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Treatment of femoral shaft fractures and pseudoarthrosis with compressive and interlocking intramedullary nailing

Femur cisim kırıkları ve psödoartrozlarının kompresif, kilitli intramedüller çivileme ile tedavisi

Erhan YILMAZ, Lokman KARAKURT, Mehmet BULUT, Oktay BELHAN, Erhan SERİN

Firat University, Medical Faculty, Department of Orthopaedics and Traumatology

Amaç: Bu çalışmada femur cisim kırıklarının kompresif, kilitli intramedüller çivilerle tedavisinden alınan sonuçlar değerlendirildi.

Çalışma planı: Otuz hastanın (23 erkek, 7 kadın; ort. yaş 36.9; dağılım 14-80) 33 femur kırığına kompresif, kilitli intramedüller çivilemeyle tespit yapıldı. Yirmi altı kırık kapalı, yedi kırık (2 tip II, 5 tip IIIA) ise açıktı. Üç olguda psödoartroz nedeniyle çivileme yapıldı. Winquist sınıflamasına göre 13 tip I, sekiz tip II, sekiz tip III, dört tip IV kırık görüldü. Klinik, radyografik ve fonksiyonel sonuçlar Thoresen ölçütlerine göre değerlendirildi. Olguların ortalama izlem süresi 29 ay (dağılım 6-59 ay) idi.

Sonuçlar: Ameliyat süresi ortalaması 105.7 dakika bulundu. Tüm olgularda ortalama 19.6 haftada kaynama sağlandı. Yeterli kallus görülmediği için altı olguda dinamizasyon uygulandı. Thoresen ölçütlerine göre 17 olguda (%56.7) mükemmel, sekiz olguda (%26.7) iyi, üç olguda (%10) orta, iki olguda (%6.7) kötü sonuç elde edildi. Üç olguda kısalık (2-4 cm), iki olguda varus (8 ve 11 derece), üç olguda dış rotasyon deformitesi, üç olguda diz ekleminde fleksiyon kısıtlılığı, sekiz olguda yüzeyel enfeksiyon, üç olguda trokanterik bursit, iki olguda distal vida iritasyonu görüldü.

Çıkarımlar: Erişkin femur cisim kırıklarında kilitli intramedüller çivileme yüksek kaynama ve düşük komplikasyon oranlarına sahip olması nedeniyle ilk tercih edilmesi gereken güvenli bir tedavi yöntemidir. Tepe vidası ile yapılan kompresyonun kırık hattında boşluk kalmasını önleyerek daha stabil bir tespit sağladığı sonucuna varıldı.

Anahtar sözcükler: Erişkin; kemik çivisi; kemik vidası; ekipman tasarımı; femur kırığı/cerrahi/radyografi; kırık fiksasyonu, intramedüller; hareket açıklığı, eklem; tedavi sonucu.

Objectives: We evaluated the results of compressive and interlocking intramedullary nailing in femoral shaft fractures.

Methods: Thirty-three femoral fractures of 30 patients (23 males, 7 females; mean age 36.9 years; range 14 to 80 years) were treated by compressive and interlocking intramedullary nailing. There were 26 closed and seven open (2 type II, 5 type IIIA) fractures. In three femurs, intramedullary nailing was performed due to pseudoarthrosis. According to the Winquist classification, there were 13, 8, 8, and 4 type I to IV fractures, respectively. Clinical, radiographic, and functional results were evaluated according to the Thoresen criteria. The mean follow-up was 29 months (range 6 to 29 months).

Results: The mean operation time was 105.7 minutes. Union was obtained in all the patients within a mean duration of 19.6 weeks. In six cases, dynamization was performed due to insufficient callus formation. The results were excellent in 17 patients (56.7%), good in eight patients (26.7%), fair in three patients (10%), and poor in two patients (6.7%). Complications included shortening (n=3; 2 to 4 cm), varus deformity (n=2; 8 and 11 degrees), external rotation (n=3), restriction in knee flexion (n=3), superficial infection (n=8), trochanteric bursitis (n=3), and irritation of the skin by distal screws (n=2).

