

# Antegrade Locked Nailing Of Adult Femoral Shaft Fractures And Non-Unions: A Retrospective Review Of 48 Cases

Erişkin Femur Şaft Kırıklarının Ve Non-Unionlarının Antegrad Kilitli Çivileme Yöntemi İle Tedavisi: 48 Olgunun Retrospektif Değerlendirilmesi

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**Amaç:** Bu makalede, akut femur cisim kırığı veya non-unionu nedeni ile antegrade kilitli intramedüller çivileme uygulandı. Akut femur cisim kırıklarının 27'sinde oymasız antegrad kilitli intramedüller çivileme uygulandı. Akut femur kırığı olan 4 ve non-union olan 21 hastada ise fiksasyon oymalı kilitli çivileme ile sağlandı. Olguların yaş ortalaması 40.2 (17-80) idi. Serimizdeki hastaların 16'sı bayan (%33.3) ve 32'si erkekti (%66.7).

**Gereç ve Yöntem:** Bu çalışmaya dahil edilen 48 hastaya toplam 52 antegrad kilitli intramedüller çivileme uygulandı. Akut femur cisim kırıklarının 27'sinde oymasız antegrad kilitli intramedüller çivileme uygulandı. Akut femur kırığı olan 4 ve non-union olan 21 hastada ise fiksasyon oymalı kilitli çivileme ile sağlandı. Olguların yaş ortalaması 40.2 (17-80) idi. Serimizdeki hastaların 16'sı bayan (%33.3) ve 32'si erkekti (%66.7).

**Bulgular:** Hastaların takipleri ile elde edilen veriler, Thoresen kriterlerine göre; femoral aks deformitesi, femoral kısalık, diz eklemi hareket açıklığı ve ağrı veya ödem varlığı incelenerek değerlendirildi. Hastalar ortalama 21 ay (10-46 ay) takip edildi. Bir tanesi haricinde tüm olgularda kaynama görüldü (%98.07). Yüzeysel enfeksiyon üç hastada izlendi ve bunlardan bir olgunun takiplerinde derin enfeksiyon gelişti. Akut kırık grubundan gastrointestinal kanama öyküsü olan Winquist tip IV kırıklı bir hastaya, antikoagülan tedavi verilemediğinden, derin venöz trombüs izlendi. Non-union grubundan bir hastada ise, ameliyattan sonraki dördüncü günde pulmoner emboli gelişti.

**Sonuç:** İntramedüller çivileme yöntemleri akut femur cisim kırıkları ve non-unionlarında etkili bir tedavi metodudur. Oymalı çivileme metodu, oymasız çivileme metodu ile karşılaştırıldığında daha az başarısızlık izlenirken, yöntem sağlam stabilizasyon sağlar.

Anahtar Kelimeler: **femur, kırık tespiti, kırık iyileşmesi, intramedüller çivileme,**

**Background:** Here we present a retrospective evaluation of the functional outcomes of 48 patients who underwent antegrade locked intramedullary nailing for acute femoral shaft fracture or non-union.

**Methods:** A total of 52 antegrade locked intramedullary nailings were performed in the 48 patients included in the study. In 27 of the acute femoral shaft fractures, fixation was provided via unreamed antegrade locked intramedullary nailing. In 4 acute femoral fractures and in all 21 cases of nonunion, fixation was provided via reamed antegrade locked intramedullary nailing. Average age was 40.2 years (range 17-80 years). Of these patients, 16 were female (33.3%) and 32 were male (66.7%).

**Results:** Patient data obtained during follow up were evaluated according to the Thoresen criteria, in which lower extremity function is graded in terms of femoral axis deformity, femoral shortening, knee range of motion and pain or oedema. Patients were followed up for an average of 21 months (range 10-46 months). Union was found in all patients except one (98.07%). Superficial infection occurred in three patients, and in one of these a deep infection developed. In the acute fracture group, one patient with a Winquist type IV fracture had a history of gastrointestinal bleeding and could not be given anticoagulants, and developed a deep venous thrombosis. In the nonunion group, one patient developed pulmonary emboli on the 4th postoperative day.

