Intramedullary Kirschner wire (K-wire) fixation of femoral fracture in children

Ayman Hussain Jawadi · Adham Abdul-Samad

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Abstract

Purpose The aim of this study was to evaluate the efficacy of standard intramedullary Kirschner wires (K-wires) for the treatment of femoral shaft fracture in children.

Methods We report the results of intramedullary K-wires nailing in 178 children with a mean age of 7.7 years (range, 4–14 years) from 2000 to 2005, retrospectively. A total of 184 diaphyseal femoral fractures were treated with both antegrade and retrograde nailing using the same principles of elastic stable intramedullary nailing (ESIN). The patients were followed for 12 months on average (range, 6–24 months).

Results No major complication (limb length discrepancy >15 mm, non-union, avascular necrosis, knee joint stiffness) occurred during the observation period. All fractures healed within 7.1 weeks on average (range, 5–12 weeks). Associated injuries were seen in 16.9% of the cases. All but seven fractures were reduced by closed manipulation. Early mobilization and weight bearing was allowed. Intramedullary K-wires were removed after an average of 4.8 months (range, 3–12 months) without any complications.

Conclusions In children, intramedullary fixation by using standard K-wires provides effective treatment for the diaphyseal femoral fracture that has excellent clinical results. Each intramedullary K-wire costs US \$5, which adds a cost effective advantage to this method of treatment.

Keywords Femoral shaft fractures · Children · Intramedullary K-wires · Flexible intramedullary nails · Pediatric

Introduction

Femoral fractures in children are a disabling injury that, together with tibial and forearm fractures, constitute the most common pediatric long bone injuries [1, 2]. The femoral shaft fracture may be an isolated injury or may be one of multiple injuries, especially with high-energy trauma [3].

Femoral shaft fractures in children can pose a therapeutic challenge. For most patients younger than 5 years old, the initial treatment of choice is with hip spica with or without initial traction, which can give satisfactory results [4], while in older patients conservative treatment provides less satisfactory results [5, 6]. In adolescent patients, non-operative treatment does not always ensure complete fracture site rotational and translational stability, often resulting in angular and rotational deformities as well as in limb length discrepancy [7].

There are many options for operative fixation including external fixators, flexible intramedullary nails, locked intramedullary nails, and plate and screws. Choice for fixation is based on many factors, including the age and size of the child, associated injuries, the location and pattern of the fracture, and the social situation of the child [8].

Recently, flexible intramedullary nail has become the most popular choice of treatment of most femoral shaft fractures in children. This technique provides early ambulation, short hospital stays as well as less complication compared to other surgical options. We would like to share with you our experience of using intramedullary

A. H. Jawadi (✉) · A. Abdul-Samad
Department of surgery, King Saud bin Abdulaziz University
for Health Science (KSAU-HS), King Abdulaziz Medical City,
P.O.Box 286681, Riyadh 11323, Saudi Arabia
e-mail: jawadiortho@gmail.com

Kirschner wires (K-wires) for femoral shaft fracture, using the same principles of elastic stable intramedullary nailing (ESIN).

Materials and methods

A total of 184 femoral shaft fractures were managed at the author's institution, which is a first level trauma center, between 2000 and 2005. The charts of all children treated with intramedullary K-wires were reviewed ($n = 214$). To establish a more uniform study group, pathological fractures and cases who did not return for follow-up were eliminated from the study. This left us with 178 children in our study group. Demographic data, Gustilo and Anderson classification of open fracture [9], type of reduction (open versus closed), intramedullary K-wires duration and position, length of follow-up, range of motion at last follow-up, time to union for femur fractures, and complications were evaluated. Fracture union was defined as the appearance of bridging cortex on both anteroposterior (AP) and lateral radiographs.

Surgical technique

All procedures were performed directly by consultants and associate consultants, or under their supervision, by using a mostly similar surgical technique. The criteria for operative fixation were open fractures, displaced femoral shaft fractures with or without comminution, multiple trauma injuries, floating knees, and associated head injuries.