Conclusion: High rates of union with low complication rates makes interlocking intramedullary nailing an appropriate method in the treatment of femoral shaft fractures in adults. Compression with top screws contributes to the stability of fixation by eliminating any looseness through the fracture line.

Key words: Adult; bone nails; bone screws; equipment design; femoral fractures/surgery/radiography; fracture fixation, intramedullary; range of motion, articular; treatment outcome.

Correspondance to: Dr. Erhan Yılmaz. Firat University, Medical Faculty, Department of Orthopaedics and Traumatology
Phone : 0424 - 238 80 80 Fax: 0424 - 237 26 12 e-mail: yilmazerh@yahoo.com

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Gold standard in all femoral fractures in adult including those open, comminuted and segmental fractures between subtrochanteric and supracondylar regions is fixation by intramedullary nailing which is ideally suitable for the anatomical and physiological structure of the bone.[1-5] However, this technique is not suitable for a fracture in the coronal plan in the femoral condyl (AO type B3 and C3 fractures).[5] In particular, it is possible to protect the length and rotation of the bone successfully as well as to obtain low malunion and infection rates and high union rates exceeding 95% in the treatments with intramedullary nails interlocking statically and engraved intramedullary nails.[3, 4, 6, 9] It is known that rotation and telescopic movement cannot be controlled and that a significant cortical contact is required for sufficient fixation.[10, 11]

Distribution of load in the intramedullary nails extends along the loading axis of the limb; resistance against the bending and torsion forces is better than with plates and screws.[11, 12] However, there are several complications in both plated osteosynthesis and osteosynthesis performed with external fixators such as increased risk of non-union and osteomyelitis, nail tract infections, restricted motion on the knee joint, plate insufficiency and increased need to primary bone grafting. Furthermore, most orthopedic surgeons prefer using intramedullary nails in the treatment of femoral shaft fractures because of the fact that the treatment of these fractures with plated osteosynthesis causes more damage in soft tissues and wide surgical exploration increases the operation time and blood loss is more in this type of treatment.[5, 11, 13]

In order to achieve successful outcomes and suitable reduction, anterograde nailing was advised for proximal femoral fractures and retrograde nailing for distal femoral fractures.[2] In the present study, we evaluated the results of compressive and interlocking intramedullary nailing in femoral shaft fractures in adult.

Patients and methods

Between 1998 and 2000, thirty-three femoral fractures of 30 patients (23 males, 7 females; mean age 36.9 years; range 14 to 80 years) were treated by compressive and interlocking intramedullary nailing (C-75, Hipokrat Ltd Co). 12 patients had fractures on the left side, 15 had on the right side and 3 patients bilateral fractures. There were 26 closed and seven open fractures. Open fractures were of type II in 2 patients and of type IIIA in 5 patients. Those patients with ischemic heart disease, vascular pathologies, acute or chronic infections, pathological fractures, open fractures of type IIIB or IIIC, fracture on the femoral neck or intertrochanteric fracture on the same side, fractures extending into the joint and floating knee as well as those with multitrauma.

Femoral shaft fractures developed on the area extending until 4 cm proximal of trochanter minor and 6 cm proximal of knee joint were fixed by intramedullary nailing. 12 of the fractures were located on the junction of 1/3 proximal and mid femur, 14 on mid femur and 7 on the junction of 1/3 mid and distal femur. Types of fractures were classified according to the Winquist classification. [14] Accordingly there were 13 fractures of type I, 8 type II, 8 type III and 4 type IV (Table 1). Causes of the fractures were as follows: in-vehicle traffic accident in 8 patients, traffic accident out of the vehicle in 5, falling from motorcycle or bicycle in 6, falling while walking or from height in 5, sports injury in 1, gun shoot in 3 and occupational injury in 2.

