Internal fixation of subtrochanteric femoral fractures in children using a T-plate

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Received 29 November 2015
Accepted 19 September 2015

Egyptian Orthopedic Journal 2015, 50:268–272

Background
Displaced subtrochanteric femoral fractures in children can be difficult to treat because of inherent fracture instability, a short metaphyseal fragment, and close proximity of the fracture to the growth plate. Different treatment options are used: traction, spica casting, internal fixation, and external fixation.

Objective
The aim of this study was to present our results with internal fixation of subtrochanteric femoral fractures in children using a 3.5-mm T-plate.

Patients and methods
Between January 2012 and July 2014, 10 patients with closed displaced subtrochanteric femoral fractures were treated in Al-Azhar University Hospitals. The average age at the time of injury was 7.2 years (range: 5.5–9.3 years). Open fractures, pathological fractures, and fractures associated with neuromuscular diseases were excluded from this study. Three patients had multiple injuries and seven (70%) patients had isolated subtrochanteric femoral fractures. In all cases a single 3.5-mm T-plate was used, and two or three 4-mm cancellous screws were inserted through the plate into the femoral neck. Average follow-up was 12 months (range: 9–18 months).

Results
All fractures united with anatomical alignment within an average of 8 weeks (range: 6–12 weeks). There were no complications. At the latest follow-up, no patient had any restriction of activities.

Conclusion
Internal fixation with a T-plate appears to be a good treatment option for children with subtrochanteric femoral fractures.

Keywords:
Internal fixation, subtrochanteric femoral fractures in children, T-plate

Egypt Orthop J 50:268–272

1110-1148

Introduction

Subtrochanteric femur fractures are uncommon injuries in children, representing only 4–10% of pediatric femur fractures [1]. Because of lack of a uniform definition for subtrochanteric fractures in children and varied fracture patterns, many studies tend to combine proximal shaft fractures with subtrochanteric fractures and report higher incidence rates for these fractures [2].

Several unique characteristics make these fractures difficult to manage. One characteristic is a short proximal metaphyseal fragment that usually displaces in flexion, abduction, and external rotation, causing difficulty in obtaining and maintaining reduction [3].

The common fracture patterns (oblique or spiral) impart instability to the fracture, especially in maintaining length. The remodeling potential of these fractures is limited, as the growth from the proximal femur is less than the growth from the distal femur [4].

The treatment of subtrochanteric femoral fractures in children is controversial. Different treatment options have been used: traction, immediate spica casting, internal fixation, and external fixation. Treatment choices are influenced by the child's age, size, and whether the femoral fracture is an isolated injury or part of a polytrauma [5].

The indications for operative treatment include multiple trauma, head injury, open fracture, floating knee, vascular or neurological injuries, failure of conservative treatment, older child or adolescent, and social indications [6]. Methods of internal fixation include intramedullary nails, compression plating, and external fixator [7,8].

The aim of the study was to evaluate the results of T-plate fixation of subtrochanteric femoral fractures in children.

Patients and methods

This was a prospective study performed at the Department of Orthopedics Surgery, Al-Azhar University Hospitals, between January 2012 and July 2014. Ten children with closed displaced subtrochanteric femoral fractures were treated with a 3.5-mm T-plate. The average age at the time of injury was 7.2 years (range: 5.5–9.3 years). There were six (60%) boys and four (40%) girls. The mechanism of injury included a motor car accident in seven (70%) patients and a fall from a height in three (30%) patients. The right femur was affected in six (60%) patients and the left in four (40%). Three (30%) patients had multiple injuries and seven (70%) patients had isolated subtrochanteric femoral fractures (Table 1). Open fracture, pathological fractures, and fractures associated with neuromuscular diseases were excluded from this study. Surgery was performed 1–5 days after injury. One unit of blood was available.

Surgical technique

Under general anesthesia, the lateral approach and posterolateral muscle splitting were used. Minimal soft tissue dissection and periosteal elevation were done. Manual reduction and distraction was attempted for reduction, correction of angulation, and restoration of length. In all cases a single 3.5-mm T-plate was used, and two or three 4-mm cancellous screws were inserted through the plate into the femoral neck to give good purchase for internal fixation. An intraoperative radiograph was taken to confirm that the proximal 4-mm cancellous screws were inserted into the femoral neck. No patient underwent bone grafting.

