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ORIGINAL STUDY

Percutaneous K-wire fixation for femoral shaft fractures in children

Abdul Qayyum KHAN, Mohd K. A. SHERWANI, Saurabh AGARWAL

From Jawahal Lal Nehru Medical College, Aligarh, India

From November 2001 to January 2004, sixty-five children with femoral shaft fractures were treated by closed reduction and percutaneous K-wire fixation. The aims of the treatment were early mobilisation, easy nursing care and rapid rehabilitation. Kirschner wires were introduced under image-intensifier control from the distal or proximal metaphyseal region of the femur, avoiding injury to the physeal plate. The average duration of hospital stay was 4 days, including training for non-weight bearing axillary crutch walk. Union was achieved in all cases between 6 and 10 weeks (average, 8 weeks). No significant complications were encountered, except refracture in one case. K-wires were removed after an average of 5 months. This is a simple and easy-to-learn technique with the added advantage of cost effectiveness.

Keywords : percutaneous K-wires ; femoral shaft fractures ; children.

INTRODUCTION

Femoral shaft fractures in children are usually treated by conservative means, such as immediate spica cast immobilisation or initial traction followed by hip spica application (*18*). Traditional methods do give satisfactory results in younger children but older children may have complications such as malunion, delayed union, rotational deformities and psychological problems (*4*). The aim of fracture treatment in children is rapid healing without complications, easy nursing care, rapid rehabilitation and minimal negative psychological impact on children and their families (*19*). Keeping this in mind, the recent treatment modality has evolved, from conservative to operative approach. Operative methods for femoral shaft fractures in children include external fixation (*2,14*), plating (*9*), rigid or flexible intramedullary nailing (*10, 15-18*). Flexible intramedullary nailing has revolutionised the treatment of femoral shaft fractures in children. The idea of using multiple flexible intramedullary nails (Ender nails) was first conceptualised by Ender and Simon Weidner (*5*). More recently Ligier and Métaizeau advocated the use of elastic titanium nails (Nancy nails) for femoral shaft fractures in children (*15-18*). Their technique is known as Elastic Stable Intramedullary Nailing (ESIN) or Métaizeau technique. Qidwai *et al* (*19*) and Al-Zaharani *et al* (*1*) advocated the use of closed intramedullary K-wire fixation for femoral fractures in children. We present our experience with the use of percutaneous K-wire fixation for femoral shaft fractures in children.

■ Abdul Qayyum Khan, M.S., Orthopaedic Surgeon.
■ Mohd K.A. Sherwani, M.S., Professor.
■ Saurabh Agarwal, M.S., Orthopaedic registrar.
Department of Orthopaedic Surgery, J.N. Medical College, A.M.U., Aligarh, PIN-202002, (U.P.), India.
Correspondence : Prof. Mohd K. A. Sherwani, Department of Orthopaedic Surgery, J.N.Medical College, A.M.U., Aligarh, PIN-202002, (U.P.), India.
E-mail : drabdulqayyum@rediffmail.com

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MATERIAL AND METHODS

This was a prospective study involving 65 children with diaphyseal fractures of the femoral shaft treated with percutaneous K-wire fixation. The study was conducted at the Department of Orthopaedic Surgery, Jawaharlal Nehru Medical College and Hospital, A.M.U., Aligarh (India), between November 2001 and January 2004. We adopted the following inclusion criteria :

A) Displaced femoral shaft fractures, with or without comminution, in children, between 4 and 16 years of age.
B) Compound grade I, II and IIIa fractures (Gustilo *et al*)
C) Femoral fractures in children with associated head injury or multiple fractures.

During this study, children below 4 years of age were treated by conventional hip spica immobilisation, as it was not possible to train them for early mobilisation.

Surgical technique

With the patient lying supine on an orthopaedic traction table, under general or spinal anaesthesia, the fracture was reduced under the guidance of an image intensifier. Through small skin incisions, an entry hole was made with a bone awl on the medial and the lateral cortex of the distal femur, avoiding the physeal plate. Standard Kirschner wires of 45-cm length were chosen with a variable thickness according to the age of the child. We used K-wires of 2-2.5 mm for children under 10 years of age and 3.0 mm for children above 10 years. K-wires were bent to an angle of 30°-40° at a point 2-cm from one end and the sharp tips were made blunt. The bent and blunt tip avoided perforation of the opposite cortex during introduction and also helped in negotiating through the fracture site. The K-wire with bent tip was loaded on the T-handle chuck and was introduced into the medullary canal, through the prepared holes. Under image intensifier control, the wires were advanced through the fracture site and made to engage into the proximal metaphysis, preferably into the neck and trochanteric region (fig 1). Spread of wire tips, in opposite directions, increased the rotational stability of the construct. Thr protruding distal ends of the wires were bent, cut and the wound stitched.

No cast supplementation was done in the immediate post-operative period. All the patients received one shot of intravenous antibiotic, 20 minutes before operation.

