



Retrograde intramedullary interlocking nailing in fractures of the distal femur

Femur alt uç kırıklarında retrograd kilitli intramedüller çivileme

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Amaç: Femur distal uç kırıklı hastalarda retrograd kilitli intramedüller (İM) çivi uygulaması değerlendirildi.

Çalışma planı: Suprakondiler femur kırığı nedeniyle 16 hasta (11 erkek, 5 kadın; ort. yaş 45; dağılım 25-69) retrograd kilitli İM çivileme ile tedavi edildi. Bir olguda iki taraflı kırık vardı. Kırıkların AO sınıflaması şöyleydi: A1 (n=8), A2 (n=4), A3 (n=4), C1 (n=1). On üç kırık (%76.5) kapalı, dördü (%23.5) açık kırık idi. Hastalar travma sonrası ortalama 10. günde (dağılım 2-20 gün) ameliyat edildi. Dokuz kırıkta açık girişim, sekizinde perkütan teknik (mini artrotomi) kullanıldı. Ameliyat öncesinde yüzen diz sorunu olan üç hasta manyetik rezonans görüntüleme ile incelendi ve bu hastalarda çapraz bağ yırtığı saptandı. Tüm hastalara ameliyat sırasında diz muayenesi yapıldı ve beş hastada çapraz bağ yırtığı görüldü. Hastalar ortalama 32.6 ay (dağılım 12-68 ay) izlendi. Son kontrollerde fonksiyonel sonuçların değerlendirilmesinde modifiye HSS (Hospital for Special Surgery) diz değerlendirme ölçeği kullanıldı.

Sonuçlar: Ortalama kaynama süresi 25 hafta (dağılım 14-42 hafta) bulundu. Bir hastada geç kaynama (42 hafta) görüldü. Eklem hareket açıklığı üç dizde (%17.7) normal bulunurken, dokuz dizde (%52.9) 100-110°, dört dizde (%23.5) 80°, bir dizde ise (%5.9) 80 derecenin altında idi. Modifiye HSS diz değerlendirme ölçeğine göre, beş femurda (%29.4) mükemmel, altı femurda (%35.3) iyi, beş femurda orta, bir femurda (%5.9) kötü sonuç elde edildi. Ameliyat sonrası radyografik incelemelerde, dört hastada (%23.5) varus açılanması (10°), dört hastada posteriora açılanma (10-20°) görüldü. Bir olguda ise aşırı deformasyonla (30° posteriora açılanma) iyileşme gözlemlendi. Hiçbir hastada ameliyat sonrası yara yeri sorunu ya da enfeksiyon gelişmedi. Bir hastada ameliyat sonrası erken dönemde derin ven trombozu gelişti.

Çıkarımlar: Yetişkinlerdeki femur alt uç kırıklarının tedavisinde retrograd kilitli İM çivilemenin sonuçları tatmin edicidir.

Anahtar sözcükler: Kemik çivisi; femur kırığı/cerrahi; kırık tespiti, intramedüller/yöntem; diz eklemi.

Objectives: We evaluated retrograde locked intramedullary nail applications in patients with distal femur fractures.

Methods: Distal femur fractures of 16 patients (11 males, 5 females; mean age 45 years; range 25 to 69 years) were treated with retrograde locked intramedullary nailing. One patient had bilateral fractures. According to the AO classification, the fractures were A1 (n=8), A2 (n=4), A3 (n=4), and C1 (n=1). There were 13 closed (76.5%), and four open (23.5%) fractures. The mean time to surgery was 10 days (range 2 to 20 days). Open technique was used for nine fractures, and percutaneous technique for eight fractures. Preoperatively, three patients with a floating knee were evaluated with magnetic resonance imaging and were found to have a ruptured cruciate ligament. All patients underwent intraoperative knee examination, which showed a ruptured cruciate ligament in five patients. Functional results were assessed using the modified HSS (Hospital for Special Surgery) knee rating scale at the end of a mean follow-up period of 32.6 months (range 12 to 68 months).

Results: The mean time to union was 25 weeks (range 14 to 42 weeks). One patient had delayed union (42 weeks). Joint range of motion was normal in three knees (17.7%), was 100 to 110° in nine knees (52.9%), 80° in four knees (23.5%), and below 80° in one knee (5.9%). According to the modified HSS knee scale, the results were excellent in five femurs (29.4%), good in six femurs (35.3%), moderate in five femurs, and poor in one femur (5.9%). Postoperative radiographic examination showed varus angulation (10°) in four patients (23.5%), and posterior angulation (10-20°) in four patients. In one patient, healing occurred with extreme deformation (30° posterior angulation). None of the patients experienced wound site problems or infections. One patient developed deep vein thrombosis in the early postoperative period.

