Elastic stable intramedullary nail fixation for severely displaced fractures of the neck of the radius in children

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Several techniques are available for the treatment of displaced fractures of the neck of the radius in children. We report our experience in 14 children treated by indirect reduction and fixation using an elastic stable intramedullary nail. The patients were followed up for a mean of 28 months. One developed asymptomatic avascular necrosis. The rest had excellent results. One had a neuropraxia of the posterior interosseous nerve, which recovered within six weeks. We advocate elastic stable intramedullary nailing for the closed reduction and fixation of these fractures in children.

Fractures of the neck of the radius constitute 5% of elbow injuries and 1% of all injuries in children.¹ Ossification of the epiphysis of the head of the radius begins at four years of age and it fuses at the age of 14 in females and 17 in males.¹ By four years of age the head and neck have assumed their adult shape,² with a physiological angulation of the neck in the anteroposterior (AP) plane of an average of 12.5° laterally³ and in the lateral plane of an average of 3.5° anteriorly. This should be recognised during treatment. Displaced fractures are rare, but when they occur they can be difficult to treat. Reported complications of these injuries in children include elbow stiffness, avascular necrosis (AVN) and overgrowth of the head of the radius.³⁻⁵ The elastic stable intramedullary nailing (ESIN) technique⁴ uses indirect reduction and fixation of the fracture with preservation of the soft-tissue attachments. We report a series of children treated with this technique.

Materials and Methods

The patients were grouped according to Judet's classification (Table I).⁶ Judet types I and II can be treated non-operatively with good long-term results^{4,5} and we excluded such fractures from our study. All children who attended our unit between October 2000 and March 2005 with type III or IV fractures were included. The majority were treated initially by closed manipulation to improve the position of the fracture, followed by ESIN. They were followed up until full functional recovery was achieved, when the outcome was assessed by the Metaizeau functional scoring system.⁴ This

Table I. Judet classification of fractures of the neck of the radius

Type	Description
I	Undisplaced
II	Angulation < 30°
III	Angulation 30° to 60°
IV	a) Angulation 60° to 80° b) Angulation > 80°

is based on range of movement in any direction (excellent: no loss of movement; good: < 20° loss; fair: 20° to 40° loss; and poor: > 40° loss). At final follow-up the children were reviewed with regard to any long-term problems. All had standard AP and lateral radiographs of the affected elbow on admission, post-operatively, at six weeks, and at discharge.

Surgical technique. A single nail was used in all cases. Its length is measured from the subchondral area of the head to the distal radial growth plate using an image intensifier, with an extra 5 cm added to facilitate a secure hold on the T handle during rotation of the nail. The diameter of the nail is 2 or 2.5 mm, the former being used in children under ten years of age and the latter in older children. The implant can be stainless steel or titanium. A sharp tip helps penetrate the cancellous bone of the proximal epiphysis.⁷ The terminal 3 to 4 mm of the nail is bent to approximately 45° to catch the displaced epiphysis and the rest is pre-bent as a gentle curve of 20° to obtain three-point fixation. Under a general anaesthetic, the patient lies supine with the upper limb draped and placed on a hand table. A lateral skin incision of 2 to 3 cm extends proximally from the distal

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Fig. 1

Surgical technique of elastic stable intramedullary nailing assisted reduction and fixation of severely displaced fracture of the neck of the radius.

Fig. 2a

Fig. 2b

Figure 2a – Pre-operative radiograph showing Judet type IVb fracture of the neck of the radius. Figure 2b – Post-operative re-alignment of the radial head using elastic stable intramedullary nailing.

Table II. Patients details

Patient	Age (yrs)	Sex	Type of fracture	Associated fracture	Mechanism of injury	Complication	Approach
1	10	M	IVa		Fall – football		Closed
2	11	F	III		Fall – bike		Closed
3	9	F	IVa		Fall – climbing frame		Closed
4	12	F	IVb	Ulnar shaft	Fall – slide		Closed
5	10	F	IVb		Fall – on the steps		Percutaneous K-wire [†] assisted
6	12	M	IVa	Olecranon	Fall – trampoline		Closed
7	4	F	III		Fall – slide		Open reduction
8	11	F	IVb		Fall – bouncy castle	AVN*, Neuropraxia	Open reduction
9	12	F	IVb		Fall – trampoline		Closed
10	9	M	IVa		Fall – bike		Closed
11	10	F	IVa		Fall – handstand		Percutaneous K-wire assisted
12	10	M	IVb		Fall – football		Closed
13	7	F	IVb		Tripped on kerb		Percutaneous K-wire assisted
14	13	M	III	Olecranon	Fall – football		Closed

* AVN, avascular necrosis

† K-wire, Kirschner wire

radial physis, carefully protecting the superficial branch of the radial nerve. Using a drill 1 mm wider than the chosen nail, an entry point is made 2 cm proximal to the physis. The nail is attached to a T handle, introduced (Fig. 1a) and, using the image intensifier, advanced proximally with gentle rotational movements until it reaches the fracture. Displacement needs to be assessed by the image intensifier and the tip of the nail directed towards the maximum tilt of the epiphysis. External manipulation is used to try and reduce the fracture as much as possible. The nail is advanced with gentle taps across the fracture and up to the subchondral bone (Fig. 1b), avoiding penetration of the joint. Displacement of the radial head is usually lateral or posterolateral, and therefore the nail is rotated anteriorly (Fig. 1c) and then medially (Fig. 1d). The intact periosteum prevents over-correction of the fragment. Pronation of the forearm may also help reduction. If the epiphysis is displaced anterolaterally, the nail needs to be rotated posteriorly and medially.

