RESEARCH ARTICLE / *Araştırma Makalesi*

Comparison of Percutaneous Plate Osteosynthesis and Retrograde Intramedullary Nail for Femur Supracondyler Fractures

Femur Suprakondiler Kırıklarında Perkütan Plak Osteosentez ile Retrograd İntramedüller Çivi Tedavilerinin Karşılaştırılması

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Abstract

Objective There is not optimal treatment option for distal femur. Implant failure, delayed union, nonunion and knee stiffness are the most common problem occur after distal femur fractures. The aim of this study is to compare clinical and radiological outcomes of the most used two techniques.

Materials and Methods Sixty-nine patients with distal femur fractures were included in this study. 45 patients (group A) undergone locked-bridge plating and 24 patients (group B) undergone retrograde intramedullary nail (RIMN). Patients were evaluated in terms of duration of union, complications, range of motion and functional results. Functional results were evaluated according to the knee range of motion and Knee Society Score.

Results There were no significant differences between the two groups in terms of demographic characteristics. While the mean union time was 7.2±2.1 months in the percutaneous plate group, it was 6.5±2 months in the RIMN group; however, there was no statistically significant difference between the study groups in terms of duration of bone healing (p=0.125). There was no statistically significant difference in the range of motion between the two groups at the last follow-up (p=0.371). There was no statistically significant difference in the Knee Society Scores between the two groups (p=0.353) too and also there was no statistically significant difference in the incidence of alignment disorders at the last follow-up between the two groups (p=0.791).

Conclusion Both groups had similar results in terms of duration of union, range of motion, and Knee Society Scores. Furthermore, there were also similar complication rates in both groups. Both techniques can be used safely in the treatment of distal femoral fractures with satisfactory outcomes.

Keywords Distal femur fractures; Percutaneous plate osteosynthesis; Intramedullary nail

Öz

Amaç *Femur suprakondiler kırıklarının uygun cerrahi tedavisi net olarak aydınlatılmış değildir. Bu bölge kırıkları sonrası implant yetmezliği, kaynama gecikmesi, kaynamama ve diz eklem sertliği en sık görülen komplikasyonlardandır. Bu çalışmanın amacı suprakondiler femur kırıkları için en sık kullanılan iki cerrahi tekniğinin radyolojik ve klinik sonuçlarının karşılaştırılmasıdır.*

Gereç ve Yöntemle *Femur suprakondiler kırığı için kliniğimizde tedavi edilen 69 hasta çalışmaya alındı. Hastaların 45'i perkütan plak osteosentez (grup A) ile ve 24'ü retrograd intramedüller femur çivi (grup B) ile opere edildi. Hastalar ameliyat sonrası kaynama süresi, komplikasyon, eklem hareket açıklığı ve fonksiyonel sonuç açısından değerlendirildi. Hastaların fonksiyonel sonuçları diz eklem hareket açıklığı ve diz cemiyeti skoru ölçülerek değerlendirildi.*

Bulgular *Her iki grubun demografik sonuçları birbirleriyle aynıydı. Kaynama süresi perkütan plak ile osteosentez yapılan hastalarda ortalama olarak 7.2±2.1 ay iken retrograd intramedüller çivi ile tedavi edilenlerde 6.5±2 ay idi ve iki grup arasında istatiksel açısından farklılık saptanmadı (p=0.125). Aynı zamanda her iki grup arasındaki eklem hareket açıklığı (p=0.371) ve diz cemiyet skoru (p=0.371) karşılaştırmalarında istatistiki olarak anlamlı fark bulunmadı. Hastaların son değerlendirilmelerinde alt ekstremite dizilim anormalliği açısından da istatistiksel açıdan anlamlı fark bulunmadı (p=0.791).*

Sonuç *Her iki grupta kaynama süresi, hareket açıklığı ve diz cemiyeti skoru açısından benzer sonuçlar elde edildi. Ayrıca her iki grupta da benzer komplikasyon oranları vardı. Her iki yöntemde distal femur kırıklarının tedavisinde güvenle kullanılabilir.*