In addition to the femoral fractures, 2 patients had also fractures of ischium and pubic rami, 1 had patellar and pilon fractures, 1 had open tibia-fibula fracture of third degree, 1 had femoral neck fracture on the contralateral side, 1 had forearm fracture, 3 had multiple costal fractures, 1 had fibula fracture and 1 had L3 vertebral fracture. One patient exhibited splenic rupture. Posteroanterior and lateral femoral X-ray were taken routinely together with pelvis, hip and knee radiographies in the patients presented to the emergency service department. Vascular and neurological examinations of the limb were performed with greater

Table 1. Winquist-Hansen clasification and fracture distribution

	Cortical Contact	Fracture number
Type I	>75	13
Type II	50-75	8
Type III	25-50	8
Type IV	<25	4

attention for distal femoral fractures. Prophylaxis for tetanus, debridement and irrigation with saline was performed prior to the operation in those patients with open fractures. First generation cephalosporin alone was started in the patients with closed fractures, whereas aminoglycoside and anti-anaerobic antibiotic therapy was added to cephalosporin in those with open fractures. All patients received low molecular weight heparin for 10 days from the time of admission to the postoperative period. The patients underwent skeletal traction with Braun-Böhler cast Steinman wire through tuberositas tibia prior to the operation. Sufficiency of the traction was evaluated based on the lateral X-rays. Diameters of the nails were 10 mm in one fracture, 11 mm in 11, 12 mm in 6, 14 mm in 6 and 15 mm in 2 fractures.

For the closed fractures nailed primarily, mean duration between injury and operation was 8.9 days (range: 1 – 40 days). 2 patients with type II open fractures and those patients with type III open fractures were excluded from the evaluation for the time to operation. 2 of 5 patients with type III open fractures had undergone fixation with external fixators in another clinic and one patient in our own clinic. External fixators were removed and fixation was performed with intramedullary nailing in these patients as they developed pseudoarthrosis. Another patient with type IIIA open fracture and bilateral femoral fractures underwent fixation with nailing following antibiotic treatment for 3 weeks (figure 1a, b). Intramedullary nailing was performed because of breakage of the plate on 6th month in a closed fracture underwent plated osteosynthesis (figure 2a-c).

The patients were assumed lateral decubitus position during the operation. For all fractures, an incision of 4 to 5 cm was made on the fracture line. Guiding wire which was passed through the fracture line was removed from fossa pyriformis. Engraving process was performed by the engravers inserted through the guiding wire. Fixation was made with a nail of suitable length and diameter which was usually 1 mm less than the last engraver. Static interlocking was usually made by putting 1to the proximal to the nail and 2 screws distal to the nail. First, compression was applied to the fracture line with compression screw and then top screw was inserted. Controlled compression was performed in segmented fractures in order not to alter the alignment. Targeting device was used for the proximal and distal interlocking screws. Fluoroscopy was not used in any patient for interlocking screws. The bone was reached with a lateral longitudinal incision of 3 to 4 cm on the distal site of the guiding system and lateral cortex of the

