Results of the Treatment of Type-C Distal Femoral Fractures using Four Different Implants: Condylar Blade Plate, Dynamic Condylar Screw, Condylar Buttress Plate, and Distal Femoral Locking Plate

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Objective: *To evaluate clinical results of surgical treatment of type-C distal femoral fracture using four different types of implants.*
Material and Method: *A retrospective study of 86 patients, all with type-C distal femoral fractures, and who underwent surgery using four different types of implants. The use of condylar blade plate, dynamic condylar screw, condylar buttress plate, or distal femoral locking plate, was evaluated. Following bone union, the functional outcome and the degree of knee flexion were assessed according to Schatzker and Lambert criteria.*
Results: *Good to excellent functional outcomes of the studied group were found in 72% of the 86 patients. Average knee flexion was 108.6 degrees. Among the four different implants, the functional outcomes were as follows: good to excellent results in 89% of the distal femoral locking plate group, in 78% of the dynamic condylar screw group, in 66% of the condylar blade plate group, and in 50% of the condylar buttress plate group. Knee flexion in patients treated with the distal femoral locking plate was significantly superior to that found in those who underwent condylar buttress plate implant. However, there were no significant differences encountered in other paired comparisons.*
Conclusion: *Of the four different implants used in surgical treatment of type-C distal femoral fracture, the distal femoral locking plate fixation implant provided the highest percentage of good to excellent functional outcome, and achieved a better degree of knee flexion than the condylar buttress plate. No significant differences were demonstrated in other paired comparisons.*

Keywords: *Type-C distal femoral fracture, condylar blade plate, dynamic condylar screw, condylar buttress plate, distal femoral locking plate*

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In the past, the treatment of distal femoral fractures did not achieve a high percentage of excellent clinical results because of difficulties in fixation stability, caused by thin femoral cortex, wide intramedullary canal, and/or comminution of the fracture[1]. However, the operative treatment has been proven to provide much better outcomes, with fewer complications than those of conservative treatment. Nonetheless, nonunion, delayed union, malunion, infection, and knee stiffness still persisted[2].

In the 1970s, the treatment of distal femoral fracture evolved with the advent of Arbeitsgemeinschaft für Osteosynthesefragen (AO) implants, instruments and fixation techniques such as condylar blade plate, dynamic condylar screw, and condylar buttress plate. In spite of these developments, numerous problems related to fixation technique failures, and varus collapses continued to be reported[3,4], especially when a comminuted fracture at the medial metaphyseal area was involved. In resolving such cases, Sanders et al.[4] advised the use of the medial buttress plate in order to prevent varus deformity. In an attempt to address this issue, Simonian et al.[5] introduced the 45º angulated screw placement in the lateral condylar buttress plate to strengthen the overall construction, and thus resist the tendency toward varus deformity. In addition, biological reduction techniques using direct reduction at the articular surface, and indirect reduction at the metaphyseal area enabled better bone union, and at the same time reduced implant failure[6,7,8]. Subsequently, the implants and instruments, including fixation techniques for distal femoral fracture such as distal femoral locking plate[9,10], supracondylar nail and

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distal femoral nail[11] were designed and developed. Nonetheless, problems still abounded with delayed union and implant failure[12,13,14].

Objective

The objective of this study was to report on the results of treatment of distal femoral fracture type-C in patients who underwent four different types of implants: condylar blade plate, dynamic condylar screw, condylar buttress plate, and distal femoral locking plate. After bone union, functional outcomes were assessed according to Schatzker and Lambert criteria. Subsequently, evaluation of the degree of knee flexion was made and the results obtained in the four groups compared.

