

Original Article

High incidence of varus deformity in association with condylar buttress plates used to treat supracondylar fracture of the femur

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ARTICLE INFO

Article history:

Received 28 November 2011

Received in revised form

26 January 2012

Accepted 13 February 2012

Available online 11 May 2012

Keywords:

condylar buttress plates

femur

supra-intercondylar fractures

ABSTRACT

Purpose: Supracondylar fractures of the femur are rare. Generally, the use of plate systems is the favored method of treatment, but the optimal plate for treatment is not well defined. Therefore, we carried out a retrospective study to investigate the outcome of using condylar buttress plates to treat supracondylar fracture of the femur.

Materials and Methods: We treated 45 patients with supracondylar fractures from 2003–2008. Thirty-four fractures in 34 patients were treated using the open reduction technique with condylar buttress plate fixation. All 34 fractures were classified as type C fractures according to classification guidelines of the Association for the Study of Internal Fixation/Orthopedic Trauma Association (AO/OTA). The clinical and functional outcomes of the knee were assessed on the basis of the Knee Society score (including knee score and functional score), and knee function was evaluated based on the criteria provided by Mize et al.

Results: Thirty patients were followed up for at least 1 year (range: 13–89 months; average: 29 months). The union rate of the fractures was 90% (27/30), and the average union time was 6.4 months (range: 2–12 months). Complications included deep infection (2 cases; 6.7%), knee stiffness (4 cases; 13.3%) and varus deformities (5 cases; 16.7%). Functional knee function outcomes included satisfactory Knee Society functional score, satisfactory Knee Society knee score, and satisfactory score based on the criteria suggested by Mize et al, which were 50% (15), 73% (22), and 50% (15) of patients, respectively.

Conclusion: A union rate of 90% can be achieved in cases of supracondylar fracture of the femur when treated with condylar buttress plates; however, the functional outcome can be fair to poor. Furthermore, the stability of fixation achieved with this technique is insufficient, which leads to a high rate of malunion.

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1. Introduction

Supracondylar fracture of the femur is relatively rare and difficult to treat.¹ Due to improvements in surgical techniques and orthopedic implants, open reduction and internal fixation (ORIF) is widely used as the standard treatment of supracondylar fracture of the femur.^{1–15} Previously, various types of internal fixation were used to achieve anatomic reduction and rigid fixation. The use of plate systems is the favored method of treatment, including condylar buttress plates,^{1,4,7,8,10,11,16} dynamic condylar screws,^{10,12,14,17} and fixed-angle condylar plates.^{1,10,15,18} However, the optimal plate system for treating these fractures and achieving

the best clinical outcome is controversial. The purpose of this study was to investigate the clinical outcomes and complications associated with the use of condylar buttress plates for the treatment of supracondylar fracture of the femur.

2. Materials and methods

We treated 45 patients with supracondylar fractures of the femur from 2003–2008 at Chang Gung Memorial Hospital, Taoyuan, Taiwan. Thirty-four fractures in 34 patients were treated by open reduction with condylar buttress plate fixation; the remaining patients were treated using other internal-fixation implants such as fixed-angle plates or dynamic condylar plates. We excluded four patients who were lost on follow-up within 1 year of surgery; thus, 30 patients were included in the final evaluation. These patients included 17 men and 13 women. The average patient age at the time of the fracture was 42.9 years (age range: 16–91 years). Ten patients had a fracture on the left side, and 20

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patients had fractures on the right side. According to the classification guidelines of the Association for the Study of Internal Fixation/Orthopedic Trauma Association (AO/OTA),¹⁹ 10 fractures were type C1, 14 were type C2, and six were type C3.

All patients underwent ORIF, which was performed by experienced surgeons via the standard lateral approach. In patients with complex fractures, supplementary screw fixation was used for additional support. After surgery, passive range-of-motion exercises were initiated without delay.