Under general anesthesia, the patient is placed on the orthopedic fracture table. All children received one dose of prophylactic intravenous antibiotics after general anesthesia induction. After fracture reduction under fluoroscopy guidance, small longitudinal skin incisions are made at the medial and lateral distal femoral metaphysis. By using an awl, two holes are made on each side of distal metaphysis about 1.5 cm proximal to growth plate (Fig. 1a). Through the holes, two long standard K-wires of 2.5–3.5 mm in diameter (depending on femoral isthmus and patient age) are introduced with bent proximal end (30°) by using a T-handle chuck one after the other. Once the K-wires have passed the fracture site, the tips of the wires are driven up to the level of proximal metaphysis with divergent to provide three-point fixation (Fig. 1b). At this stage, traction is released and the wires pushed further, fixing their tips at the proximal metaphysis without perforating the cortex. Care is taken during the wire insertion to avoid rotational deformity. The outer wire ends are bent, cut to the desired length, and buried under the skin.

Fig. 1 **a** A hole is made at distal metaphysis by an awl and a pre-bent K-wire is introduced with a T-handle chuck. **b** Two K-wires have passed the fracture site, providing a three-point fixation

Antegrade intramedullary K-wires were used in five patients with distal femoral shaft fracture. After a small longitudinal skin incision distal to greater trochanter, an awl is used to make two holes at mid lateral cortex 2 cm distal to the greater trochanter, with about 1 cm distance between the two holes. The wires are introduced using the same technique until the tips reach distal femoral metaphysis and diverge to provide three-point fixation. If the fracture is located at the very distal end of the shaft, the wires can pass the growth plate to be anchored at the femoral condyles to add more stability. Care is taken not to damage the growth plate by manipulating the wires back and forth through the growth plate during the insertion.

All but three children (with comminuted fractures) had no splint after surgery. Children were allowed walking (non-weight bearing with crutches) the next day as tolerated. They were instructed to put full weight bearing early within 2 weeks, if they had no comminuted or long spiral fracture.

Results

There were 126 male and 52 female patients who had 184 femoral fractures (88 left sided, 84 right sided, and 6 bilateral fractures). The mean age was 7.7 years, ranging from 4 to 14 years. The follow-up was an average of 12 months (range, 6–24 months).

The mechanisms of injuries were variable as shown in Table 1. Pedestrian and motor vehicle accident accounted for 75.3% of injuries. There were 180 closed (97.8%), and 4 open fractures (2.2%). There were one grade 1, and three grade 2 open fractures, according to the Gustilo and Anderson classification [9].

Table 1 Mechanisms of injuries

Mechanisms of injuries	Number of cases	%
Pedestrian	98	55.1
Motor vehicle accident	36	20.2
Fell at home	18	10.2
Soccer injury	12	6.7
Fell from height	10	5.6
All terrain vehicle	2	1.1
fell from swing	2	1.1

There were 72 proximal one-third femoral shaft fractures (39.1%), 94 middle one-third fractures (51.1%), and 18 lower one-third fractures (9.8%). There were 28 spiral (15.2%), 58 transverse (31.5%), 54 oblique (29.4%), and 44 (23.9%) comminuted fractures.

Associated injuries were seen in 60 patients (33.7%): associated fractures (38 patients), abdominal injuries (14 patients), head injuries (22 patients), eye injuries (4 patients), and spinal cord injuries (2 patients).

The median time for operative procedure was 55 min. Seven fractures (3.8%) required open reduction because of soft tissue interposition: proximal one-third (three fractures), and middle one-third (four fractures). Partial weight bearing ambulation with crutches was allowed during the second week as soon as the patient could tolerate. Full weight bearing was resumed 2–8 weeks after surgery according to the fracture type, amount of soft tissue injuries, and patient age. Most of patients with closed transverse middle one-third fractures were able to put full weight bearing as early as 2–4 weeks after surgery. All but three children (with comminuted fractures) had no splint after surgery.

The average time to union, as defined by bridging cortex on two orthogonal views, was 7.1 weeks (range, 5–12 weeks). Intramedullary K-wires were removed after an average of 4.8 months (range, 3–12 months). All patients had full range of knee motion after removal of Intramedullary K-wires.

