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Evaluating the Results of Retrograde Intramedullary Nailing for Distal Femur Fractures: A Level 3 Trauma Center Retrospective Study

Distal Femur Kırıkları için Retrograd Intramedüller Çivileme Sonuçlarının Değerlendirilmesi: 3. Basamak Travma Merkezi Retrospektif Çalışması

Tuğrul ERGÜN[1]
0000-0002-5615-3394
Mehmet Kürşat BAYRAKTAR[2]
0000-0003-3860-7847
Bülent KARSLIOĞLU[2]
0000-0001-6127-9672
Ersin TAŞATAN[2]
0000-0002-4018-0320
Ali Çağrı TEKİN[2]
0000-0002-4308-8167
Esra AKTAŞ TEKİN[3]
0000-0001-8538-2893
Hakan GÜRBÜZ[2]
0000-0002-6437-5771

[1]Department of Orthopedics and Traumatology, İstinye University Faculty of Medicine, İstanbul, Turkey

[2]Department of Orthopedics and Traumatology, Prof. Dr. Cemil Taşçıoğlu City Hospital, İstanbul, Turkey

[3]Department of Anesthesiology and Reanimation, Prof. Dr. Cemil Taşçıoğlu City Hospital, İstanbul, Turkey

Corresponding Author
Sorumlu Yazar
Tuğrul ERGÜN
drergun14@gmail.com

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ABSTRACT

Aim: Distal femur fractures can be treated with modern anatomic plates and nails. This study aimed to examine the clinical and radiological results of displaced distal femur fractures in adult people who had been treated with a retrograde intramedullary nail (RIN).
Material and Methods: The study included all patients who underwent RIN surgery for distal femur fracture between January 2013 and April 2018 in a level 3 trauma center. Patients were divided into two groups based on fracture pattern: open fracture and closed fracture. The preoperative and postoperative clinical, radiological and functional characteristics of patients who had RIN for a distal femur fracture were analyzed.
Results: Thirty patients were included in the study. 21 (70%) patients were male. The median age of the patients was 39 (range, 18-58) years. 17 (56.7%) of the affected femur were left-sided. The etiology of the fractures was traffic accident and fall in 19 (63.3%) patients and gunshot injury in 11 (36.7%) patients. Of the patients, 17 (56.7%) were closed fractures and 13 (43.3%) were open fractures. There were no significant differences between two groups related to the surgery time (p=0.086), fluoroscopy time (p=0.805), blood loss (p=0.967), and hospitalization time (p=0.967), clinical pain and function scores (p=0.341, p=0.902), and union time (p=0.385) at the postoperative period.
Conclusion: RIN is a minimally invasive method that may prevent excessive blood loss and decrease the duration of surgery time. It is an effective and reliable surgical intervention that should be considered for the treatment of distal femur fractures.
Keywords: Distal femur fractures; trauma; intramedullary nail; retrograde.

ÖZ

Amaç: Distal femur kırıkları modern anatomik plak ve çiviler ile tedavi edilebilmektedir. Bu çalışmanın amacı retrograd intramedüller çivi (RİÇ) ile tedavi edilen erişkin kişilerde deplase distal femur kırıklarının klinik ve radyolojik sonuçlarının incelenmesidir.
Gereç ve Yöntemler: Çalışmaya, Ocak 2013 ile Nisan 2018 arasında 3. seviye bir travma merkezinde distal femur kırığı nedeniyle RİÇ ameliyatı geçiren tüm hastalar dahil edildi. Hastalar kırık paternine göre açık kırık ve kapalı kırık olmak üzere iki gruba ayrıldı. Distal femur kırığı nedeniyle RİÇ tedavisi yapılan hastaların ameliyat süreci ve ameliyat sonrası dönemdeki klinik, radyolojik ve fonksiyonel özellikleri analiz edildi.
Bulgular: Çalışmaya 30 hasta dahil edildi. 21 (%70) hasta erkekti. Hastaların ortanca yaşı 39 (aralık, 18-58) yıl idi. Etkilenen femurların 17 (%56,7)'si sol taraflıydı. Kırık etiyolojisi 19 (%63,3) hastada trafik kazası ve düşme, 11 (%36,7) hastada ise ateşli silah yaralanmasıydı. Hastaların 17 (%56,7)'si kapalı kırık, 13 (%43,3)'ü açık kırıktı. İki grup arasında ameliyat süresi (p=0,086), floroskopi süresi (p=0,805), kan kaybı (p=0,967) açısından ve ameliyat sonrası dönemde hastanede yatış süresi (p=0,967), klinik ağrı ve fonksiyon skoru (p=0,341; p=0,902) ve kaynama zamanı (p=0,385) açısından istatistiksel olarak anlamlı fark bulunmadı.
Sonuç: RIN fazla kan kaybını engelleyen ve ameliyat süresini de kısaltabilen minimal invaziv bir cerrahi yöntemdir. Distal femur kırıklarının tedavisinde akla getirilmesi gereken etkili ve güvenilir bir cerrahi seçenektir.
Anahtar kelimeler: Distal femur kırıkları; travma; intramedüller çivi; retrograd.

