Fixation of distal femoral fractures: Restoration of the knee motion

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ABSTRACT

BACKGROUND: Most of healed lower femoral fractures resulted in various degree of loss of the knee motion. Flexion deficit is a serious problem for the Eastern persons that are where squatting and sitting on the ground are necessary for daily activities. The aims of this study were to compare outcomes of using condylar buttress plate and dynamic condylar screw (DCS) in treatment of distal femoral fractures. Secondly, we present our clinical experience for optimizing the technical application of the studied implants.

METHODS: Two groups (plate and DCS) of 57 patients were treated for 59 lower femoral fractures with condylar buttress plate or DCS and followed prospectively for 24 months.

RESULTS: Plate group reported adequate reduction in 67% and varus angulation in 13.3% of the fractures. DCS group reported adequate reduction in 72.4% and posterior angulations in 17% of the fractures. Other reasons for inadequacy of reduction were reported in both groups. Full knee motion range was achieved in 50% of plate group and in 55% of DCS group. 75% and 90 % satisfactory functional outcomes were reported in the plate and DCS groups respectively.

CONCLUSION: Both implants nearly achieved equal results concerning restoration of knee motion range. The condylar buttress plate and DCS are liable for technical optimization.

Key words: Condylar buttress plate; dynamic condylar screw; fracture; knee motion; lower femur.

INTRODUCTION

Most healed lower femoral fractures result in various degree of loss in knee motion. Fractures treated conservatively complicate with extension lag, flexion deficit or locked knee. Deformity and loss of knee motion have led to widespread attempts at internal fixation.[1] However, surgical treatment has preserved knee extension but failed in restoration of the knee flexion. Fixation using retrograde nails obligates healing with posterior angulation particularly if the distal interlocking screws are fixed while the knee is extended. Posterior attachment of the gastrocnemius muscle encouraged healing with posterior angulation.[2,3] On the other hand, dynamic condylar screw (DCS) and condylar buttress plate give liberty for surgeon to adjust flexion and extension of the distal fragment at the main fracture line.[4] Flexion deficit is a serious problem for Eastern people who need to squat and sit on the ground for daily activities, which renders a search for a technique that restores knee motion range mandatory.

The aim of this study was to compare the outcomes of using condylar buttress plate and DCS in the treatment of distal femoral fractures. Our clinical experience for optimizing technical application of the studied implants was also presented.

MATERIALS AND METHODS

Fifty-seven patients, who agreed to participate in this prospective study between October 2006 and October 2011, were included and managed for 59 lower femoral fractures. Local Ethics Committee approved the study. The fracture patterns were determined radiographically according to AO classification. Preoperative details of the included patients are listed in Table 1. The mean age of the patients at the time of operation was 48 years (range, 24-82 years). The patients were divided into two groups, consisting the plate group and DCS group. The plate group included twenty-eight patients with 30 fractures, of which two were type B3 that was not encountered lone in this study. Coronal fractures (type B3) were fixed using 6.5 mm cancellous screws. The DCS group

included twenty-nine patients with 29 fractures.

A thigh tourniquet was used when the fracture did not extend too far proximally. Primary bone grafting was not done for any of our patients.

Postoperative management was individualized based on the quality of reduction obtained. Active and passive knee motions were started on the second postoperative day. Patients were allowed to walk using crutches and toe touch until absence of pain and a good callus had been observed on radiographs. Afterwards, progressive weight bearing was started. However, if the reduction was considered inadequate, partial weight bearing was allowed only when the callus bridged the fracture gap. Follow-up reviews were undertaken at every other week for 16 weeks, and then monthly. After the first year, patients were re-evaluated twice per year. The outcomes were assessed 24 months postoperatively.