Ten patients (5.6%) had complications, of which there were five types (Table 2). There were three cases which developed nail erosions through the skin distally; one of them required trimming of the K-wire tip, while the other two required removal of K-wires. One case with nail erosion had hip spica for 3 weeks (because of early removal of the wires), while the other one had healed fracture at the time of the K-wires removal. There was one patient who developed inflammation of the soft tissue near the knee by the wire tip, which resolved after K-wire removal. Two patients had transient peroneal nerve palsy due to excessive traction force intraoperatively, which resolved spontaneously after

Table 2 Complications

Complications	Number of patients
Skin erosion	3
Soft tissue knee irritation	1
Limb length discrepancy <1.5 mm	3
Transient peroneal nerve palsy	2
Superficial wound infection	1

5 months. There was one superficial wound infection in a patient who had closed fracture, which was treated by oral antibiotics for 2 weeks.

Three patients (1.7%) had limb length discrepancy less than 15 mm. None of the study patients developed deep infection, growth plate injuries, delayed union, non-union, avascular necrosis or knee joint stiffness.

Discussion

Immediate hip spica and skin traction followed by hip spica have been the standard treatment of femoral shaft fracture. Union can be readily achieved but requires prolonged hospitalization or immobility [1, 2, 10]. Although immediate hip spica casting is still commonly recommended in children between 1 and 6 years of age, [11] operative treatment has become increasingly common in older children [12]. Many authors have raised awareness of the possible social, economic, educational, and emotional costs of prolonged immobilization [13–15].

There are many options for operative fixation including external fixators, flexible and locked intramedullary nails, and compression and bridge plating [8]. After publication of good outcomes by the Nancy [16, 17] group in the early 1980s, elastic stable intramedullary nailing (ESIN) has become a well-accepted method of surgical treatment of long bone fractures in children and adolescents. Compared to plating, flexible intramedullary nailing of the femoral shaft fractures in patients over 6 years of age and less than 45 kg provides better results [18]. There are many reasons for this acceptance including absence of postoperative casting in most cases, primary bone union without growth plate injury, rapid recovery of joint motion and return to physical activities, minimally invasive surgery allowing small and aesthetic scars, low infection rate, and shortened hospital stays [19].

In our series, we used the same principles of ESIN to treat femoral shaft fracture using two intramedullary K-wires in children between 4 and 14 years of age. Three point fixations of intramedullary K-wires as well as micromovements at the fracture site provide balance with

compression and distraction forces leading to bone union. Therefore, post operative cast was not used, except in three patients as personally preferred by some surgeons, allowing full weight bearing 4–6 weeks after surgery. Both antegrade and retrograde nailing were used depending on the level of the fracture site.

Nail erosions through the skin distally and the soft tissue inflammation near the knee that occurred in four cases could be avoided by bending the tip of nail at about 90°, and turning it away from the skin so it will sit neatly on the bone surface. Limb length discrepancies less than 15 mm were noticed in three patients with transverse shaft fractures, indicating overgrowth at the fracture site. None of them has significant clinical limping, and all families were happy at the end. None of the study patients developed deep infection, growth plate injuries, delayed union, non-union, avascular necrosis or knee joint stiffness.

Most of the complications in this study (although they were not significant) were due to technical errors, including cutting the nail longer than the desired length, failing to bend the tip and turning it appropriately, and excessive traction force intraoperatively.

This study shares the good outcome and few complications of using intramedullary K-wires in treating femoral shaft fractures with Al-Zahrani et al. [20] and Qidwai and Khattak [4]. Intramedullary K-wire is a cost effective method, since each K-wire costs US \$5.

In conclusion, good results with this technique can be obtained when the principles of ESIN are used by surgeons who have good knowledge of fracture treating principles. We are looking in the future to compare this technique with elastic stable intramedullary nailing (ESIN). We believe this technique is safe, cheap (compare to other surgical methods), with fewer complications and excellent results.

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