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Femoral elastic nailing in the older child: proceed with caution

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Summary Six children aged 9–14 years had primary TEN fixation of an isolated femoral diaphyseal fracture. Three of the six patients had major complications, including knee haemarthrosis, loss of position and refracture; two required revision to locked intra-medullary nails without early complication. Two of the six had significant stiffness of the knee requiring manipulation. In the age group 9–14 years, TEN fixation has a significant major complication rate. This needs to be recognised when TEN fixation with other treatment options.

Introduction

Flexible intra-medullary nailing of paediatric femoral shaft fractures has been a routine procedure in Europe for about 20 years with several large series reported.[2,10] In theory, the use of elastic nails allows stable fixation of the fracture with minimal soft tissue dissection and avoids the risk of avascular necrosis of the femoral head and damage to the growth plates. It has been shown to give superior results to external fixation of femoral shaft fractures in children.[1]

The procedure has justifiably become a popular technique for managing paediatric fractures. With increasing experience the indications for elastic nail fixation have expanded with series reporting its use in patients from the age of 3 to 18 years.[7] There are, however, increasing numbers of reports of both major and minor complications of the procedure as it becomes more widely used.[9,14]

Materials and methods

Over a period of 2 years [2001–2003], a consecutive series of six children between 9 and 14 years admitted with femoral shaft fractures to Dunedin Hospital were treated by intra-medullary fixation using flexible nails [titanium elastic nail, TEN, Synthes].

In all six cases, two retrograde TENs (4 mm or 3.5 mm) were inserted using a medial and lateral approach. Postoperative immobilisation, and time of protected weight bearing varied according to surgeon preference.

The patients were followed with clinical and radiological evaluation at 2 and 6 weeks, 3 and 6

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Table 1 Patients details

	Case 1	2 WD	3 R	4 CH	5 JE	6 AH
Age and Sex	12; M	9; F	14; M	9; F	13; M	14; M
Injury Mechanism	Waterslide	MVA	Pushbike	MVA	MVA	MVA
Weight (kg)	55	24	67	26	62	48
*Weight nail ratio	7.2	3.1	8.3	3.7	8.9	6
Type of #	Proximal 1/3 transverse	Midshaft transverse	Proximal 1/3 transverse	Midshaft transverse	Midshaft, comminution Type 1 open	Midshaft comminution
Radiological nail diameter, canal diameter (isthmus)	4 mm, 3.5 mm	3.5 mm	4 mm	3.5 mm	3.5 mm	4 mm
Nail: canal ratio	10 mm	10 mm	11 mm	9 mm	14 mm	13 mm
Extraosseous part of the nail (mm) [medial/lateral]	37.5%	35%	36%	39%	25%	31%
Radiological Nail diameter Canal diameter (isthmus)	25, 15	15, 25	20, 30	30, 20	20, 20	25, 25
Post-op rehabilitation	TWB** with ROM brace	TWB	TWB	TWB	TWB with ROM brace	TWB with ROM brace
Hospital stay [days]	9 days	11 days	6 days	7 days	4 days	6 days
Healing time	?	8 weeks	20 weeks	12 weeks	NA	16 weeks [partial]
Varus-Valgus	4° Varus	6° Varus	4° Varus	5° Varus	2° Varus	5° Varus
Complications: knee	None	None	Knee pain Delayed union	Knee pain Hemarthrosis	Knee pain Knee stiff, Bent nail	Knee pain Knee stiff, Refracture
Treatment for complication	None	None	Observation	Joint lavage and removal of the nail	Removal of TEN and intra-medullary fixation at 4 weeks MUA knee	intra-medullary fixation MUA knee
Time to TEN removal	N/K	4 months	6 months	4 months	5 weeks	5 months

ROM: range of movement knee brace.
* Weight nail ratio [Luhmann]: weight in kg/total diameter of the implanted nail.
** TWB: touch weight bearing.

months or until bony union. One patient had moved overseas and was not able to be traced. Inpatient medical records, outpatient clinic notes, and radiographs were reviewed for all patients. Details of age, weight, mechanism of injury, fracture type, TEN size implanted, hospital stay, time to union, knee range of motion, pain at the nail insertion site and complications were recorded (Table 1). The radiographs were evaluated for alignment, callus formation, nail:canal ratio and extra-osseous nail length. A weight:nail ratio was calculated as described by Luhmann et al.[9]

Results and complications

The mean age at injury was 12 years (range: 9—14 years). There were four boys and two girls. All fractures were sustained in a high-energy impact. There was one open fracture [type 1]. The most common pattern was midshaft (four cases) and two were proximal.