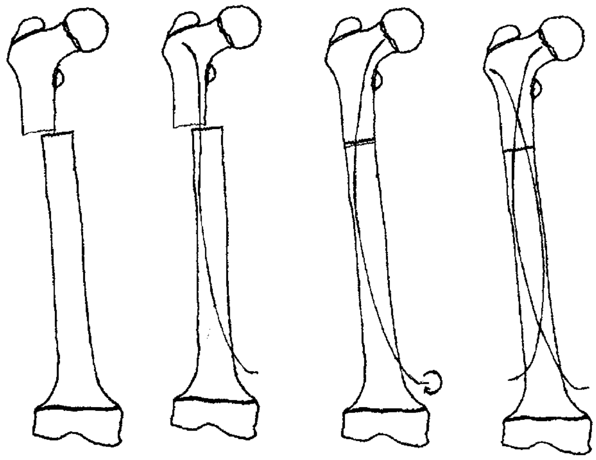

Fig. 1. — Fixation of proximal-third femoral shaft fractures by retrograde percutaneous Kirschner wiring.

Evaluation on follow-up was done according to a fixed protocol. The time to weight bearing and to union was recorded, as well as the range of knee motion and limb–length discrepancy (LLD). Union was defined radiographically when bridging callus was visible on two standard views with partial obliteration of the fracture line, and clinically when bony tenderness and pain on weight bearing were absent. Any difference in the limb length was measured, keeping both lower limbs in identical position (with pelvis squared) and measuring the distance from the anterior superior iliac spine to the inferior tip of the medial malleolus. Rotational deformity was measured, with the patient prone and the knee flexed to 90 degrees. The flexed leg was then moved sideways and the angle between the leg and the midline was measured. Any significant varus or valgus angulation at the fracture site was measured radiologically.

Patients were called for an out-patient visit, on the 12th post-operative day (for stitch removal), 6 weeks post-operatively (for partial weight bearing walking), at 8 weeks (for full weight bearing and radiographic evaluation). Thereafter, they were called after 5 months, for implant removal.

RESULTS

In this study the mean age of the patients was 9 years (range = 4 to16 years). Forty were male and 25 female (table I). The average period of follow-up was 22 months. None was lost to follow-up. A road traffic accident was the mode of injury in

Fig. 2a. — Mid-diaphyseal fracture of the femur : radiograph immediately after trauma.

Fig. 2b. — Radiograph showing union at 8 weeks with K-wires *in situ*.

Table I. — Age and sex distribution

Age (years)	Number of cases		
	Male	Female	Total
04-06 yrs.	13	7	20
07-09 yrs.	15	11	26
10-12 yrs.	7	3	10
13-15 yrs	4	4	8
> 15 yrs	1	0	1
Total	40	25	65

45 patients and a fall from a height, in 20. The fracture site was the proximal third in 18 cases, the middle third in 35 and the distal third in 12. There were 58 cases of closed and 7 cases of open fracture including 4 grade I, two grade II and one grade III-A (Gustilo *et al*) (*8*). There were 44 transverse, 8 oblique, 5 spiral, 7 comminuted and 1 segmental fractures. Associated injuries were present in 24 cases, including head injury in 19 patients, humeral shaft fractures in 2 patients, epiphyseal injury of the distal radius in 2 patients and fracture of the lateral malleolus in 1 patient.

The mean interval between trauma and operation was 2 to 5 days. The delay in surgery was usually attributable to the general condition of the patient. Successful closed reduction was achieved in all cases. We mostly used 2 K-wires, one from the medial and another from the lateral femoral cortex in children under 10 years of age. In children over 10 years, 4 K-wires were used, two each from the medial and lateral sides, to increase the stability of the fixation (fig 2a, b). We introduced 3 K-wires from the lateral side only, in 10 patients under 10 years of age, due to abrasions or wounds on the medial side (fig 3a, b). The most common per-operative problem encountered in our series was nego-

Fig. 3a. — Radiograph immediately after trauma (fracture of femoral shaft in its proximal third).

Fig. 3b. — Radiograph showing union at 10 weeks with K-wires *in situ.*

tiation of the wire tip through the fracture site. This problem was minimised as we became more familiar with the technique. The average duration of hospital stay was 4-6 days, including training for non-weight bearing walking (NWB). Non-weight bearing walk with axillary crutches was started as soon as the pain was tolerable, usually by the end of the third day. Partial weight bearing was started at 6^{th} week post-operatively in younger children, but it was delayed by another 2 weeks in older children (more than 12 years old). Full weight bearing was allowed, when bridging callus was visible on standard antero-posterior and lateral radiographs with partial obliteration of the fracture line.

Union was achieved in all cases between 6 to 10 weeks (average = 8 weeks). K-wires were removed after union at an average of 5 months, as a day case procedure. None of the patients in our series developed migration or sinking of the intramedullary wires. Skin irritation by the protruding wire ends was the most common complication encountered in our series (15 patients). Refracture occurred in one case, while the patient was on partial weight bearing and slipped on the floor. Femoral lengthening of 1.0 cm was observed in one case 4 months after operation and became static after that. No case of malunion, delayed union or nonunion was seen. None of the patients developed knee stiffness or impairment of gait.

