

Radiographic and functional results of osteosynthesis with locked unreamed intramedullary nailing of femoral shaft fractures in adults

Erişkinlerdeki femur cisim kırıklarında kilitli oymasız intramedüller çivi osteosentezinin radyografik ve fonksiyonel sonuçları

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Amaç: Femur cisim kırığı nedeniyle kilitli intramedüller (İM) çivi osteosentezi uygulanan erişkin hastalarda radyografik ve fonksiyonel sonuçlar değerlendirildi.

Çalışma planı: Yetmiş üç hastanın (57 erkek, 16 kadın; ort. yaş 36; dağılım 18-77) 78 femur cisim kırığı kilitli İM çivi osteosentezi ile tedavi edildi. Kırıklar 39 hastada sol, 29 hastada sağ taraftaydı; beş hastada iki taraflı femur diafiz kırığı vardı. On sekiz hastada (%24.7) açık kırık, 28 hastada travmaya bağlı başka patolojiler vardı. Travma ile ameliyat arasında geçen süre ortalama 10.7 gün (dağılım 3-15 gün) idi. Kırık tipi Winquist-Hansen sınıflaması, fonksiyonel sonuçlar Thoresen sistemine göre değerlendirildi. Hastalar ortalama 25 ay (dağılım 12-54 ay) izlendi.

Sonuçlar: Altmış dokuz hastanın 73 kemiğinde (%93.6) tam kaynama elde edildi. Radyografik kaynama süresi ortalama 14 hafta (dağılım 10-28 hafta) idi. Dört kırıkta (%5.2) kaynama dinamizasyon sonrasında elde edildi. Dinamizasyona rağmen kaynama elde edilemeyen bir hastada (%1.2) sirküler eksternal fiksator ile revizyon uygulandı. Hastanede yatış süresi ortalama 19.8 gün (dağılım 8-26 gün) idi. Thoresen ölçütlerine göre 64 hastada (%87.7) çok iyi veya iyi, dokuz hastada (%12.3) orta veya kötü sonuç alındı. Elli altı hasta (%76.7) kısıtlamasız, 13 hasta (%17.8) hafif kısıtlamalarla ortalama 12 haftada eski iş ve aktivitelerine döndü. Ameliyat sırasında dokuz hastada distal kısımda kelebek parçası oluştu, iki hastada distal kilitleme vidalarının uygunsuz yerleştirildiği görüldü. Ameliyat sonrası dönemde dört hastada kaynama gecikmesi, bir hastada kaynamama, iki hastada distal kilitleme vida yerinde yüzeysel enfeksiyon görüldü.

Çıkarımlar: Erişkinlerde femur cisim kırıklarının tedavisinde İM kilitli çivi uygulaması, yüksek kaynama ve düşük komplikasyon oranları, yaşam aktivitelerine kısa sürede dönüş ve tatminkar fonksiyonel sonuçlar elde edilmesi nedeniyle iyi bir seçenektir.

Anahtar sözcükler: Kemik çivisi; femur kırığı/cerrahi/radyografik; kırık fiksasyonu, intramedüller/enstrümantasyon.

Objectives: We evaluated the radiographic and functional results of treatment with locked unreamed intramedullary nailing of femoral shaft fractures in adults.

Methods: Seventy-eight femoral shaft fractures of 70 adult patients (57 men, 16 women; mean age 36 years; range 18 to 77 years) were treated with locked unreamed intramedullary nailing. The fractures were on the right in 39, on the left in 29, and bilateral in five patients. Eighteen patients (24.7%) had open fractures and 28 patients had associated pathologies. The mean time from injury to surgery was 10.7 days (range 3 to 15 days). The fractures were classified according to the Winquist-Hansen system and functional results were evaluated according to the Thoresen criteria. The mean follow-up was 25 months (range 12 to 54 months).