Radiological Assessment

Reduction was categorized adequate if there was no angulation (extension/flexion, varus/valgus), displacement or rotation at the main fracture line. Angulation >10°, displacement between the main proximal and distal segments >2 mm or rotation was deemed inadequate. Displacements between the fragments within the articular block would be considered a technical failure of fixation. Angulations (varus/valgus and extension/flexion) were assessed by measuring the anatomic lateral distal femoral angle and anatomic posterior distal femoral angle, respectively. The anatomic lateral distal femoral angle describes the intersection between the anatomic axis and the horizontal line tangential to the subchondral surface of the femoral condyles, its normal mean value is 81° (range: 79-83°). The anatomic posterior distal femoral angle describes the intersection between the anatomic axis and the sagittal distal femoral joint orientation line, its normal mean value is 83° (range: 79-87°).[5,6] Proper rotation of the distal segment was judged radiographically using one of the techniques described by Krettek et al.[7] These techniques include: 1) cortical thickness 2) cortical diameters and 3) profile of the lesser trochanter. Choosing any of these technique depends on fracture pattern, site and comminution at the fracture line.

Technical failures were defined as screw penetration of ar-

ticular surface of the distal articular block, displacement >2 mm between the femoral condyles or condylar fragments (type B3 fracture), implant breakage or loosening, or non-union. Penetration of the medial cortex was not considered a technical failure.

The fracture was defined healed if there were visible trabeculae across the fracture line. Time to union was calculated from the surgery date to the healing date. Non-union was defined as the absence of bridging bone at the fracture line by follow-up at 12 months, including progressive displacements.

Clinical Assessment

Knee joint motion was measured using a goniometer and compared to the healthy side. Leg length was assessed by measuring the distance between the anterior superior iliac spine and the tip of medial malleolus. Lengths of the lower extremities were compared. Functional outcome was classified according to Schatzker and Lambert criteria.[8] The results were then classified satisfactory (excellent and good) and unsatisfactory (fair and poor).

Statistical Analysis

The results were expressed as maximum and minimum values, mean and standard deviation (SD). Z test was used for unpaired groups and nominal (categorical) data was used in the comparison between the plate group and the DCS group variables. Wilcoxon Rank Sum Test (Mann-Whitney U test) for unpaired data was used in the comparison between the plate group and the DCS group. Significance was set at p<0.05. Microsoft Excel 2010 was used, and the web site was http://www.socscistatistics.com/tests/ztest/Default2.aspx

RESULTS

The baseline data of the patients included into the study are listed in Table 1. Reduction was categorized in the plate group as adequate in 20 fractures (67%) and inadequate in 10 fractures (33%). In the DCS group, reduction was categorized as adequate in 21 fractures (72.4%) and inadequate in 8 fractures (27.6%) (Table 2). Difference between the two groups using Z test, was statistically insignificant (p=0.63122). Reasons for inadequate reduction in the plate group were varus angulation in 4 fractures (13.3%), displacement between the main proxi-

Table 1. Preoperative baseline data for two groups of patients with lower femoral fractures

Groups	Patients No.	Fractures No	Side		Sex		Fracture types								
			Right	Left	Male	Female	Type A			Type B			Type C		
							A1	A2	A3	B1	B2	B3	C1	C2	C3
Plate	28	30	15	13	17	11	5	3	6	0	1	2	3	3	7
DCS	29	29	18	11	20	9	5	5	5	0	1	0	3	3	7

Table 2. The results for two groups of patients treated for lower femoral fractures with condylar buttress plate and DCS