Anahtar Kelimeler *Distalfemur kırıkları;Perkütan plak osteosentez;İntramedüller çivi*

INTRODUCTION

Femur supracondylar fractures develop with high-energy trauma in young people, while in the elderly it occurs with low-energy trauma.[1] 27% of cases are open fracture sand 58% have a fracture involving the joint[2]. An increased incidence of road traffic accidents has led to increases in distal femur fracture cases in both populations.[3]

The most appropriate treatment option for these fractures is still under debate[4]. The traditional open reduction and plate-screw fixation method disrupts the fracture healing process and causes an increase in infection and nonunion rates. However, fewer complications have been found in biological osteosynthesis using minimally invasive methods.5Commonly applied biological fixation methods include bridge plating and retrograde intramedullary nailing (RIMN).[5-10]

The popularity of the locking compression plate method of bridge plating has increased in recent years. It stimulates callus formation as it gives limited movement to the fracture fracture and is advantageous in comminuted metaphyseal fractures and osteoporotic fractures as it provides good fixation.[11-14] In this technique, fixation is performed from the lateral side of the femur, thus reducing complications that would otherwise develop due to entry into the knee joint; however, weightbearing may be delayed. In additionproblems such as, delayed union, nonunion and implant failure may occur.[15,16]

RIMN is frequently used in supracondylar femoral fractures due to its low complication rates and satisfactory results.[9,11] Since it is applied intramedullary, it facilitates load distribution and offers the advantage of early weight bearing.[8,17] Its disadvantages are that it may cause joint arthrosis, anterior knee pain, insufficient reduction in metaphyseal partial fractures, and embolism problems due to reamerization, especially in patients with chest trauma.[11,18-20]

Although both methods are widely used in the treatment of femoral supracondylar fractures, there are very few studies comparing nail and plate methods.[3,21] The aim of this study was to compare the treatment outcomes of RIMN versus percutaneous plate osteosynthesis in managing distal supracondylar femoral fractures.

MATERIALS and METHODS

This study is a cross-sectional descriptive study. Forty-five patient (23 males and 22 females; mean age, 49 years; age range, 21-83 years) who had undergone locked-bridge plating and 24 patients (14 males and 10 females; mean age, 49 years; age range, 21-85 years) who had undergone RIMN for the treatment of supracondylar femoral fractures between 2015 and 2018 were included in this study. The study was approved by theSakarya University Ethics Committee (71522473/050.01.04/182) and performed in accordance with the ethical standards of the Helsinki Declaration. Informed consent was obtained from all patients. The inclusion criteria were as follows:

- Patients older than 18 years;
- Supracondylar fracture of the femur where the fracture does not reach the proximal part of the distal third of the femoral shaft;

The exclusion criteria were as follows:

- Patients with a follow-up less than 18 months;
- Patients with concomitant knee ligament injury;
- Fractures longer than 3 weeks;
- Grade 3b and 3c fractures according to Gustilo-Anderson classification;
- Intraarticular fractures;
- Fractures with neurovascular injury;
- Ipsilateral extremity disease that will prevent postoperative rehabilitation;
- Periprosthetic fractures;

While AO classification system was used in fracture classification, Gustilo-Anderson classification system was used for classification of open fractures.[22,23]

Parenteral prophylactic antibiotics were administered to all patients 30 to 60 minutes before skin incisions were made.In both groups, routine surgical aseptic preparation was carried out. In the plate group, the knee joint was positioned at approximately 45 degrees of flexion using a pillow under the joint. The bone was exposed with an incision of approximately 4 cm on the lateral femoral condyle, through which the plate (TST, Istanbul, Turkey) was inserted percutaneously to bridge the fracture site under fluoroscopic guidance. Then, another approximately 4-cm incision was made to expose the proximal end of the plate. The plate was adjusted to be at the center of the lateral femur and fixed to the bone with a temporary K-wire. Further manipulation was done to achieve fracture reduction under fluoroscopy, and the plate was leaned into the bone using a non-locking screw in both the proximal and distal ends. Fracture alignment was thus achieved by making use of the anatomical structure of the plate. Rotational alignment was also checked simultaneously. After acceptable alignment was achieved, the fracture was fixed with locking screws.

