



Titanium elastic intramedullary nailing : closed or mini-open reduction ?

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The authors retrospectively studied 43 children with femoral fractures, treated with titanium elastic nailing (TEN). Twenty-two underwent closed fluoroscopic reduction (Group I), whereas the other 21 underwent mini-open reduction (Group II). The operation time averaged 71 minutes in group I, and 48 minutes in group II ($p < 0.001$). The mean fluoroscopy time was 79.3 seconds in group I, and 35.5 seconds in group II ($p < 0.001$). However, blood loss and hospital stay were significantly higher in group II ($p < 0.001$ and $p = 0.001$ respectively). Time to full weight bearing, time to radiographic union and TEN outcome score did not differ significantly. Overall, no one technique was really superior. From a practical viewpoint, a mini-open reduction may be decided intra-operatively if closed reduction proves to be problematic. This decreases intra-operative radiation and length of the surgical procedure.

Keywords : paediatric ; femur ; fracture ; titanium elastic nails ; mini-open reduction.

immobilization (5,8). However, prolonged immobilization, pin-tract complications and refracture are annoying side effects of this conservative treatment. In recent years, the advantages of surgical treatment and rapid mobilization have been increasingly recognized. In the past, successful results have been obtained with external fixation (3,22), plating (15,23), or solid antegrade intramedullary nailing (4,7,11). More recently (2001), a multicenter study conducted by Flynn *et al* (9) showed titanium elastic nailing (TEN) to be an ideal and effective method. Meanwhile this technique has become increasingly popular in children. In this study, we retrospectively compared closed and mini-open reduction, followed by titanium elastic nailing.

INTRODUCTION

The femoral shaft fracture is one of the most common major paediatric fractures. It usually occurs as a result of a fall or a traffic accident. This fracture is more critical than its homologue in adults because the psychological, social, and financial situation affects the entire family. Previous studies have indicated that good results can be obtained nonoperatively with traction, manipulation or cast

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PATIENTS AND METHODS

Study Design

Forty-three children (30 males, 13 females) were treated for a closed femoral fracture with titanium elastic nailing between September 2008 and May 2011. Their mean age was 8 ± 1.9 years (range : 5-12). The trauma mechanisms were traffic accidents and falls from a height. Exclusion criteria were open fracture, closed fracture with additional injuries, underlying neuromuscular disease, metabolic bone disorder, or pathological fracture.

Twenty-two patients (6 females, 16 males) (group I) underwent closed reduction, whereas 21 other patients (7 females, 14 males) (group II) underwent a mini-open reduction through a 2-cm lateral incision. In group I, 9 patients had a left fracture, and 12 a right fracture. In group II, 6 patients had a left fracture and 16 a right fracture. The fracture was oblique in 24 patients (11 in group I, 13 in group II), transverse in 10 patients (6 in group I, 4 in group II), and spiral in 9 patients (4 in group I, 5 in group II).

All parents gave informed consent, and the study was authorized by the local ethics committee at Dicle University Medical School.

The mean follow-up period was 21.6 ± 11.1 months for group I and 23.3 ± 10.7 months for group II. Radiographs were taken at 2, 6, 12, 24, 36, and 48 weeks, and at a final follow-up. The criterion for radiographic union was bridging callus on 4 cortices. Malalignment was measured on plain radiographs ; leg length discrepancy (LDD) by means of a scanogram at final follow-up.

The TEN outcome score (9) was used to evaluate the clinical outcomes.

Operative Technique

Closed reduction was first tried under fluoroscopic control. Whether it succeeded or not, the medial and lateral aspect of the distal femoral metaphysis were subsequently opened with a drill, 2 cm proximal to the growth cartilage, again under fluoroscopic control. If closed reduction had failed, a mini-open reduction was now performed, through a 2-cm long lateral incision, centered on the fracture line, after blunt dissection with a finger. Fluoroscopy was used again.

