



ARAŞTIRMA / RESEARCH

Comparison of retrograde intramedullary nailing and percutaneous plate osteosynthesis methods in distal femur fractures

Distal femur kırıklarında retrograd intramedüller çivi ve perkutan plak osteosentez yöntemlerinin karşılaştırılması

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Abstract

Purpose: The aim of this study is to make prospective randomized comprehensive analysis of treatment results between the retrograde interlocking femoral nail and the percutan plate osteosynthesis in distal femoral fractures.

Material and Methods: Forty seven patients (34M, 13F) underwent surgical treatment in our clinic with distal femoral fractures were evaluated. While 23 patients underwent retrograde interlocking femoral nailing, 24 patients underwent percutan plate osteosynthesis. Patients fractures were classified according to the AO Classification. The patients had open fractures were classified according to Gustilo Anderson. The patients were evaluated about functional fracture healing, union time and complication rates.

Results: The mean union times were 25.3±5.7 weeks to 22.3±9 weeks. There were 8 excellent, 6 good, 7 moderate, 2 fair results in retrograde nail group and 12 excellent, 9 good, 3 moderate results in percutaneous plate group. The mean joint range of motion was 102.6±16.5° in the retrograde nail group and 115.8±18.3° in the percutan plate group.

Conclusion: Although union times are similar in both groups, percutan plate osteosynthesis is significantly superior than retrograde interlocking femoral nails about functions. Percutan plate osteosynthesis is significantly superior than retrograde interlocking femoral nail about complications.

Key words: Femoral fracture, intramedullary, fracture fixation.

Öz

Amaç: Distal femur kırıklarında retrograde kilitli intramedüller çivi uygulaması ile minimal invazif perkutan plakla osteosentez uygulamasının prospektif randomize olarak karşılaştırmalı analizi amaçlandı.

Gereç ve Yöntem: Distal femur kırığı nedeniyle kliniğimizde cerrahi tedavi uygulanan 47 hasta (34 E, 13K) değerlendirmeye alındı. Hastaların ortalama yaşı 40 (22- 69 arası) idi. 23 hastaya retrograde kilitli intramedüller çivi, 24 hastaya ise perkutan plakla osteosentez uygulandı. Hastaların kırıkları AO sınıflamasına göre sınıflandırıldı. Açık kırığı olan hastalar Gustilo Anderson sınıflamasına göre sınıflandırıldı. Hastalar fonksiyonel kırık iyileşmesi, kaynama süresi ve komplikasyonlar açısından değerlendirildi.

Bulgular: Ortalama kaynama süreleri retrograd çivi yapılanlarda 26 hafta, perkutan plak yapılanlarda 22 hafta idi. Retrograd çivi yapılan hastalarda 8 mükemmel, 6 iyi, 7 orta, 2 kötü sonuç elde edilirken perkutan plak yapılan hastalarda 12 mükemmel, 9 iyi, 3 orta sonuç elde edildi. Retrograd çivi yapılan hastaların ortalama diz eklem hareket açıklığı 100 derece idi. Perkutan plak yapılan hastaların ortalama diz eklem hareket açıklığı 115 derecedeydi.

Sonuç: Kaynama süreleri açısından her iki grupta da sonuçlar benzer olsa da perkutan plakla osteosentez fonksiyonel açıdan (retrograd kilitli intramedüller çiviye göre anlamlı olarak üstündür. Komplikasyonlar açısından da perkutan plakla osteosentez retrograd kilitli intramedüller çiviye göre anlamlı olarak üstündür.

Anahtar kelimeler: Femur kırığı, kırık tespiti, intramedüller yöntem.

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INTRODUCTION

The optimal method for the treatment of distal femoral fractures remains controversial. These fractures are usually complex and their management is fraught with a wide range of potential complications¹. Outcomes after nonoperative treatment are generally unsatisfactory, with a high incidence of ankylosis, varus and valgus malalignment, and malrotation². Improved implants, instrumentation and extensive surgical experience have made operative treatment the standard care for the management of these fractures¹.