In the nail group, the joint was accessed using a medial parapatellar approach of approximately 3 to 4 cm in length. The fracture was reduced, and length and alignment were restored with manual traction under fluoroscopy control. A guidewire was then introduced into the medullary cavity just anterior to the insertion point of the posterior cruciate ligament on the medial condyle and advanced in a retrograde manner towards the lesser trochanter level of the femur. The femoral medullary cavity was rimmed over the guidewire, and a RIMN (Biomet UK Ltd., Bridgend, South Wales, UK) was inserted. In all patients, the nail was locked with at least two locking screws at the distal part and at least one locking screw at the proximal end.

On the second postoperative day, exercises to increase the knee range of motion and strengthen the quadriceps were commenced. All patients were mobilized on the second day without weightbearing. Patients were discharged from hospital and routinely followed up as outpatients. Sutures were removed approximately 15 days post-surgery. Orthogonal-view (anteroposterior and lateral) plain radiographs were taken monthly for 6 months. The patients were asked to commence partial weightbearing after bone union activity was evident in the radiographs; full weightbearing was not advised until optimum union was observed.

All patients were evaluated in term of complications, time to union, range of motion, and functional results. In the evaluation of functional results, knee range of motion was checked a Knee Society Scoring was performed.[24]

Statistics

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 21 and presented in figures and tables with the aid of Microsoft Office Word and Excel. Descriptive statistics; number and percentage for categorical variables, mean, standard deviation, minimum, maximum for numerical variables. Comparisons of two independent groups were made with Student's t test when numerical variables met the normal distribution condition, and with the Mann Whitney U test when they did not meet the normal distribution condition.Proportions in independent groups were compared using Chi-Square Analysis. Relationships between numerical variables were analyzed by Spearman Correlation Analysis since the distribution normal condition was not met. Statistical significance level of alpha was accepted as $p < 0.05$.

RESULTS

There were no significant differences between the two groups in terms of demographic characteristics. The mean age was 49.3 years in the percutaneous plate osteosynthesis group and 49.8 years in the RIMN group (p=0.896). Patients included in both groups are type A fractures according to AO classification. With regard to the causes of injury, the plate osteosynthesis group comprised 28 patients (62.2%) from traffic accidents, 12 patients (26.6%) from falls from heights, and 5 patients (11.1%) from simple falls;

the RIMN group comprised 11 patients (45.8%) from traffic accidents, 7 patients (29.1%) from falls from heights, 2 patients (8.3%) from simple falls, and 4 patients (16.6%) from ballistic injuries.

The demographic characteristics of the patients are presented in Table 1. The mean duration of injury before surgery was 2.8 days (range, 1–6 days) in the plate group and 3 days (range, 1–13 days) in the RIMN group.

Table 1. Characteristics of patients in the percutan plate group and the retrograde nail groups

Variables		Percutan-PlateGroup n=45	Retrograd Nail Group n=24
Meanage (year)		49,3±15,9	49,8±19,1
Gender	Male	23 (51.1%)	14 (58.3%)
	Female	22 (48.9%)	10 (41.7%)
Side	Right	21 (46.7%)	14 (58.3%)
	Left	24 (53.3%)	10 (41.7%)
Traumamechanism	TrafficAccident	28 (62.2%)	11 (45.8%)
	Fallingfrom-Height	12 (26.6%)	7 (29.1%)
	Simple Fall	5 (11.1%)	2 (8.3%)
	Ballistic	0	4 (16.3%)
Type of fracture	Close fracture	38 (84.4%)	18 (75%)
	Open fracture	7 (15.5%)	6 (25%)
	Grade 1	5	1
	Grade 2	2	1
	Grade 3a	0	4
Classification (AO/OTA)	33-A1	16 (35.5%)	8 (33.3%)
	33-A2	17 (37,7%)	8 (33.3%)
	33-A3	12 (26.6%)	8 (33.3%)
MeanPreoperativeStay ±SD (days)		2,8±1,3	3,0±2,8
Meanfollowup± SD (months)		35,1±9,0	30,8±9,0