**Conclusion:** Intramedullary nailing is an effective treatment method for both acute femoral shaft fracture and nonunion. It provides rigid stabilization, and the reamed method is associated with less frequent failures compared to the unreamed method.

Key Words: **femur, fracture fixation, fracture healing, intramedullary nailing,**

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Femoral shaft fractures result from high-energy trauma and are the most frequent cause of morbidity and mortality in patients with lower extremity injuries. For acu-

te fracture or non-union of the femoral shaft, intramedullary nailing has become the treatment of choice (1,5). It is appropriate for intramedullary fixation because of

the femoral shaft's straight, tubular structure. In comparison with plates and external fixation devices, the intramedullary nail provides more stable support for axial loading because of its central position. For this reason, implant failure is seen less frequently in nailing, and the procedure promotes bone union and remodeling.

Intramedullary nailing can be performed with or without reaming of the bone, but the reaming method has recently become preferred. Reaming allows the insertion of a larger nail, which improves its mechanical purchase and provides greater stability (6).

The purpose of this study was to evaluate the functional outcomes



Figure 1a

Figure 1. These radiographs were taken in a 21-year-old female with left-sided closed acute femoral shaft fracture (Winqvist type IV): A) preoperative radiograph; B) immediate postoperative radiograph; C) 6-month follow-up radiograph.



Figure 1b



Figure 1c

of patients in our clinic who underwent antegrade locked intramedullary nailing for acute femoral shaft fracture or non-union.

### Patients And Methods

A total of 52 antegrade locked intramedullary nailings were performed in 48 patients who were treated at our institution's department of orthopaedic surgery. Of these patients, 16 were female (33.3%) and 32 were male (66.7%). Average age was 40.2 years (range 17-80 years). The lesion was on the left side in 22 patients (45.8%), on the right in 25 patients (52.1%) and was bilateral in one patient (2.1%).

Of the 52 nailings performed, 31 were for acute femoral shaft fracture (30 patients; one patient had bilateral fractures). Of the patients in the acute fracture group, the causes of the fractures were as follows: traffic accident in 22 patients (73.3%), high fall in 4 patients (13.3%), work accident in 2 patients (6.7%) and low-velocity gunshot wound in 2 patients (6.7%). The fracture was isolated in 11 patients (36.6%) but in 19 patients (63.3%) it was associated with one or more sites of secondary trauma or systemic injury (Table I). An example of nailing performed for acute femoral shaft fracture is shown in Figure 1.

Of the 21 nailings performed for non-union, 3 were made in patients from the acute fracture group (all 3 had received unreamed nailings). Of the remaining 18 patients, 15 had previously undergone plate fixation, and 3 had previously undergone external fixation for open fracture.

The 31 acute femoral shaft fractures were classified according to the Winquist-Hansen scale (6) (Table II). Of these, 10 were open fractures. In terms of the Gustillo-Anderson scale, these open fractures were classified as follows: 5 Type I open (including low-velocity gunshot wounds in 2 patients), 3 Type II open, and 2 Type III-B (7,8).

**Table II.** Degree of comminution of the 31 femoral shaft fractures according to the classification of Winquist et al.5

Type of fracture	Number of patients
I	13
II	9
III	6
IV	3

In 27 of the acute femoral shaft fractures, fixation was provided via unreamed antegrade locked intramedullary nailing (Synthes solid titanium nail, Davos, Switzerland, Figure 1). In 4 acute femoral fractures and in all 21 cases of non-

union, fixation was provided via reamed antegrade locked intramedullary nailing (Russell-Taylor femoral nail, Smith and Nephew Richards, Memphis, USA).

For the patients with acute femoral shaft fracture, the average time between trauma and surgery was 2 days (range 0-4 days). Open femoral fractures were cleaned and covered with a sterile dressing in the emergency room and surgery was performed at the soonest appropriate time. In two patients skin graft was applied. Patients with open fractures received broad-spectrum antibiotic therapy (first-generation cephalosporin + aminoglycoside), whereas patients with closed fractures received a first-generation cephalosporin as prophylaxis. In addition, patients having no contraindications to low molecular weight heparin received it for prophylaxis against deep venous thrombosis.