Results: Union was achieved in 73 fractures (93.6%) of 69 patients within a mean duration of 14 weeks (range 10 to 28 weeks). Four fractures (5.2%) united after dynamization and one patient (1.2%) required revision with a circular external fixator following dynamization. The mean duration of hospitalization was 19.8 days (range 8 to 26 days). According to the Thoresen criteria, the results were excellent or good in 64 patients (87.7%), and moderate or poor in nine patients (12.3%). Fifty-six (76.7%) and 13 (17.8%) patients returned to previous work and daily activities with no or minor limitations in a mean of 12 weeks, respectively. Perioperatively, a distal fissure occurred in nine patients, and distal locked screws were improperly placed in two patients. Postoperative complications included delayed union in four patients, nonunion in one patient, and superficial infection at the site of distal screws in two patients.

Conclusion: Intramedullary locked nailing may be the preferred method in the treatment of femoral shaft fractures in adults due to high union but low complication rates, early mobilization of the patient, and satisfactory functional results.

Key words: Bone nails; femoral fractures/surgery/radiography; fracture fixation, intramedullary/instrumentation.

Femoral fractures, generally observed in young adults after high-energy traumas may also be observed in elderly population as a result of osteoporosis due to minor traumas.^[1-3] Severity of the trauma also defines the type of the fracture. Generally, segmental fractures are formed due to high-energy traumas while low-energy traumas lead to the formation of simpler fracture types.^[1,3,4]

Plate-screw osteosynthesis, osteosynthesis with external fixators and intramedullary nailing may be applied for the surgical treatment of femoral fractures. Recently, osteosynthesis with locked intramedullary nailing is considered as the best and the most reliable method.^[1,5-11]

In this study, radiographic and functional results of osteosynthesis with locked unreamed intramedullary nailing were evaluated and the efficacy of this type of surgery was evaluated.

Patients and methods

Between the years of 1998 and 2002, among 92 patients who underwent locked IM nailing osteosynthesis due to femoral shaft fractures, 73 patients with 78 fractures (57 male, 16 female, mean age; 36, range; 18-77), who were followed sufficiently, were included in the study. Of the fractures of femoral diaphyses, 39 were on the left side, 29 were on the right side and 5 were bilateral. Eighteen patients (24.7%) had open fracture (according to the Gustilo classification (11); 5 patients type I, 5 patients type II, and 8 patients: type III A). Fractures were due to non-vehic-

le accidents in 22 patients (30.1%), due to vehicle accidents in 18 patients (24.7%), due to high fall in 18 patients (24.7%), due to firearm injuries in 8 patients (10.9%), due to simple fall in 5 patients (6.9%), and due to physical attack in 2 patients (2.7%). None of the patients had arterial or neural lesions. Twenty eight patients had associated pathologies due to trauma (Table 1). The interval between trauma and operation and hospitalization period were defined. Fractures were classified according to the Winquist - Hansen classification (Table 2) (6). Prophylaxis was applied with lower molecule heparin (enoxaparine sodium 0.6 ml, once daily or nadroparin calcium 0.4 ml, once daily) against the risk of deep vein thrombosis. Depending on the fracture type, single, double or triple antibiotic therapies (cephalosine Na, gentamycine, crystallized penicillin) were applied in subjects with open fractures.

We performed IM nailing osteosynthesis on traction table under general or spinal anesthesia. Priformis fossa to the proximal of femur was chosen as the entry site. Fractures of 39 patients were reposed with closed methods (50%) and 39 were reposed with open methods (50%). Unreamed IM nailing osteosynthesis was used for all patients (Russel-Taylor®; 44 fractures, Unku®; 34 fractures).

Diameters of the nails were 9 to 11 mm. In order to define the diameter of the nails, standard posterior and anterior radiographies of femur were used with an IM nail, of which diameter was predefined and nails with diameters which fill the medulla completely were preferred. In 62 fractures (79.4%) static locking and in 16 fractures (20.5%) dynamic locking were carried out. Distal screws were locked by using free hand technique while proximal screws were advanced using the guide on the nailing system.

