Closed reduction and Nancy nail fixation for forearm fractures in children

Ahmed El Naggar, Molham M. Mohammad

Department of Orthopedics, Cairo University, Giza, Egypt

Correspondence to Molham M. Mohammad, MD, 84 Road No. 10; Maadi, Cairo, Egypt; Tel: +20 227 549 394; e-mail: molhammf@hotmail.com

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Background
Forearm fractures in children are common. Children forearm fractures are managed differently than are similar injuries in adults. Treatment alternatives of irreducible unstable pediatric forearm fractures are closed remanipulation under general anesthesia and casting, Kirschner wire and casting, closed or miniopen reduction and intramedullary fixation, and open reduction and internal fixation with plates. The intramedullary nail fixation is preferable in many circumstances to open reduction and plating of the forearm bones as it prevents stripping of the soft tissues; in addition, there is little in the way of surgical scar tissue and is therefore cosmetically acceptable.

Patients and methods
Thirty-six [32 (88.8%) boys and four (11.2%) girls] patients with fractures of both bones of the forearm were treated with elastic stable intramedullary nails. The surgery was performed within 20 h (range: 12 h–2 days). The fractures were classified according to the Orthopedic Trauma Association classification. All operations were carried out under general anesthesia and under an image intensifier control. Closed manipulation of fractures was performed to correct the length, rotation, and angulation. Blunt-ended 1.5–2.5-mm diameter titanium nails were used. An above elbow splint was applied.

Results
Functional results were evaluated according to the criteria of Price and colleagues. An excellent result was achieved in 30 (83.3%) patients and a good result in six (16.7%) patients. Three (8.3%) patients had olecranon bursitis due to irritation of the nail, which was resolved after nail removal. Two (5.6%) patients had superficial wound infection (redness and hotness) at the entry site of radial nail and were treated with repeated dressings and empirical antibiotics for 10 days.

Conclusion
The advantages of an elastic intramedullary nail fixation for the radius and ulna fractures are that it is technically straightforward, allows a high rate of osseous consolidation, is minimally invasive, and allows early mobilization.

Keywords:
children, fractures, Nancy nails, radius and ulna

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Introduction

Forearm fractures in children are common. Diaphyseal fractures of the forearm account for ~13% of all pediatric fractures [1,2]. In boys, there is a bimodal peak, the first at approximately age 9 years and the second at ~13 or 14 years. Girls show a single peak at approximately age 5 or 6 years. Children forearm fractures are managed differently than are similar injuries in adults. Historically, the results of nonoperative treatment of adult forearm fractures have been poor, with reports of nonunion, malalignment, and stiffness due to the lengthy immobilization required for union. Currently, most adults with both-bone forearm fractures are treated by open reduction and internal fixation. In pediatric patients, treatment is primarily nonoperative because of rapid healing and the potential for remodeling of residual deformity. A small proportion (3–4%) is unstable and requires operative intervention [3].

Treatment alternatives of irreducible unstable pediatric forearm fractures are closed remanipulation under general anesthesia and casting, Kirschner wire and casting [4], closed or miniopen reduction and intramedullary fixation [5], and open reduction and internal fixation with plates [6].

The intramedullary nail fixation is preferable in many circumstances to open reduction and plating of the forearm bones as it prevents stripping of the soft tissues; in addition, there is little in the way of surgical scar tissue and is therefore cosmetically acceptable [5].

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The aim of our study was to evaluate the Nancy nails (elastic stable intramedullary nail) fixation as a modality of treatment for fractures of shaft of both bones of forearm.

Patients and methods

From March 2008 to September 2011, 36 [32 (88.8%) boys and four (11.2%) girls] patients with fractures of both bones of the forearm were treated with elastic stable intramedullary nails. This study approved by the Ethical committee of Cairo University, Giza, Egypt. Patients with the following criteria were included in our study: irreducible fractures, with or without soft-tissue interposition; fractures shortly before skeletal maturity; patients for whom it was not possible to achieve a stable reduction and thus had to undergo fixation under the same anesthesia; patients with unaccepted reduction; and patients with unstable fractures in whom redisplacement occurred within 1 week of closed reduction and casting.

Patients with open fractures and patients with a stable accepted reduction of fractures were excluded from the study.

Their average age at presentation was 10.5 years (range: 6–15 years). The right forearm was affected in 15 (41.7%) patients and left forearm in 21 (58.3%) patients. The mechanisms of injury were motor vehicle accident in two (5.5%) patients, fall during sporting activities in 26 (72.3%) patients, and bicycle accident in eight (22.2%) patients. The surgery was performed within 20 h (range: 12 h–2 days).