AO: Arbeitsgemeinschaft für Osteosynthesefragen; OTA: Orthopedic Trauma Association

The mean follow-up period for the percutaneous plate osteosynthesis group was 35.1±9 months (range, 21-51 months) while in the RIMN group it was 30.8±9 months (range, 19-54 months).Bony union achieved in all patients. The mean union time was 7.2±2.1 months in the percutaneous plate group (Figure 1) , it was 6.5±2 months in the RIMN group (Figure 2). There was no statistically significant difference between the two groups (p=0.125).

Figür 1: Radiographs (a,b) before and (c,d) 8 months after percutaneous plate osteosynthesis for distal femur fracture.

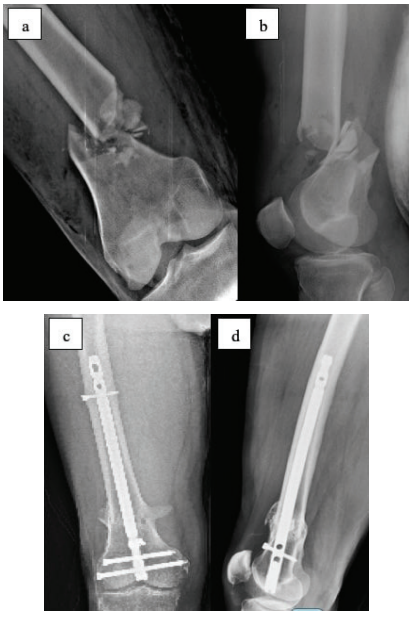

Figure 2: Radiographs (a,b) before and (c,d) 7 months after retrograde interlocking femoral nail osteosynthesis for distal femur fracture.

The patients' knee range of motion was evaluated at the last follow-up. In the percutaneous plate osteosynthesis group, the range of motion was greater than 120 degrees in 19 patients (42.2%), 100 to 110 degrees in 17 patients (37.7%), 80 to 100 degrees in 6 patients (13.3%), and under 80 degrees in 3 patients (6.6%). The mean range of motion was 112.3±22.4 degrees.

In the RIMN group, the range of motion was greater than 120 degrees in 7 patients (29.1%), 100 to 110 degrees in 10 patients (41.6%), 80 to 100 degrees in 5 patients (20.8%), and under 80 degrees in 2 patients (8.3%). The mean range of motion was 107.1±22.5 degrees. There was no statistically significant difference between the two groups at the last follow-up (p=0.371).

The patients' functional ability was evaluated using the Knee Society Score (23). The mean Knee Society Score was 83.7±8.7 (range, 60-95) in the percutaneous plate osteosynthesis group and 82.1±8.7 (range, 60-95) in the RIMN group. There was no statistically significant difference according Knee Society Scores between the two groups (p=0.353).

Additionally, the patients were evaluated for postoperative complications. Three patients (6.7%) had postoperative surgical site infections in the percutaneous plate osteosynthesis group, but this was experienced by only one patient (4.2%) in the RIMN group. All 4 patients had this complication within the first 4 weeks after surgery and underwent irrigation and debridement within the same period.

Five patients (11.1%) in the percutaneous plate osteosynthesis group had revision surgery (with plate screws and autologous bone grafts) at 7 months post-surgery due a combination of delayed union and implant failure (broken plate), and 3 patients had revision with only autologous bone grafts because of delayed union. One patient (4.2%) in the RIMN group had revision surgery (exchange nailing and autograft) at 7 months post-surgery because of delayed union, and one other patient (4.2%) underwent only autografting due to delayed union. In these patients who had revision surgery, union was achieved by 12 months post-surgery.