For surgery, all patients were in a supine position on a traction table. Antegrade nailing with static locking was performed. Average duration of surgery was 98 minutes (range 70 - 210 minutes). Average fluoroscopy time for closed intramedullary nailing was 2.1 minutes (range 0.8 - 4 minutes).

For the patients undergoing surgery for non-union (n = 21), autogenous iliac crest bone graft was performed in 11 patients, allograft in 4, hydroxyapatite in 5, and tricalcium phosphate (TCP) in 1 patient. Of the patients undergoing surgery for acute fracture, autogenous iliac crest bone graft was performed in 4. First preference was given to autogenous graft, but other graft types were used in patients who did not permit autogenous graft or who had undergone autogenous grafting previously (9,11).

**Table I.** Injuries associated with acute femoral fracture

Associated injuries	Number of patients with injury
Head trauma	12
Contralateral lower limb fracture	4
Contralateral femoral neck fracture	2
Upper limb fracture	5
Pelvic trauma	2
Thoracic trauma	2

All patients received physical and radiological follow-up examinations every six weeks. For patients whose medical condition permitted it, walking with crutches and partial weight bearing was started on postoperative day 2. Walking with full weight bearing was started when initial callus formation was visible on anteroposterior and lateral radiographs.

Fracture union was defined as a circumferential callus visible on radiologic exam, absence of pain in the fracture region during walking with full weight bearing, and absence of tenderness during physical exam. Nonunion was defined as pain and motion at the fracture site and radiographic persistence of a radiolucent line without progressive callus formation on three sequential radiographs following fracture fixation. Shortening was assessed radiologically with the use of a radiopaque ruler. Hip and knee range of motion and lower extremity rotational profile were evaluated. Degree of deformity during weight bearing was measured with a goniometer on anteroposterior and lateral radiographs.

## Results

Average Hospital stay was 10 days (range 6 - 15 days), and average follow up time was 21 months (range 10 - 46 months).

Patient data obtained during follow-up were evaluated according to the Thoresen criteria,(12) in which lower extremity function is graded in terms of femoral axis deformity, femoral shortening, knee range of motion and pain or edema.

In this series, of the 31 nailings performed for acute femoral shaft fracture (27 unreamed, 4 reamed), union

was achieved in all but three fractures, these three having been treated with unreamed nailing. In the 24 other fractures that underwent unreamed nailing, union was seen at an average of 7.2 months, whereas in the 4 patients who received reamed nailing the average time to union was 6.5 months.

In 4 patients in the acute fracture group, union was not observed by the 4<sup>th</sup> postoperative month and dynamization was performed. In one of these 4 patients, full union was seen in the 7<sup>th</sup> postoperative month. Of the 3 remaining patients, 2 had breakage of the distal locking screw and 1 had bending of the intramedullary nail. For these 3 patients the unreamed nail was removed and replaced with a thick, reamed intramedullary nail. Union was seen in these 3 patients at an average of 8 months after this procedure.

For the 21 cases of femoral fracture nonunion in this series, reamed nailing was performed and union was subsequently seen in all fractures except 1. In these 20 fractures, union was observed at an average time of 6.1 months after surgery. Included in this group were the 3 patients who had previously undergone unreamed femoral nailing and did not achieve union with that earlier procedure. These 3 patients all achieved union with the subsequent reamed nailing procedure. For the 1 patient in the nonunion group who did not achieve union even after reamed nailing, dynamization was applied in the 4<sup>th</sup> postoperative month. Despite this procedure, union was not achieved. Approximately 14 months later the nail was removed and an autogenous bone graft was put in its place with plate fixation, and union was observed in follow-up.

Final postoperative knee flexion (48

patients, 49 knees) was greater than 120 degrees in 20 knees, between 90 and 120 degrees in 25 knees and less than 90 degrees in 4 knees. As for the 4 patients with this severe loss of flexion, 2 were very elderly and 2 had received multiple traumas and as a result could not be sufficiently mobilized early while in the intensive care unit.