Conclusion: Treatment of distal femur fractures with retrograde locked intramedullary nailing yields satisfactory results in adults.

Key words: Bone nails; femoral fractures/surgery; fracture fixation, intramedullary/methods; knee joint.

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The incidence of distal femur fractures is increasing continuously in our country as traffic accidents increase. Problems with a distal femur fracture may not be limited to the femur itself, but may extend to internal knee structures. Previously, the preferred fixation method that was plate-and-screw fixation, but retrograde intramedullary interlocking nailing has become a popular option. However, to obtain good results, the evaluation of the knee, the surgical procedure, and rehabilitation must be done properly.

Materials and methods

Our study included 16 patients (11 males, 5 females; mean age, 45 years; range, 25-69) who had supracondylar femur fractures and were treated in our clinic with retrograde intramedullary interlocking nailing between 2000 and 2007. The fracture site was the left femur in 10 (62.5%) and the right in five (31.3%). One (6.3%) patient had bilateral femoral fractures. Trauma etiology according to frequency was: traffic accidents in eight patients, simple falls in four patients, gun shot in three patients, and falling from a height in one patient. Classification of fractures according to AO was: A1 in eight, A2 in four; A3 in four, and C1 in one. The patient who had bilateral femoral fractures was classified as A3 for both femurs. Thirteen (76.5%) fractures were closed, one (5.9%) was a type-I open fracture, and three (17.7%) were type-IIIA fractures. Body mass index (BMI) was calculated for the patients. In six patients, BMI was determined to be 30 kg/m² or greater.

Additional pathologies were found in eight cases who were exposed to high energy traumas. These were: ipsilateral tibial diaphysis fractures in three patients, cranial trauma in one, contralateral supracondylar femur fracture in one, ipsilateral intertrochanteric and patella avulsion fracture in one, and an ipsilateral fracture and elbow dislocation in one. Furthermore, an anterior cruciate ligament (ACL) rupture was found in four patients, and a medial collateral ligament (MCL) rupture was found in one patient. The dynamic hip screw was performed in a different session for the patient who had patellar and hip fractures in addition to his femur fracture. The patellar fracture was treated conservatively with a long leg cast. Both femurs of the patient who had a bilateral supracondylar femur fracture were operated on during the same session. The patient with a fractured and dislocated elbow was operated on in different sessions.

Patients were evaluated with a multidisciplinary approach by the orthopedic, general surgery, and neurosurgery clinics. Femur anterior-posterior and lateral routine radiographs were taken. After diagnosis, skeletal traction from the tuberositas tibia was performed and the patient was prepared for operation. Open-fracture patients were managed in an emergency operating room with an open fracture approach. The mean time to operation after trauma was 10 days (range, 2-20). All operations were performed in the supine position on a radiolucent operating table with scope controls. General anesthesia was provided for 13 patients, whereas spinal anesthesia was provided for three patients. Nailing was applied by an open approach in nine patients, whereas the percutaneous technique (mini arthrotomy) was applied in eight patients. Technique preference changed according to the surgeon's initiative. None of the patients who were operated on with the percutaneous technique required an open intraoperative approach. For the open approach, a medial parapatellar incision was preferred, and an arthrotomy was made by turning the patella over laterally. For the percutaneous technique, a 5-6 cm incision was made between the lower pole of the patella and the tuberositas tibia, and the arthrotomy was performed by longitudinally splitting the tendon. The mean operation length was 131 min for open approach patients, whereas it was 127.5 min for the percutaneous approach. The mean blood loss was 720 mL (range, 300-1200) for the open approach patients and 357 mL (range, 250-500) for the percutaneous approach patients. A tourniquet was not used on any patient. Open reduction was performed in 10 patients and a closed reduction was performed in seven patients.

Short nails (25 cm) were used in all patients except one. A 32 cm tibia nail was inserted retrogradely in the one patient with a mid-distal shaft fracture. Intraoperative complications were not seen in this patient, and there was no problem in the long-term follow-up. In nine fractures, one locking screw was used for proximal locking, whereas in eight fractures two locking screws were used for proximal locking. The choice of one or two locking screws was left to the surgeon's preference.