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INTRODUCTION

Distal femur fractures are rare fractures (1). They occur in approximately 3-5% of all femur fractures (1,2). In young patients, high-energy trauma causes distal femur fractures; in older patients, low-energy trauma causes distal femur fractures (2,3). These fractures are associated with high mortality and morbidity (4). They are difficult to treat (2). They can lead to long-term permanent disabilities and serious injuries, such as nonunion, delayed union, and implant failure (5,6). Surgical treatment of distal femur fractures is more effective than conservative treatment (2). These fractures can be treated with external fixation, fixed-angle blade plates, dynamic condylar screws (DCS), locking plates, and intramedullary nails (7). Nails cause the least amount of damage to the fracture site, provide a possible mechanical advantage from a device near to the femur's axis, and promote blood supply by reaming the intramedullary canal (8,9). However, antegrade intramedullary nails are inadequate to fix small and osteoporotic fragments located distal femur (10).

The major goal of this study was to look back on the clinical and radiological results of displaced distal femur fractures in adult people who had been treated with a retrograde intramedullary nail (RIN).

MATERIAL AND METHODS

This study was approved by the local ethics committee (Prof. Dr. Cemil Taşçıoğlu City Hospital ethics committee, dated 17/04/2018, and numbered 883). Patients' informed consents were obtained. The study included patients who underwent RIN surgery between January 2013 and April 2018 in a level 3 trauma center. We excluded patients with pathological fractures, vascular injuries, neurological disease, and unfollowed patients. Two groups of patients were formed as close fractures and open fractures according to Gustilo-Anderson's classification (11). Patient data including surgical time, perioperative hemorrhage, preoperative and postoperative hospitalization period, time to union, and knee function after complete fracture healing according to the Knee Society Score (KSS) were recorded from the Prof. Dr. Cemil Taşçıoğlu City Hospital data center. Patient characteristics between the two groups were compared.

Surgical Technique

The patients underwent surgery in the supine position under general anesthesia or spinal anesthesia as per the decision of the anesthesia team. To ensure the reduction of the distal fragment, a sterile operating sheet was placed under the knee to maintain the knee at 30 degrees of flexion (Figure 1a). An incision from the lower pole of the patella to the tuberous tibia is made to expose the patellar tendon. The patellar tendon is splitted longitudinally and the knee joint was observed between the tendon while preserving the paratenon (Figure 1b). To determine the femur entry point, a single Kirchner (K) wire was advanced from the incision line. All surgeries were performed under C-arm fluoroscopy to determine the appropriate entry point (Figure 2a, 2b). Afterward, the entrance was engraved with the thickest (16 mm) cannula with simultaneous closed reduction of the fracture. An intramedullary guidewire was advanced from the center of the medulla. The femur was reamed through the guidewire with a flexible reamer. A nail (Tasarım Medical branded locking retrograde femoral nail) one millimeter smaller than the medullary thickness measured for fracture fixation was prepared using the height measurement guide and placed on the femur. The distal screws were statically locked using the distal screw guide. Proximal screws were