Table 1 Demographic features of patients and fractures

	N (%)
N	10 patients
Age (years)	
Average	7.2
Range	5.5–9.3
Sex	
Male	6 (60)
Female	4 (40)
Right femur	6 (60)
Left femur	4 (40)
Mechanism of injury	
MCA	7 (70)
Fall from height	3 (30)
Associated injuries	3 (30)
Isolated fractures	7 (70)
Types of fractures	
Spiral	3 (30)
Oblique	5 (50)
Transverse	2 (20)
Follow-up (months)	
Average	12
Range	9–18
Duration of healing (weeks)	
Average	8
Range	6–12

MCA, Medisch Centrum Alkmaar.

Postoperative management

Spica casts were used 3 weeks postoperatively. Crutch-assisted walking with limited weight-bearing was allowed 3 weeks postoperatively and full weight-bearing after 8–12 weeks.

Evaluation

Clinical and radiological assessment of the patients included radiographs in anteroposterior and lateral views, duration of healing, presence or absence of postoperative complications, hip and knee motion, leg-length discrepancy, and functional daily activities. A scanogram was taken for all patients to detect any leg-length discrepancy. The average follow-up period was 9 months (range: 12–18 months).

Results

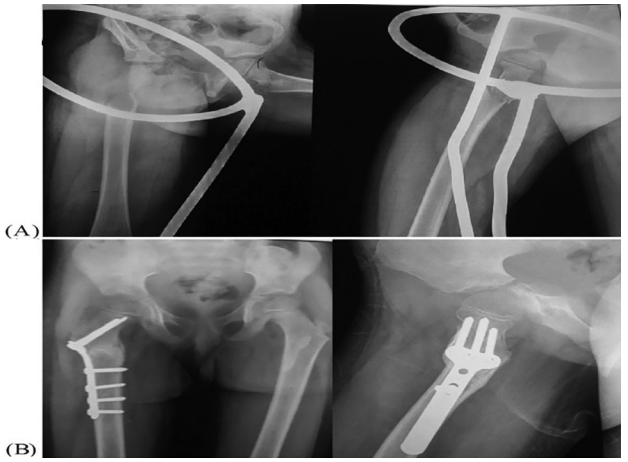
During the study period, ten patients with displaced subtrochanteric femoral fractures were fixed with 3.5-mm T-plates. Totally, six boys and four girls of a mean age of 7.2 years (range: 5.5–9.3 years) were included.

Radiographic evaluation revealed that the most common fracture pattern was a short oblique fracture in five (50%) patients. Three (30%) patients had a spiral fracture and two (20%) had transverse fractures. All fractures united with anatomical alignment (Figs. 1 and 2) within an average of 8 weeks (range: 6–12 weeks). There were no deep infections, but one (10%) patient presented a superficial wound infection that responded well to antibiotics and careful wound care. Patients with multiple injuries were hospitalized for a longer period compared with those with isolated subtrochanteric femoral fractures. In this study, only one (10%) child needed blood transfusion because of the associated injuries. Clinical evaluation revealed a full range of motion at both the hip and the knee joints in all patients. Patients participated fully in sports activities and none had restriction of activities. Scanograms revealed overgrowth of the injured femur, with an average of 0.6 cm (range: 0.3–1.2 cm) in three (30%) patients. No patient had noticed the leg-length inequality. At the latest follow-up, there

Figure 1

A female patient aged 6 years. (a) Preoperative anteroposterior and lateral views with subtrochanteric fracture of the femur (right). (b) Immediate postoperative anteroposterior and lateral views with T-plate fixation and hip spica cast. (c) Anteroposterior and lateral views 8 weeks postoperatively with complete healing.

Figure 2



A female patient aged 7 years. (a) Preoperative anteroposterior and lateral views with subtrochanteric fracture of the femur. (b) Eight-week postoperative anteroposterior and lateral views with T-plate fixation and complete healing.

were no patients with implant failure, refracture, heterotopic bone formation, or avascular necrosis of the femoral head.

Discussion

Pediatric subtrochanteric femoral fractures can be challenging to treat because of instability and displacement of the short metaphyseal fragments, as well as limited remodeling potential of the proximal femur in subtrochanteric fractures [3,4].

Pediatric subtrochanteric femoral fractures are a special type of unstable fractures that have received no special attention in the literature [6]. The patient's age may be the most important single variable for pediatric femoral fracture treatment. Treatment for children between the ages of 6–10 years is the most controversial. Treatment options include immediate spica casting, traction followed by hip spica cast, cast bracing, internal fixation, and external fixation [9].

Immediate spica casting is indicated for isolated femoral shaft fractures in children under 6 years of age [10]. Infante *et al.* [11] expanded the indications for spica casts to children up to 10 years of age. Its primary advantages are simplicity, low cost, and generally good results. Ferguson and Nicol [12] reported early spica casting in children less than 10 years of age. They found that age greater than 7 years was a variable predictive of a higher risk for failure of this technique to achieve satisfactory alignment. Martinez *et al.* [13] reported excessive shortening and angular deformity in 26 of 51 patients after immediate spica casting.