Fracture union and bony alignment were evaluated roentgenographically by obtaining anteroposterior and lateral plain film images of the injured leg. Fracture union was defined as the identification of trabeculae crossing the fracture site on serial roentgenograms. On the other hand, nonunion of the fracture was defined as the identification of the absence of trabeculae crossing the fracture site on plain film roentgenograms 1 year after surgery or as the need for revision surgery within 1 year after the first surgery. Bony alignment was assessed by measuring the lateral distal femoral angle.²⁰ This angle describes the intersection between the anatomic axis and the horizontal line tangential to the subchondral surface of the femoral condyles. The normal range of the lateral distal femoral angle is 79–83°. Varus deformity was defined as a lateral distal femoral angle >88°, and valgus deformity was defined as an angle <69°.

For each fracture, the clinical and functional outcomes of the knee were rated according to two scoring systems: the Knee Society score,^{22,23} which includes both the knee score and functional score (Table 1), and the criteria suggested by Schatzker and Lambert²⁴ (and further modified by Mize²⁵; Table 2). The Knee Society score is based on the following parameters: pain, range of motion, stability (mediolateral and anteroposterior), and deductions (flexion contracture, extension lag, and alignment). The functional score is based on walking, stair climbing, and deductions. The maximum attainable scores for the knee and functional scores are 100 points (grading: 80–100, excellent; 70–79, good; 60–69, fair; and <60, poor). We also further modified the criteria suggested by Mize (Table 2).²⁵

3. Results

Of the 34 patients treated with buttress plates, 30 were followed up for at least 1 year (range: 13–89 months; average: 29 months). The 1-year follow-up rate was 88.2%. More than a year after the surgery, bone union was observed in two fractures. The union rate was 90% (27/30), and the average time required for union was 6.4 months (range: 2–12 months). Complications included deep infections (2 cases; 6.7%), knee stiffness (4 cases; 13.3%), and varus deformities (5 cases; 16.7%). The two patients with deep infection were treated with antibiotics and surgical debridement; one of these patients developed chronic osteomyelitis. Two patients demonstrated nonunion of the fracture, and one patient who did not show callus formation at 9 months after surgery underwent revision surgery with intramedullary nailing that verified callus formation (Fig. 1).

The clinical and functional outcomes were evaluated using two systems. The mean knee score was 73.6 (range: 18–100); among these, 50% (15/30) had excellent scores, 23.3% (7/30) had good scores, 13.3% (4/30) had fair scores, and 13.3% (4/30) had poor scores. The satisfaction rate was 73% (22/30). We obtained an average score of 62.5 (range: 0–100) based on the Knee Society Functional Scoring System; among these, 46.7% (14/30) had excellent scores, 3.3% (1/30) had good scores; 6.7% (2/30) had fair scores, and 43.3% (13/30) had poor scores. The satisfaction rate was 50% (15/30). Evaluation based on the modified Mize criteria revealed that 10% of the patients (3/30) had excellent scores, 40% (12/30) had

Table 1
Knee Society knee and functional scores.

Parameter	Points	Parameter	Points
Pain		Functions	
None	50	Walking	
Mild or occasional	45	Unlimited	50
Stairs only	40	>10 blocks	40
Walking and stairs	30	5–10 blocks	30
Moderate		<5 blocks	20
Occasional	20	Housebound	10
Continual	10	Inability to walk	0
Severe	0	Stairs	
Range of motion		Normal up and down	50
5° = 1 point	25	Normal up; down	40
Stability		holding rail	
Anteroposterior		Up and down holding rail	
<5 mm	10	Up holding rail; inability	30
5–10 mm	5	to walk down	
10 mm	0	Inability to climb stairs	15
Mediolateral		Deductions (minus)	
<5°	15	Cane	5
6–9°	10	2 canes	10
10–14°	5	Crutches or walker	20
15°	0	Total deductions	–
Deductions		Function score	–
Flexion contracture			
5–10°	–2		
10–15°	–5		
15–20°	–10		
>20°	–15		
Extension lag			
<10°	–5		
10–20°	–10		
>20°	–15		
Alignment			
5–10°	0		
0–4°	–3 per degree		
11–15°	–3 per degree		
Total deduction			
Knee score (if the total is a negative number, the score is considered 0)			

good scores, 26.7% (8/30) had fair scores, and 23.3% (7/30) demonstrated failure. The satisfaction rate was 50% (15/30). All the results, including the clinical outcomes and complications, are shown in Tables 3 and 4.