Type/no	Plate group								Sum	DCS group								Sum
	A1	A2	A3	B2	B3	C1	C2	C3		A1	A2	A3	B2	B3	C1	C2	C3	
	5	3	6	1	2	3	3	7	30	5	5	5	1	0	3	3	7	29
Reduction																		
Adequate	5	3	2	1	1	2	3	3	20 (67%)	3	3	5	1	0	2	2	5	21 (72.4%)
Inadequate	0	0	4	0	1	1	0	4	10 (33%)	2	2	0	0	0	1	1	2	8 (27.6%)
Shortening	0	0	3	0	0	0	0	4	7 (25%)	1	2	0	0	0	1	1	2	7 (24%)
Flexion deficit	1	1	3	1	2	1	0	5	14 (50%)	1	2	3	1	0	1	1	4	13 (45%)
Pain	0	0	0	0	0	0	0	2	2	0	0	1	0	0	0	0	0	1
Complications																		
Tf	0	0	0	0	1	0	0	2	3	0	1	0	0	0	1	0	2	4
Infection	0	0	0	0	0	0	0	2	2	0	1	1	0	0	0	0	0	2
Nonunion	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Grading																		
Excellent	4	2	3	0	–	2	3	2	16 (57%)	4	3	2	0	0	1	2	4	16 (55%)
Good	1	1	1	1	–	0	0	1	5 (18%)	1	1	2	1	0	2	1	2	10 (34.5%)
Fair	0	0	2	0	–	1	0	2	5 (18%)	0	1	0	0	0	0	1	0	2 (7%)
Poor	0	0	0	0	–	0	0	2	2 (7%)	0	0	1	0	0	0	0	0	1 (3.5%)

Tf: Technical failure.

mal and distal segments in 8 fractures (26.7%) and rotation in one fracture (3.3%). Reasons for inadequacy of reduction in the DCS group were posterior angulation in 5 fractures (17%), displacement between main proximal and distal segments in 7 fractures (24%) and rotation in 2 fractures (6.9%). In both groups, there was more than one reason for inadequacy of reduction per one fracture. It was remarkable that the posterior angulation was detected in the DCS group (Fig. 1); however, it was not observed in the plate group.

The fractures united within an average period of 15.5 weeks (8-28 weeks) in the plate group and 12.8 weeks (8-24 weeks) in the DCS group. Non-union was reported in one patient in the DCS group.
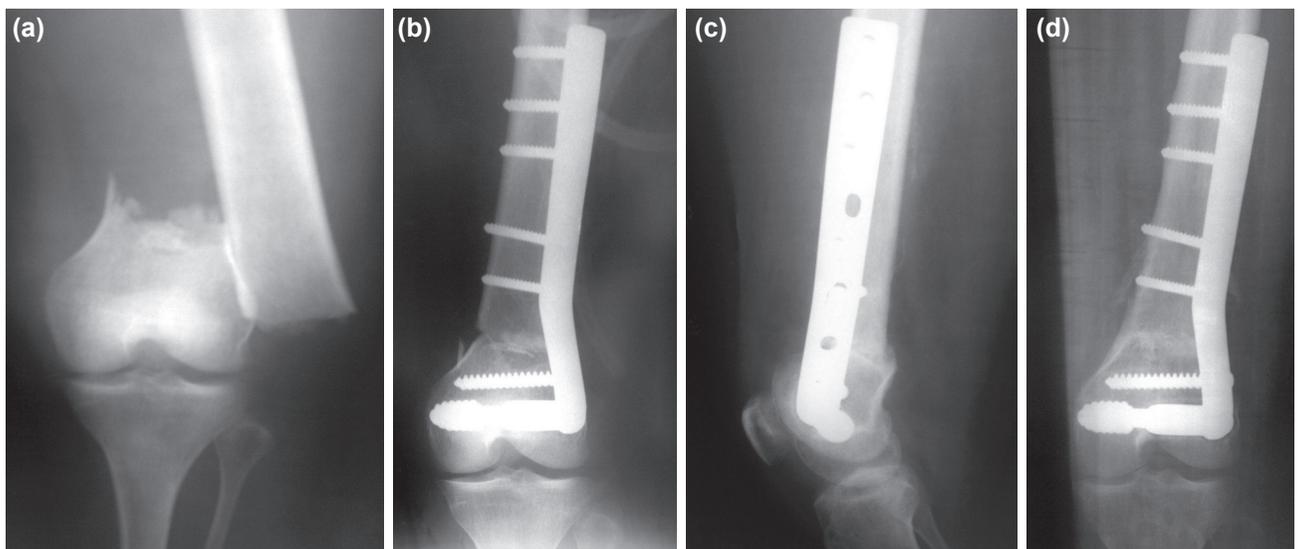
Figure 1. (a) Preoperative anteroposterior (AP) radiograph for right knee of a 45-year-old female shows AO type A1 lower femoral fracture; **(b, c)** the AP and lateral radiographs made immediately postoperative shows the fracture was fixed with DCS. The AP view shows medial cortical defect and the lateral view shows posterior angulation; **(d)** shows healed fracture with no varus collapse.

