Submuscular plating of femoral fractures in children: the importance of anatomic plate precontouring

Mark Eidelman[a], Nabil Ghrayeb[b], Alexander Katzman[a] and Yaniv Keren[a,c]

Despite many treatment options, the treatment of metaphyseal pediatric femoral fractures remains to be controversial. Fixation of most metaphyseal femoral fractures in older children is difficult to perform. Recently, bridging fixation of such fractures by submuscular plating has become popular. Plate precontouring as close as possible to anatomic bony structure is important, as the femur will subsequently reduce to the contour of the plate with screw placement. Our technique is using plates that are anatomically precontoured to a cadaver adolescent femur to ensure proper postoperative alignment. In this study we evaluate the effectiveness of submuscular plating performed in our institution using this technique, in 11 patients. All fractures united with good alignment. No major complication occurred. In conclusion, submuscular plating of adolescent femoral fractures with precontoured plates is an effective, predictable, and save procedure. ***J Pediatr Orthop B*** **00:000–000 © 2010 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

Journal of Pediatric Orthopaedics B 2010, **00**:000–000

Keywords: femur fracture, precontouring, submuscular plating

[a]Pediatric Orthopedic Unit, [b]Department of Orthopedic Surgery B and [c]Department of Orthopedic Surgery A, Rambam Health Care Campus, Haifa, Israel

Correspondence to Yaniv Keren, MD, Department of Orthopedic Surgery A, Rambam Health Care Campus, PO Box 3602, Haifa 31096, Israel
Tel: +972 4 854 2018; fax: +972 4 854 2022;
e-mail: y_keren@rambam.health.gov.il

Introduction

Most fractures in children younger than 6 years of age can be treated conservatively by traction and spica cast fixation. However, nonoperative treatment modalities have fallen out of favor in older children because of the cost of hospitalization and prolonged immobility. Operative treatment modalities include intrameduallary nailing by flexible or rigid nails, external fixation, traditional open reduction and plate fixation, and submuscular bridging plating. Each operative treatment modality should preserve femoral blood supply, avoid damage to the physis, and achieve adequate fracture stability [1].

Plate precontouring as close as possible to the anatomic plate structure is important as the femur will reduce to the contour of the plate with screw placement [2]. Plate precontouring can be done by molding the plate to the contour of the unfractured femur based on preoperative X-rays, or intraoperatively using fluoroscopy after reduction of the fracture. We find plate precontouring to an adolescent cadaver femur to be more precise and easy to perform. In this study we evaluated the result of 11 patients who were treated in our institution by plate precontouring using this technique.

Materials and methods

During a 3-year period, we used submuscular plating in 11 patients with femoral fractures (10 boys, one girl). Mean age at the time of surgery was 10.8 years (range 8–16 years). One was an open fracture, classified to be a Gustilo type 1 fracture (Fig. 1a and b). Five fractures were subtrochanteric, four supracondylar, and two diaphyseal (Table 1).

We used 4.5 mm narrow low contact dynamic compression plate (LC-DCP) plates (Synthes, Glutz-Blotzheim-str.3, Switzerland) in six patients and 4.5 mm LCP plates (Synthes) in the remaining five patients. The patients were placed supine on a radiolucent table with both legs draped free for estimation of length and rotation. In all of the supracondylar fractures radiolucent triangles were used to achieve sagittal alignment. To minimize exposure of the patient and surgical team to radiation we use two incisions. One incision is made proximally over the greater trochanter. The other is made distally just above the physeal line. The length of each incision match the length of three subsequent screws of the plate (Fig. 2a). This way, all screws are placed under direct visualization without using fluoroscopy. All plates were precontoured to an adolescent cadaver femur that was placed in a sterile plastic bag intraoperatively (Fig. 2b and c). Proximal and distal femoral flares were carefully precontoured (Fig. 3a and b). Plates were inserted subperiostally using long thoracic Kelli clamps.

Two 2 mm Kirschner wires were inserted distally and proximally to maintain femur length. After the surgery the fixation was evaluated radiographically by long X-rays that included the lower limb from pelvis to ankle for the estimation of leg length discrepancy and deformity analysis. No additional cast fixation was used.

Postoperative ambulation was started immediately the next day on the opposite leg using crutches. Unsupported full weight bearing began at 8 weeks after surgery. Patients were followed radiographically and clinically every 6–8

 DOI: 10.1097/BPB.0b013e32833c665e

Fig. 1

(a and b) Open comminuted distal third femur fracture in a 9-year-old boy.