Moreover, we used the Chi-square test as the statistical method to see if there was any significant difference between the occurrence rate of malunion for each type of fracture. The results demonstrate that there was no significant difference between the

Table 2
Modification of the Mize-modified criteria (original criteria suggested by Schatzker and Lambert).

Grading	Description
Excellent	All of the following: loss of flexion <10°; full extension; no varus, valgus, or rotatory deformities; no pain; and perfect joint congruency
Good	No more than any one of the following: loss of flexion >20°; loss of extension >10°; varus deformity >5°; valgus deformity >10°; or minimum pain
Fair	Any 2 of the criteria listed in the previous category
Failure	Any of the following: flexion ≤90°; varus deformity >10°; valgus deformity >15°; joint incongruency; or disabling pain, irrespective of the radiographic appearance

Alignment was determined by measuring the anatomic lateral distal femoral angle; the normal range of the angle was considered to be 79–83°.

Table 3
Clinical outcomes.

Parameter	Percentage
Union rate	90% (27/30)
Time to union	6.4 months (range: 2–12 months)
Complications	
Infection	6.7% (2/30)
Stiffness (knee flexion <90°)	13.3% (4/30)
Varus deformity	16.7% (5/30)

Table 4
Functional outcomes.

Parameter	Percentage
Knee Society score (Knee score)	
Excellent	50% (15/30)
Good	23.3% (7/30)
Fair	13.3% (4/30)
Poor	13.3% (4/30)
Knee Society Score (Functional score)	
Excellent	46.7% (14/30)
Good	3.3% (1/30)
Fair	6.7% (2/30)
Poor	43.3% (13/30)
Criteria suggested by Schatzker and Lambert	
Excellent	10% (3/30)
Good	40% (12/30)
Fair	26.7% (8/30)
Poor	23.3% (7/30)

malunion rates of each type of fracture ($p = 0.934$). In other words, the occurrence rate of varus deformity does not correlate with fracture type.

4. Discussion

In the past, the preferred treatment for supracondylar fracture of the femur has been controversial. Neer et al²⁶ collected data on 110 fractures from 1942–1966 and found satisfactory results using closed reduction and skeletal traction. Mooney et al²⁷ recommends cast-brace treatment for fractures of the distal femur. Nonsurgical methods of treatment yield a high union rate with a lower complication rates, such as infection, complications caused by technical errors, and increased risk of nonunion, than those associated with surgical treatment.^{26–29}

In the 1970s, with improvements in surgical techniques and the development of new implant designs, surgical treatments afforded better results and became widely accepted.^{1,7–15,25} Rigid internal fixation was thought to permit early rehabilitation, thus decreasing the incidence of malunion, nonunion, and loss of fixation.²⁹ Several devices can be used for internal fixation, such as an angulated blade plates,^{1,10,18,25} interlocking intramedullary nailing,^{6,9} condylar buttress plates,^{4,8,13,16,29} rush pins,¹⁰ and dynamic compression plates.^{10,12,14,17} Series of studies have investigated the outcomes and complications of each of these treatment methods (Fig. 1).^{1,4,6,8–10,12–14,16–18,25,29}

In our study, a union rate of 90% was achieved using ORIF with condylar buttress plates (Fig. 2); however, the functional outcomes were generally fair to poor. The stability of fixation was insufficient, resulting in a high rate of varus deformity (16.7%; Fig. 3). This indicates that condylar buttress plates may not have stable fixation strength, thus resulting in varus deformity. Studies on different treatment methods have shown comparable results.^{1,4,6,8–10,12–14,16–18,25,29}

Sanders et al¹² performed a study on 35 supracondylar/intercondylar fractures of the femur that presented in 32 patients who



Fig. 1. A 33-year-old man was involved in a traffic accident and diagnosed with supracondylar fracture of the left femur. Open reduction and internal fixation (ORIF) was performed using a condylar buttress plate. Follow-up roentgenography performed 9 months after surgery did not reveal callus formation. Therefore, revision surgery, including retrograde locking nail insertion, was performed and a bone graft substitute was positioned at the fracture site. Subsequent follow-up roentgenography revealed good bone union. Left to right: preoperatively obtained image of the anteroposterior (AP) view, AP view 9 months after surgery, AP view after revision surgery, follow-up AP view after the last visit to the outpatient department.