All patients were evaluated with radiography – anteroposterior and lateral views for forearm. The fractures were classified according to the Orthopedic Trauma Association classification. All the patients had simple fractures of both ulna and radius (22-A3). All patients had complete fractures; the fractures were angulated more than 20° in 23 (63.9%) patients, angulation between 10 and 20° in five (13.9%) patients, and unaccepted displacement (>75%) in eight (22.2%) patients.

Operative technique

The parents were consented for the operation and they were informed at the time of surgery that their child would need to attend hospital for a day for the removal of the implant under general anesthesia after the fractures were united.

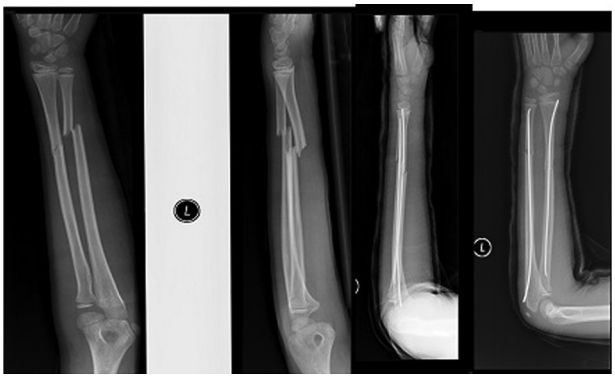
All operations were carried out under general anesthesia and under an image intensifier control. A pneumatic tourniquet was applied to minimize bleeding. Closed manipulation of fractures was performed to correct the length, rotation, and angulation. Open reduction was not needed in any fracture. We introduced the first nail in the bone with the most accepted reduction. We used a standard distal approach to the radius and a proximal approach to the ulna, as described by Lascombes *et al.* [7], who entered the ulna just distal and lateral to the olecranon apophysis. The radius was approached radially just proximal to the distal physis with protection of the superficial radial nerve. A 45° oblique hole was drilled in the lateral cortex of the metaphysis to allow nail insertion. Blunt-ended 1.5–2.5-mm diameter titanium nails were used. The nails were curved slightly to allow three-point fixation. The tip was bent 30–40° to allow manipulation in the medullary canal. The bent tip should not exceed 5 mm in length. The nail was manipulated across the fracture site and advanced to the cancellous bone of the metaphysis. Rotation of the curved nail allows correction of angulation and restoration of radial bow. The range of motion was examined to assess restoration of normal range and to assess the stability of the fixation. The nails were then bent at the insertion site and cut short enough to avoid skin irritation (Fig. 1).

An above elbow splint was applied. All patients remained in hospital overnight for assessment of postoperative pain and swelling.

Follow-up

Patients reviewed initially at weekly intervals for wound inspections and to ensure satisfactory position of the nails and the fracture. Splint was removed at 4 weeks and below elbow cast was applied for 2 weeks. Cast was removed at 6 weeks when callus appeared in radiography. The normal activity was allowed but sports activity was prohibited for 3 months. The

Figure 1



Radiography of left forearm in a 12 years boy showing fractures of radius and ulna before and after the elastic nail fixation.

Figure 2

Radiography at time of cast removal at 6 weeks (a) and at 6 months before nails removal (b).

fractures were followed up for union with radiography. The nails were removed after 6 months. The average follow-up time was 18 months (range: 6–24 months) (Fig. 2).

Results

The average operative time was 55 min (range: 35–90 min). The results were evaluated according to the fracture union, functional results, and complications. Bony union was observed in all patients in an average 7.4 weeks (range: 6–9 weeks).

Functional results were evaluated according to the criteria of Price *et al.* [8]. They assessed the presence of pain and/or the degree of loss in forearm rotation (Table 1).

According to the criteria of Price *et al.* [8], an excellent result was achieved in 30 (83.3%) patients and a good result in six (16.7%) patients. Three (8.3%) patients had olecranon bursitis due to irritation of the nail, which resolved after nail removal. Two (5.6%) patients had superficial wound infection (redness and hotness) at the entry site of radial nail and were treated with repeated dressings and empirical antibiotics for 10 days.

None of the patients had complications such as compartment syndrome, limb-length discrepancy, epiphyseal damage, angular or rotational deformity, synostosis, limited elbow or wrist range of motion, or refracture after nail removal.

Discussion

The initial treatment of pediatric forearm fractures should be closed reduction and casting [9,10]. However, this treatment is associated with loss of reduction and poor functional results in 5–7% of the patients [11,12].