Material and Method

Eighty-eight patients who sustained distal femoral fractures, using the AO classification as type-C (Fig.1), underwent surgery. Four different types of implants, namely condylar blade plate, dynamic condylar screw, condylar buttress plate, and distal femoral locking plate were used. All patients were admitted to and treated at Saraburi Hospital between 2002 and 2010. All patients in this study had sustained a type-C distal femoral fracture, and were treated with one of the above four implants, and could be followed till bone union. Exclusion criteria were patients with bone diseases, local limb disorders, systemic skeletal diseases, and motor function disorders. Prior to trauma, all 88 patients were reported to be in good physical health. Only 86 patients were included in the study. Two patients were subsequently excluded, one lost to follow up, and one to death.

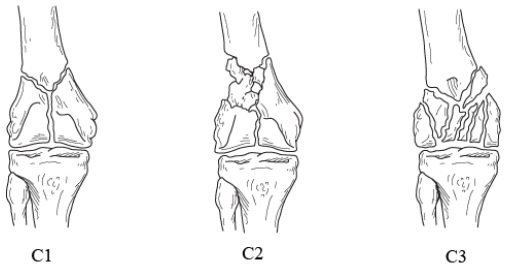

Fig. 1 Classification of fracture of distal femur type-C (Redrawn from Müller ME, Nazarian J, Koch P.: The comprehensive classification of fractures of longbones, Berlin, 1990, Springer-Verlag).

Operative treatments were performed by board certified orthopaedic surgeons who had surgical experience in trauma fixation. All surgeons executed the surgeries and the implants based on their skill and expertise. Following surgery, all patients underwent a similar rehabilitation protocol, and were discharged when able to walk (non-weight bearing), and with a minimum of 45 degrees of knee flexion. At discharge, they were educated to perform a home rehabilitation program which included improving knee range of motion. Follow-up appointments were scheduled on a monthly basis, at which time radiographs were obtained. Fracture healing was defined as complete bridging of the cortices, as seen on the radiographs, accompanied by full weight-bearing without pain. After bone union, the time for the union of the bone for each patient and the range of knee motion were evaluated. The range of knee motion was compared to the contralateral knee. Evaluation of the final radiograph for valgus and varus malalignment was carried out using the intramedullary line of the femur relative to the distal femoral articular surface, and again compared to the non injured side. All complications were documented. Treatment results were determined and assessed using two indicators: the functional outcomes classified according to Schatzker and Lambert criteria[15] (Table 1), and the degree of knee flexion. Clinical outcomes were evaluated using medical records and documented radiographic malalignment.

Statistical Analysis

Descriptive statistics (mean, standard deviation, and range) were used for demographic data. Functional outcomes were presented in the form of percentages. To determine the degree of knee flexion, the author applied the Kruskal-Wallis test as a statistical analysis for the comparison and evaluation of the values of the variables, which were graded according to the use of the four implants. Mann-Whitney U Test and Bonferroni Adjustment (significant $P<0.05/6$ or 0.0083) were used to reveal the differences between each paired-comparison (condylar blade plate/dynamic condylar screw, condylar blade plate/condylar buttress plate, condylar blade plate/distal femoral locking plate, dynamic condylar screw/condylar buttress plate, dynamic condylar screw/distal femoral locking plate, condylar buttress plate/distal femoral locking plate).

Results

Of the eighty-six patients who received four different implants (Fig.2), 54 were male and 32 female. The patients' ages ranged from 15-71 years (mean 45 years). Using the AO classification, there were C1, C2 and C3 in 23, 52 and 11patients, respectively. In addition, there were 7 open fractures. The average time to bone union was 20.98 weeks (range 12-36 weeks). The assessment, classified according to Schatzker and Lambert criteria, revealed that the functional outcomes were excellent in 41%, good in 31%, fair in 18%, and poor in 10% of patients. The average degree of

knee flexion, evaluated after bone union of the studied patients, was 108.6 degrees (range 45-140 degrees).

The details of implant options used for the studied patients were listed in Table 2. As to functional outcomes, good to excellent results were found in 89%, 78%, 66% and 50% in patients who underwent distal femoral locking plate, dynamic condylar screw, condylar blade plate, and condylar buttress plate, respectively.

