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Femoral diaphysis fractures: treatment with unreamed intramedullary nailing and its results

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ABSTRACT

Background: Femoral shaft fractures are an important cause of mortality and morbidity in the lower extremity injuries.
Methods: 21 femoral body fractures of 19 adult patients were treated with the unreamed intramedullary nailing. Of 19 patients 14 were males and 5 were females.
Results: All fractures healed. Deep infection was not encountered. According to the Thoresen criteria, the rate of excellent-good results was 78%. In two patients, who had also cranial trauma, development of excessive callus was observed. None of the patients required a secondary operation.
Conclusions: Unreamed intramedullary nailing, if it can be implemented with closed technique and with double lock screw at the distal side, provides satisfactory results in the femoral shaft fractures.

Keywords: Femur fractures, Unreamed intramedullary nailing, Closed technique

INTRODUCTION

Femoral shaft fractures are an important cause of mortality and morbidity in the lower extremity injuries. For the fracture of the most strong bone of the body, forces with high energy are necessary (except the pathological fractures) and therefore the impact may also cause injuries to other systems. Direct examination of the head, thorax, abdomen and pelvis should be performed. Such an injury may cause a loss of 2-3 units blood. The most common causes of such fractures are motor vehicle accidents, vehicle-pedestrian accidents, firearm injuries, falling down from height and flight accidents respectively. Femur shaft fracture can be life-threatening if there are complications such as open fracture, fat embolism and ARDS.[1-3]

The femur is the basic component of the normal ambulation of a person. It responds to the axial loading, bending forces and torsional loads during walking. The proximal and distal ends constitute the half of the hip and knee joints and shaft fractures have a significant impact on these two joints.

Many treatment modalities have been identified and implemented in the shaft fractures. Treatment options include balanced skeletal traction, implementation of an external fixator, intramedullary nailing, plate and screw fixation.[2,4]

In femur shaft fractures, intramedullary locked nailing is currently the method that enables highest bone healing and early ambulation.[5,6]

Intramedullary locked nailing can be reamed and unreamed. In this study, our objective was to report the results of the treatment with unreamed intramedullary nailing in patients with femur shaft fracture, who were treated in our clinic.

METHODS

In this series 19 patients with 21 femoral shaft fractures, treated from April 1998 to June 2000 at Taksim Training and Research Hospital, Istanbul were evaluated, retrospectively. This retrospective trial approved by hospital board. This article was extracted from a graduation thesis. Their operative and follow up records were accessed from the hospital data base.

The inclusion criteria were all femoral shaft fracture, age more than 18 years, closed fracture, type 1, type 2, type 3a open fractures. Exclusion criteria include type 3b and type 3c open fractures.

The results were evaluated according to the criteria of Thoresen and his colleagues as shown in Table 1.

Table 1: Thoresen's evaluation system.

Evaluation	Excellent	Good	Moderate	Poor
Angulation				
Varus-Valgus	5°	5°	10°	>10°
Antecurvation	5°	10°	15°	>15°
External rotation	10°	15°	20°	> 20°
Internal rotation	5°	10 °	15°	>15°
Femoral shortness (cm)	1 cm	2 cm	3 cm	>3 cm
Knee flexion	>120°	100–120°	90-100°	<90°
Loss of extension in knee	5°	10°	15°	>15°
pain and swelling	None	Mild	Prominent	Severe

Surgical technique

All patients were tried to be done with the closed technique on the traction table under general anesthesia and fluoroscopic control. After the administration of the general anesthesia in the supine position, the extremity with the fracture positioned to adduction as far as possible, the healthy extremity put into abduction as far as possible and the affected pelvis was tried to put in a flexion with a degree of 15. The positioning of the patient was completed after the broken extremity positioned with an internal rotation with an angle of 20-30 degrees. Traction was carried out from the heel to the big toe with a special foot holder (If traction is already done, the traction can be extended from the skeletal traction). The rotations of the proximal and distal fragments were determined with fluoroscopy. As a standard approach, the area from the 10 cm proximal iliac wing to the ankle was stained with a scrub. A drape was applied to cover lateral hip and gluteus up to popliteal crease.

The most frequently used nail diameter was 10 and 11 mm.

Although our general approach to type 1 open fractures is nailing within the shortest possible time, the intervention can be delayed in the presence of additional morbidity.

In the postoperative period, follow-up with haemogram, drains, thromboembolic prophylaxis and antibiotic prophylaxis were performed. After postoperative radiological examination, we started to seat the patients. Patients, who were in good overall condition, were encouraged to stand up with crutch.