On the first postoperative day, patients began knee and hip exercises. Patients treated with dynamically

Table 1. Distribution of associated bone fractures and traumatic pathologies

Location	Number of patients
Scapular Fractures	1
Fractures of the Clavicle	3
Fractures of the Humerus	2
Fractures of the Distal Radius	3
Fractures of the Tibial Diaphysis	4
Fractures of the Tibial Plateau	3
Fractures of the Patella	5
Pelvic Fractures	2
Vertebral Fractures	3
Intertrochanteric Femur Fractures	2
Femoral Neck Fractures	2
Head Trauma	4
Internal Organ Injury	3

Table 2. Distribution of the fracture types according to Winquist - Hansen classification

Type of fracture	Number of fractures	%
Type 0	25	32.1
Type 1	17	21.8
Type 2	6	7.7
Type 3	18	23.1
Type 4	12	15.4

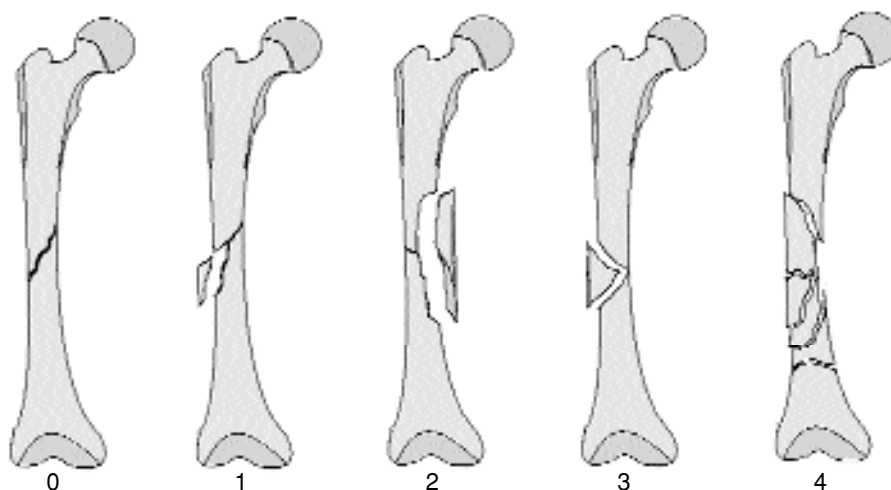


Figure 1. Winquist - Hansen classification.^[11]

locked intramedullary nailing were allowed immediate weight-bearing while the patients treated with statically locked intramedullary nailing were allowed full weight-bearing by the fourth postoperative week. Functional results of the patients, followed for about 25 months (12-54), were evaluated using Thoresen system (1) (Table 3). Overall time required for patients to return to their work and regular activities were also evaluated.

Results

The average interval between trauma and operation was 10.7 days (range, 3-15 days) and the total hospitalization period was 19.8 days (range, 8-26 days). Complete union was achieved in 73 fractures of 69 patients (93.6%). Absence of clinical pain and bone continuity in at least three cortices as assessed by radiography were accepted as signs of complete union. The average complete union time was 14 weeks (range, 10-28 weeks). Dynamization was per-

formed in five fractures (6.4%) which failed to unite at the twentieth week and union was achieved in four of them at the 28th week. We performed revision surgery using circular external fixator in one patient (1.2%) who showed no union despite dynamization. Average interval between trauma and operation was 10.7 days and the average total hospitalization period was 19.8 days. According to Thoresen criteria, the results of the fractures were very good in 46 patients (63%), good in 18 patients (24.7%), average in 6 patients (8.2%), and bad in 3 patients (4.1%). Of 9 patients with average or bad results, 4 underwent dynamization due to delayed union. Three of these 4 fractures were treated with open reduction. The rate of very good and good results was 90.2% in fractures treated with closed reduction and 80.4% in fractures treated with open reduction. The average union time was 12.8 days (range, 10-28 days) in closed method and 14.6 days (range, 11-28 days) in open method. Nine patients