DISCUSSION

Femoral shaft fracture is a common injury in children. Conservative management, in the form of traction or hip spica immobilisation, had been the treatment of choice in the past and is still being used at many centres worldwide *(12)*. Conventional treatment exposes to the problems of malunion, pressure sores, redisplacement of fragments, prolonged immobilisation and psychological problems (*4*). To combat them, there has been an increasing trend towards surgical management of these fractures in older children (*3, 4, 6, 10, 16*).

Compression plating recommended by Hansen (*9*) does provide anatomical reduction and rigid immobilisation, but has the disadvantages of larger soft tissue dissection, a large scar and a second major operation for removal of the plate. The risk of deep infection and refracture, after implant removal, due to the stress shielding effect, is always there. External fixation advocated by Krettek *et al* (*14*) has advantages of stability and early mobilisation, but it is associated with problems of pin-track infection and refracture through the pin tracks (*4*). Rigid intramedullary nailing with a Kuntscher nail or interlocking nail offers advantages of good stability, rigid fixation and early weight bearing, but rigid nailing in children is associated with problems of physeal damage and coxa valga or epiphysiodesis of the greater trochanter, avascular necrosis of the femoral head and growth disturbances (*7*). Ender nails and Rush pins are not sufficiently elastic for paediatric fractures and they may cause straightening of normal femoral curves (*19*).

Flexible intramedullary titanium nails (Nancy nails) devised by Ligier and Métaizeau *et al* (*15-18*) revolutionised the treatment of femoral shaft fractures in children. Based on the concept of flexible intramedullary nails Al-Zaharani *et al* (*1*) and Qidwai and Khattak (*19*), recently advocated the use of intramedullary Kirschner wire fixation for femoral fractures in children with encouraging results. Huber *et al* (*11*) advocated flexible titanium nailing for the treatment of all diaphyseal fractures in children.

The principle of osteosynthesis with intramedullary K-wires is a biomechanical idea that aims at early bridging callus formation leading to rapid restoration of bony continuity (*11*). Just like the Nancy nails, the flexible K-wires allow controlled oscillating micromovements that permit changing compression on different parts of the fracture line, leading to early external callus formation. Each K-wire provides three points of fixation : one at the entry point, a second at the apex of the curve of the K-wire and a third at the tip, which is embedded in the cancellous bone of the proximal metaphysis. Stability is provided not only by the intramedullary K-wires but also by the bone itself and surrounding soft tissues (*15-18*). The bone provides axial stability and each wire provides three-point fixation. The bent tips provide rotational stability. The surrounding muscles also provide stability by acting as guide-ropes. Increasing the number of K-wires enhances the stability of fixation (*15-19*). Kiely *et al* (*13*) tested the mechanical properties of different combinations of flexible nails in a model of a paediatric femoral fracture. They found no difference in the mechanical properties of paired straight, S-shaped and C-shaped nails.

In most of our cases, we used K-wires from both medial and lateral cortices. As we became familiar with the technique, we used three K-wires from the lateral side only in 10 children. There was no difference in the union rates, as compared to the patients in which wires were used from both sides. In one case with a distal femoral shaft fracture, antegrade K-wiring was done from the subtrochanteric region, avoiding the trochanteric apophysis. Reduction was easier by rotating the wire tip in the smaller distal fragment with the added advantage that the entry point was far away from the fracture site (*19*).

In 15 cases, we encountered skin irritation by protruding wire ends at the entry point. Cutting the wires close to the bone and hairpin bend of the wire ends, minimised this problem. One patient sustained refracture after 6 weeks of operation, with K-wires in situ. Hip spica was then applied after correction of the deformity and the fracture united well after another 8 weeks. One of our patients had a femoral lengthening of 1.0 cm, 4 months after the operation, measured clinically from ASIS to lateral joint line of the knee, thus avoiding the chance of error attributable to ipsilateral leg fracture. Qidwai and Khattak reported an average lengthening of 5 mm in 6 cases out of 53 at the final follow up (19).

Percutaneous K-wire fixation for femoral shaft fractures in children has distinct advantages over other conservative and over operative techniques. The low cost and universal availability of K-wires (as compared to titanium nails and the short hospital stay make this treatment cost effective and particularly suitable for developing and under-developed countries. This is a simple technique, and sophisticated instrumentation is not required. This is a minimally invasive technique with small stab incisions at the entry point. The amount of blood loss is small as compared to plating (*19*). Cosmetic damage is minimal (as compared to other open techniques like plating). In contrast with the hip spica, it affords advantages of easy nursing care, early mobilisation and avoidance of psychological problems due to prolonged immobilisation (*15-18*). As the children are mobilised early on axillary crutches, they can return to school and playing activities, earlier. The technique is of considerable value in head injury and comatose patients, when compared to traction or spica cast immobilisation. Percutaneous K-wire fixation is a biological method of fixation, which provides a combination of elastic stability and mobility. Closed methods leave the fracture haematoma intact, leading to the formation of early bridging callus. This is an easy to learn technique, with a small learning curve. It may be adapted to treat other diaphyseal fractures in children (*15-18*).

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