Table 1 Patients details

Name	Age (years)	Sex	Fracture type	Plate	Associated injuries	Complications
1. AI	8	Male	Subtrochanteric, spiral	4.5 LC-DCP	None	None
2. NB	9	Male	Subtrochanteric, spiral	4.5 LC-DCP	None	None
3. AU	14	Male	Supracondylar, spiral	4.5 LC-DCP	None	18 mm shortening
4. IB	11	Male	Supracondylar	4.5 LC-DCP	Ipsilateral open tibia fracture with 40 mm bone loss	None
5. UC	12	Male	Subtrochanteric, comminuted	4.5 LCP	Clavicular fracture	None
6. AS	9	Male	Subtrochanteric, spiral	4.5 LC-DCP	None	None
7. SA	16	Female	Diaphyseal	4.5 LCP	None	None
8. HA	9	Male	Open (gustilo type 1), comminuted, distal third	4.5 LCP	None	None
9. OS	8	Male	Subtrochanteric, comminuted	4.5 LCP	Ipsilateral tibia fracture	None
10. LA	12	Male	Supracondylar, spiral	4.5 LC-DCP	None	None
11. KM	11	Male	Diaphyseal	4.5 LCP	None	None

LC-DCP, low contact dynamic compression plate

weeks. Long radiographs, in standing position, have been taken 12 weeks and 1 year after surgery (Fig. 3c and d). All fractures were followed for at least 1 year after surgery.

Results

All fractures united in proper alignment, without clinically detectable rotational or angular deformity. One patient with spiral supracondylar fracture had 18 mm leg length discrepancy. There were no superficial or deep infections. Radiographic union was apparent after 6–10 weeks and solid union was detected in all fractures after 12 weeks .There was no complication related to hardware failure. Plates were removed in five patients easily, with no subsequent fracture.

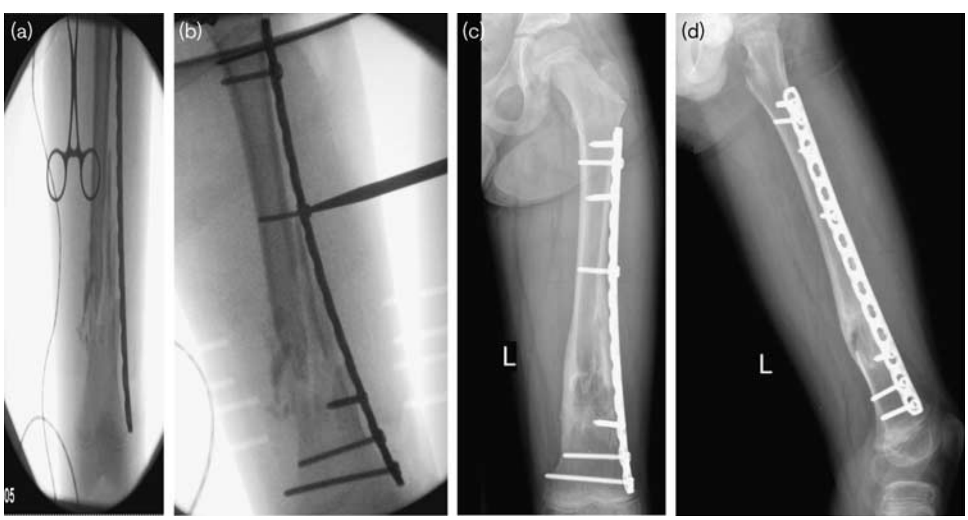
Discussion

There are several treatment options available today to treat femoral fractures in older children: Plaster cast, internal fixation using plates, external fixation, and intramedullary nailing using flexible or rigid nails. Cast is not a good option for older children and patients with multiple trauma [3]. External fixation is prone to pin tract infection and high refracture rate after hardware removal [4]. Titanium elastic nailing is probably the most popular method for fixation of femoral fractures up to the age of 6 years. This method allows fixation of most femoral shaft fractures through small incisions. However, elastic nails are not free of complications. Sink *et al.* [5] analyzed the result of 39 children with mid shaft femoral

Fig. 2

(a) Skin incisions. Length of each incision matches the length of three subsequent plate holes. (b) A cadaver adolescent femur in a sterile plastic bag. (c) Plate precontoured.