Two nails (Fig. 1), one medial and one lateral, were now inserted in a retrograde fashion. The lateral nail came to rest just below the greater trochanter. The medial nail reached the same level, but its tip pointed towards

the calcar region of the femoral neck. Distally, the nails were cut so that one cm remained outside of the cortex. The extraosseous portion of every nail was bent away from the bone. All patients were immobilized in a hip spica for two weeks. Subsequently, physiotherapy was started. Weight bearing with an assistive device was permitted after 6 weeks.

Statistical analysis

Outcome measures were analyzed using the SPSS package program, and data were shown as a mean \pm the standard deviation. Due to the small cell sizes, non-parametric statistical tests were used. The Mann-Whitney U test was used to compare the clinical details and results of the two groups (Table I). Fisher's Exact test was used to compare the TEN outcome scores of the patients (Table II). A p-value < 0.05 was accepted as statistically significant.

RESULTS

The operation time averaged 71 minutes in Group I, and 48 minutes in group II ($p < 0.001$) (Table I). The mean intraoperative fluoroscopy time was 79.3 seconds in group I, and 35.5 seconds in group II ($p < 0.001$). The average estimated blood loss was 53 ml in Group I, and 79 ml in Group II ($p < 0.001$).

The hospital stay averaged 3.7 days in group I (range : 2-5), and 4.5 days in group II (range : 3-6 days) ($p = 0.001$). The time until full weight bearing without assistive device was 9.5 weeks in group I, and 9.4 weeks in group II ($p = 0.91$, not significant). Radiographic union (Fig. 1) was seen after 10.6 and 10.9 weeks, respectively in group I and II ($p = 0.547$, not significant). Nonunions were not noted.

Two superficial wound infections in group I, and 3 in group II, were conservatively treated with antibiotics. There were 4 patients with leg length discrepancy in each group : in group I all 1 cm ; in Group II : 1 cm in 2 patients, and 1.5 cm in 2 others. All patients had less than 5° of malalignment at last follow-up. There were no pain complaints.

According to the TEN score, 18 out of 22 patients (82%) in Group I had an excellent result, versus 15 out of 21 (71%) in group II ; 4 out of 22 in group I and 6 out of 21 in group II had a satisfactory result

