullary devices used in the management of paediatric radial neck fractures and to suggest methods to avoid the pitfalls of the technique.

Methods: Thirty patients with isolated Judet III and IV fractures were included in this prospective study. Judet I and II fractures and radial neck fractures associated with other injuries were excluded. The final results were graded using the Metaizeau functional scoring system and Oxford Elbow Score.

Results: The functional result was good to excellent in 24 of 30 cases (80%). The mean Oxford Elbow Score was 44.32. The mean follow-up was 40.11 months. The complications seen were radiocapitellar joint penetration in 6 cases at mean 4.87 weeks, redisplacement in 6, radial epiphyseal sclerosis in 5, and heterotopic ossification in 1 case.

Conclusion: Intramedullary K wires may result in radiocapitellar joint penetration. Titanium Elastic Nail System should not be used as purely fixation devices as they may not prevent redisplacement. Regular follow-up until at least 6 weeks is essential. Patients who have a Judet IV fracture and need open reduction should be given a guarded prognosis. The paper highlights the pitfalls of the technique and makes recommendations regarding the type of implant, follow-up and patient counselling in Judet IV fractures.

Keywords: Paediatric radial neck fractures, Judet, Metaizeau, Titanium Elastic Nail System, Level of evidence – IV

Introduction

Radial neck fractures are rare injuries accounting for about 1% of paediatric fractures. However, they constitute 5%–10% of elbow injuries. Minimally displaced Judet I and II fractures can be treated with closed reduction and immobilisation with good long term functional results. In contrast, significantly displaced fractures (>30°) could be managed with manipulation under anaesthesia and percutaneous K wire fixation, reduction with intramedullary devices using the Metaizeau technique or open reduction and internal fixation. The vascular supply to the radial head is precarious. Therefore, indirect reduction techniques using intramedullary devices, which cause less secondary insult, are thought to have better outcomes than open reduction. The present study reports the functional and radiological outcome of displaced radial neck fractures treated with different intramedullary devices, elucidates pitfalls with the techniques used and suggests a pathway to achieve the best possible outcome.

Materials and methods

All the radial neck fractures that presented to our hospital between 2008 and 2015 were radiologically evaluated for the degree of angulation and classified according to Judet’s classification by two independent observers, both senior fellows with a special interest in paediatric orthopaedics. Ethics committee approval was obtained. Isolated closed Judet III and IV fractures in which intramedullary devices had been used were included in our study. All Judet I and II fractures and radial neck fractures associated with other injuries were excluded. Fractures fixed with lateral K wires were excluded. Analysis of prospectively collected demographic data, surgical procedure and functional and radiological outcomes was performed.
The final radiological result was graded as excellent if the fracture healed anatomically; good, if it healed with less than 20° angulation; fair, if it healed with 20°–40° angulation; and poor if the final angulation was more than 40°. Patients with avascular necrosis were graded as a poor result.9

The final functional results were evaluated by the Metaizeau functional scoring system and Oxford Elbow Score to evaluate both physician and patient reported outcome measures. The Metaizeau functional scoring system was based on the loss of movement in any direction.4 The result was graded as excellent if there was no loss compared to the other elbow, good if the loss was less than 20°, fair if the loss was between 20° and 40°, and poor if it was more than 40°. The Oxford Elbow Score was completed by a telephone conversation with the patients and parents. Fisher exact test was performed to find any significant difference in complications between the two groups of devices. Intra and inter observer variability was assessed using intra-class and interclass correlation coefficient.

Surgical technique

In theatre, closed reduction by the Patterson manoeuvre applying traction with the forearm supinated and digital pressure on the radial head along with varus stress was attempted. If it failed, percutaneous K wires were used as a joystick to reduce the fracture. If the fracture was not reduced by this manoeuvre, a decision was made to reduce the fracture using intramedullary devices.

Two types of intramedullary devices were used in our study, K wires with the tip bent 30° to 45° to enable reduction and Titanium Elastic Nail System (TENS, Synthes; Paoli, PA). TENS has a prebend at the tip. The size used depended on the medullary canal’s diameter, so as to allow easy passage rather than a snug fit, filling about 2/3 of the canal diameter as described by Metaizeau. The position of the radial head was noted using the image intensifier, and the nail was advanced to engage it. The surgeon attempted to rotate the tip by 180°, to get anatomical reduction of the fracture. A click and fluoroscopic guidance were used to confirm reduction. Percutaneous K wires were used as a joystick if the tip could not engage the fragment. In the cases where this procedure failed, an incision was made, and partial reduction with the K wire joystick manoeuvre was attempted again to allow engagement of the fragment onto the intramedullary device, failing which the fragment was formally exposed and reduced, with the TENS working only as a fixation device. An above elbow cast was used to immobilise the fracture for 4 weeks.