There is controversy on the degree of acceptable angulation after closed reduction and casting. Despite

Table 1 Grading system of Price *et al.* [8]

Outcomes	Symptoms	Loss of forearm rotation
Excellent	No complaints with strenuous activity	≤10°
Good	Mild complaints with strenuous activity	11–30°
Fair	Mild complaints with daily activity	31–90°
Poor	All other results	>90°

reports considering more than 20° of angulation an indication for surgery in pediatric diaphyseal forearm fractures [13], many studies recommend surgical intervention in the presence of more than 10° of angulation following closed reduction [8,14–19].

However, there is an agreement that a rotational deformity cannot be accepted in any case [14].

In fractures with angular deformities, the amount of spontaneous remodeling is related to the age of the patient [8,13], degree of deformity [15], proximity of the fracture line to the physis [8], and the degree of radial and/or volar angulation [20].

After the age of 10 years, the remodeling potential of the bones decreases significantly [5,8,12,16]. Thus, anatomic reduction is essential in children older than 10 years to avoid limitation in forearm supination or pronation [21].

The localization of the fracture is another factor affecting the clinical outcome. It has been reported that middle-third fractures cause more functional limitations compared with distal-third diaphyseal forearm fractures [15,22].

For these reasons, the age of the patient in relation to the degree of angulation was considered in deciding the favor of the surgical intervention. Thus, angulations greater than 20 and 10° were treated surgically in children younger and older than 10 years, respectively [15].

Good results have been reported with open reduction and internal fixation using plates in the management of both-bone forearm fractures [6,16,23,24]. However, this method requires a wide surgical exposure and is preferred in more skeletally mature pediatric patients [24].

Various types of intramedullary implants have been used to stabilize adult forearm fractures [7,25–28]. However, supplemental immobilization is often

required, and nonunion rates in adults have ranged from 6 to 20% [25–29]. In children, nonunions are rare, and minimal intramedullary fixation can maintain acceptable alignment until fracture healing occurs. The advent of image intensification has made it easier to stabilize a closed reduction with intramedullary devices inserted through percutaneous routes. The relative simplicity and low morbidity of intramedullary fixation have popularized this technique for pediatric forearm fractures.

The site for ulnar nail insertion is controversial. Amit *et al*. [30] recommended pinning the ulna first through a 1-cm incision over the olecranon apophysis, and Rabinovich *et al*. [31] reported that intramuscular nail fixation through the olecranon apophysis for surgically indicated ulnar fractures has minimal outcome limitations, with no evidence of prospective growth disruption. We preferred to approach the ulna distal to the apophysis as Lascombes *et al*. [7] recommended, avoiding injury to apophysis and irritation at the elbow.

In general, it is easier to begin from the proximal ulna due to the subcutaneous approach, the straight shape of the bone, and wide medullary canal [32,33]. However, we preferred to start with less-comminuted and less-displaced fracture as it is easier in introduction and it might help in restoring the length and alignment of the forearm.

Fixation of only one bone (when both are fractured) is a less invasive modification of the technique that facilitates treatment by allowing the other fracture to be rotated into reduction. Although Flynn and Waters [34] and Myers *et al*. [35] have reported good results with this technique, others have cited a slightly higher risk for loss of reduction with single-bone fixation [21,36].

Lascombes *et al*. [7] reported 6% of their patients needed an open reduction because of soft-tissue interposition but, on the contrary, Verstreken *et al*. [9] reported they did not need open reduction in any of their patients. In our study no patient needed an open reduction.

The necessity and duration of immobilization in the postoperative period is unclear. Some authors have recommended early active range of motion without immobilization for better soft-tissue and fracture healing [7,9]. Lascombes *et al*. [7] reported secondary displacement of the fracture in 5% of the patients when postoperative immobilization was not used. In our study, postoperative immobilization was used as an adjunct to the osteosynthesis till callus formation after 6 weeks and no redisplacement was recorded.

Bony union was achieved in all patients and it was similar to the results of other reports using elastic intramedullary nails [7,9,11,31,37].

Our functional results were comparable with the results of other surgeons using elastic intramedullary nails. Amit *et al*. [30], Versrtreken *et al*. [11], and Luhman *et al*. [37] reported excellent results in all their patients. Lascombes *et al*. [7] reported excellent results in 92% of their patients. Richter *et al*. [11] reported excellent results in 80% and good results in 16% of cases. Cullen *et al*. [21] obtained excellent or good clinical results in 95% of their patients.

Minor complications reported as wound infection and ulnar bursitis were reported in the literatures and they did not affect the functional results [7,21,33].

Limitations of our study were the small number of patients and that there was no control group for comparison.

Conclusion

The advantages of an elastic intramedullary nail fixation for the radius and ulna fractures are that it is technically straightforward, allows a high rate of osseous consolidation, is minimally invasive, and allows early mobilization.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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