The average operative time was 70 min [60—120 min]. The average hospital stay was 8.5 days (range: 4—11 days). The most frequent postoperative malalignment was varus, which was less than 5 degrees in five patients and between 5 and 10 degrees in one. Complete union was noted within 12 weeks in two patients. There was one delayed union which took 20 weeks for complete healing. Four of the five patients with full follow up had significant pain at the knee from the nail tips. This was associated with significant stiffness in two and more mild stiffness in the other two.

Three patients had major complications requiring re-operation.

Case 4: CH, a 9-year-old girl was knocked down by a car and sustained a transverse fracture at the midshaft of right femur. At 3 months, although the fracture healed well with 5 degrees of varus, she had discomfort at the nail site. She was booked electively for removal of nail. A week before her scheduled surgery, she was admitted acutely with a tense swelling in the right knee which was very painful. At admission her blood report and aspirate did not indicate infection. Radiologically, there was backing-out of the medial nail which has been placed more anteriorly than medial. She underwent immediate removal of the nail and arthroscopic wash out of the knee, with no further sequence.

Case 5: JE, a 13-year-old boy involved in a motorbike accident presented with a type I open fracture of his femur. The fracture was midshaft with medial comminution. After initial wound debridement, the fracture was stabilised with two 3.5 mm TENs. Reduction and fixation appeared stable. He was mobilised touch weight bearing crutches in a knee brace. At 4 weeks, he fell on his R leg, while he was trying to get out of a chair and presented with shortening and deformity of the leg. Radiological examination showed a bent lateral pin at the fracture site with 20 degrees varus deformity [Fig. 1a and b]. The TEN pins were removed and a locked intra-medullary nail inserted through the tip of the greater trochanter. He only had 40 degrees of flexion so his knee was manipulated under anaesthetic to 120 degrees. At 3 months post-op, he was fully weight bearing with normal movement at the knee. At 6 months, there was complete healing with no avascular necrosis of the femoral head.

Case 6: AH, a 14-year-old boy had significant stiffness and pain around the knee joint 5 months after titanium nail fixation with only 30 degrees of knee flexion. He was fully weight bearing and the fracture appeared to be united radiologically. The nails were removed but two weeks later he refractured following a simple fall on a level ground [Fig. 2a and b]. This was treated with a locked intra-medullary rod through a trochanteric entry point. The knee was manipulated to 120 degrees of flexion. The fracture healed uneventfully and full knee movement has been regained.

Figure 1 Case 5: (a) Shows initial placement of flexible intra-medullary nails. (b) Radiographs taken 4 weeks after surgery, showing varus displacement and a bend in the lateral nail.

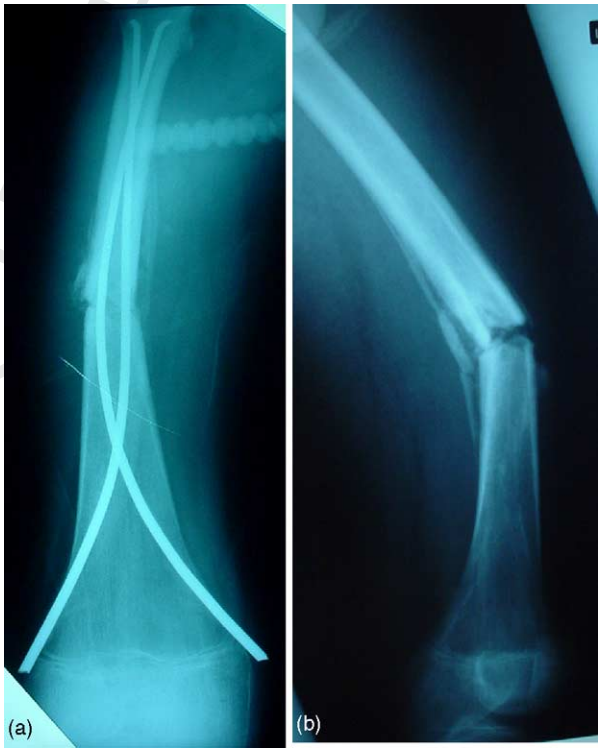

Figure 2 Case 6: (a) Anteroposterior radiograph 4 months after internal fixation with titanium elastic nails. (b) Radiograph showing refracture taken two weeks after early removal of nails for pain and knee stiffness at 5 months.