The patients were followed up at weeks 1, 2 and week 4, to look for any displacement. The cast was removed after noting the periosteal reaction of early union on radiographs. The patient had the provision to come to the hospital at any time if they experienced any problem. The cast was commonly removed at 4 weeks and the elbow was mobilised. The patients were followed up at 6 weeks, 3 months and 6 months. Removal of the intramedullary device was performed after six months.

Results

Thirty patients with closed isolated Judet III and IV radial neck fractures were included in our study. Judet’s classification based on the angulation of the fracture did not show a significant inter and intra-observer variability between the two senior fellows (correlation 0.8). The mean age of the patients was 8.96 years (4.5–12.7 years). The right side was involved in 21 patients (70%) and the fracture had occurred in the dominant hand in 25 patients (83.3%). The demographic and radiological parameters are shown in Table 1.

K wires were used in 10 patients (33.3%) and TENS in 20 patients (66.6%). The method of reduction and fixation is shown in Table 2.

Complications

Pin penetration into the radio-capitellar joint occurred in 6 cases, five of which occurred with K wires. There was a statistically significant difference in pin penetration between K wires and TENS.

Table 1
Demographic and radiological parameters

| Variables          | Number |
|--------------------|--------|
| Gender             |        |
| Male               | 19     |
| Female             | 11     |
| Side               |        |
| Right              | 21     |
| Left               | 9      |
| Hand dominance     |        |
| Dominant           | 25     |
| Non-dominant       | 5      |
| Judet’s classification |      |
| Type III           | 18     |
| Type IVa           | 7      |
| Type IVb           | 5      |

Table 2
Procedures performed

| Treatment                                      | Number |
|------------------------------------------------|--------|
| Closed reduction and fixation by intramedullary device | 20     |
| Closed partial K wire assisted reduction and further reduction by intramedullary device | 5      |
| Partial open K wire assisted reduction and intramedullary device used for fixation only | 3      |
| Open reduction, intramedullary device used for fixation only | 2      |

Fig. 1. Pin penetration.
(Fisher exact test $p = 0.008$). The mean time after fixation, that pin penetration was noted, was 4.87 weeks (range 4.28–5.85 weeks). This is shown in Fig. 1. The nails were removed, followed by an above elbow cast for 2 weeks. Redisplacement of the fracture occurred in one of these cases.

Redisplacement of the fracture occurred in 6 cases (20%). TENS had been used in five of these cases. This is shown in Fig. 2. Analysis of intra-operative images suggested TENS had been used as a fixation device only, rather than a reduction tool. Additionally, the tip had not been turned 180° to the original position of the fragment. The angulation after redisplacement was between 12° and 18°.

Sclerosis of the radial epiphysis was seen in 5 cases, four of which were Judet IV fractures. This is shown in Fig. 3. Two of these cases had an incision made, with partial reduction with K wires and a further reduction using the intramedullary device. The other two cases had a formal open reduction of the fragment. One Judet III fracture developed sclerosis, despite closed reduction and fixation using TENS. Three of the 5 cases were pain free and had a full range of movement at final follow-up.

Of the two cases with formal open reduction, heterotopic ossification was seen in one case, resulting in loss of the range of movement more than 40°. The other case had stiffness and pain at the extremes of movement.

**Outcome**

The mean follow-up was 40.11 months (range 14–86 months). The final functional and radiological results are shown in Table 3. The mean Oxford Elbow Score was 44.32 (range 34–48). There was no statistically significant difference in Oxford Elbow Score between the cases that redisplaced and the cases that had no complications ($p = 0.783$).

**Discussion**

Minimally displaced radial neck fractures can be treated conservatively. Significantly displaced fractures are rare and their management can be challenging. The proximal radial epiphysis is covered with cartilage that receives its vascular supply from the periosteum, in a distal to proximal direction. Intramedullary devices enable fracture reduction, minimally invasive internal fixation and preservation of the vascular supply. However, in fractures with significant displacement, the inability of the nail tip to engage the fragment necessitates additional techniques like usage of percutaneous K wires as a joystick or formal open reduction.