During the period of time from the fixation with traditional standard plate and screws to the locking intramedullary nails, the introduction of locked plates has enabled the biological percutaneous fixation of distal femoral fractures to be utilised effectively^{1,2}.

Traditional open reduction and plating methods disturbs the natural process of fracture healing and is often associated with a high rate of nonunion and infection. The concept of 'biological' osteosynthesis and minimally invasive approaches has resulted in decreased complication rates³. Retrograde intramedullary nailing and bridge plating are frequently applied biological fixation methods. The advantages retrograd nailing include the allowance of load sharing by its intramedullary localization and resultant early loading. On the other hand, some of the disadvantages of retrograd nailing include the potential development of arthrosis due to knee joint damage during the retrograde application of the nail, observation of pain in the anterior part of the knee and systemic complications such as embolism during reaming, especially in patients with concomitant thorax trauma⁴.

Bridge plating, which has become more popular in recent years, together with locked plate manufacturing, causes external callus formation by allowing limited fracture movement against physiological loading and provides good fixation. As fixation is provided from the lateral side with this technique, knee problems that might develop due to the opening of the joint and embolism risk decreases; however, weight-bearing might be delayed⁴. Despite the widespread use of both techniques, few clinical studies have directly compared locked plates to nails^{3,4}.

The aim of this study is to make prospective randomized comprehensive analysis of treatment results between the retrograde interlocking femoral nail and the percutan plate osteosynthesis in distal femoral fractures.

MATERIAL AND METHODS

From July 2009 to January 2011, 58 patients with distal femur fracture were treated surgically in Adana Numune Training and Research Hospital and 47 (34 Male, 13 Female) of them followed completely. Eleven patients could not be re-examined because they died (5 patients) or changed address (6 patients). The study was approved by the Ethics Committee and performed in accordance with ethical standards of the Helsinki Declaration. A informed consent was taken from the patients.

Trauma mechanisms consisted, in order of frequency, of 31 patients (66%) from traffic accidents, 14 patients (30%) from falls from a height and 2 patients (4%) from simple falls. Two groups were randomly formed for a comparative evaluation and the mean age of the patients was 40 (between 22 and 69). The first group, which consisted of 23 patients, underwent retrograde locking intramedullary nail, while the second group, which consisted of 24 patients, underwent percutaneous plate osteosynthesis (Table 1).

Fractures of the patients were classified according to AO classification^{5,6}. While five patients were Type A1, 14 patients were Type A2 and 4 patients were Type A3 in the retrograde nail group; 5 patients were Type A1, 10 patients were Type A2, 7 patients were Type A3, 1 patient was Type B1 and 1 patient was Type C1 in the percutan plate group. Patients with open fractures were classified according to Gustilo classification⁹. While 5 patients were Type I and 2 patients were Type II in the retrograde nail group, 3 patients were Type I and 5 patients were Type II in the percutan plate group (Table 1).

Seven patients had additional pathologies. There was contralateral tibial fracture in three patients, ipsilateral pertrocanteric femoral fracture in two patients, elbow fracture and dislocation in two patients. One of the patients with tibial fracture had an additional frontal compression fracture. The patient with frontal crush was followed conservatively for any cranial pathology. Patients with tibial fractures were operated simultaneously

with intramedullary nailing. Patients with ipsilateral pertrochanteric femoral fracture were operated simultaneously with a 135-degree dynamic hip screw. The patients who had fracture dislocation of the elbow underwent an open reduction and plate-screws fixation simultaneously.

When the patients were first admitted into our clinic, double side femur and knee joint x-rays were taken. Ischium molded long-leg splint, following the tests towards additional pathologies, was performed to all patients. Anticoagulant prophylaxis with 0.4 IU enoksoparin was administered to all of the patients.