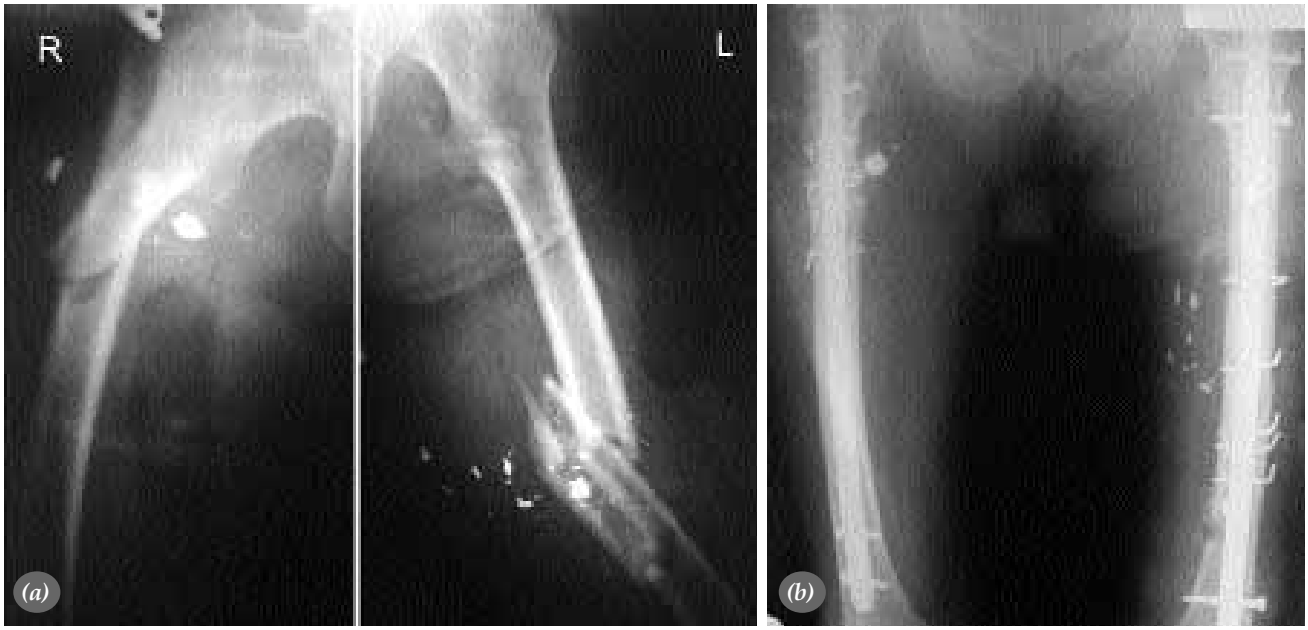

Figure 1. Bilateral type IIIA open femoral fracture due to gun-shot wound in a 65 years old man. Note that 1/3 proximal-to-mid long oblique fracture on the right femur and 1/3 mid-to-distal segmented fracture on the left femur. **(a)** Radiograph taken 3 months prior to operation and **(b)** radiograph taken 3 months after the operation.

Table 2. Thoresen classification system for the results of treatment

	Excellent	Good	Fair	Poor
Malalingment of the femur (degrees)				
Varus or valgus	5	5	10	>10
Antecurvatum or recurvatum	5	10	15	>15
İnternal rotation	5	10	15	>15
Eksternal rotation	10	15	20	>20
Shortening of the femur (cm)	1	2	3	>3
Range of motion of the knee (degrees)				
Flexion	>120	120	90	<90
Extension deficit	5	10	15	>15
Pain or swelling	None	Minimal	Significant	Severe

bone was made entirely visible by Hohman distracter for fasia lata not to distend the guiding system at the level of the holes.

Quadriceps strength exercises were begun on the first post-operative day and knee and hip motions were started on the second postoperative day. In the controls, from time of seeing callus tissue the patients were allowed for partial loading to the extent on which they could tolerate and full weight-bearing was allowed two weeks after this. Indomethacine, at a dose of 25 mg three times daily was given for 6 weeks beginning on the first post-operative day for heterotopic ossification (with 400 mg of misoprostol for gastrointestinal side-effects). The patients were invited to control visits on 3, 6 and 12th weeks, on the 6th month after the operation and then once in every 6 months. The screw or screws away from the fracture line were removed and dynamization was performed in the patients in whom union evidence was not found at the controls on 12th postoperative week at most.

The patients were evaluated clinically, radiologically and functionally based on Thoresen criteria considering the presence of swelling, rates of