In terms of Thoresen criteria for femoral axis deformity and Winquist fracture type, findings in the acute fracture group were as follows. Of the Winquist type III fractures, 1 had a 5° varus, and another had a 10° internal rotation. Of the Winquist type IV fractures, 1 had a 15° external rotation deformity. As for the findings in the nonunion group, 2 fractures had a 5° and 3 fractures had an average 15° external rotation deformity (range 12-18°).

Femoral shortening findings were as follows. In the acute fracture group, 3 Winquist type IV fractures had an average of 2 cm shortening (range 1.5-2.5 cm). In the nonunion group, 8 fractures had an average of 2.5 cm shortening (range 2-5 cm).

Superficial infection occurred in 3 patients, and in one of these a deep infection developed. These patients were treated with debridement and a first-generation cephalosporin, and the infections were controlled.

Two other complications were encountered. In the acute fracture group, 1 patient with a Winquist type IV fracture had a history of gastrointestinal bleeding and could not be given anticoagulants, and developed a deep venous thrombosis. In the nonunion group, 1 patient developed pulmonary emboli on the 4<sup>th</sup> postoperative day. These complications were successfully managed with appropriate treatments.

## Discussion

Femoral shaft fractures are the most frequent cause of morbidity and mortality in patients with lower extremity injuries, and usually result from high-energy trauma. In this series, of the 30 patients who underwent intramedullary nailing for acute femoral shaft fracture, the fracture was due to traffic accidents in 73.3% of the patients, while 63.3% had additional fractures and/or systemic injuries.

Despite some authors' reports of satisfactory results, many investigators have reported high rates of nonunion, pin tract infection and loss of knee joint range of motion with the use of external fixation devices (13,14). In a retrospective study, Murphy et al. compared external fixation to intramedullary nailing in patients who had closed femoral shaft fractures (15). In non-complicated fractures, intramedullary nailing provided significantly better clinical results (15).

Another surgical method for treating femoral shaft fractures is internal fixation with plates. Disadvantages of this technique include the wide surgical exposure needed for the procedure, reduction in knee joint range of motion and the related increases in blood loss, infection, nonunion and implant failure compared to intramedullary nailing (16,17)

In patients with closed femoral shaft fractures, infection rates are higher with plate internal fixation than with closed intramedullary nailing (16,17) In the plating procedure, devitalized bone fragments that result from the injury-related trauma can be disrupted, and the additional iatrogenic trauma involved in dissection can lead to infection and problems with union. Despite the 90-95% union rates reported

in studies of fixation with plating, infection rates of up to 11% have been encountered.<sup>17,19</sup> High rates of union are also found with intramedullary nailing, but infection rates of 1% have been commonly reported (5,6,20).

Other disadvantages of internal fixation with plating include implant and fixation failure. Reported implant failure rates have ranged from 5-10%, and the great majority of these patients need a second operation (19,21). Our series included 15 patients who had previously undergone internal fixation with plating; all of these subsequently underwent intramedullary nailing for nonunion and/or implant failure.

Intramedullary nailing (reamed or unreamed) offers several advantages compared to other methods of surgical fixation. Closed intramedullary nailing permits fixation without removal of the fracture hematoma and the resulting loss of needed osteoinductive factors. Less surgical trauma, lower infection rates and less scarring of the quadriceps muscle are other advantages of this method (22). In a series of 551 fractures, Wolinsky et al. performed reamed antegrade intramedullary nailing and found a union rate of 98.9 % with a very low rate of complications.<sup>6</sup> Other series in the literature have reported union rates of 95-100% (6,23). In our series the overall rate of union was 92.4% (acute fracture group, 90.4%; nonunion group, 95.3%). One reason for the lower rate of union in our acute fracture group might be that the unreamed nailing method was used in all but four of these patients.

Several studies have compared the results of the reamed and unreamed methods of intramedullary fixation. For reamed intrame-

dullary nailing in particular, the most important advantage is its ability to provide for axial loading at the fracture site. In addition, the reaming procedure appears to stimulate bone healing (23). Tornetta and Tiburzi found no significant difference between the reamed and unreamed procedures in terms of operation time and blood loss, but found that union occurred sooner after the reamed procedure (23). Union rates were higher with reamed nailing than with unreamed nailing in a multicenter study.<sup>1</sup> In our series, union occurred at an average of 7.2 months after unreamed nailing for acute femoral fracture (n = 24 fractures), while union occurred at an average of 6.5 months after reamed nailing for acute femoral fracture (n = 4 fractures). These figures are consistent with those in other studies but are not large enough for statistical analysis.