Full knee motion range compared to contralateral side was achieved in fourteen patients (50%) of plate group and in sixteen patients (55%) in the DCS group (Table 2). The difference between the two groups using Z test, was statistically insignificant (p=0.69654). Extension lag was not reported in any of the groups even in those with posterior angulation. Flexion deficit in the plate group averaged 10.5° (SD=11.7, range 0-30°) and in the DCS group averaged 10.3° (SD=12.7, range 0-40°). The difference between the two groups using U test, was statistically insignificant (p=0.90448).

Leg length inequality was reported in seven patients (25%) in the plate group and in seven patients (24%) in the DCS group (Table 2). The difference between the two groups using Z test was statistically insignificant (p=0.93624). Leg shortening in the plate group averaged 0.5 cm (SD=0.88, range 0-2 cm) and in the DCS group averaged 0.3 cm (SD=0.51, range 0-1.5 cm). The difference between the two groups using U test was statistically insignificant (p=0.67448). Persistent pain was reported in two patients of the plate group and in one patient of the DCS group (Table 2).

Functional outcomes (Table 2) in the plate group were reported as satisfactory (excellent and good) in twenty-one patients (75%) and unsatisfactory (fair and poor) in seven (25%). In the DCS group, satisfactory results were reported in twenty-six patients (90%) and unsatisfactory in three (10%). The difference between the two groups using Z test was statistically insignificant (p=0.14706).

Complications

Technical failure and deep infections were reported in five patients (17.9%) of the plate group and in six patients (20.7%) of the DCS group (Table 2). The difference between the two groups using Z test was statistically insignificant (p=0.64514). Technical failure due to displacement between fragments of the articular block was reported in 3 fractures (10%) of the plate group and in 3 fractures (10.3%) of the DCS group. Screw penetration of the distal articular block exclusively reported in one patient of the DCS group. The lag screw was reinserted soundly once discovered.

Deep infection was reported in two fractures in each group, three fractures healed after surgical intervention and parenteral antibiotics. The fourth was in the DCS group, an obese diabetic female with type A3 fracture. Deep infection was not controlled and the fracture was not united at the end of the follow-up period despite extensive surgical debridement, parenteral antibiotics and two attempts for bone grafting. Superficial wound infection was reported in three and five patients of the plate and DCS groups, respectively. In one patient of the DCS group with type A1 fracture, lag screw penetration of the medial cortex was observed. Upon bone healing, the lag screw was removed through small medial and lateral incisions, and rest of the DCS components were left (Fig. 2).