The fixation method to be applied to the patients was randomly determined. Pneumatic tourniquet was not applied in any of the patients. The patients were operated in the supine position on radiolucent surgical table. Fixation was made under fluoroscopic control in all surgical patients. All surgeries were performed by the same surgeon.

Surgical technique

Following the necessary preparation for patients who underwent percutaneous plate, the knee was supported and positioned by putting a pillow under the knee to set the knee in an approximately 45 degree flexion position. The bone was exposed with an approximately 4 cm incision on the lateral of the distal femur. After the placement of the plate as percutaneous, approximately 4 cm incision was made to expose the proximal of the plate. The plate, after being adapted to the femur proximally on the central side, was fixed to the bone with a temporary K-wire. After the fracture was reduced under fluoroscopic control, the plate was leaned into the bone by using 1 non-locking screw in the proximal and distal for each. Thus, fracture alignment was achieved by making use of the anatomical structure of the plate. In the meantime, the rotational alignment was also checked. After an acceptable alignment was achieved, the fracture was fixed with locking screws. For the patients treated with retrograde nails, following the necessary preparation, the knee was supported with a poplitea pillow by positioning the knee approximately 45 degrees flexion. The patellar tendon was splitted through longitudinal incision which was applied from the lower pole of the patella to tibia tuberosity. The joint was accessed and medulla was opened with the help of the awl from the 6-8 mm anterior of the femoral notch. The fractures were reduced under

fluoroscopic control and the guidewire was extended to medulla. Nine of 23 patients were reduced with the help of the mini-incision made on fracture line. The other 14 patients were reduced closedly. After medullar reaming, nail with appropriate length and thickness was adopted. By controlling the alignment of the fracture with fluoroscopy, the proximal locking screws applied by free hand technique and the distal locking screws were sent with the help of the external guide and the fracture fixation was completed. Two screws were used proximally and distally in all the patients.

None of the patients had complications during the operation. In the second postoperative day, exercises that protect the knee joint range of motion and strengthen quadriceps muscle were started. The patients were mobilized beginning from the 2nd day without weightbearing. Patients who were discharged from hospital were routinely called for the necessary controls. Approximately on the 15th day, the sutures were removed. Double side plain radiographs were taken monthly for six months. The patients who were exposed to partial weightbearing after union began to be seen, full weightbearing was not applied until the optimum union was observed.

Mean follow up time was 38 months (between 18 and 80 months). In the last examination, the patients were evaluated by using HSS 7 (Hospital for Special Surgery) knee rating scale 30 which was modified by Leung 7 et al. Through this evaluation system, the patients were evaluated in terms of pain (30 points), function (22 points), muscle strength (15 points), flexion deformity (10 points) and instability (5 points). The final evaluation point was calculated by decreasing 1-3 scores from the total points taking into account the support that was used, the presence of deformity and extension loss. The values over 85 were regarded as "excellent", while those between 70-84 "good", those between 60-69 "moderate" and those under 60 "fair".

Statistical analysis

In the course of our evaluation, whether the distribution of continuous variables was near the normal limit or not was investigated with the Shapiro Wilk test. Continuous variables were reported as mean \pm standard deviation or in the form of median (minimum-maximum), whereas the nominal variables were reported as the number of cases and percentage.

The significance of the difference between the groups in terms of the averages was investigated through student's T-test, and whether there was a significant difference between groups in terms of the median was conducted through the Mann-Whitney U-test. Nominal variables were evaluated through chi-square test. The results for $p < 0.05$ were considered statistically significant.