After the operation, the patients were called for routine controls in the first, third, fifth months and after the first year. They were invited for routine controls throughout the year. Patients with stable fracture and reduction were encouraged to implement partial load in the first month. For the implementation of full load, we waited until the appearance of the callus in the radiological images.

Statistical analysis

In the statistical study, the percentage of the treatment outcome was determined according to Thoresen's criteria.

RESULTS

Of the 19 patients, 5 were females (26.3%) and 14 were males (73.7%). The mean age of the patients was 37.7 years (21 - 94 years). As shown in Table 2, the majority of patients (68.3%) were in their active ages (19-39 years).

Of the 21 treated femurs, 9 were right and 12 were left femurs. The mean follow-up was 6.86 months (3.5-14 months).

Traffic accidents are the leading cause regarding the etiology as shown in Table 3.

Open or closed fractures are shown in Table 4 according to the Gustilo classification.

We did not detect any angular problem in the antero-posterior or lateral images and no internal or external rotation deformity in the radiological examinations.

Table 2: Patients' age distribution and its percentage

Age	20-29	30-39	40-49	50-59	60-69	70-79↑	Total
Number	7	6	3	1	-	2	19
%	36.8	31.5	15.7	5.2	-	10.5	≈100

Table 3. Etiological distribution.

Fracture etiology	Number	Percentage (%)
Traffic accident	12	63.1
Falling down from Height	1	5.2
Simple falling	2	10.5
Firearm ınjury	2	10.5
Others	2	10.5

Table 4. Open/closed fracture distribution according to the Gustillo classification.

Type	Number of fractures	Percentage (%)
Closed	18	85.7
Type 1 open	-	-
Type 2 open	1	4.7
Type 3a open	2	9.5

We did not observe any implant failure in our patients and none of the patients required a secondary operation.

The most common co-morbidity was clavicle fracture (3 patients)

No deep infection was observed in any of our patients.

In a patient, who had concomitant cranial trauma and was hospitalized for 15 days in the reanimation unit, solid bone union developed along with a severe myositis ossificans in the contralateral pelvis in the 8th month after the operation. Currently, the patient is included in an intensive physiotherapy program.

In another patient, who had also a concomitant cranial trauma, severe myositis ossificans emerged in the ipsilateral hip and knee. Although bone healing was fast and sufficient, his condition was evaluated as "poor" due to the movement restriction in the knee and hip.

We did not recommend the application of full load before the appearance of bridging callus in the radiological follow-up examinations. Although we determined a 2 cm shortness in the affected extremity of these two patients, they did not hobble and did not need any support during walking.

Two patients, who had also cranial trauma in their medical history, developed an exuberant callus. One of the patients complained of severe knee pain during the knee movements, but his pain improved significantly within 2 months.

None of the patients complained of distal screw irritation. Nailing caused a fissure at the distal side of the fracture in one patient, but it healed completely during the follow-up.

Eventually, after the evaluation of 21 fractures in 19 patients, we started to apply partial load after two months except for one patient. The results were evaluated according to the criteria of Thoresen and his colleagues.

Table 5: Treatment results according to the Thoresen criteria.

	No.	Percentage (%)
Excellent	8	42
Good	7	36
Moderate	2	10
Poor	2	10
Total	19	≈100

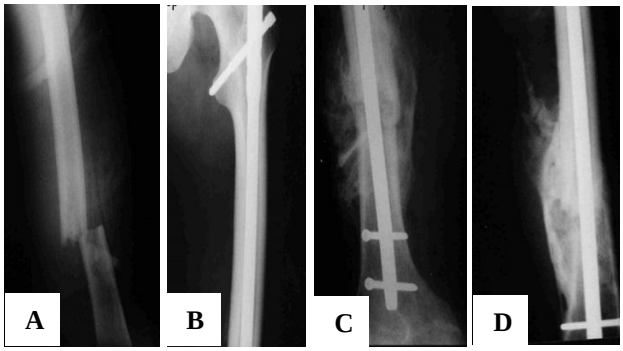

Figure 1: 35 years old male patient: femoral diaphysis fracture after a fall down from height. A= Left femur - preoperative; B= early postoperative; C= 2nd month - postoperative, D= 5th month-postoperative excessive callus development at the fracture line.

In our series consisting of 21 fractures in 19 patients, the sum of excellent and good results was 15 (78%). One of the two cases, who were categorized as "poor", developed pseudoarthrosis after the application of plate screw and the poor outcome depended on the excessive shortness. The other patient had an end-stage disease with bone metastases and low functional capacity. Although bone pain, which was very severe before the operation, did not improve after the operation, the patient was classified as "poor outcome".