DISCUSSION

Condylar buttress plate has comparable advantages as DCS
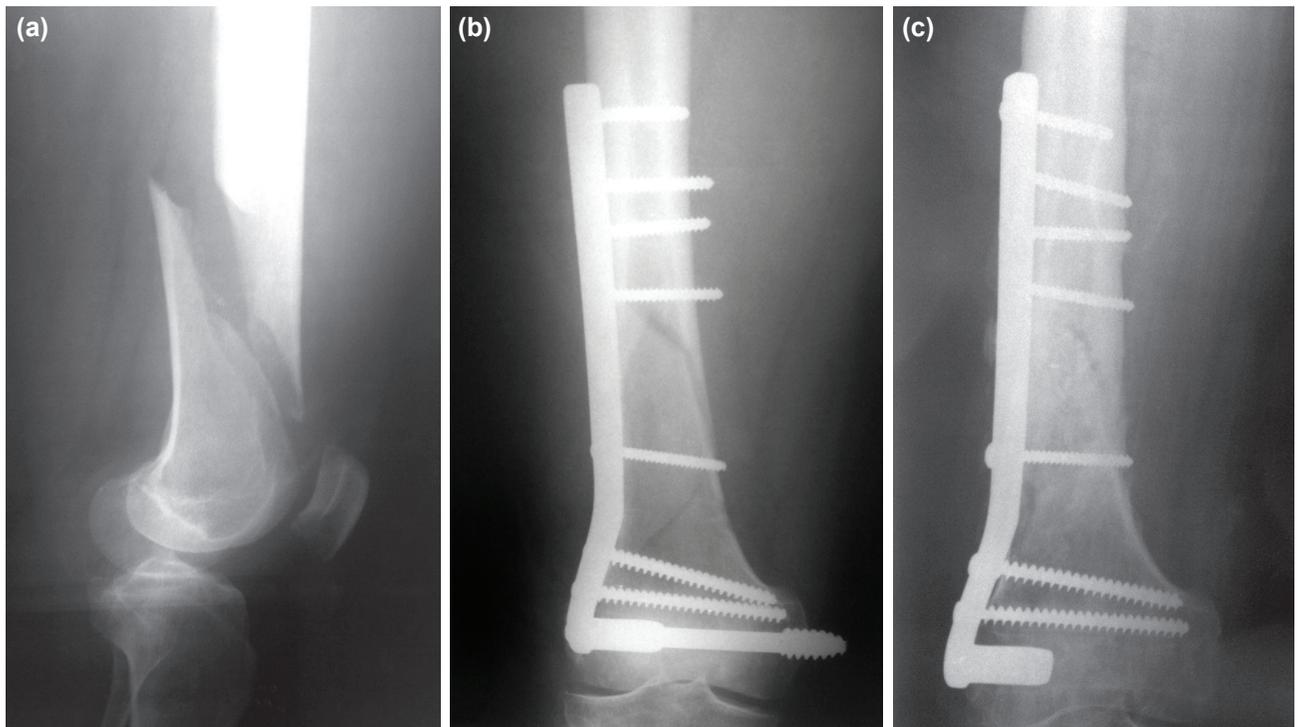
Figure 2. (a) Preoperative AP radiograph for left knee of a 57-year-old male shows AO type A1 lower femoral fracture; (b) AP radiograph made one month postoperatively shows lag screw penetration of the medial cortex; (c) AP radiograph made 6 months postoperatively shows healed fracture and lag screw was removed, rest of DCS composite was left.

such as familiarity and liberty for surgeons to reduce anatomically the distal fragment(s). However, it is required to know whether full knee motion range will be restored by using any of them.

Angle blade plates have been reported to give good results,[9] but the need to hammer the implant into position risks separating the femoral condyles.[10] DCS, which has a design analogous to that of the angled plate, is technically easier to apply and allows more freedom in the coronal and sagittal planes since the plate and screw are separate pieces.[11] Thereby, it makes accurate reduction, particularly when the fractures are intra-articular and the lag screw held well, even in osteoporotic bone.[10] Moreover, DCS did not fail with fatigue testing.[12] On the other hand, the condylar buttress plate was designed to allow multiple lag screw fixations of complex condylar fractures. However, this plate is not a fixed-angle device, and therefore, does not maintain correct alignment of the joint axis.[13]

Alignment of the distal articular block of the femur is the main treatment concern. Although the DCS design has the described stability, posterior angulation was reported in five fractures in the DCS group. In the earlier cases of the study, we had used one plate holding forceps prior to insertion of the cortical screws to the proximal bone segment, as we usually do with proximal femoral fractures, which allowed rotation of the distal segment around the lag screw, and consequently, posterior angulation (Fig. 1). Once the error was

realised, the second inserted screw was inserted to distal segment. When the distal segment was excessively short, a plate holding forceps was used to resist the rotation. In this way, posterior angulation was not observed again.