When comparing the degree of knee flexion, the results demonstrated significant differences (P=0.03) in the patients who underwent four different implants. Consequently, the outcomes between the six paired comparisons, demonstrated that patients who underwent distal femoral locking plate had a significantly higher degree of knee flexion than those treated with condylar buttress plate (P=0.008). However, there were no significant differences demonstrated in other paired comparisons (Table 3).

Table 1 Functional outcomes classified according to Schatzker and Lambert Criteria.

Excellent:	Full extension Flexion loss of < 10º No varus, valgus, or rotary deformity No pain Perfect joint congruency
Good:	Not more than one of the following Length loss of not > 1.2 cm. Varus or valgus deformity of <10º Flexion loss of not >20º Minimal pain
Fair:	Any 2 of the criteria in good category
Poor:	Any of the following Flexion loss of ≤ 90º Varus or valgus deformity exceeding 15º Joint incongruency Disabling pain

Table 2 Comparison of treatment results on Distal Femoral Fracture Type-C treated with four implants.

	Condylar Blade Plate	**Dynamic Condylar Screw**	**Condylar Buttress Plate**	**Distal Femoral Locking Plate**
Number of patients (n= 86) classified according to A-O Classification:	12	23	24	27
C-1 (n=23)	5	10	4	4
C-2 (n=52)	7	13	15	17
C-3 (n=11)	0	0	5	6
Age (years):				
- Mean	46.10	43.48	46.67	44.26
- Standard deviation	12.91	12.75	11.01	11.68
- Range	20-70	19-68	16-69	15-71
Time for bone union (weeks):				
- Mean	20.33	20.30	22.25	20.7
- Standard deviation	6.62	5.1	4.9	4.52
- Range	12-33	12-32	12-36	16-34

	Condylar Blade Plate	Dynamic Condylar Screw	Condylar Buttress Plate	Distal Femoral Locking Plate
Functional outcomes according to Schatzker and Lambert Criteria:				
-Excellent	3 (25%)	11 (48%)	6 (25%)	15 (56%)
-Good	5 (41%)	7 (30%)	6 (25%)	9 (33%)
-Fair	2 (17%)	4 (17%)	7 (29%)	2 (7%)
-Poor	2 (17%)	1 (5%)	5 (21%)	1 (4%)
Degree of knee flexion after bone union:				
- Mean	105.83º	113.26º	98.51º	114.81º
- Standard deviation	17.65	17.79	25.10	12.13
- Median	100º	120º	100º	115º
Complications:				
- Varus deformity>5º	3 (25%)	5 (22%)	10 (42%)	4 (15%)
- Knee stiffness (flexion<90º)	2 (17%)	1 (4%)	5 (21%)	1 (4%)
- Leg length discrepancy>2 cm	1 (8%)	1 (4%)	3 (12%)	1 (4%)

Fig. 2 (a) Radiographs of type-C distal femoral fracture treated with condylar blade plate, (b) dynamic condylar screw, (c) condylar buttress plate, (d) distal femoral locking plate.

Table 3 Statistical analysis used to determine the difference of the degree of knee flexion of each pair-comparison.

	Dynamic Condylar Screw	Condylar Buttress Plate	Distal Femoral Locking Plate
Condylar blade plate	0.218	0.576	0.081
Dynamic condylar screw		0.027	0.961
Condylar buttress plate			0.008*
P values were determined with the Mann-Whitney U Test and Bonferroni Adjustment. * Significant (P <0.05/6 or 0.0083)			

Complications: the overall rate was highest in the patients who underwent condylar buttress plate and lowest in the patients treated with distal femoral locking plate. Malalignment (>5º of varus deformity): 42% (10 patients) was found in those who underwent condylar buttress plate, and 15% (4 patients) in those treated with distal femoral locking plate. Furthermore, five patients (6%), with open fractures and bone loss, had to undergo secondary bone graft: two in the group treated with condylar buttress plate, and one in each of the remaining three groups.