Four patients (11%) in the percutaneous plate osteosynthesis group had postoperative lateral knee pain due to iliotibial band irritation. They were treated satisfactorily with anti-inflammatory drugs.

Similarly, 5 patients (21%) in the RIMN group had anterior knee joint pain. However, chondromalacia patella was identified in all of these patients, and they were referred for physiotherapy, including exercise, to strengthen the quadriceps muscle. The follow-up of these patients for anterior knee pain is still ongoing at the time of writing.

We also evaluated the patients for post-operative alignment disorders. Among those who had undergone percutaneous plate osteosynthesis, 4 patients (12.5%) had varus deformities of less than 10 degrees, while 8 patients (17.8%) had valgus deformities of less than 10 degrees; there was posterior angulation of between 10 and 20 degrees in 3 patients (6.7%). Among those in the RIMN group, 3 patients (12.5%) had varus deformities of less than 10 degrees, while 2 patients (8.3%) had valgus deformities of less than 10 degrees; there was posterior angulation of between 10 and 20 degrees in 2 patients (8.3%). Overall, the incidence of alignment disorders was 33.3% (15 patients) in the percutaneous plate osteosynthesis group and 29.1% (7 patients) in the RIMN group. However, there was no statistically significant difference in the incidence of alignment disorders at the last follow-up between the two groups (p=0.791) (Table 2).

Table 2. Comparison of results in the percutan plate and retrograde nail groups

		PercutanPlateGroup		Retrograd Nail Group		
		Mean±SD	Min-Max	Mean±SD	Min-Max	p
Meanunion time (months)		7,2±2,1	5-12	6,5±2,0	4-12	0,125
Range of motion of knee (degrees)		112,3±22,4	40-130	107,1±22,5	50-130	0,371
KneeSocietyScore		83,7±8,7	60-95	82,1±8,7	60-95	0,353
		n	%	n	%	p
Malalignment	No	30	66,7	17	70,8	0,791
	10 DegreeValgus	8	17,8	2	8,3	
	10 DegreeVarus	4	8,9	3	12,5	
	Posterior	3	6,7	2	8,3	
Infection		3	6,7	1	4,2	1,000
Grafting		8	17,8	2	8,3	0,475
ImplantRevision		5	11,1	1	4,2	0,657
Nonunion		0	0,0	0	0,0	-

DISCUSSION

Despite the advent of modern fixation techniques for treating distal femur fractures, patients still experience poor results.[25] With the development of fixation methods, the success of treatment of these fractures has increased, but there is no consensus on the choice of treatment yet.Two commonly utilized methods are minimally invasive plate osteosynthesis and RIMN.[8,21] Minimally invasive percutaneous plate osteosynthesis (MIPPO) acts as an extramedullary fixator and also causes minimal damage to soft tissues.[26] With a retrograde intramedullary nail, weight distribution is achieved and early weight bearing is enabled, but the development of knee arthrosis, knee pain and systemic complications are the disadvantages of this method.[8]

Different results were found in studies comparing RIMN methods with minimally invasive plating in the treatment of femoral supracondylar fractures.[8,13] In the study conducted by Hierholzer et al., It was found that 90% of the fractures healed at the end of 6 in both groups in patients with femoral supracondylar fractures treated with MIPPO or RIMN, and there was no difference between both groups.8In the study conducted by Henderson et al., more callus formation was detected in the RIMN group compared to the MIPPO group at the end of 12 weeks postoperatively.13In our study, the time to union in the plate group was 7.2 months and 6.5 months in the RIMN group, and there was no statistically significant difference between the two groups, and the union times were similar to the results of the study conducted by Hierholzer et al.[8]