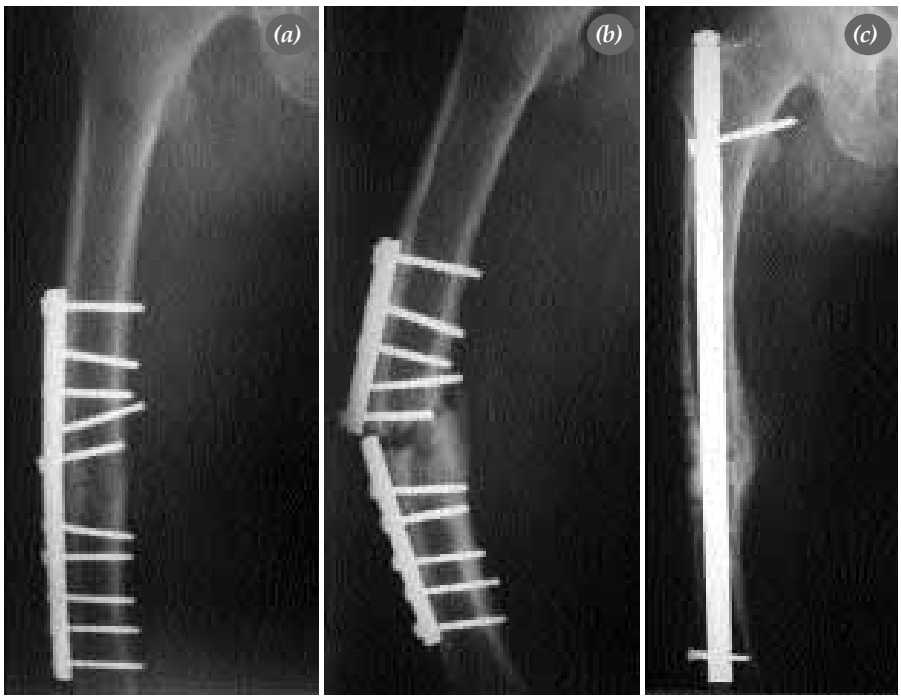

Figure 2. Closed transverse fracture on the 1/3 mid femur on the right side occurred to the falling from stair in a 72 years old woman. Radiographies showing **(a)** application of plated osteosynthesis and **(b)** breakage of the plate and re-fracture 6 months after the operation and **(c)** fixation of the recurrent fracture with interlocking intramedullary nail.

motion in knee joint and angulation degree of the fracture (table 2). [10] Mean follow-up period was 29 months (range: 6 – 59 months).

Results

Mean operation time from the skin incision to the closure of the wound was 105.7 ± 22.3 minutes. No patient developed breakage of the nails or screws. But proximal interlocking screws in two patients were broken deu to squeezing during the compression applied (figure 3). No problem of nonunion was seen in these 2 patients with broken proximal screws. Additionally, curving occurred due to early loading at the level of fracture line on the 4th week in the intramedullary nail on the right femur of a patient with bilateral femoral fractures. Union was achieved without complication on the 28th week in this patient in which the nail was changed. Serclaging was performed in 4 patients in whom breakage occurred on the injury time or during nailing. Serclaging was not performed in other patients. In one patient, the guiding wire curved in the nail and squeezed. The wire and nail were removed in this patient and the nail was inserted under direct vision without guiding wire. Based on the classification of the patients according to Thoresen criteria excellent outcome was achieved in 17 (56.7%) patients, good outcome in 8 (26.7%), fair outcome in 3 (10%) and poor outcome in 2 (6.7%). 8 patients developed superficial infection requiring antibiotic therapy. No patient developed deep infection. Heterotopic ossification was observed in 2 patients. No patient developed gastrointestinal side effects from indomethacine.

Figure 3. Closed oblique fracture on 1/3 proximal-to-mid femur due to motorcycle accident. in a 29 years old man. Note that breakage of the proximal interlocking screw following application of top compression.

Restricted flexion was seen in 3 patients. Flexion range was measured to be 110, 120 and 90 degrees, respectively. All these 3 patients were those who first underwent unilateral or ring-type external fixation for type IIIA open fractures and then underwent intramedullary nailing because of non-union.