Three patients with floating knees were evaluated with magnetic resonance imaging (MRI). Among them, two had an ACL rupture, and one had an MCL



Figure 1. (a) anterior-posterior and (b) lateral radiographs of a patient with a supracondylar femur fracture that occurred 2 years after amputation (c) postoperative anterior-posterior and (d) lateral radiographs.

rupture. A knee examination was performed in all patients after the locking nail procedure. As a result, four had an ACL rupture and one an MCL rupture. In three patients with an ACL rupture, their fractures did not extend to the joint and elective arthroscopic ACL reconstruction was planned. The patient with a grade 2 MCL rupture was treated with a long leg cast. Among the three floating knee patients, tibia intramedullary nails were inserted in two, and only one incision was used. A plate-and-screw fixation was performed for the other patient with a floating knee.

One patient had a leg amputated 2 years ago due to chronic arterial disease and was walking with a prosthesis. As a result of a simple fall, he had a supracondylar femoral fracture, which was operated on with the retrograde intramedullary nail and the percutaneous technique (Fig. 1).

Exercise was initiated in all patients on the first day postoperatively, and all patients received physical therapy after being discharged from the hospital. One patient who had an MCL rupture and was treated with a long leg cast received physical therapy 4 weeks after the cast was applied.

The mean follow-up was 32.6 months (range, 12-68). Follow-up was scheduled once per month for the first 6 months and then bimonthly for the second 6 months. Anterior-posterior radiographs were taken at each visit. When union was seen, partial weight-bearing was started, and when there was sufficient

union, full weight-bearing was started. At last follow-up, the HSS (Hospital for Special Surgery) knee evaluation scoring was used, as modified by Leung et al. [1]. In this scoring system, pain (30 points), function (22 points), knee range of motion (15 points), muscle strength (15 points), flexion deformity (10 points), and instability (5 points) were evaluated. According to the presence of using a brace, extension loss in knee and deformity, 1-3 points was deducted from the HSS score to give a final result. According to this scheme, > 85 was evaluated as excellent, 70-84 as good, 60-69 as moderate, and < 60 poor.

The SPSS software (ver. 11.5 for Windows) was used for statistical analyses. Differences were compared with a t-test for matched groups. A p-value < 0.05 was deemed to be statistically significant.

Results

The mean length to union was 25 weeks (range, 14-42). Range of motion in three (17.7%) knees was normal (135°), 100-110° in nine (52.9%), and 80° in four (23.5%). Only the one (5.9%) patient who had bilateral fractures had < 80° knee motion (Fig. 2). According to the modified HSS knee scoring system, five (29.4%) femurs were excellent, six (35.3%) were good, five (29.4%) were moderate, and one (5.9%) was poor.

There was no significant difference between the surgical techniques (percutaneous mini arthrotomy



Figure 2. (a) anterior-posterior and (b) lateral radiographs of a patient with bilateral femoral fractures. (c) The nail end was in the joint space at the 7th month postoperatively; anterior-posterior graph and (d) 30° posterior angulation was remarkable in lateral radiographs. The result was poor, and the knee range of motion was less than 90°.

vs. medial parapatellar open approach) based on range of motion ($p > 0.05$). Knee motion was limited in eight patients whose nails were in the joint. Among them, the result was good for two and the others were moderate or poor.

One patient was operated on due to a supracondylar femur fracture 1 year ago, and a plate fixation was performed. Fixation insufficiency and pseudoarthrosis were seen in that patient, in addition to his gonarthrosis, so IM interlocking nail fixation and total knee arthroplasty were performed at the same session, resulting in an 80° range of knee motion.

According to X-ray findings, postoperative alignment was anatomic in eight fractures (47.1%). In four patients (23.5%) there was 10° anterior-posterior varus angulation, and in four patients there was 10-20° posterior angulation. Healing occurred with extreme deformation (30° posterior angulation) in one case (5.9%; Fig. 2). In two (12.5%) patients there was a 1 cm shortening, and a 2 cm shortening occurred in one patient.