Similar complication rates were found in studies comparing MIPPO and RIMN methods in femoral supracondylar fractures.[5,8,10,13] Since RIMN is made with the help of small incisions, it traumatizes the soft tissues less and causes less blood loss.8However, the authors stated that there was no difference between the two groups in terms of infection and union rates. In the study conducted by Markmiller et al., It was found that there was no difference between MIPPO and RIMN groups in terms of malalignment, infection or nonunion rates.[10] Gao et al. compared femoral supracondylar fractures treated with RIMN and MIPPO and found no difference between the two groups in terms of range of motion, knee pain, infection, malalignment and implant failure.[5] Although there was more blood loss in the RIMN group, there was more delayed union and nonunion in the MIPPO group, but there was no statistically significant difference between the two groups in terms of delayed union and nonunion rates.[5]

Post-operative anterior knee pain can be seen as a permanent complication. This condition has been reported in 30% of patients undergoing surgery for femoral fractures.[27] In our study, anterior knee pain was observed in 5 patients (21%) in the RIMN group. In all 5 patients, chondromalacia patella was identified and physiotherapy was started with quadriceps-strengthening exercises. Furthermore, in patients who undergo RIMN, articular cartilage can be damaged, and leaving the nail in the knee joint may cause limitation of motion, resulting in the need for subsequent revision surgery.

In their series, Becher et al. reported a 6% incidence rate of arthrofibrosis requiring manipulation.[28] All our patients were evaluated in the hospital by physiotherapists on first day post-surgery and commenced active and assisted range-of-motion exercises for the knee. Only 3 patients who had percutaneous plates (6%) and 2 patients who had RIMN (8%) had a knee range of motion of less than 80 degrees.

Although concerns are expressed that systemic complications may develop due to fat embolism during RIMN application,[11,18] no such complication has been encountered in our practice.

The other important disadvantage of RIMN is exposure of the knee joint when placing the implant, which may predispose patients to septic arthritis. In the literature, the rate of septic arthritis after RIMN has been reported to be up to 14%.[20,29] However, in our study, septic arthritis was not observed in any of the patients.

For percutaneous plate osteosynthesis, the most significant disadvantage is that it is forced to support more weight since it is placed more laterally than the existing mechanical axis of the body when compared to RIMN. This can result in implant failure. The rate of implant failure has been reported to be 5 to 10%.30,31 In our study, five patients (11%) developed implant failures; the fractures were revised with plates and autologous bone grafting at 7 months post-surgery, and union was achieved 12 months after the initial surgery.

Another disadvantage of percutaneous plate osteosynthesis is irritation of the iliotibial band on the lateral distal femur, depending on plate size and thickness. This condition may lead to implant removal.[31] In our study, irritation of the iliotibial band was seen in 4 patients (11%); however, with satisfactory anti-inflammatory treatment, implant removal was not necessary in all cases.

The limitations of this study are its retrospective design and short follow-up duration. The frequency of development of posttraumatic osteoarthritis can only be determined as a result of long-term follow-up.

CONCLUSION

When comparing the use of percutaneous plate osteosynthesis with RIMN to treat supracondylar femur fractures, both groups had similar results in terms of duration of union, range of motion, and Knee Society Scores. Furthermore, there were also similar complication rates in both groups. Both techniques can be used safely in the treatment of distal femoral fractures with satisfactory outcomes.

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None

Abbreviations

RIMN: Retrograde intramedullary nailing
SPSS: Statistical Package for Social Sciences

OTA: Orthopedic Trauma Association
MIPPO: Minimally invasive percutaneous plate osteosynthesis

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Ethics Committee Approval

Our study. Was approved by the Sakarya University Ethics Committee (Date: 19.09.2018, decisionno: 182). The present study was conducted in accordance with the ethical standarts laiddown in the 1964 Declaration of Helsinki and its lateramendments. Our instutional review board approved the study protocol, and all the patients provided written informed consent prior to their inclusion in thestudy.

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