Two patients who underwent condylar buttress plate implants were found to have deep wound infection. These patients had sustained an open fracture, but recovered fully after a subsequent session of operative debridement. With regard to the implant failure, 2 cases were found only in patients who underwent surgery using condylar buttress plate; one case was with screw loosening on a male patient. The patient had a comminuted fracture at the medial metaphyseal area. At 28 weeks after the fracture, union of the fracture was 10º varus with three screws loosening. The patient needed a walking cane for outdoors movement. His knee flexion was 0º-45º. The other case (female psychiatric patient) had a broken condylar buttress plate. The broken plate occurred at six-months post operatively, but the patient declined to undergo further surgery. The fracture healed in 15º of varus with abundant medial methaphyseal callus at thirty-six weeks. Her knee flexion was 10º-45º.

Discussion

Operative treatment of fractures of the distal femur has been proven to provide much better results and fewer complications than conservative treatment. Shatzker et al.[16] reported good to excellent results in 75% of patients within a surgically treated series, whereas only 32% of those treated by nonsurgical means obtained good to excellent results. In this present study, the good to excellent results demonstrated that 89% of these patients underwent distal femoral locking plate, 78% of the patients were treated with dynamic condylar screw, 66% of the patients were treated with condylar blade plate, and 50% of the patients underwent condylar buttress plate. With regard to the study of varus deformity > 5º, the highest in 42% was found in patients who underwent condylar buttress plate, 25% was found in patients treated with condylar blade plate, 22% in patients who underwent dynamic condylar screw, and only 15% was found in patients treated with distal femoral locking plate. The results differed because of dissimilarities in the structure of the four types of implants. Distal femoral locking plate, dynamic condylar screw, as well as condylar blade plate are fixed angle devices which attach the femoral condyle to the femoral shaft. This provides stronger fixation stability than the condylar buttress plate. Furthermore, screws often become loose at the femoral condyle with patients treated with condylar buttress plate. This is due to screws pulling out and toggling the screw-plate junction. These fractures may result in varus deformity and limb shortening. Koval et al.[17] performed a biomehanical cadaver study and found that the condylar buttress plate with locked distal screws provided significantly stronger fixation stability than the standard condylar buttress plate, and the 95-degree blade plate, the results of which were in agreement with those of the present study.

Sanders et al.[18] suggested that patients with a fracture line <4 cm. in the lateral cortex near the knee joint should not be treated with condylar blade plate, or dynamic condylar screw. The condylar buttress plate and distal femoral locking plate offer an effective alternative since there are multiple screw-holes which provide better fixation. This suggestion agrees well with the finding of this present study, in which patients with comminuted fractures at the articular cartilage area (type C 3) were alternatively treated with the distal femoral locking plate and the condylar buttress plate, as recommended by Sanders et al.

With regard to the degree of knee flexion after bone union, most patients treated with a distal femoral locking plate attained an average of 114.8º of flexion; patients who underwent dynamic condylar screw experienced 113.2º; patients who underwent condylar blade plate attained 105.8º; and patients treated with condylar buttress plate, 98.5º. The present study reveals that there are significant differences in results obtained using a distal femoral locking plate and a condylar buttress plate; the distal femoral locking plate provided stronger fixation stability for comminuted fractures at the articular cartilage area than the condylar buttress plate, as mentioned earlier. However, no significant differences in the degree of knee flexion could be identified in the other five paired comparisons because in this study the condylar blade plate and the dynamic condylar screw were used only with non-comminuted intraarticular fracture patients (types C1, and C2), whereas the distal femoral locking plate and condylar buttress plate were used with both non-comminuted intra articular fractures and comminuted intra articular fracture patients (types C 1, C 2, and C 3). In point of fact, the knee flexion of the non-comminuted intra articular fractures, after surgery, demonstrated a better outcome than those of the comminuted intraarticular fracture patients. Thus, the comparison between these groups could not identify significant differences.