RESULTS

A total of 47 (34 male, 13 female) patients were included in the study. The mean age of the two randomly formed groups of patients was 40 (22 to 69) (Table 1). The mean age of both groups (while

those undergoing retrograde nail was 37.2 ± 12.7 , those undergoing percutaneous plate osteosynthesis was 42.6 ± 13) were statistically similar ($p = 0.163$). The mean follow-up period for the patients who underwent retrograde nail was 40 months (24 - 80 months) (Figure 1), while that of those who underwent percutaneous plate was 35 months (18-50 months) (Figure 2). Bony union was achieved in all patients. While the mean union time was 25.3 ± 5.7 weeks in the retrograde group, it was 22.3 ± 9 weeks in the percutan plate group. No statistically significant difference was observed between the study groups in terms of the duration of bone healing ($p = 0.163$).

Table 1. Demographical characteristics of the patients

	Retrograd Nail Group n=23	Percutan Plate Group n=24
Mean age (year)	37.2 ± 12.7	42.6 ± 13
Gender		
Male	16	18
Female	7	6
Trauma mechanism		
Traffic Accident	15	17
Falling from Height	7	6
Simple Fall	1	1
Closed Fracture	16	16
Open Fracture	7	8
Gustilo-Anderson Type		
Type 1	5	3
Type 2	2	5
AO/OTA Type		
A1	5	5
A2	14	10
A3	4	7
B1	-	1
C1	-	1

AO/OTA: Arbeitsgemeinschaft für Osteosynthese/Orthopaedic Trauma Association



Figure 1: The images of preoperative, early postoperative and the 6th postoperative month of the patient with AO Type A2 fractures who was applied retrograde nails.



Figure 2. The images of preoperative, early postoperative, and the 6th postoperative month of the patient with AO Type C1 fractures who was applied percutaneous plate osteosynthesis.

The ranges of knee joint motion were evaluated in the last follow-up of patients. In 5 patients who underwent retrograde nails (22%) over 120 degrees was obtained while in the others, the obtained degrees were as follows: in 9 patients (39%) from 100 to 110 degrees, in 8 patients (35%) from 80 to 100 degrees, and in 1 patient (4%) and under 80 degrees. The mean knee range of motion was 102.6 ± 16.5 degrees. In 10 patients who underwent percutaneous plate (42%), over 120 degrees was obtained, while in the others, the obtained degrees were as follows: in 11 patients (46%) from 100 to 110 degrees, in 3 patients (12%) between 80-100 degree. The mean knee range of motion was 115.8 ± 18.3 degrees. Significant difference was obtained between the two groups in the last follow-up of patients in terms of range of motion in the statistical evaluation ($p = 0.013$).

The patients were evaluated through modified HSS score⁷ in terms of functional classification (Table 2). In patients who underwent retrograde nail, the following results were obtained; 8 patients (35%) excellent, 6 patients (26%) good, 7 patients (30%) moderate, and 2 patients (9%) fair. In patients who underwent percutaneous plate, the following results were obtained; 12 patients (50%) excellent, 9 patients (37.5%) good, and 3 patients (12.5%) fair. The evaluation of both groups in terms of “excellent and good” results indicated that 61% (14 patients) of those who underwent retrograde nail and 87,5% (21 patients) of those who underwent percutaneous plate fell into the “excellent and good” category. Significant difference was obtained ($p=0.013$) between the two groups in the statistical evaluation conducted to compare HSS scores of the groups.

Table 2. Modified HSS Scores in the retrograde nail and percutan plate groups

	Retrograd Nail Group n=23	Percutan Plate Group n=24
Excellent	8 (35%)	12 (50%)
Good	6 (26%)	9 (37.5%)
Moderate	7 (30%)	-
Pair	2 (9%)	3 (12.5%)

Modified HSS: Modified Hospital for Special Surgery Knee Scoring System

Patients were evaluated for postoperative complications. No patients had postoperative infection. 1 patient (4%) who underwent percutaneous plate, revision (with plate-screws and allograft) was performed in the 24th week because of delayed union and breakage of the plate. In this patient, union was achieved in the 60th week. In 2 patients (8%) who underwent percutaneous plate, lateral knee pain was observed in the postoperative period due to the irritation of the iliotibial band. Implants of patients, whose complaints declined

following anti-inflammatory treatment, did not need to be removed.