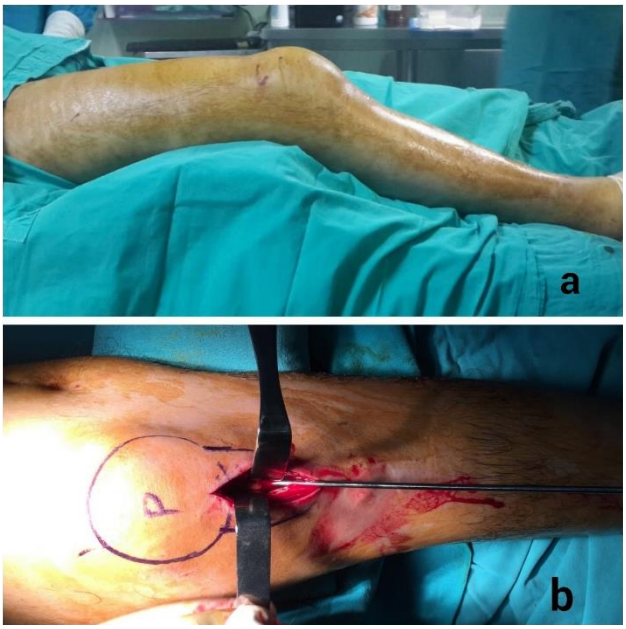

Figure 1. Surgical preparation and incision appearance; **a)** retrograde nail application position; **b)** surgical skin incision

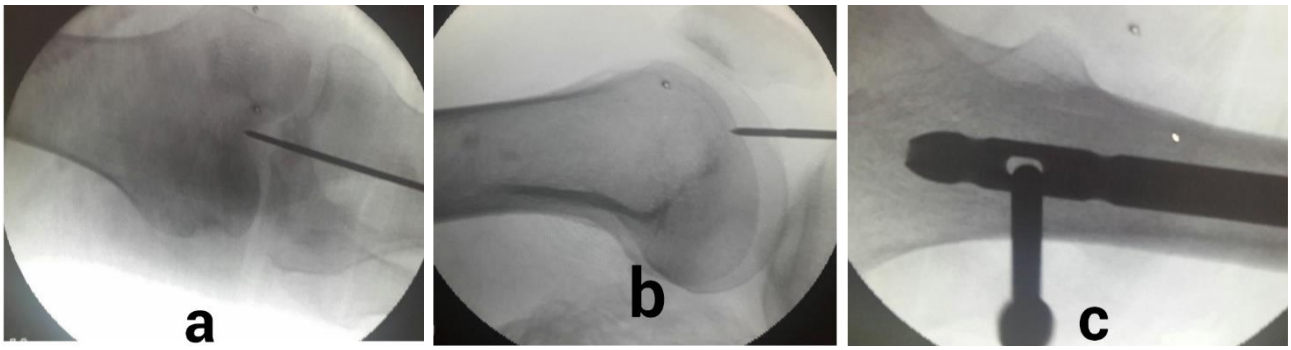

Figure 2. X-ray shown of retrograde nail placement; **a)** appropriate entry site for retrograde intramedullary nail on x-ray table anterior-posterior; **b)** appropriate entry site for retrograde intramedullary nail on x-ray table lateral; **c)** screw placement to proximal hole of retrograde nail by free hand

applied in the anteroposterior plane using the free-hand technique so most of the time spent under fluoroscopy was during the proximal screw fixation (Figure 2c) The fracture line and nail were checked under fluoroscopy and the end cup was adapted to the nail. The incision layers were closed in a standard fashion. No hemovac drainage was used in the patients. If there is an open fracture, firstly the wound was debrided and washed with 5000 cc saline. The skin defects were repaired primarily without excessive tension. No patient required a secondary reconstruction for skin coverage.

Statistical Analysis

The normality test for continuous variables was performed using the Shapiro-Wilk test. Descriptive statistics for continuous variables were expressed as median (interquartile range, Q3-Q1) [minimum-maximum] and as numbers and percentages for categorical variables. The Mann-Whitney U test was used to compare the variables of two independent groups. The Pearson chi-square test and the Fisher-Freeman-Halton test were used to compare categorical variables. A p value of <0.050 was accepted as the statistical significance level. Data were analyzed using IBM SPSS v.22.0 (IBM Corporation, New York, USA).

RESULTS

The records of 35 patients were evaluated retrospectively. Five patients were excluded (four for not followed up, and one for vascular complication). The study group consisted of 30 patients. Twenty-one (70%) of the patients were male, and 9 (30%) were female. The median age of the patients was 39 (range, 18-58) years. Seventeen (56.7%) of the affected femur was left-sided, while 13 (43.3%) were right-sided. The etiology of the fractures was gunshot injury in 11 (36.7%) patients and traffic accident and fall in 19 (63.3%) patients. The median follow-up period was 18 (range, 12-48) months.

The median preoperative fluoroscopy usage time was 81 (range, 68-116) seconds. The median perioperative blood loss was 129.5 (range, 114-150) ml. The median duration of surgery was 59.5 (range, 51-74) minutes. The median postoperative length of hospital stay was 3.5 (range, 2-6) days. The median time of union was 25 (range, 21-30) weeks.