Fig. 3



(a) Insertion of a precontoured plate. (b) Femoral alignment reduced to precontoured plate. (c and d) Postoperative radiographs, 3 months after the operation.

fractures, treated with flexible nails. Complication rate was as high as 62%, with eight patients (21%) who underwent unplanned surgeries before removal. Another multicenteric study analyzed the result of titanium elastic nails [6]. The investigators cited significant complications in 10% of the cases. Narayanan *et al.* [7] reported early loss of reduction and malunion in comminuted, unstable fractures, after flexible nailing. Rigid intramedullary nailing before the age of 12 years is too risky because of the potential for femoral head osteonecrosis [8].

The treatment of metaphyseal femoral fractures is a debatable subject. Unstable and complex fractures, especially in polytrauma patients, are less suitable for elastic nails, as they cannot provide enough stability and do not prevent shortening and angulation [1]. Submuscular bridge plating offer the advantages of sparing growth plates, minimal soft tissue and periosteal damage, preservation of proximal femoral blood supply, ensuring alignment, and preventing significant femoral shortening.

Several studies reported the successful treatment of pediatric most complex femoral fractures by submuscular bridge plating. Kanlic *et al.* [9] described 51 patients with complex femoral fractures treated by submuscular bridge plating. Only two patients (4%) had significant complication. Sink *et al.* [2] reported 27 cases of unstable pediatric femoral fractures. The investigators described a technique where a precontoured plate was tunneled proximally through a small distal incision in the subvastus plane to bridge the fracture without intraoperative or postoperative complications.

We use a two incision technique, where the length of each incision matches the length of three holes of the chosen plate. With this technique we minimize radiation exposure. In our opinion, precontouring of the plate is crucially important. We agree with Sink *et al.* [2] that the plate should be contoured as anatomic as possible to the femur, for accurate fracture reduction with screw placement (Fig. 3a and b). There are several options to precontour the plate. We find precontouring the plate to an adolescent cadaveric model, to be most practical and easy to perform.

Although patients have different femur length and size, we believe that the proximal and distal flares of the femur are most important, but do not change significantly with age. Therefore, one model can be used for children at different ages, with different femur length and size.

Conclusion

We find submuscular plating of adolescent femoral fractures with precontoured plates to be an effective and save procedure. Precontouring of the plate to a cadaver femur intraoperatively is precise and easy to perform. According to our experience, this technique achieves predictable good results with low complication rates.

References

1 Kuremsky MA, Frick SL. Advances in the surgical management of pediatric femoral fractures. *Curr Opin Pediatr* 2007; **19**:51–57.

2 Sink E, Hedequist D, Morgan SJ, Hresko T. Results and technique of unstable pediatric femoral fractures treated with submuscular bridge plating. *J Pediatr Orthop* 2006; **26**:177–181.

3 Buechsenshuetz KE, Mehlman TC, Shaw KJ, Crawford AH, Immerman EB. Femoral shaft fractures in children: traction and casting versus elastic stable intramedullary nailing. *J Trauma* 2002; **53**:914–921.

4 Miner T, Caroll KL. Outcomes of external fixation of pediatric femoral shaft fractures. *J Pediatr Orthop* 2000; **20**:405–410.

5 Sink E, Gralla J, Repine M. Complications of pediatric femur fractures treated with titanium elastic nails. *J Pediatr Orthop* 2005; **25**:577–580.

6 Flynn J, Moroz L, Launay F. An international, multicenter analysis of complications of elastic stable intramedullary nailing of pediatric femur fractures. Podium presentation, 2004 POSNA annual meeting. St Louis.

7 Narayanan UG, Hyman JE, Wainwright AM, Rang M, Alman BA. Complications of elastic stable intramedullary nail fixation of pediatric femoral fractures, and how to avoid them. *J Pediatr Orthop* 2004; **24**:363–369.

8 Buford DJ, Christiansen K, Weathrall P. Intramedullary nailing of femoral fractures in adolescents. *Clin Orthop Relat Res* 1998; **350**:85–89.

9 Kanlic EM, Anglen JO, Smith DG, Morgan JS, Pesantez RF. Advantages of submuscular plating for complex pediatric femur fractures. *Clin Orthop Relat Res* 2004; **426**:244–251.

AUTHOR QUERY FORM

LIPPINCOTT WILLIAMS AND WILKINS

JOURNAL NAME: BPB

ARTICLE NO: 200470

QUERIES AND / OR REMARKS

QUERY NO.	Details Required	Author's Response
Q1	No queries.	