Observing callus bridge radiologically and absence of pain on the fracture line were considered as union. All patients achieved union averagely 19.6 ± 3.5 weeks after intramedullary nailing. Dynamization was performed in 6 patients upon not observing sufficient callus tissue on control visits. Late union was seen in one of these patients. In others, union on appropriate time was achieved. Union was considered to be late if callus tissue couldn't be seen on X-rays on the controls on 6th month. Union was delayed in 2 patients one of whom underwent dynamization. For both patients, union was achieved following application of autograft around the fracture without need of chaning the nail. 3 patients developed shortening (3, 4 and 2 cm, respectively). In 2 of these patients, external fixator had been applied prior to intramedullary nail and excision had been performed on the fracture area because of nonunion. The other patient was one with recurrent femoral fracture due to breakage of plate following treatment with plated osteosynthesis (figure 2a-c). No patient developed anterior or posterior angulation more than 10O. varus deformity of 11 degrees developed in a patient with type IV segmented, comminuted and type III open fracture on the junction line between 1/3 proximal and mid parts of the femur and varus deformity of 8 degrees developed in the other patient with type III open fracture on

the junction line between 1/3 mid and distal parts of the femur. Rotation deformity of 10 degrees was seen in 2 patients and of 15 degrees in another one.

Two patients had sciatic and peroneal nerve injury before the operation. Findings of nerve injury resolved spontaneously within 6 months. No patients showed nerve injury due to intramedullary nailing. One patient developed gluteal insufficiency due to the trauma caused by proximal tip of the nail on the gluteal region. This caused gait disorder. No nerve injury was found on EMG and the patient received physiotherapy. Gait disorder of the patient begun to improve spontaneously on the 5th month. Hip pain was observed responding to the anti-inflammatory treatment in 3 patients developed trochanteric bursitis. 2 patients had distal screw irritation. In these patients, the nails leading to irritation were removed as sufficient callus was seen on fracture line. No patient exhibited migration of the nail to the knee joint.

Evidence of fat emboli prior to application of intramedullary nailing was seen in one patient with bilateral femoral fracture and in another one with left femoral fracture. One of these patients was begun mechanical ventilation in the intensive care unit and intubated. Both patients were operated on without complication following treatment of fat emboli. No sign of emboli developed following the operation.

Discussion

Treatment of the shaft fractures of long-bones with interloking intramedullary nails has been treatment of choice because this method provides a stabile fixation against torsion and bending forces, doesn't allow shortening, angulation and rotation, allows appropriate distribution of the forces on the bone, its union rate is high and malunion and infection rates are low and it doesn't alter the bone physiology.[1-5] Interlocking nails may be applied dynamic or statically, with or without engraving the medulla, with open or closed methods.

Although it is known that engraving process alters endosteal blood flow, experimental studies indicated that periosteal blood flow and blood flow to the surrounding muscles increased six-fold.[6, 15] Engraving increases stability by creating a wider contact surface between the nail and bone because allows insertion of a nail of large diameter; furthermore, material obtained with curettage of the medulla during the procedure affects the healing of fracture in a positive way as it is an autologous bone graft.[6, 12, 15-18] Operation time is longer and blood loss is more in engraved nailing although the complications such as iatrogenic smashing are less frequent. [3, 6, 18] In a multi-centered study, nonunion was found in 8 of 107 fractures (7.5%) nailed without engraving and in only 2 of 121 fractures (1.7%) nailed with engraving.[15] Clatworthy et al. [16] reported that union time was shorter in those in whom engraving was performed than those in whom engraving was not performed. We applied fixation in the present study with intramedullary nailing of engraved type because it was such a method that doesn't impair endosteal and periosteal blood flow as well as it improves stability by allowing using a nail of larger diameter. Since bending force of the intramedullary nail is 4 times the radius of the nail, nails of 13 or 14 mm should be used in order to minimize the risk of screw breakage and improving stability. [11]

Mean diameter of the nails we used for the fractures was 12.4 cm and those nails with a diameter of 10 and 15 mm were the least frequently used ones. For proximal and distal femoral fractures, dynamic nailing can be performed by inserting only one interlocking screw on one tip of the nail. [10] This type of nailing has been advised for only transverse and short oblique type I and type II fractures of femoral isthmus. However, it was found that insufficient fixation developed in 10% of the dynamic fixations. [19] For static nailing, transition to dynamization was advised on 3 to 6th months after the operation in order to improve consolidation if the callus of sufficient amount isn't seen. Rates of applying dynamization range from 2.3 to 40%.[1, 11, 12, 20, 21] In the present study, we applied static nailing for all femoral fractures. We performed dynamizatino by removing the nails away from the fracture line in only 6 (20%) of our patients. 5 of these patients showed union without complication although one the patients underwent grafting around the fracture line due to the lack of sufficient callus tissue within 3 months after dynamization and union was achieved.

