

# ELASTIC STABLE INTRAMEDULLARY NAILING OF FEMORAL SHAFT FRACTURES IN CHILDREN

J. N. LIGIER, J. P. METAIZEAU, J. PRÉVOT, P. LASCOMBES

*From the Department of Paediatric Surgery, Children's Hospital, Nancy*

**We report the use of elastic stable intramedullary nailing (ESIN) in 123 fractures of the femoral shaft in children. Flexible rods are introduced through the distal metaphyseal area, and the aim is to develop bridging callus. Early weight-bearing is possible and is recommended.**

**There was one case of bone infection and no delayed union. Complications were minimal, the most common being minor skin ulceration caused by the ends of the rods. A surprising feature was the low incidence of growth changes, with a mean lengthening of only 1.2 mm after an average follow-up of 22 months. Compared with conservative treatment, ESIN obviates the need for prolonged bed rest and is thus particularly advantageous for treating children.**

In children, fractures of the femoral shaft are commonly treated by various types of traction for about three weeks, followed by plaster cast immobilisation. This safe form of treatment has two major drawbacks. The first is that prolonged bed rest separates the child from his normal environment; the second is the cost of such periods in hospital and the use of beds which might serve other patients.

During the past five years we have used elastic stable intramedullary nailing (ESIN) for such cases. This closed surgical procedure allows early weight-bearing and walking; it aims to develop early bridging callus and contributes to rapid restoration of bone continuity. In the series we report, the results were at least equal to those of more conventional methods.

## PATIENTS AND METHODS

Between September 1979 and June 1985 118 children with 123 femoral shaft fractures were admitted to the Nancy Children's Hospital (Service de Chirurgie Infantile Orthopédique, Hôpital d'Enfants, Centre Hospitalier Universitaire de Nancy) and treated with ESIN. Initially, the patients were selected from among

children over 10 years old, but later, because of the favourable preliminary results, children over seven years old were treated in this way, and a few even younger children with an associated head injury or multiple trauma also had ESIN.

The ages of the children ranged from 5 to 16 years (mean 10 years  $\pm$  2 months). There were 80 boys and 38 girls who had sustained 64 right-sided and 59 left-sided fractures (five had bilateral injuries). In all, 42 fractures were in the proximal third, 35 in the middle third and 36 in the distal third; there were also six pertrochanteric fractures and four double fractures. Of the 63 transverse fractures (Figs 1 to 3) 16 presented with comminution of one cortex. Twenty-eight fractures were spiral, nine of which had a large butterfly fragment (Figs 4 and 5). There were 22 oblique fractures, six had comminution of both cortices, and four were double fractures (Figs 6 to 8). Associated injuries were present in 42% of patients: 35 had a head injury, four had an abdominal injury, and 11 had other lower-limb fractures. One patient had a posterior hip dislocation with an ipsilateral femoral shaft fracture.

Three children had a lumbosacral myelomeningocele, two were affected by poliomyelitis and three had some form of cerebral palsy.

**Operative technique.** The patient is placed on an orthopaedic table and the fracture partially reduced by traction guided by fluoroscopy. Blunt-ended nails of the finest quality steel (cold-hammered at 140°) or titanium were used. The nails were 45 cm long with diameters of 3, 3.5 or 4 mm depending on the child's weight and age. It should be noted that Ender nails are not elastic enough for treating children and that they often lead to straightening of the normal curves of the bone.

An important step is the preparation of the nails by the surgeon. These are angled at 45° about 2 cm from one

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J. N. Ligier, Senior Hospital Fellow  
J. Prévot, Professor of Paediatric Surgery and Paediatric Orthopaedic Surgery  
P. Lascombes, Paediatric Orthopaedic Surgeon  
Children's Hospital, Allée du Morvan, 54511 Vandoeuvre-Nancy-Cedex, France.

J. P. Metaizeau, Paediatric Orthopaedic Surgeon  
Hôpital Belle-Isle, 54045 Metz-Cedex 1, France.

Requests for reprints should be sent to Professor J. Prévot.