Traction followed by hip spica cast is the method preferred by many surgeons for the treatment of children aged 6–10 years [6]. Aronson *et al.* [14] studied 54 children who had been treated with traction for an average of 24 days before being placed in a hip spica cast. At the end of an average follow-up of 4.3 years, all children were functionally normal. However, this requires a relatively long hospitalization period and accurate control of fracture alignment with frequent radiographs and adjustment in traction as needed [15].

Several studies have documented superior results with fixation compared with nonoperative treatment [16]. The indications for operative fixation of pediatric subtrochanteric femoral fractures were presence of associated closed head injury and/or multiple injuries, open fractures, failure of conservative treatment, and isolated displaced pediatric subtrochanteric femoral fractures, as it is difficult to maintain such fractures in an accepted position by nonoperative means [17].

Methods of fixation of pediatric subtrochanteric fractures include compression plating, intramedullary nails, and external fixators [5].

Awareness of the advantages and disadvantages of intramedullary nails, compression plates, and external fixator and the skill needed to apply each tool safely are requisites for the ideal management of such fractures [18].

Good results were reported with external fixators, but the rates of pin tract infection, refracture, and loss of reduction are high as there is no sufficient room for

application of the pins into the proximal femoral fragment [5].

Flexible intramedullary nailing is the treatment of choice in pediatric femoral fractures. Patients are able to partially weight-bear early because nail is a load-sharing device and there is rapid fracture healing and a low incidence of malunion and nonunion [19]. Disadvantages of intramedullary nailing are lack of rotational control, exposure to irradiation, and backing-out of implants. Healing with an anterior angulation (apex anterior) was common after elastic nailing of pediatric subtrochanteric fractures [20].

Plate fixation has been shown to work well in the pediatric age group [21]. The disadvantages of plating are the need for plate removal, poor cosmetic appearance of the scar, blood loss associated with exposure and reduction of the fracture, and reported higher degree of overgrowth induced by the plates compared with intramedullary fixation. However, patients treated with a plate require less assistance, can walk with crutches within 3 weeks postoperatively, and can return to school sooner than children treated conservative measures [15].

Ward *et al.* [22] reported the use of a 4.5-mm AO (AO Foundation, Switzerland) dynamic compression plate for the treatment of femoral shaft fractures in 25 children, 6–16 years of age, 22 of whom had associated fractures or multisystem injury. The primary indication for this technique was simplification of nursing care and rehabilitation of children with an associated head injury or polytrauma. The average time to fracture union was 11 weeks. There were no infections and no angular deformities. Kregor *et al.* [17] reported on 12 patients who had 15 femoral fractures treated with compression plating. All fractures healed at an average of 8 weeks. Eren *et al.* [21] reported one case of infection that occurred in a child with polytrauma. In our study, we used a T-plate because the presence of two or three screws in the neck of the affected femur through the plate allowed good purchase for internal fixation and we encountered no deep infections, although one (10%) patient had superficial wound infection that responded well to antibiotics and careful wound care. Many other reports documented no deep infection with plate fixation [8].

The dissection and periosteal stripping during plate application may lead to overgrowth. Overgrowth was not a significant problem in the series of Kregor *et al.* [17], with an average increase in length of 0.9 cm (range: 0.3–1.4 cm), but Ward *et al.* [22] reported several patients with considerable overgrowth (~2.5 cm), and Hansen [23] reported overgrowth of 2.5 cm in a 12-year-old patient, suggesting that overgrowth is possible in children over 10 years of age. In our study scanograms revealed overgrowth of the injured femur with an average of 0.6 cm (range: 0.3–1.2 cm) in three (30%) patients. The overgrowth was not a significant problem.

Hardware failure is a possible complication in any implant. Fyodorov *et al.* [8] reported hardware failure in two of 23 femoral fractures treated with dynamic compression plating. Ward *et al.* [22] reported one broken plate postoperatively in a patient who began full weight-bearing a few days postoperatively. In this study, implant failure did not occur in any patient with a T-plate.

The need for hardware removal is controversial. Ward *et al.* [22] do not recommend plate removal in asymptomatic children. Eren *et al.* [21] also reported one patient (out of 40 patients) with refracture 9 years after plate removal. In this study, we reported no refracture or problems during the follow-up period.

Conclusion

Internal fixation with a 3.5-mm T-plate appears to be a good treatment option for subtrochanteric femoral fractures in children.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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