Classically, intramedullary nailing is performed with closed method by using the traction table with-

out opening the fracture area. Additionally, it may be performed manually with the use of femoral distractor or manual distractor on the radioluscent table. It has been reported that the rate of internal malrotation and operation time was higher in the patients in whom traction table used than those in whom radioluscent table was used. On the other hand, manual traction is efficient if it is performed within 24 hours after occurrence of the fracture.[6, 7] We applied skeletal traction to all fractures through tuberositas tibia and performed intramedullary nailing in open manner with mini-incision because our operation table was not radioluscent and we had no traction table. Although we performed manual traction, we didn't encounter any difficulty irrespective of the time prior to the operation.

Mean operation time was 105.7 minutes. This time was reported to be 139 minutes in those in whom traction table was used and 119 minutes in those in whom radioluscent table was used.[7] We attributed short operation times in our patients to the fact that manual traction was used instead of traction table, scopy was not used and open reduction was performed at the level of fracture line after mini incision.

Although anterograde nailing has a high rate of union and low rate of infection, it has such complications as difficult application in the obese patients with multi-trauma, occurrence of heterotopic ossification in the hip, risk of pudendal nerve injury, abductor weakness causing limping, impaired stair-climbing.[6, 22, 23] No difference was found between anterograde and retrograde nailing techniques in operation time, blood loss, union time, range of motions of the knee and hip joints.[22, 24] However, retrograde fixation is a better choice in the treatment of femoral shaft fractures than anterograde fixation for the femoral neck fractures on the same side, pelvis or acertabular fractures on the same side, periprosthetic fractures, knee disarticulation, floating knee or open knee injuries and in the cases of obesity or pregnancy.[6, 22, 23] We cannot perform intramedullary nailing as a necessity of clinical protocol in these patients in which anterograde nailing was difficult. In the present study, anterograde nailing was made in all fractures. In regard to this method, abductor insufficiency leading to limping was observed in one patient.

It has been reported that heterotopic ossification was more in those patients undergoing engraving process than in those not and that this was due to leaking out of this material in between the abductors of the hip.[24] We consider that heterotopic ossification we saw in two patients (6.7%) was related to engraving process. It has been reported that indomethacine given for treatment of heterotopic ossification was efficient, safe and cheaper than radiation therapy but increased the risk of nonunion in the long bones.[25] Despite indomethacine treatment and except for two patients with delayed union, mean time for union was similar to the reported times in another study and there was no anomaly.

Chance of angulations and displacement is higher in metaphyseal fracture than in shaft fractures. [1, 2, 26] Rates ranging from 0 to 37% have been reported in the literature.[2] Ricci et al. [2] reported that fractures of distal and proximal femur were stabile and malalignment was seen in 30% of proximal fractures and 10% of distal fractures, but shaft fractures were more stabile and showed malalignment at a rate of only 2%. We found varus angulations in two (6.7%) patients. One of these patients had fracture on the proximal metaphysis and other had on the distal metaphysis. The view that proximal and distal fractures are unstable is supported by the fact that these two patients with angulation had no metaphyseal fracture.

Intramedullary nailing was not advised for open fractures before 1980s because it was believed that all open fractures were contaminated, necrosis and periosteal peeling occurred with tissue crushing and engraving process altered endosteal blood flow in these cases. However, in recent it has been realized that infections rates were not high with early intramedullary nailing in type I, II and III open fractures (0 to 2.6%) and contamination has been shown not to be a contra indication.[20]

Of the fractures in the present study, 23 were closed and 7 were open. Of the open fractures two were of type II and 5 were of type IIIA. Whereas early intramedullary nailing was performed for type II open fractures, 3 patients with type IIIA open fracture underwent external fixation in the early period and intramedullary nailing in the late period. Nailing was performed following antibiotic therapy of 3

weeks in a patient with type IIIA open and bilateral fractures. No patient developed nonunion or deep infection.