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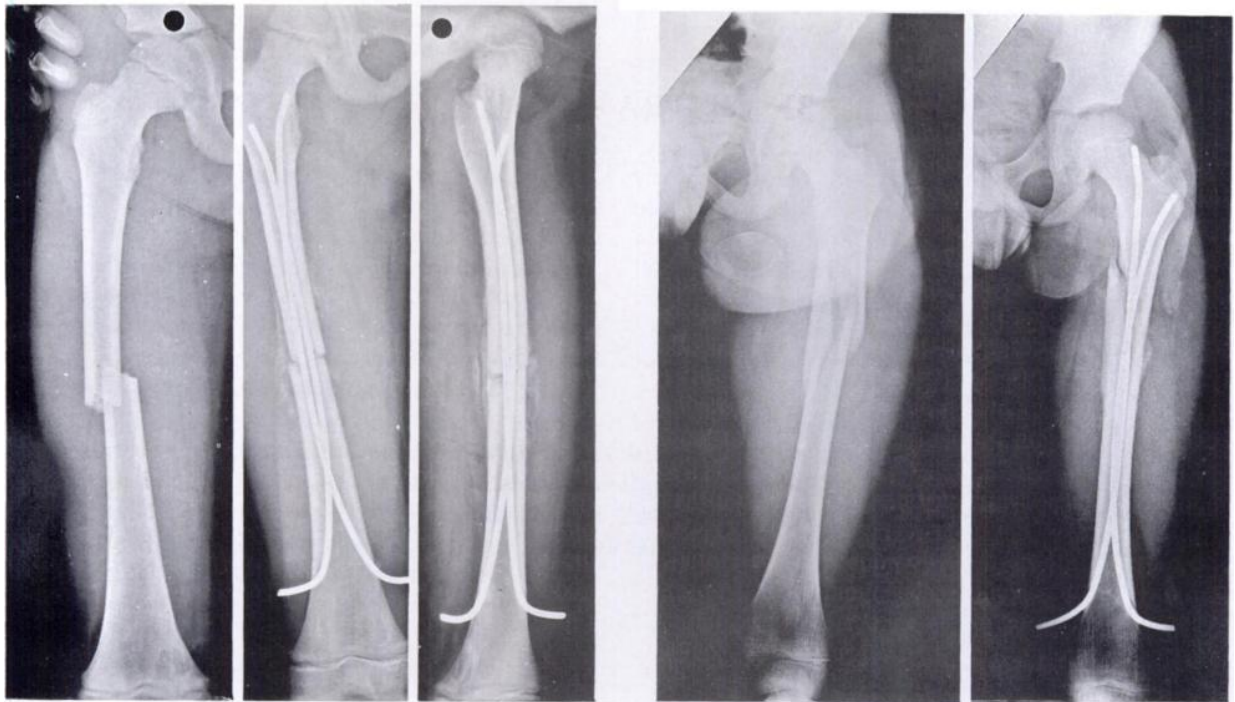


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Radiographs of an eight-year old boy with a simple transverse femoral shaft fracture. Figure 1 - On admission. Figure 2 - An anteroposterior radiograph taken 21 days after the fracture shows external callus. Figure 3 - The lateral radiograph shows restoration of the normal anterior bowing of the shaft.

Radiographs of an 11-year-old boy with a comminuted spiral fracture. Figure 4 - On admission. Figure 5 - The radiograph taken 21 days after the injury shows some external callus.



Fig. 6

Fig. 7

Fig. 8

Radiographs of a nine-year-old boy with a double fracture of the femoral shaft. Figure 6 - On admission. Figure 7 - Two months after nailing. Figure 8 - One year after injury, there had been no overgrowth of the femur.

end to facilitate penetration of the medullary canal and are also bent into an even curve over their entire length. The nails are introduced through a hole made in the distal femoral metaphysis just above the growth cartilage. They are carefully pushed up the medullary canal to the already-reduced fracture site. Under fluoroscopy, the bend at the tip allows the nail to pass the fracture site satisfactorily. Two nails, one lateral and one medial, are adequate to stabilise the fracture. To avoid residual angulation it is important that the nails are introduced at the same level and that they have identical curvatures. After operation the limb is simply rested on a pillow. Mobilisation using crutches but without weight-bearing is allowed as soon as the fracture is painfree. At the beginning of the third week partial weight-bearing is possible, and this is soon followed by full weight-bearing. This coincides with the appearance of calcified external callus. The nails are removed at the beginning of the third postoperative month. No patient required antibiotics after operation.

## RESULTS

There were no surgical failures and because the operation is rapid and uses only small incisions, blood loss is minimal. Early in the series, four patients had spica casts after operation and five had skin traction; by the end of the study period, the average hospital stay had been reduced to 4.5 days. Sound union was achieved in every case and there were no fractures after removal of the nails.

**Complications.** The distal ends of the nails sometimes caused discomfort at the knee; this occurred most often if knee movement was begun soon after operation. There were 13 cases of skin ulceration or local inflammatory reaction due to nail protrusion: three of these required re-introduction of the nail while in the remaining 10 the nails were trimmed under local anaesthesia.