Discussion

In a multicentre study of early results from the USA, Flynn et al.[5] reported some of the technical pitfalls in the insertion of flexible nails. He emphasises choosing the correct diameter nail, which should be 40% of the diameter of the isthmus, accurate precontouring of the nail and the importance of only leaving 1–2 cm protruding beyond the cortex.

With the conventional retrograde insertion technique of a medial and lateral wire there is an incidence of nail tip pain, bursitis and skin ulceration which ranges from 1 to 40% (Table 2). This has led to repeat nailing,[10] cutting nails shorter,[10] deep infections,[5,10] knee synovitis or hemarthrosis,[14] knee stiffness and pain,[11] early removal of nails[1,5,11] and subsequent refractures.[5,7] Heinrick et al.[7] however reported nail tip problems in only 3 of 78 fractures and strongly recommended the technique. Luhmann et al.[9] found an increased incidence of discomfort and complications when the nails protruded more than 40 mm beyond the cortex. In Case 4, the medial nail was placed too anteriorly and backed out, leaving 3 cm protruding, which resulted in erosion of the joint capsule causing the hemarthrosis. Most authors recommend leaving as short a nail as possible commensurate with allowing its ultimate removal. Special instrumentation to allow cutting the nail short and its subsequent removal would be helpful in reducing this problem.Bourdelat[2] has recommended descending nailing in all but comminuted proximal fractures to avoid irritation problems around the knee.

We found knee stiffness to be a major problem in the postoperative and rehabilitation phase. Ligier et al.[10] suggested that early motion should be discouraged to reduce knee irritation but other authors have not found this to be necessary. In Case 6, a very stiff knee with a range of only 0–30° flexion, necessitated removal of the device early leading to the refracture after a minor.

Fall. Although knee flexion may be regained eventually we believe the incidence of early knee stiffness causes significant problems with rehabilitation.

It has been suggested that TEN fixation should be used with caution in the older, heavier patient especially if there is comminution at the fracture site.[3,8,15] Use of larger diameter nails may help reduce the risk of malunion or loss of position. Luhmann et al.[9] suggested a nail weight ratio of <4 kg per mm diameter of titanium nail implanted in the 6–9 years age group. However, this is not possible in the heavier adolescent patient even with

Table 2 Reported complications of Flexible femoral nails

Authors	Fractures	Total complications	Nail tip problems	Unplanned reoperation	Complications
[1]	10 [5–15 years]	3 (30%)	3 (30%)	2	1 Migration 1 Bursitis
[2]	70 [5–15 years]	3 (25%)	3 (25%)	3	1 Non-union 3 Nails recut 2 Scar concerns
[5]	58 [4–16 years]	7 (12%)	5 (9%)	5	1 Refracture 1 Malunion 3 Nail tip problems 2 Infections
[7]	78 [6–18 Years]	8 (5)	7 (9%)	4	1 Refracture 1 Excess valgus 1 Nail migration 1 Bursitis
[10]	123 [5–16 years]	14	13(11%)	13	1 Deep infection 10 Nail was trimmed 3 Nails reintroduced
[9]	43 [3–9 years]	21 (49%)	17 (40%)	2	1 Intraoperative fracture 1 Septic arthritis 1 Non-union 1 Delayed union
[11]	34 [6–17 years]	10 (33%)	10 (33%)		10 Early removal of rods for pain and knee stiffness
[14]	2 [8–11 years]			2	2 Acute synovitis of knee
[15]	11 [8–13 years][	1 (9%)			1 Loss of position
[16]	141 [5–17 years]		(1%)		1% Pin site irritation

the largest nail [4 mm]. A functional hip brace supplementing nail fixation has been recommended[13] in such a situation.

Non-union or delayed union is uncommon in children's femoral fractures. The delayed union in patient 3 in our series was probably due to varus angulation but this has had no long term sequelae. The refracture in patient 6 after a minor fall also suggests delayed union.

Many of the technical complications reported have been ascribed to technical error or the learning curve. With the small numbers that most centres see this is likely to remain a problem. While some of the errors can be minimised by careful attention to detail there remain problems inherent in the technique.

We believe that elastic nails are an important and useful addition to pediatric fracture management. They should be used with caution in the older and heavier patient in whom the recently released trochanteric intra-medullary nails may be a better option.[4,12,5,6,8] With the risk of both major and minor complications we believe the technique should be used cautiously.

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