In the present study, mean time to union was 19.6 months. This time was reported to be 28.5 weeks in the group without engraving and 39.4 weeks in the group with engraving in the study by Clatworthy et al. [16], 20 weeks in the study by Baixauli et al.[20], 21.8 weeks in the study by Özcan et al. [21], and 16.5 weeks in the study by Arpacioglu et al. [27] No significant difference was found between the present study and the studies mentioned above in terms of union time. Infection rate in intramedullary nailing has been reported to be 0.9%. [14] For the treatment of infections following intramedullary nailing, removal of the nail has been advised if the fracture is stable and union evidence is apparent and removal of the nail plus application of external fixation if uncontrolled osteomyelitis exists. [28, 29] In the present study, superficial infection in 8 patients was treated with appropriate antibiotics and no patient was seen with deep infection requiring removal of the nail. Length difference may occur in the limbs with fractures with serious smashing. In several studies, this has been reported at a rate of 2 to 16.6% [10, 14, 20, 30 and 31] and rotational deformity has been reported to be seen at a rate of 0 to 8%. [10, 20] The problem was not related to application of intramedullary nail in three patients (10%) with shortening, rather it was related to pseudoarthroses from the previous surgeries. Rotational deformity was seen in 2 (6.7%) patients.

Snapping or bursitis may develop on the ilio-tibial band with soft tissue irritation caused by interlocking screws. If union has been achieved in the fracture, removal of the proximal or distal screws leading to this problem may overcome this problem. [12] Brumback et al. [12] removed interlocking screws because of irritation in 6 patients (6%). In the present study, distal screws were removed in two patients (6.7%) with distal screw irritation as sufficient callus occurred in the fracture line. Similarly, trochanteric bursitis developed in 3 patients due to the irritation caused by proximal tip of the nail; however, this problem was addressed with anti-inflammatory treatment without need of removing the nail.

Despite a number of studies on intramedullary nailing of the femur, complications related to the palsy of pudendal nerve is scant. It has been reported that palsy of pudendal nerve was seen in 17% of the cases due to the pressure between the perinea and traction pillar in intramedullary nailing on the traction table and that this palsy was related to the degree of forces applied during traction rather than traction time. [32] In the present study, pudendal nerve palsy from the operation was not seen because no perinea pressure occurred as no traction table was used. Nerve palsy was seen related to the trauma causing the fracture in only 2 patients. Static interlocking prevents shortening and rotation on the fracture area. Gap between the proximal and distal interlocking screws leads to transfer of axial loads to the fracture line by decreasing rigidity and looseness between the screw holes and the screw by allowing motion on the fracture line.[12, 19] Static interlocking with distractor or compressor has been advised for the patients with delayed or absent diaphyseal union. Compression applied improves stability on the repair area and motion related to the pain decreases. This facilitates vascular development against nonunion. [33] In the patients in whom we performed intramedullary nailing stability was improved by applying controlled compression with top compression screw in addition to static interlocking. We didn't find a report in the literature on the top compression we applied. Experimental studies are required on what type of biomechanical and clinical affects this compression have on the stability of the system.

For the treatment of femoral fractures with intramedullary nailing of engraving type, it has been reported that adult respiratory distress syndrome, pulmonary emboli, multiple organ failure, pneumonia and higher mortality rates as a complication didn't increase.[34] One patient with bilateral femoral fracture developed respiratory distress syndrome on the second day of the trauma. No other problem occurred following the operation in the patient treated with ventilator for 2 weeks. In conclusion intramedullary nailing is a safe method of treatment that should be considered with priority because of its providing stable fixation in all open and closed femoral shaft fractures between the lesser trochanter and adductor tubercle, preventing shortening and rotation, allowing compressive forces to pass through fracture line and having high rates of union and low rates of complications.

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