In type IVb fractures (Fig. 2a) it may be difficult to catch the displaced epiphysis. Percutaneous K-wires are then used to obtain partial reduction before the nail is advanced. The distal end of the nail is cut 1 cm proud of the bone to facilitate later removal. The skin is sutured and an above-elbow back slab applied for comfort. This is removed after two to three weeks and the elbow mobilised.

Results

We treated 14 patients with severely displaced fractures (Table II). All were closed injuries and 12 were sports related. The mean age of the patients was 10 years (4 to 13), nine were girls and three cases involved the non-dominant side. Three patients had associated injuries, two with fractures of the olecranon and one of the shaft of ulna, in the same limb. These were also treated surgically.

All children stayed in hospital overnight, and were followed up as outpatients until functional recovery was achieved. All were operated on within 48 hours, except for

one who had an open reduction at nine days following referral from another hospital a week after the injury. Three children required immobilisation for six weeks because of associated fractures. The nails were removed at a mean of 12 weeks (8 to 18), being retained for longer in the three patients with associated injuries. Twelve patients had a closed reduction, three with K-wire assistance, and two had an open reduction followed by ESIN. One patient with an open reduction had a neuropraxia of the posterior interosseous nerve, which recovered completely after six weeks, and later developed asymptomatic avascular necrosis of the radial head. She remains under long-term care. At the final review all patients were assessed for pain, movement of the elbow and forearm and radiological union. Functional outcome showed 13 as excellent and one good.

Discussion

The proximal epiphysis of the radius has no soft-tissue attachments and open reduction of fractures can compromise the periosteal blood supply, leading to avascular necrosis.^{3-5,8,9} Various methods are described to treat severely displaced fractures in children.^{4,5,7-14} The role of open reduction is controversial. Traditionally, it was performed if closed manipulation failed, but as complications after open reduction are common; many authors advocate closed reduction and stabilisation whenever possible.^{12,15,16} Open reduction is reserved for fractures where possible functional problems secondary to deformity may outweigh the risk of disturbing the blood supply.

The ESIN technique of Metaizeau et al⁴ has been shown to give better results in severely displaced fractures^{4,7} of the radial neck in children. It has the advantage of achieving acceptable indirect reduction without disturbing the blood supply. As the distal end of the nail is left under the skin, the chance of pin-tract infection is minimal. Rotational movements can be regained after a short period of immobilisation. Removal of the implant is easy and without major complications.

In our series three patients (21%) had an associated fracture compared with a reported incidence of 30% to 50%.^{10,16} We have treated all our patients with a single nail without losing reduction. We used blunt titanium nails in seven of the patients and sharp stainless steel nails in the remainder. We found no difference in outcome, although the sharp nail facilitates the technique and more easily engages the epiphysis to assist in reduction. Theoretically, the blunt nail can distract the fracture site and struggle to engage the epiphysis.

We recommend ESIN for severely displaced radial neck fractures in children. The technique is not as difficult as may be thought; our results were good, with a low rate of complications.

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References

1. O'Brien PJ. Injuries involving radial head epiphysis. *Clin Orthop* 1965;41:51-8.
2. Roger W Somers. Skeletal system. In: *Gray's anatomy*. 35th ed. Churchill Livingstone 1995:635.
3. Vahvanen V, Gripenbergh. Fracture of the radial neck in children: a long-term follow-up study of 43 cases. *Acta Orthop Scand* 1978;49:32-8.
4. Metaizeau JP, Lascombes P, Lemelle JL, Finlayson D, Prevot J. Reduction and fixation of displaced radial neck fractures by closed intramedullary pinning. *J Pediatr Orthop* 1993;13:355-60.
5. Schmittenebecher PP, Havernick B, Harold A, Knorr P, Schmid E. Treatment decision, method of osteosynthesis and outcome in radial neck fractures in children. *J Pediatr Orthop* 2005;25:45-50.
6. Judet H, Judet J. *Fractures and orthopedique de l'enfant*. Paris: Maloine, 1974: 31-9.
7. Lascombes P. Radial head and neck fractures in children. *Surgical techniques in Orthopaedics and Traumatology* 2000.
8. Biyani A, Mehara A, Bhan S. Percutaneous pinning for radial neck fractures. *Injury* 1994;25:169-71.
9. Futami T, Tsukamoto Y, Itoman M. Percutaneous reduction of displaced radial neck fractures. *J Shoulder Elbow Surg* 1995;4:162-7.
10. Radomisli TE, Rosen AL. Controversies regarding radial neck fractures in children. *Clin Orthop* 1998;353:30-9.
11. Huber RI, Keller HW, Huber PM, Rehm KE. Flexible intramedullary nailing as fracture treatment in children. *J Pediatr Orthop* 1996;16:602-5.
12. Metaizeau JP. Reduction and osteosynthesis of radial neck fractures in children by centromedullary pinning. *Injury* 2005;36 (Suppl 1):75-7.
13. Dawson FA, Inostroza F. Arthroscopic reduction and percutaneous fixation of a radial neck fracture in a child. *Arthroscopy* 2004;20(Suppl 2):90-3.
14. Steele JA, Graham HK. Angulated radial neck fractures in children: a prospective study of percutaneous reduction. *J Bone Joint Surg [Br]* 1992;74-B:760-4.
15. Vocke AK, Von Laer L. Displaced fractures of the radial neck in children: long-term results and prognosis of conservative treatment. *J Pediatr Orthop B* 1998;7:217-22.
16. D'souza S, Vaishya R, Klenerman L. Management of radial neck fractures in children: a retrospective analysis of one hundred patients. *J Pediatr Orthop* 1993;13: 232-8.