Fig. 2. A 55-year-old woman experienced a fall, after which she was diagnosed with supraintercondylar fracture of the left femur. Open reduction and internal fixation (ORIF) was performed using a condylar buttress plate. Follow-up roentgenography revealed bony union without malalignment. Left to right: preoperatively obtained image of the anteroposterior (AP) view, postoperative AP view, follow-up AP view after a visit to the outpatient department (OPD), and follow-up lateral view after the last visit to the last OPD.

were treated with dynamic condylar screws. They reported good to excellent results in 71% of the patients. The rate of nonunion was 5.7% and that of infection was 2.9%. Rademakers et al¹¹ performed a study on 67 monocondylar or bicondylar distal

femoral fractures in 67 patients treated with screws, with or without condylar buttress plates. They described good to excellent results in 84% of patients based on Neer scores and in 85% of patients based on the Hospital for Special Surgery knee score.¹¹

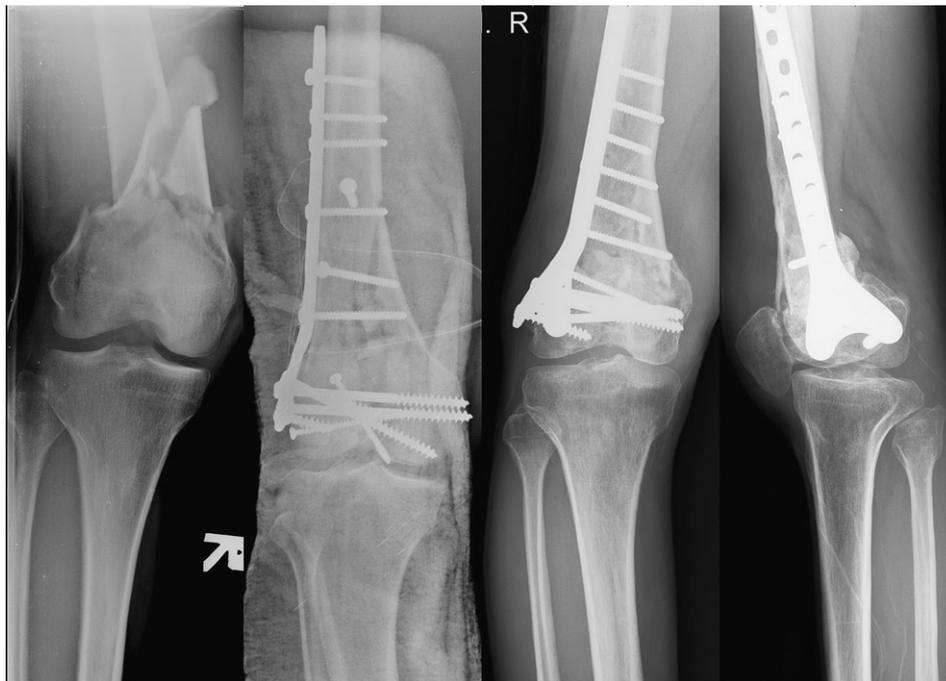


Fig. 3. A 33-year-old man was involved in a traffic accident and diagnosed with supraintercondylar fracture of the right femur. Open reduction and internal fixation (ORIF) was performed using a condylar buttress plate. A follow-up X-ray roentgenography performed 11 months after the surgery revealed good bony union but showed varus deformity. Left to right: preoperatively obtained image of the anteroposterior (AP) view, postoperative AP view, and AP- and lateral views obtained 11 months after surgery.

Table 5
Results of surgical treatment for supracondylar fracture of the femur using plates.

Author	Publication year	Treatment method	Number of fractures treated	Union rate	Nonunion rate	Malunion rate
Mize et al ²	1982	Fixed-angle plate	30	100%	0	7%
Giles et al ¹	1982	Dynamic condylar screw	26	100%	0	12%
Sanders et al ⁴	1989	Dynamic condylar screw	17	94%	6%	0
Shewring et al ⁵	1992	Dynamic condylar screw	10	80%	20%	0
Petsatodis et al ³	2010	Buttress plate	38	100%	0	26%
		Fixed-angle plate	24	100%	0	25%
		Dynamic condylar screw	54	100%	0	4%

¹ J. B. Giles, J. C. DeLee, J. D. Heckman, and J. E. Keever, 'Supracondylar-Intercondylar Fractures of the Femur Treated with a Supracondylar Plate and Lag Screw', *J Bone Joint Surg Am*, 64 (1982), 864–70.