Table 3. Thoresen evaluation system^[11]

	RESULT			
	Very good	Good	Average	Bad
Varus - Valgus(°)	5	5	10	>10
Antecurvatum - Recurvatum (°)	5	10	15	>15
Internal rotation (°)	5	10	15	>15
External rotation (°)	10	15	20	>20
Femoral shortness (cm)	1	2	3	>3
Knee flexion (°)	>120	120	90	<90
Limitation of Knee extension (°)	5	10	15	>15
Pain - swelling	NA	Mild	Significant	Severe

with average and bad results also had associated fractures and/or traumatic pathologies (internal organ injury, head trauma). According to Denis scale, 56 patients (76.7%) returned to their previous work and activities, 13 (17.8%) returned with mild limitations and 4 (5.5%) had major limitations. Of the 4 patients with major limitations, 3 had bilateral fractures and 12 of the patients with mild limitations had associated fractures. Average time required for patients to return their previous work was 12 weeks.

Formation of butterfly fragments in 9 patients and incorrect placement of distal locking screws in 2 patients were the complications observed during surgery. Postoperative complications consisted of delayed union in 4 patients, nonunion in 1 patient and superficial infection at the site of distal locking screw placement. We also performed cerclage fixation in 7 patients with butterfly fragment formation at the distal part. Seven patients, with delayed union, showed union after dynamization. One patient with pseudoarthrosis underwent surgical revision with circular external fixator. Two patients with superficial infection on distal locking nail sites were treated with oral antibiotic therapy. In subjects treated with open reduction, infection was not observed on the reduction site.

Discussion

The aim of the treatment of the fractures of femoral diaphyses may be described as achieving union in order to enable weight-bearing in the early postoperative period, achieving the normal length and alignment of the bone after improvement, providing functional movement angle to the knee and hip.^[1,2,5-8,11] Providing mechanic stability, avoiding any separation among the fractured parts, reformation of the endosteal vascular continuity, maintenance of the integrity of the periost tissue and allowing a certain stress on the fracture line are the requirements of ideal union.^[6-8,12-15] However, an osteosynthesis method providing all these factors is not available yet.

Plate and screw osteosynthesis is one of the most common techniques used in the surgical treatment of femoral diaphyses fractures. In this technique, the load during the axial loading is directly transferred to the distal through the plate. This may lead to formation of local osteoporosis due to the plate pressure. Other drawback of plate osteosynthesis is the

separation of fracture lines and disrupted blood supply of fracture fragments. When it is applied appropriately, improvement rates up to 95% are reported. However, its use is limited due to some common complications such as restricted knee movements, impaired stability, and infection. Moreover it does not enable early weightbearing.^[10,16,17]

Particularly high union rates with circular external fixation applications in the treatment of femoral diaphyses, is striking. On the other hand, restricted knee movements and pin tract infections are the disadvantages of this method. It is clear that this method is less tolerable than IM nails.^[11,17]

Intramedullary nailing osteosynthesis allows correct alignment of fracture fragments providing a stable fixation. It allows functional weightbearing so prevents the reduction in stress. It does not limit the movements of the adjacent joints and enables early weightbearing.^[1,2,4,7,13,15,18,19] Particularly closed, unreamed nailing preserves periosteal and endosteal blood circulation for the union of the fracture.^[5,6,11,19-22]

With intramedullary nailing osteosynthesis, high rates of union is achieved in fractures of femoral diaphyses. It also decreases complications such as femoral shortness, malunion, infections, and joint hardness and enables patients to return to their normal activities in an early period. With locked IM nailing osteosynthesis, union rates up to 100% have been reported in the literature.^[4,6-9,14,18,19] In our study, this rate was 98.7 per cent when patients who had dynamization were included.