Posterior angulation was not reported in the plate group, which in our standpoint, was attributed to the fact that the plate was initially held with plate holder forceps, and distal end of the plate allowed multiple lag screw insertion. However, the plate group reported varus angulation in four fractures. The collapse of the distal fragment into varus has previously been attributed to the fact that individual lag screws are not fixed to the plate, and therefore it can easily shift their angulation relative to it.[13] A biomechanical study related varus angulation to decreased rigidity and strength of this device.[14] For maintenance of fixation, some authors have adopted double plating, placement of angulated screw in the lateral condylar buttress plate (Fig. 3) or locked plating.[13-15]

Flexion deficit has serious effects on the daily activities of Eastern peoples. Moreover, it may accelerate hip joint damage or loosening of hip endoprostheses.[16] The relevant authors have concluded the etiology of flexion loss in intra and extra articular possibilities such as mal reduction of the articular surface, arthrofibrosis, hardware penetration, capsular contractures or muscular scarring.[17,18] In the current study, flexion deficit was reported with intra articular fractures as well as with intact articular block, which theoretically, meant that the cause of deficit probably related to extra articular
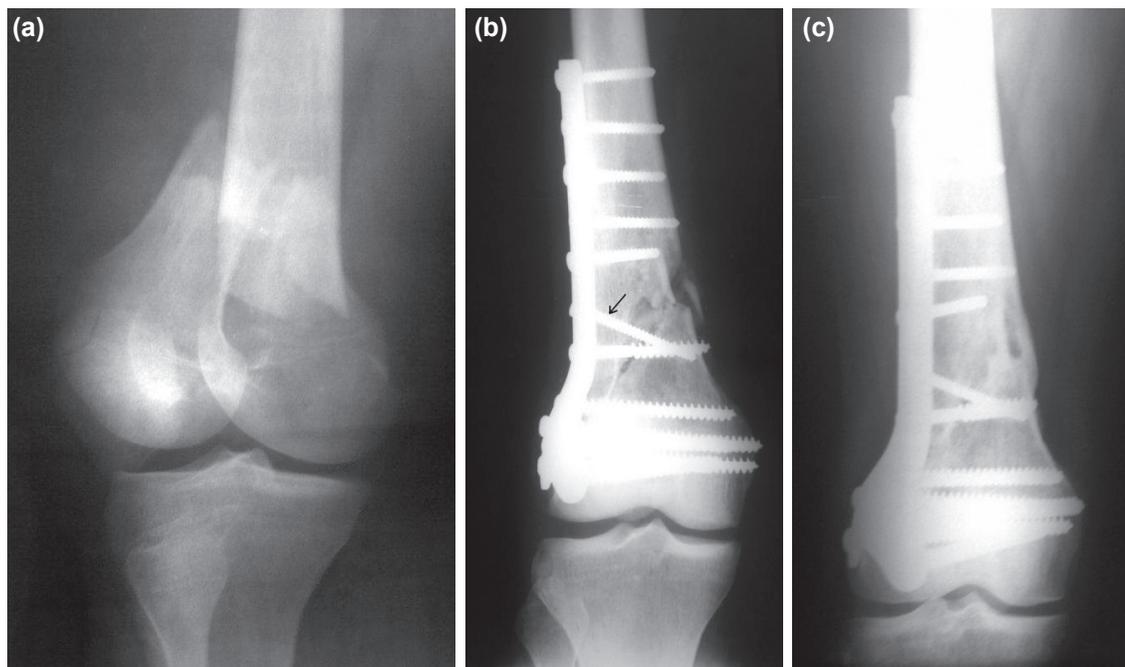
Figure 3. (a) Preoperative AP radiograph for left knee of a 30-year-old male shows AO type C2 lower femoral fracture; **(b)** AP radiograph made one month postoperatively shows the fracture was fixed with condylar buttress plate, and there is a medial cortical defect. A screw was placed diagonally across the fracture site (arrow) **(c)** AP radiograph made 6 months postoperatively shows healed fracture with no varus angulation. Screw angulation in the plate strengthened the overall construct to resist the tendency toward varus deformity.[14]