Healing occurred in all patients except one, who had a delayed union (42 weeks). One patient, who was operated on due to an enchondrom at the distal femur and was treated with curettage and grefonage, fell down on postoperative day 15 and suffered a supracondylar femoral fracture. This patient was treated

with retrograde interlocking intramedullary nailing by an open approach and was followed. At the sixth month of follow-up, there was no union, so electrical stimulation was performed. Union was established at the 42nd week. The patient had no more pain, but the knee range of motion remained at 80°.

One patient who had a past amputation established union at the sixth week postoperatively. He then returned to using a below-the-knee prosthesis. In one patient, a femoral fracture occurred from the proximal end of a 25 cm nail, so the patient was treated with an antegrade long intramedullary femoral nail. There was no significant difference between the patients whose BMI was ≥ 30 kg/m² and those with a BMI < 30 kg/m² for operation time point, blood loss, or postoperative infection.

There was no infection or wound problem in any patient postoperatively. A deep vein thrombosis was seen in one patient during the early postoperative period. The patient received low-molecular-weight heparin treatment and the issue resolved.

Discussion

At the end of the 1980s, retrograde interlocking intramedullary nailing using the intercondylar approach became prevalent for distal femur fractures. Before that period, systems such as the 95° angled condylar wedge plate, dynamic condylar compressive

screw, and condylar buttress plates were used successfully. Retrograde interlocking nails began to be used after that period and have some advantages and disadvantages.^[2]

A lateral approach is typically used for plate fixation in almost all distal femur fractures, but these systems cause extensive soft tissue dissection and drainage of the fracture hematoma. As a result, the lateral approach can cause delayed union, infection, and an extensive soft tissue scar. Papadokostakis et al.^[3] evaluated retrograde interlocking intramedullary nails from 24 studies, including 914 patients and 963 distal femur fractures, and stated that the results of retrograde nailing were good.

The less invasive stabilization system (LISS) is currently used to treat osteoporotic distal femur fractures. In this system, the approach is lateral and the system requires no extensive tissue dissection, making type-C fractures suitable for this system. Zlowodzki et al.^[4] compared the biomechanics of LISS, wedge plates, and retrograde nails. Torsional stability was sufficient and equal in all three systems, but the LISS was best for osteoporotic fractures. Meyer et al.^[5] compared the biomechanics of plate and retrograde nails on osteoporotic cadavers and found that the plate was more resistant to torsional and axial loading than the retrograde nail.

There is less of a requirement for soft tissue dissection with retrograde nails than plates, which becomes clear when using the percutaneous technique. Thus, there is less blood loss and a shorter operation time.^[6-8] In our study, the operation time for the percutaneous and open techniques were similar, but time was lost when identifying the nail entrance point with a scope and/or was due to surgeon inexperience with the percutaneous technique. Christodoulou et al.^[9] compared the retrograde nail and dynamic condylar screw systems and found the results were equally satisfactory, but that operation time and blood loss were significantly less in nailed patients. In that study, all nails were applied percutaneously. Applying nails is more biologic than plates, because too much stress is loaded on the plates, due to weight loading medial to the femur. Less stress is loaded when using intramedullary nails.^[6] Retrograde nail application is especially suitable for AO type-A patients. The nail can also be applied in type-C patients, including C3. However, a first joint restoration by arthrotomy and

fracture fixation with free lag screws must be performed, and a nail must be applied. The lag screws that are used for joint stability must not be in the way of the nail, a disadvantage of the system. An arthrotomy is needed even though the fracture does not extend to an AO type-A joint (mini arthrotomy in percutaneous technique). Opening the joint can be disadvantageous in these cases.^[2] If the fracture does not extend to the joint, then the open technique is not needed for the arthrotomy. Nails can be readily applied using a percutaneous technique and a small midline incision.^[10] The results of arthrotomy are not bad, and knee septic arthritis ratios are acceptable, at about 0-14%. Knee pain occurs in half of patients.^[8]

The true determination of the nail entrance and maintaining that point as nontraumatic are of great importance. A scope can be used, such as the arthroscopy-assisted method, to determine the nail entrance, and internal knee structures can be evaluated.^[11] Fracture reduction before applying the nail is very important surgically, because the nail can not perform reduction by itself.^[2] At this point, anterior-posterior and lateral angulation can occur. In our study, only 8 of 17 patients had postoperative anatomic alignment.