Four patients (18%) who were operated with retrograde nails displayed anterior knee pain. Chondromalacia patella was identified in all of these 4 patients and were started to have medical treatment in conjunction with exercise to strengthen quadriceps muscle. The follow-up of patients still continues in terms of anterior knee pain.

The patients were evaluated for post-operative alignment disorders. Among those who underwent

retrograde nail, 5 patients (22%) displayed varus deformity of between 0 and 10 degrees, in 4 patients (17%), posterior angulation of between 10-20 degrees and in 1 patient (4%) posterior angulation of 30 degrees were observed. Among those who underwent percutaneous plate, 3 patients (12.5%) displayed varus deformity of between 0 and 10 degrees. The alignment disorder observed in

patients who underwent retrograde nail was 43% (10 patients), whereas that in the percutaneous plate group was 12.5% (3 patients). In the statistical analysis conducted to evaluate the alignment disorders in last follow-up of patients, a significant difference was observed between the two groups ($p < 0.01$) (Table 3).

Table 3. Comparison of results in the retrograde nail and percutan plate groups

	Retrograd Nail Group n=23	Percutan Plate Group n=24	P
Mean union time (weeks)	25.3 ± 5.7	22.3 ± 9	p=0.163
Range of motion of knee (degrees)	102.6 ± 16.5 degrees	115.8 ± 18.3 degrees	p=0.013
Modified HSS Score (Excellent and good results)	14 (61%)	21 (87.5%)	p=0.013
Malalignment	10 (43%)	3 (12.5%)	p<0.01
Varus deformity (0-10 degrees)	5 (22%)	3 (12.5%)	
Posterior Angulation (10-20 degrees)	4 (17%)	0	
(>30 degrees)	1 (4%)	0	

Modified HSS: Modified Hospital for Special Surgery Knee Scoring System

DISCUSSION

Distal femur fractures often occur as a result of high-energy trauma, such as traffic accidents in young adults, while in older patients, occur as a result of low-energy trauma, such as simple falls⁸⁻¹². Although many techniques have been used in the treatment of fractures of the distal femur, osteosynthesis with percutaneous plate is the most popular technique in recent years thanks to the widespread use of retrograde intramedullary nailing and locked plates^{13,14}. Both techniques have similar principles in that they allow the biological fixation of soft tissues around the fracture without being damaged. In addition, the fact that they permit minimal movement in the fracture line by providing relative fixation speeds up union¹³⁻¹⁶.

As with all the periarticular fractures, the implant used for the fractures of the distal femur and the surgical technique applied should provide a balanced fixation which will allow the exercises towards joint range of motion in early postoperative period, along with functional reduction^{13,14,17}. The two techniques that we compared in the present study bear the qualifications to fulfill this principle^{13,14,17}.

The advantages of percutaneous fixed-angle anatomical plate and retrograde locked

intramedullary nail are similar. Both of them are placed in a minimally invasive procedure and since the soft tissues involved in the fracture site are not stripped, bone nutrition is not affected. The amount of bleeding during surgery and risk of infection are less compared with open surgery because they are minimally invasive¹⁸⁻²⁰. In both cases, it provides better patient comfort after surgery because less surgical dissection causes less soft tissue injury. Both methods can be used safely in total knee arthroplasty patients who have periprosthetic fractures²⁰.

However, each of the two methods has also disadvantages. The most important disadvantage of the retrograde intramedullary nail technique is to have to place the implant by exposing the joint, in which case a possible infection can result in septic arthritis. In the related literature, the rate of septic arthritis after retrograde nails has been reported to be 0-14%²¹⁻²³. In our study, retrograde nail infection or septic arthritis was not observed in any of the cases.