We used K wires as intramedullary devices in the beginning of our series and noticed an unacceptable number of pin penetrations into the radiocapitellar joint during follow-up, resulting in early removal. The intra-operative images and case notes were revisited and pin penetration during the procedure was not seen in any of these cases. Therefore, we believe that pin penetration occurred as a progressive phenomenon in one case where open reduction was performed and there was minimal metaphysis attached to the physis. We also noted that all the pin penetrations occurred between 4 and 6 weeks. We suspect that during this period, either

| Table 3 | Final functional and radiological result. |
|----------------|------------------------------------------|
| **Outcome**    | **n (%)**                                |
| Radiological result |                                       |
| Excellent       | 24 (80.0)                                |
| Good            | 6 (20.0)                                 |
| Metaizeau functional scoring system |                                    |
| Excellent       | 20 (66.6)                                |
| Good            | 4 (13.3)                                 |
| Fair            | 4 (13.3)                                 |
| Poor            | 2 (6.6)                                  |

![Fig. 2. Redisplacement.](image2)

![Fig. 3. Sclerosis.](image3)
some ‘settling’ occurs at the fracture site or the vascularity of the proximal fragment undergoes change to make it softer and weaker thus predisposing it to penetration with early mobilization. We therefore stress the importance of close follow-up until 6 weeks in these cases and suggest that if K wires are used, keeping the cast for at least 6 weeks may avoid this complication, similar to lateral condyle humerus fractures fixed with K wires. Although our initial experience with K wires resulted in pin penetration, our follow-up is not long enough to definitively establish the earlier occurrence of arthritis in this cohort.

In 83.3% of the cases where redisplacement occurred, blunt tipped TENS had been used as a fixation device rather than a reduction tool and had not been turned through 180° from the initial position of the proximal fragment.16 We propose that, the position of the fragment should be noted prior to the introduction of the nail, and the nail tip should be turned through 180° after properly engaging the fragment to effect reduction and secure fixation.17 Over reduction is prevented by the intact periosteum.16 A click may be heard if the reduction is adequate. We suggest that TENS should not be used as purely a fixation device after effecting reduction using K wire joystick method or open reduction, if they have not engaged the fragment. We recommend that engagement of the nail to the fragment may be checked by moving the nail and seeing the movement of the fragment, if using it to ‘fix’ the fragment after reduction by other methods.

Formal open reduction may be required when closed methods fail.12 The two cases in our series that had an open reduction had significant functional restriction due to stiffness and heterotopic ossification. Although some reports suggest no difference in outcome between open and closed reduction and fixation,12 a majority of series in literature on the subject conclude that open reduction results in a worse outcome.13

Poor results have been attribute to early closure of physis and avascular necrosis.5 Therefore, we recommend that in Judet IVb fractures, the patients should be counselled pre-operatively about the possibility of stiffness despite fracture union and feel that a non-anatomical closed reduction may result in better functional results than an anatomical open reduction.

The sclerosis seen in our cohort may allude to possible development of avascular necrosis in Judet IV fractures.11 Careful dissection and soft tissue handling is important to avoid this complication. In the medium term, these patients do not seem to have any functional deficit. We feel that revascularization of the epiphysis may have resulted in good medium term outcomes. However, the long term prognosis is unclear.

We noted good to excellent results in almost 80% of our patients, which was comparable to other series in literature.14,15 This establishes the utility of the technique in the management of these challenging cases.

In conclusion, intramedullary devices can be used in the management of significantly displaced paediatric radial neck fractures with good functional and radiological outcomes. We feel that adherence to good surgical technique which involves engagement of the nail tip into the fragment and reduction by turning the tip through 180° results in a lower complication rate. Sharp tipped intramedullary devices like K wires should not be used, as there is a high rate of radiocapitellar joint penetration. Blunt tipped devices should not be used as purely fixation devices if they were not used to engage and effect reduction of the fracture, as they may not prevent redisplacement. Patients who have a Judet IV fracture and need open reduction should be closely followed up and given a guarded prognosis.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.cjtee.2017.08.007.

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