Neither drain placement nor postoperative blood transfusion was required in any of the patients. No infection or neurovascular complication was observed in the patients. The KSS results were excellent in the 6th month, with a median functional and pain KSS scores of 95 (range, 85-100) points and 90 (range, 86-93) points, respectively.

According to Gustilo-Anderson classification, 11 (36.7%) of the patients were type 3A and 2 (6.7%) of the patients were type 1 open fractures. Of the patients, 17 (56.7%) were closed fractures and 13 (43.3%) were open fractures. There was no statistically significant difference in terms of the demographic characteristics; age (p=0.530), gender (p=0.229), and side (p=0.225) of the groups (Table 1). Also, no statistically significant differences were found between the groups related to the surgical characteristics; surgery time (p=0.086), fluoroscopy time (p=0.805), and blood loss (p=0.967), and their clinical and radiological follow-ups; hospitalization time (p=0.967), clinical score (KSS) of pain (p=0.341) and function (p=0.902), and union time (p=0.385) in the postoperative (Table 2).

DISCUSSION

In femur fractures, different orthopedic implants and different surgical techniques can be preferred by paying attention to the location of the fracture and the characteristics of the patient. In this study, we examined the clinical results of retrograde intramedullary nail treatment, which is rarely applied to distal femur fractures. Due to increased high-energy injuries, femur fracture incidence increases, and more complex fractures occur. High-energy traumas are responsible for distal femur fracture etiologies in young patients. It is most common after a traffic accident (12). Distal femur fractures seen in advanced age develop after simple falls (13). Our sample consisted of young patients, and as reported in the literature, there are high-energy traumas in their etiology.

Table 1. Demographic characteristics of the patients

	Close Fracture (n=17)	Open Fracture (n=13)	p
Age (years)	39 (26) [18-58]	39 (21) [22-55]	0.530
Gender, n (%)			
Male	11 (84.6)	10 (58.8)	0.229
Female	2 (15.4)	7 (41.2)	
Side, n (%)			
Right	4 (30.8)	9 (52.9)	0.225
Left	9 (69.2)	8 (47.1)	

Descriptive statistics were presented as median (interquartile range) [min-max]

Table 2. Clinical follow-up characteristics of the patients

	Close Fracture (n=17)	Open Fracture (n=13)	p
Union time (week)	25 (2.5) [21-29]	26 (3.5) [21-30]	0.385
Surgery time (minute)	58 (6) [52-66]	64 (15) [51-74]	0.086
Fluoroscopy time (second)	82 (13) [72-103]	80 (19.5) [68-116]	0.805
Blood loss (ml)	129 (15.5) [114-150]	130 (12) [117-145]	0.967
Hospitalization (day)	3 (2) [2-6]	4 (1) [3-5]	0.967
Clinical score (KSS)			
Pain score	92 (5) [86-93]	88 (4.5) [86-93]	0.341
Function score	95 (7.5) [90-100]	95 (7.5) [85-100]	0.902

KSS: knee society score, descriptive statistics were presented as median (interquartile range) [min-max]

The range of injuries associated with femur shaft fractures, as well as its relationship to mortality, is poorly understood. The most prevalent concomitant bone injury in the research population was to the tibia/fibula (20.5%), ribs/sternum (19.1%), and non-shaft femur (18.9%), with 5.8% of them being femur neck fractures (14). In our study, the most common type of concomitant trauma was contralateral distal radius fracture. The most common comorbid visceral organ injury was lung injury (18.9%), followed by intracranial (13.5%) and hepatic (6.2%) injuries (14). We obtained that the most common comorbid visceral organ injury was lung injury as high as 40%.

It was reported that long bone injuries are associated with substantial blood loss requiring blood transfusion in the previous studies. The amount of blood transfusion was low in patients with extra-capsular femur fractures, which were usually required in the post-operative period (15). In our study, for hemoglobin values below 10 g/dl blood transfusion was performed and the operation was performed. However perioperative blood loss was low so postoperative transfusion was not required; thus, the risks of blood transfusion were overcome.

According to recent research, periarticular knee surgery site infection (SSI) rates might range from 2% to 88%, depending on the fracture location (16). According to the study by O'Toole et al. (17), the risk of septic arthritis as a result of retrograde nailing of an open femur fracture is negligible (1.1%). In our study, 43.3% of patients had open fractures; no septic arthritis or infection developed in any of our patients.