Retrograde nails are also very effective for floating knees where the ipsilateral tibias are also fractured, and no additional approach is required in these patients. The same incision can be used, the proximal tibia can be reached by lengthening the incision, and the tibial nail can be readily applied.^[12] Application of IM nails to ipsilateral femoral and tibial fractures has become the current treatment method.^[7,13] Furthermore, an evaluation of the internal knee structures in floating knee cases must not be skipped, and, if possible, an MRI evaluation should be conducted. Also, every patient must be examined intraoperatively. In our study, three floating knee patients were preoperatively evaluated by MRI. Among them, two cases of ACL and one of MCL were determined. In our study, an MRI evaluation was not performed in every patient, but this method should especially be used in floating knee patients.

Retrograde nailing is suitable for obese patients, because more extensive tissue dissection is needed when compared to plates. This can result in significant blood loss, longer operation times, much more scar tissue, and a higher risk of infection.^[2,14] Our results

support this contention. Plate application in older and osteoporotic patients is more problematic. There are studies that show good retrograde nailing results in these patients^[15], but patients who can not walk due to myelopathic and paraplegic causes should be treated with retrograde nailing as the first choice, rather than with a conservative treatment and plate.^[16]

There is no consensus for the treatment of periprosthetic fractures with a total knee prosthesis, but retrograde nailing is an important alternative in these cases. If there is no problem with the prosthesis, nails can be applied by reaching the intercondylar notch, and no additional procedure will be required. Herrera et al.^[17] evaluated numerous supracondylar femoral fracture patients who had been operated on due to a total knee prosthesis and they showed statistically significant superiority of retrograde nails over classic plates. In another study, a patient with gonarthrosis and a supracondylar femur fracture was simultaneously treated with retrograde nails and a total knee prosthesis^[18], but the authors indicated that this simultaneous approach can not be applied for intra-articular extended fractures. In a biomechanic study, Bong et al.^[19] compared retrograde nails and LISS to stabilize supracondylar femur fractures in patients who had a total knee prosthesis and showed that retrograde nails provided much more stabilization than LISS. In our study, we inserted retrograde nails and provided a total knee prosthesis to a patient with gonarthrosis and supracondylar femur pseudoarthrosis.

It is important to remember that vascular injury or pseudoaneurysms can occur due to a squeezed popliteal artery between fracture fragments during retrograde nail application, which has been indicated as a complication.^[20] None of our patients was evaluated for a pseudoaneurysm.

Nail length and number of proximal interlocking screws to be used during the procedure is also controversial. Sears et al.^[21] compared the application of one or two proximal interlocking screws in cadavers and found no significant difference in sagittal or coronal translational stability. In our study, one or two proximal interlocking screws were used according to the surgeon's preference, and we found no difference between the results using one or two. In the study of Sears et al.^[21], there was more stress on the bone at the proximal end of short nails (20 cm) than long nails (36 cm). As a result, they advised the use of one

proximal interlocking screw with long IM nails. We used short nails (25 cm) in all patients except one, and a fracture occurred at the proximal end of the nail in only one patient. Thus, for supracondylar femur fractured patients, long retrograde IM nails are preferred. If long retrograde nails can not be obtained, standard tibial nails can be applied retrogradely to the femur.^[22] We used standard tibial nails retrogradely in one patient who had a mid-distal femoral shaft fracture, and no problem occurred intraoperatively or at follow-up.

It is important that the end of the nail not be in the joint space, which may limit knee range of motion. In our study, a nail could not be placed exactly in the medulla of the femur in eight patients, so the nail ends were in the joint space. This resulted in a limited knee range of motion and the results were moderate or poor, except in two cases. This situation was evaluated as a technical mistake, due to inexperience.

Retrograde interlocking intramedullary nailing is the current treatment option for supracondylar femur fractures, especially type-A fractures. This technique is not as effective as LISS for comminuted metaphysis fractures, but it can be used for C1 and C3 fractures. Although stabilization and fracture reduction is readily established with LISS for comminuted metaphysis fractures, retrograde nail stabilization has its place in the treatment of AO type-C fractures.^[2,4,6] Shorter operation time, a shorter incision, and less blood loss were considerations in our study, so the percutaneous technique was used. It is known that there is less blood loss with antegrade femoral nailing using the percutaneous technique, but there is no literature to support retrograde nailing.^[23] We did not find a significant difference in operation time when comparing the open and percutaneous techniques. Nevertheless, the operation time using the percutaneous technique was shorter. The percutaneous technique has become the gold standard, particularly for floating knees and supracondylar fractures after a knee prosthesis.

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