causes. Anterior adhesions was observed by authors practicing arthroscopic release in post-traumatic stiff knees. Anterior adhesions involve quadriceps expansion in the lateral and medial recesses, the suprapatellar bursa, muscle adhesions to the femur, or even shortening of the rectus femoris.[17] Excursion of the quadriceps, when the knee is flexed from zero to 90 degrees, has been shown to be six to eight centimetres. Therefore, any condition that injures the quadriceps, like a supracondylar femoral fracture, will result in limitation of the muscle elongation with loss of knee flexion.[19] Extension lag, even with posterior angulation, was not reported in the study. Brown et al. have reported that a lag in extension was present in every patient for some weeks following the operation; however, in no case did it persist.[20]

Flexion deficit was observed when the lag screw of the DCS was misplaced. In a case with type A1 supracondylar fracture, after assembly of the DCS components, passive flexion deficit was noticed. Mal-positioning of the distal femoral articular block was suspected. Mal-positioning affects patellofemoral kinematics, and abnormal tensioning of the soft tissues may also occur.[21,22] Using a triple reamer, the lag screw hole is re-reamed to a distance shorter than the screw length, which allows the distal articular block to move around the plate nozzle and relaxes the soft tissues. Thus, again tested passive flexion range increased.

Conclusion

No implant is superior to the other for restoration of knee motion when used for treatment of distal femoral fracture. Applications of the condylar buttress plate and DCS are liable for technical optimization.

Acknowledgement

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ORİJİNAL ÇALIŞMA - *ÖZET*

Distal femoral fraktürlerin fiksasyonu: Diz kinematiğinin restorasyonu

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AMAÇ: İyileşmiş distal femur kırıkları diz hareketlerinde çeşitli derecelerde kayıplara neden olmaktadır. Günlük aktiviteler için yere çömelme ve oturma gereği duyan Doğu toplumları için ciddi bir sorundur. Bu çalışmanın amacı, distal femur kırıklarında kondil destek plağı ve dinamik kondil vidası (DKV) kullanımının sonuçlarını karşılaştırmaktı. İncelenen implantların teknik uygulamasının optimizasyonunda klinik deneyimlerimizi sunduk.

GEREÇ VE YÖNTEM: İki gruba ayrılmış (plak ve DCS) 57 hastanın 59 distal femur kırıkları kondil destek plağı veya DKV ile tedavi edilmiş ve ileriye yönelik olarak 24 ay izlenmiştir.

BULGULAR: Plak grubu için kırıkların %67'sinde yeterli redüksiyon ve %13.3'ünde varus angülasyonu bildirilmiştir. DKS grubunda kırıkların %72.4'ünde yeterli redüksiyon ve %17'sinde posteriyor angülasyon bildirilmiştir. Her iki grupta redüksiyon yetersizliğinin diğer nedenleri de rapor edilmiştir. Plak grubundakilerin %50 ve DKS grubundakilerin %55'inde tam olarak diz hareket erimi gerçekleşmiştir. Plak ve DKS grubunda sırasıyla %75 ve %90 oranında tatmin edici fonksiyonel sonuçlar bildirilmiştir.

TARTIŞMA: Diz kinematiğinin restorasyonu açısından her iki implant ile hemen hemen benzer sonuçlar elde edilmiştir. Kondil destek plağı ve DKS teknik açıdan optimal düzeye getirilebilir.

Anahtar sözcükler: Dinamik kondil vidası; distal femur; diz motilitesi; fraktür; kondil destek plağı.