² R. D. Mize, R. W. Bucholz, and D. P. Grogan, 'Surgical Treatment of Displaced, Comminuted Fractures of the Distal End of the Femur', *J Bone Joint Surg Am*, 64 (1982), 871–9.

³ G. Petsatodis, A. Chatzizymeon, P. Antonarakos, P. Givissis, P. Papadopoulos, and A. Christodoulou, 'Condylar Buttress Plate Versus Fixed Angle Condylar Blade Plate Versus Dynamic Condylar Screw for Supracondylar Intra-Articular Distal Femoral Fractures', *J Orthop Surg (Hong Kong)*, 18 (2010), 35–8.

⁴ R. Sanders, P. Regazzoni, and T. P. Ruedi, 'Treatment of Supracondylar-Intracondylar Fractures of the Femur Using the Dynamic Condylar Screw', *J Orthop Trauma*, 3 (1989), 214–22.

⁵ D. J. Shewring, and B. F. Meggitt, 'Fractures of the Distal Femur Treated with the Ao Dynamic Condylar Screw', *J Bone Joint Surg Br*, 74 (1992), 122–5.

Thirty-eight percent of patients showed varus or valgus malalignment of 2–4° and 6% showed malalignment of 5–10°. Petsatodis et al¹⁰ reported 116 supracondylar/intra-articular distal femoral fractures that were treated with ORIF using three different implants, including condylar buttress plates, fixed-angle condylar blade plates, and dynamic condylar screws. They concluded that patients who were treated with dynamic condylar screws demonstrated significantly superior outcomes compared with those treated with condylar buttress plates or fixed-angle condylar blade plates. Good to excellent results were obtained in 96% of the patients treated with dynamic condylar screws. The complication rate was also lower in these patients than those treated with condylar buttress plates or fixed-angle condylar blade plates. Moreover, treatment with dynamic condylar screws is less technical and easier to perform. Sanders et al¹² and Shewring et al¹⁴ reported good results using dynamic condylar plates. Furthermore, locking plates may provide sufficient stability, resulting in better clinical and functional outcomes than those achieved with current plate systems. However, the drawback of this technique is the high cost. Therefore, further studies are needed to acquire more conclusive evidence. The results of different studies are outlined in Table 5.

In our study, we further modified the criteria originally suggested by Schatzker and Lambert and modified by Mize. We defined valgus deformity as an angle <10° smaller than the lower limit of the normal range of the lateral distal femoral angle. In other words, a lateral distal femoral angle <69° was defined as a valgus deformity. On the other hand, varus deformity was defined as a lateral distal femoral angle >88°, which is 5° above the upper limit of the normal value. Andriacchi et al³⁰ and Zhao et al³¹ reported that during the stance phase of gait, contact loads on the internal knee joint are greater than those on the lateral side. Therefore, we hypothesized that the knee joint is vulnerable to varus deformity, which adds more load and stress to the medial side of the knee joint. Thus, varus deformity needs to be more strictly defined. We evaluated the clinical and functional outcomes using the criteria suggested by Mize, but with a modified definition of varus deformity.

Moreover, the satisfaction rate is 73% in terms of the Knee Society knee score, 50% in terms of the Knee Society functional score, and 50% in terms of the modified Mize score. The Knee Society knee score was used to evaluate plain film images and the mobility of the knee joint. The evaluation parameters include pain, range of motion, stability, flexion contracture, extension lag, and alignment. The Knee Society functional score evaluates the functional ability, which is comprised of walking, climbing stairs, and the use of a walking aid. The modified Mize score evaluates the

range of motion, alignment, and symptom of pain. Due to the different parameters used by each of the three different scoring systems, the satisfaction rates of each score do not coincide.

This study has several limitations. First, patient data were collected and analyzed retrospectively. Second, the number of patients in our study is low because of the low prevalence of supracondylar fractures of the femur. Further studies are needed to gather more information regarding these fractures.

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