Traditional fixed angle devices (condylar blade plate and dynamic condylar screw) are strong fixation devices which can attach the femoral condyle to the femoral shaft. Nevertheless the traditional fixed angle devices limit their use in

comminuted intra articular fractures, whereas the condylar buttress plate and the distal femoral locking plate can be utilized in these situations since there are multiple screw holes which help obtain a better fixation. However, loosening implants and varus deformity were found in patients treated with condylar buttress plate due to toggling at the screw-plate interface. A distal femoral locking plate decreases screw-plate toggle and motion at the bone-screw interface and provides more rigid fixation. Rigid fixation is felt to be one key to the successful treatment of these fractures.

Conclusion

The present study evaluated the results of treatment of distal femoral fracture (type-C) using condylar blade plate, dynamic condylar screw, condylar buttress plate, and distal femoral locking plate. The results demonstrated a high percentage of good to excellent functional outcomes, (using the Schatzker and Lambert criteria), in patients who underwent distal femoral locking plate. The analysis revealed that the degree of knee flexion in patients treated with distal femoral locking plate was significantly superior to those who underwent condylar buttress plate. No significant differences were demonstrated in other paired comparisons.

This research was intended as a preliminary study prior to subsequent, larger studies in greater depth. It is hoped that this publication may be of some relevance for all physicians and medical practitioners, and hence bring benefits to our patients.

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การเปรียบเทียบผลการรักษา Type-C Distal Femoral Fracture โดยใช้ Condylar Blade Plate, Dynamic Condylar Screw, Condylar Buttress Plate และ Distal Femoral Locking Plate

วิกรม สู่พานิช, พบ

วัตถุประสงค์: *เพื่อศึกษาผลการรักษา distal femoral fracture type C ในกลุ่มผู้ป่วยที่ใช้ condylar blade plate, dynamic condylar screw, condylar buttress plate และ distal femoral locking plate*

วัสดุและวิธีการ: *เป็นการศึกษาแบบย้อนหลังในผู้ป่วยที่ผ่าตัดใส่โลหะดังกล่าวระหว่างปี พ.ศ.2545-2553 มีผู้ป่วย 86 คน โดยศึกษาองศาในการ งอเข่าและประเมินผลทางคลินิกตาม Schatzker and Lambert criteria เมื่อกระดูกติดดีแล้ว*

ผลการศึกษา: *การประเมินผลทางคลินิกพบว่ามี good to excellent ในกลุ่มผู้ป่วยที่ทำการศึกษาทั้งหมด 72% โดยมีความสามารถในการงอเข่า เฉลี่ย 108.6 องศา ผลการประเมินทางคลินิกของแต่ละกลุ่มพบ good to excellent 89% ในกลุ่มที่รักษาด้วย distal femoral locking plate, 78% ในกลุ่ม dynamic condylar screw, 66% ในกลุ่ม condylar blade plate และ 50% ในกลุ่ม condylar buttress plate และยังพบว่า องศาในการงอเข่าของกลุ่มที่รักษาด้วย distal femoral locking plate ดีกว่า กลุ่มที่รักษาด้วย condylar buttress plate อย่างมีนัยสำคัญ แต่ไม่พบความแตกต่างดังกล่าวในการจับคู่เปรียบเทียบกลุ่มอื่นๆ*

สรุป: *ผลการรักษา type-C distal femoral fracture โดยใช้โลหะดามกระดูก 4 ชนิด พบว่า การใช้ distal femoral locking plate ให้ผลการรักษาทางคลินิกอยู่ในเกณฑ์ ดี – ดีมาก โดยคิดเป็นร้อยละสูงที่สุดและพบว่าความสามารถในการงอเข่า ดีกว่าการใช้ condylar buttress plate แต่ไม่พบความแตกต่างดังกล่าวในกลุ่มเปรียบเทียบอื่นๆ*