Intramedullary nailing can provide for early mobilization in patients with multiple trauma, thereby reducing mortality and morbidity (24,25). Retrospective studies of patients with multiple injuries emphasize that fracture fixation performed within the first 24 hours is associated with lower mortality (26,27). The risk of sepsis related to pulmonary dysfunction can likewise be lessened in these patients. Early fracture fixation had a positive effect on pulmonary and cardiovascular parameters (24). In our series, patients who came to the emergency department for acute femoral shaft fracture received surgery as early as possible (average 2 days, range 1-4 days) and were mobilized early in the postoperative period.

In a retrospective study of 32 patients with femur fractures and head trauma, Starr et al. investigated the timing of surgery. The

study found that patients with severe head injury who were closely monitored for hypotension and hypoxia experienced no increase in central nervous system complications when undergoing early fracture fixation (25). In our series, 12 patients had head trauma; all had Glasgow Coma Scores above 8, and no pulmonary or cerebral complications were encountered in these patients after early intramedullary fixation.

In light of the research literature, we consider reamed intramedullary nailing, performed early, to be an effective and safe procedure in patients with thorax trauma and multiple injuries. Canadian Orthopaedic Trauma Society reported that there was no difference in the rate of pulmonary failure found with reamed or unreamed intramedullary nails (28). As for the possibility of pulmonary emboli, Neudeck et al. measured maximum intramedullary pressures during reaming and unreamed nailing in sheep and found no significant difference (29).

Reamed intramedullary nailing methods are also the treatment of choice for nonunion in femoral shaft fractures. Webb et al. found that in 105 cases of femoral nonunion, a 95% rate of union was achieved within 20 weeks after reamed intramedullary nailing (4). In our series, there were 21 patients who underwent reamed intrame-

dullary nailing for nonunion, and union was achieved in all but one (95.2%).

For open femoral shaft fractures, intramedullary nailing methods are the treatment of choice provided that the fixation is performed early, debridement and wound cleaning are sufficient, and appropriate antibiotic therapy is used (30). Of our patients undergoing surgery for acute femoral shaft fracture, 5 had type I open fractures (2 patients had low velocity gunshot wounds), 3 had type II open fractures, and 2 had type III-B open fractures. No problems were encountered in these patients during follow up.

Infection rates in closed intramedullary nailing for femoral shaft fractures are very low. In a study of 500 patients who underwent closed intramedullary nailing, Winquist et al. found an infection rate of 0.9% (5). In retrospective series with more than 100 patients, infection rates were found to vary between zero and 0.8% (6,20). In our series, 3 patients developed superficial infections and 1 patient developed a deep infection. The superficial infections were successfully treated with wound care and, according to culture findings, appropriate parenteral antibiotic therapy. The patient with deep infection was from the nonunion group, and 15 days after intramedullary nailing debri-

dement was performed, followed by parenteral antibiotic therapy; these were sufficient to bring the infection under control.

Implant failure after locked intramedullary nailing is rarely seen. Possible failures include breakage of proximal or distal screws or bending of the nail. Soto-Hall and McCloy reported that bending of the nail was more frequently seen with intramedullary nails 10 mm or less in diameter (31). In our patients, 3 cases of implant failure were seen; 2 of these were broken locking screws and 1 was a bent nail. All were encountered with unreamed titanium nails. Initially in our protocol we preferred unreamed nailing for acute fractures, but due to the inadequacies encountered with this method, for our later patients we preferred reamed intramedullary nailing with thicker nails to provide rigid fixation.

In conclusion, intramedullary nailing is an effective treatment method for both acute femoral shaft fracture and nonunion. It provides rigid stabilization, and the reamed method is associated with less frequent failures compared to the unreamed method. The reamed method may also stimulate bone neovascularization and healing, and these advantages make it a preferable method of treatment.

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