In treatment with distal RIN, factors playing a role in surgery time include anesthesia time, positioning of the patient, the duration for reducing the fracture, and locking of the nail with the freehand technique. Prolonged surgery favors complications such as increased bleeding and risk of infection and non-union. The method of anesthesia is usually not dependent on the surgeon's preference, depends on the anesthesia team, and is dictated by comorbid factors in the patient. However, problems can be prevented by shortening the time of surgery with appropriate techniques and methods.

A common occupational danger in orthopedic trauma surgery is radiation exposure through intra-operative fluoroscopy (18,19). Fluoroscopy is used particularly intensively to confirm the reduction of the fractures, so the patient and surgical team are exposed to radiation (20). One study showed that the median dose-area product (DAP) meter for dynamic hip screws in extra-capsular femur neck fractures was 668 mGy/cm^2 (ST 36 s); for short proximal femur nail was 1040 mGy/cm^2 (ST 49 s); for long femur nail for diaphyseal fractures was 1720 mGy/cm^2 (ST 2 m 36 s); for manipulation and Kirschner wire fixation in distal radius fractures was 25 mGy/cm^2 (ST 25 s), and for volar-locking plate fixation in the distal radius, fractures was 27 mGy/cm^2 (ST 23 s). In comparison to junior surgeons, more experienced surgeons used less radiation in the operating room (18). No study specifies the time of fluoroscopy in cases with retrograde femur nail, but the median time was 81 (range, 68-116) seconds in our study.

One complication encountered in retrograde intramedullary nailing is damaging the neurovascular structures by the proximal screw. Riina et al. (21) stated that placement of proximal anteroposterior locking screw to the level of trochanter minor and above would reduce the risk of femur artery injury. In our study, all proximal locking screws were placed at the level of the minor trochanter minor or above, with no neurovascular complications.

The reamerization of the bone has many benefits in terms of accelerating the fracture union. The disadvantages of reamerization include risk of fat embolism and impaired endosteal blood supply; and weakening of the bone caused by the thinning of the cortex (22). However, reamerization also has some advantages, increasing the stability of the fracture by increasing the contact surface between the nail and the bone cortex and contributing to recovery through internal autologous bone grafting to the fracture site (23). Our study aimed to accelerate the union by allowing autologous grafting and using larger diameter nails to increase the stability by reamerizing.

Antegrade intramedullary nails are inadequate to fix small and osteoporotic fragments located distal femur, as a result, plate osteosynthesis is the treatment of choice for distal femur fractures (10). However, excessive soft tissue dissection may impair vascular circulation such that nonunion and infection rates increase (25).

Since the fixation of these fractures with the plate-screw causes changes in the axial load transfer of the femur, osteopenia develops at the proximal end of the plate. In this case, re-fractures may be observed (2). Because the intramedullary nail is located in the medullary cavity, it leads to less stress than plates and external fixators and therefore we see less failure of fixation (2,7).

Also, the RIN is usually performed by minimally invasive techniques. Thus, the damage to the soft tissues is less (10). This is perhaps why RIN has historically been preferred in the intramedullary treatment of distal metaphyseal fractures. The duration of surgery was shorter for plate osteosynthesis than for RIN because of performing the minimally invasive technique, as well as the amount of bleeding was higher (2). RIN leads to less bleeding and our patient group required no blood transfusions. Although the operation time is relatively long, we suggest performing RIN for distal femur fractures rather than plate osteosynthesis, for lowering the complications.

Limitation: Since we conducted our study retrospectively, we do not know how many days the patients in our study were operated on and whether additional injuries were made at the same time.

CONCLUSION

Open fracture treatments have difficulties in the surgical and postoperative period compared to closed fractures due to both the trauma mechanism and the deterioration of the soft tissue cover. In our study, RIN treatment was applied to open fractures immediately after necessary debridement. However, no clinical difference was observed in the perioperative and postoperative period between closed fractures that were also treated with RIN.

RIN is a minimally invasive method that may prevent excessive blood loss and decrease the duration of surgery time. It is an effective and reliable surgical intervention that should be considered for the treatment of the distal femur fractures.

Ethics Committee Approval: The study was approved by the Ethics Committee of Prof. Dr. Cemil Taşçıoğlu City Hospital (17.04.2018, 883).

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