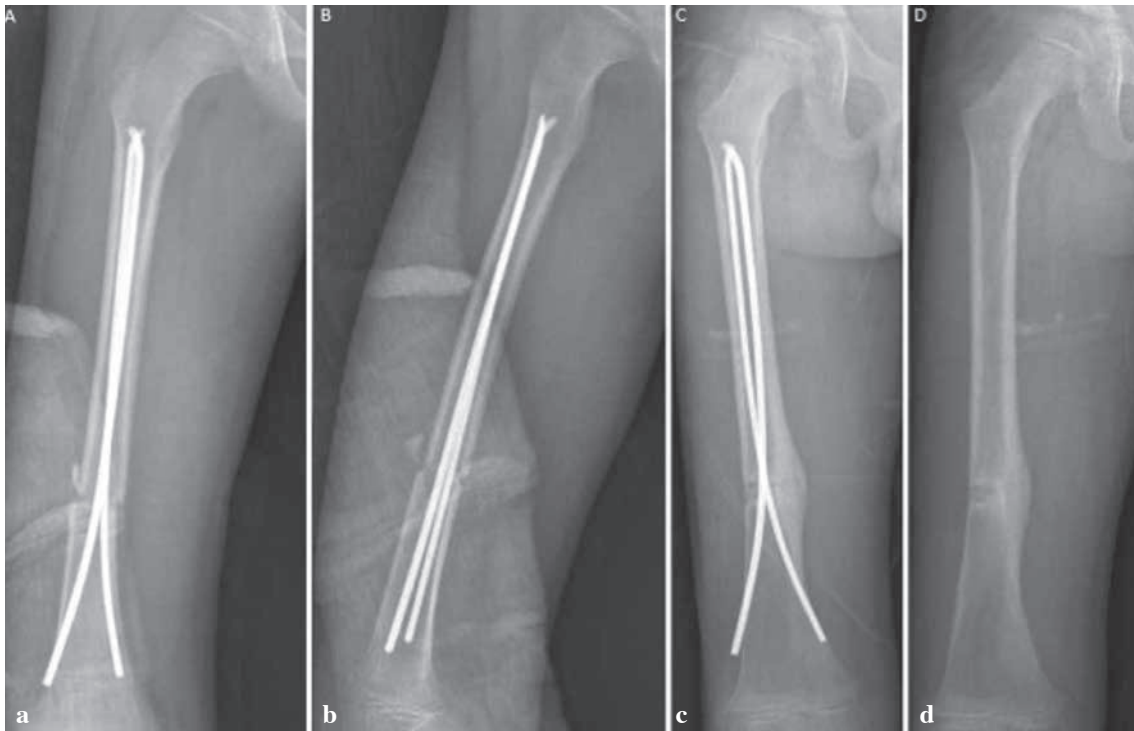


Fig. 1. — Paediatric femoral fracture treated with mini-open reduction and nailing. (a) (b) : AP and lateral post-operative radiographs ; (c) : AP view after 13 weeks ; (d) AP view after removal of the nails.

Table I. — Clinical variables : mean values

	Group I (closed red.) (n = 22)	Group II (mini-open red.) (n = 21)	p value
Operation time (minutes)	71	48	< 0.001
Fluoroscopy time (seconds)	79.3	35.5	< 0.001
Estimated blood loss (ml.)	53	79	< 0.001
Length of hospital stay (days)	3.7	4.5	0.001
Time to full weight bearing (weeks)	9.5	9.4	0.91
Time to radiographic union (weeks)	10.6	10.9	0.547

(Table II), but the difference was not significant ($p = 0.535$). There were no poor results.

All nails were removed after radiographic union of the fracture, at a mean time of 15 weeks (range, 13-19 weeks). There was no significant difference between the two groups as to the time to nail removal ($p = 0.954$).

DISCUSSION

Titanium elastic intramedullary nailing (TEN) has gained international approval for the treatment of femoral fractures in children. The current study confirms its effectiveness. The titanium elastic nail is advantageous because it is simple, while it helps

Table II. — TEN outcome score (9) : no difference between groups

Result	Excellent	Satisfactory	Poor
Leg length discrepancy (cm)	< 1	1-2	> 2
Malalignment (degrees)	< 5	5-10	> 10
Pain	none	none	present
Complications	none	minor and resolved	Major +/- lasting morbidity
Current study : group I / group II	18 / 15	4 / 6	0 / 0

control alignment, length, and rotation. Moreover, it is a load-sharing internal splint which allows early mobilization without violating an open physis. The micromotion conferred by the elasticity of the fixation promotes faster external bridging callus formation. The elasticity of titanium is also reported to reduce the amount of nail deformation during insertion, and to promote callus formation by limiting stress shielding (9,10,16). Ligier *et al* (16) claim that the elasticity of flexible nails enhances the development of an early callus by converting shear forces into compression and traction forces.

The literature mentions uniformly good results, with few complications (2,6,9,12,17,19,21). Excellent results have been obtained in 52% to 86% of the cases (9,17,19,21). The current study led to excellent results in 33 of 43 patients (77%) and to satisfactory results in the other 10 patients (23%), according to the criteria of Flynn *et al* (9).

TEN requires exposure to x-rays like any other intramedullary technique (18). However, the literature is scarce about this issue in TEN. Image intensifier times from 70 to 180 seconds have been reported (1,13,14,20). Kraus *et al* (14) noted an average fluoroscopy time of 70 seconds in a series of 53 children with femoral fractures, and they proposed several solutions. First of all, training of the personnel and improvement of the equipment might play a role. Secondly, switching from closed to open reduction would also be helpful. This was confirmed by the current study : 79 seconds for closed reduction, but only 35.5 seconds for mini-open reduction (< 0.001). Altay *et al* (1) came to comparable results : 75 seconds and 33 seconds, respectively.

As far as operation time is concerned in case of closed reduction, Anastasopoulos *et al* (2) reported 85 minutes, Saikia (19) 70 minutes, Ho *et al* (12) also 70 minutes. Similarly, the authors needed on average

71 minutes for the closed technique (versus 48 minutes for the mini-open technique) ($p < 0.001$).

Overall, no one technique was really superior.

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