One case of deep wound infection occurred six weeks after operation in a paraplegic child with urinary tract infection. Removal of the nail and drainage of the fracture site was required and the fracture then healed after immobilisation in plaster.

**Long-term results.** Sixty-two children have been followed up for over one year with an average period of one year and 10 months. Clinically, none of the patients complained of disability and no gait abnormalities were noted.

*Lengthening and shortening.* All 62 children were assessed radiographically, and a mean lengthening of 1.2 mm was noted. An attempt was made to discover whether this mean figure resulted from the algebraic sum of lengthening in transverse fractures without overlap and shortening in spiral fractures. Within narrow limits this hypothesis was confirmed. In 29 simple transverse fractures the mean lengthening was 2.06 mm, with four cases of lengthening of more than 10 mm (11, 15, 17 and

23 mm), and three of shortening greater than 10 mm (15, 15, and 13 mm). By contrast, in 12 spiral fractures the mean shortening was 0.7 mm: the range in this group was from a loss in length of 12 mm to an increase of 17 mm.

Distal femoral epiphysiodesis was used later to treat the two cases which presented the greatest difference in leg length (23 mm and 20 mm).

*Angulation and rotation.* At follow-up, residual angulation never exceeded 10°. In 14 patients, angulation of more than 5° was observed; this was varus in eight, valgus in two, anterior in three and posterior in one.

In 20 patients biplanar radiography was used to measure femoral anteversion. A rotational deformity was found in only one patient with 10° of retroversion of the femoral neck as against 5° of anteversion on the normal side.

*Cost of treatment.* This is essentially the cost of hospital bed rest. We reviewed two comparable series of patients aged between 7 and 15 years, one treated by skin traction during 1977, the second treated by ESIN during 1983.

Conservative treatment involved a mean hospital stay of 25.5 days, comparable to that reported elsewhere (Holmes, Sedgwick and Scobie 1983; Henderson et al. 1984). The ESIN series had a mean hospital stay of only 7.5 days including the removal of the nails. A cost reduction of 70% is thus another advantage of this technique.

## DISCUSSION

Derived from Ender's elastic nail (Ender and Simon-Weidner 1970), and from other fixation techniques, ESIN provides a combination of elastic mobility and stability.

*Stability.* In contrast with techniques involving rigid fixation, stability is not only ensured by the nails, but also by the bone and the surrounding soft tissues. The nails provide internal elastic support, channelling forces and preventing excessive displacement by the automatic adjustment of the bone fragments. The double ascending nailing increases the stability of the fixation (Ender and Simon-Weidner 1970); this has been confirmed in adult femoral shaft fractures (Eriksson and Hovelius 1979; Pankovich, Goldflies and Pearson 1979).

The bone provides axial stability provided that there is no overlap at the fracture site. This is ensured either by cortical contact in end-to-end reduction or by anchoring the nails in the metaphysis. The cancellous bone of children is very dense, so that the nail-drop seen in the elderly patient is less common.

The soft tissues also have an important role. The muscles, in particular, serve as guy-ropes. This helps to explain the spontaneous postoperative correction of slight angular deviation, the rarity of excessive callus and the retention of the normal anterior bow of the femoral shaft (Figs 1 to 3).

Stability provided mainly by living tissue allows rapid return of function and weight-bearing without fear of secondary displacement, even in hyperactive children. The value of this technique for the agitated, comatose or multiply-injured child is considerable.

*Elastic mobility.* ESIN allows a certain amount of movement at the fracture site, thus ensuring optimal development of the external callus by reducing shear and converting it into compression and traction forces (Firica et al. 1981). The early development of bridging callus results in early consolidation; this takes from four to six weeks depending on the child's age, almost twice as fast as with conventional treatment.

*Advantages of closed reduction.* The technique of ESIN causes no increase in muscle or periosteal damage and leaves the fracture haematoma intact. Cosmetic damage is minimal, being limited to small scars at the sites of introduction of the nails. Irradiation can be kept to the minimum by the use of two intensifiers of modern low-dosage type at right angles to each other.

**Conclusions.** Because of early weight-bearing, rapid healing and minimal disturbance of bone growth, ESIN may be considered to be a physiological method of treatment. The technique can be adapted to all cases, in contrast with the early spica cast technique recommended by Irani, Nicholson and Chung (1976); it gives better control of axial length and rotation, and can be adapted to treat other diaphyseal long-bone fractures in the child (Ligier et al. 1985). The method is also being adapted for

the treatment of certain metaphyseal fractures (Metaizeau, Prévot and Schmitt 1980; Metaizeau and Ligier 1984).

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