Unlocked IM nailing osteosynthesis of femoral diaphyses fractures in adults may not be sufficient in preserving the anatomic alignment of segmental, instable fractures and in preventing femoral shortness. However, locked intramedullary nailing osteosynthesis prevents rotation and shortness. In dynamic intramedullary nailing, locking screws are inserted at one side, either distal or proximal thus providing rotational stability. As for the static IM nailing, the locking between the bone and the screw is applied at both sides providing rotational stability as well as avoiding femoral shortness.^[1,4,7-9,13,18] Reduction in stress and problems in early weightbearing are the drawbacks of statically locked IM nailing osteosynthesis. However, Brumback et al. have shown that subjects treated with statically

locked IM nailing were able to weightbear early.^[23] In our study, depending on the fracture type and surgical findings, statically locked subjects were also allowed early weightbearing and no complications occurred. Dynamically locked method is particularly recommended for stable diaphyses fractures (Winqvist-Hansen type 0-2).^[2,8,9,14,18,20] For these fractures, rate of cortical contact between main proximal and distal fragments are above 50% (11). In our series, the proportion of subjects treated with dynamically locked IM nailing was 20.5% and they all had stable fractures. Immediate postoperative weightbearing was allowed for these patients. Only one of the subjects treated with dynamically locked IM nailing showed femoral shortness of more than 2 cm, none of the subjects exhibited varus or valgus over 5 degrees. Cerclage fixation for the butterfly fragment distal to the fracture line was insufficient in the subject with femoral shortness. Locked screws did not break in any of the subjects.

Following locked intramedullary nailing, deep infection or osteomyelitis prevalence has been reported as less than 1% in literature.^[6,11,15] None of the patients in our series including the patients treated with open reduction and patients operated after open fracture, showed deep infection or osteomyelitis. In literature, it is reported that early IM nailing osteosynthesis can be performed in Gustilo type I, II and IIIA open fractures which are debrided and irrigated in the first 8 hours following trauma.^[11,21] In our study, the average interval from trauma to operation is 8.2 days (distribution 4 to 12 days) for open fractures. However, major factor causing the extension of this period was the financial or bureaucratic procedures for the material supply.

All our patients underwent unreamed IM nailing osteosynthesis. During reaming, lung problems particularly related to fat emboli and sudden death risk is a matter of discussion in the literature. Wolinsky et al. have reported a higher risk of fat embolism in reamed IM osteosynthesis while no significant effect on pulmonary functions has been defined^[23] Again, Bosse et al. have shown that immediate reamed IM nailing osteosynthesis applied to patients with femoral fractures with chest trauma and without any other problems than trauma did not increase the risk of ARDS, pulmonary emboli, organ insufficiency, pneumonia, and sudden death^[24] In unreamed IM nailing osteosynthesis, endosteal blood flow renews

itself rapidly and provides a more suitable environment for union.^[22] On the other hand, mechanical problems are less in reamed IM nailing osteosynthesis.^[12] Bhandari et al. have reported that implant insufficiency and nonunion problems might be reduced with the use of reamed nailing.^[25] In unreamed nailing, stability deficiency due to insufficient bone-implant surface contact may be avoided with the use of locked intramedullary nails.^[26] In our study, union was achieved within average 14 weeks with unreamed IM nailing osteosynthesis and no complication due to instability was observed. We think that selecting a nail with a diameter that fits the diameter of the medullar canal and selecting the locking technique according to the type and location of fracture may avoid the possible problems which may arise due to instability in unreamed IM nailing osteosynthesis.

Results of our study show that locked unreamed intramedullary nailing osteosynthesis may be a treatment of choice almost for all femoral shaft fractures in adults owing to its high union rates, low complication risks and perfect functional results. However, associated bone fractures or other traumatic injuries, fractures of bilateral femoral diaphyses, and open reduction affect the functional results negatively.

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