Post-operative anterior knee pain can be seen as permanent. This situation has been reported in the literature as 30%²⁴⁻²⁷. In our study, anterior knee pain was observed in 4 (18%) patients who were applied retrograde nails. In all of these 4 patients,

chondromalacia patella was identified and medical treatment was started with quadriceps strengthening exercises. The follow-up of these patients in terms of anterior knee pain is still performed. Furthermore, in patients who undergo retrograde nail, articular cartilage can be damaged, leaving the nail in the knee joint may cause limitation of motion and may lead to the need to remove the implant. Moreover, following retrograde intramedullary nailing, deficiency in the nourishment of the anterior and posterior cruciate ligament has been reported in the related literature²⁸⁻²⁹.

Retrograde nailing is recommended in AO type A fractures. It can also be used in Type C fractures²⁷. But here, the restoration of the joint surface with arthrotomy and fixation the articular fragments with lag screws must first be achieved and subsequently, the fracture must be fixed with the nail. Of course, these screws should not be placed in the input path of the nail. The technical difficulty of this situation is a disadvantage of the retrograde nail. On the other hand, percutaneous plate osteosynthesis can be used safely in all distal femur fractures except for AO Type B Hoffa fractures³¹⁻³³. For proper retrograde nailing, the entry point should be determined correctly. Wrong entry can damage the intra-articular structures or make fracture reduction difficult. Due to the nature of the distal wide femur metaphysis, nails are insufficient alone in providing fracture reduction. Fracture reduction must be made before inserting the retrograde nail. If nail is inserted without making reduction, it is likely to increase the possibility of the angulation in the anterior-posterior and lateral plans. This is a disadvantage of the retrograde nail. In the present study, alignment disorder was observed in 10 patients (43%) who were applied retrograde nails.

The most important disadvantage of percutaneous plate osteosynthesis is that it is forced to support more weight since it is placed more laterally than the existing mechanical axis of the body, compared with the intramedullary nail. This can result in implant failure. The rate of implant failure has been reported to be 5-10%³⁴⁻³⁶ in the related literature. In our study, only one patient developed implant failure and after open reduction, the patient's fracture was revised with a plate by grafting the fracture site in the 24th week and union was achieved in 60th week. In our study, implant failure rate is 4%. Although the number of the patients is insufficient, the result is close to the rates in the literature.

Another disadvantage of percutaneous plate osteosynthesis is the possibility that it may irritate the iliotibial band on the lateral distal femur depending on plate size and thickness. This condition may lead to extraction of the implant³⁶. In our study, irritation of iliotibial band was seen in 2 patients (8%). With anti-inflammatory treatment, extraction of the implant was not needed because complaints of the patients decreased.

In our study, a comparative analysis of the patients who were applied retrograde nailing and percutaneous plate in our clinic owing to distal femur fractures was conducted in terms of union time, functional union and the complications in range of joint motion. Considering the statistical analysis in terms of mean union duration, no significant difference was found between the two groups. Range of joint motion and modified HSS scores were evaluated in terms of functional union on the last follow-up of patients. It was identified in the statistical study conducted that, in terms of functional union, percutaneous plate osteosynthesis was significantly superior to retrograde nail. In terms of complications in the statistical analysis, significant difference was found in the group who were applied retrograde intramedullary nail.

Limitations of this study is limited number of patients that was not large enough to strengthen the significance of the differences in rates of malunion and also delayed union. The other limitation is being a retrospective study, there was scope for selection bias; however, the groups were properly matched for age, sex, AO/OTA classification, mean duration between surgery and the occurrence of injuries and associated injuries.

Retrograde locked intramedullary nail and percutaneous plate osteosynthesis techniques can be used safely in the treatment of the distal femoral fractures. Although there are similar results in terms of duration of union in both groups, percutaneous plate osteosynthesis is significantly superior to retrograde locked intramedullary nail in terms of functional aspects (range of joint motion and modified HSS scores). Furthermore, in terms of complications, percutaneous plate osteosynthesis is also significantly superior to retrograde locked intramedullary nail.

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