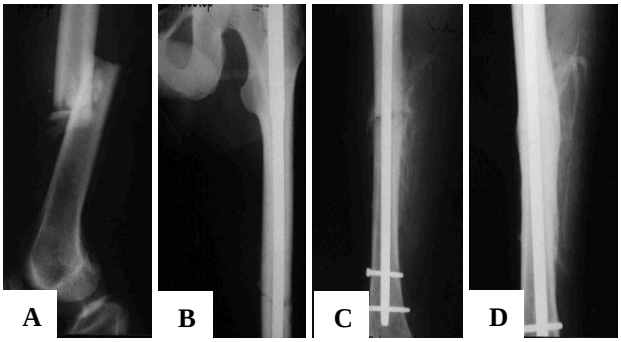

Figure 2: Right femur shaft fracture of the same patient. A= Right side preoperative; B= dynamic nailing-early postoperative; C= Appearance in the 2nd month–postoperative; D= 5th month-postoperative excessive callus development at the right side, even not so much as at the left side.

DISCUSSION

Femur shaft fractures occur as a result of a high-energy trauma and encountered most frequently in male adults.[2,4]

The mean age was reported by Wiss as 28 years, by Alho as 24, by Thoresen as 28, by Rinaldi as 27 and by Chi-Chuan Wu as 38 years. In our study with a limited number of subjects, the average age was 37 years. Older people participate increasingly more in the active life, so that the mean age might also be expected to increase.[5,7-10]

Intramedullary (IM) nailing method might also be implemented in the femur shaft fractures of adolescents and even sometimes of children. As the growth potential at the physis line is limited in males older than 15 years and in females older than 12-13 years, they can be treated as they were adults, but the distal physis should not be touched. In this group of patients, nails with a smaller diameter may be used, as they possibly cause less damage.[1-3]

Regarding the gender distribution, there is an accumulation on the male side in every series. The ratios reported by the authors were 88% (Wiss), 80% (Rinaldi) and 61% (Albo). In our study, the majority of the patients were males (73%).[10]

Regarding the etiology, high-energy traumas are the leading cause and traffic accidents are encountered in every series. The ratios given by investigators were 65% (Thoresen), 65% (Beaty) and 94% (McDonald). German reported 75% and 89% respectively, while our result was 63%, which is in concordance with the literature.[9,10]

As the most common etiological factor is high-energy trauma, the possibility of comminuted fracture, open fracture and additional pathological conditions is increased. The incidence of open fractures was reported as 12.5% by Thoresen and as 12% by Chi-Chuan, while our incidence was 15%, which is in concordance with the literature.[9-11]

In our series, we used static nailing and tried to insert 2 screws at the distal side regardless of the fracture type (except being open or closed fracture).

In our study group, the body fracture classification was the following: Type 0: 14%; Type 1: 33%; Type II: 28%; Type 3: 19% and Type 4: 4%. The classification and being open or closed fracture are factors, which determine the timing and type of the treatment.

Regarding the older literature information, the location of the fracture was the determining factor for the selection of the static or dynamic locking nail, but recent trends indicate that all nails should be inserted statically. The increase in the usage of unreamed nails with a small diameter is an influencing factor regarding this change.[3,12,13]

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Lateral decubitus position is not recommended in the reconstruction procedures, because the anteroposterior and lateral images of the head and neck are required.

In the past, IM nailing was approached with caution in open fractures, but after Sjoberg reported that he had observed no infection in 11 patients with Type 1 and 2 open fractures with the closed technique, the encouragement in this regard has increased.[15]

Lhowe et al. published a study with type 1 (36%), type 2 (45%) and type 3 (19%) open fractures.[14,16]

Although plates were used less frequently in the treatment of femur shaft fractures, they are still preferred in certain cases (osteosynthesis with a plate is indicated in shaft fracture+ipsilateral proximal or distal fracture, femur shaft fractures at the junction site with major arterial injuries, which requires repairment). Taking its disadvantages into consideration, plates are still not indicated in the cases, where IM nailing cannot be carried out due to the technical reasons. [2]

Brumback, Templeman, Hansen, Lhowe et al could not detect any significant difference between the immediate and delayed closed IM nailing regarding the infection during the treatment of open femur fractures.[14,17]

In open fractures, IM nailing provides a better stabilization and an easier wound care compared to the external fixation. Infections at the roots of wires do not

develop. It also requires less soft tissue dissection than the osteosynthesis with a plate.[2]

Considering the Gustilo type 1 and 2 open femur shaft fractures, in recent years the approach, which we accepted and tried to implement, is that it is necessary to implement the closed IM nailing technique in the same day following wound irrigation and debridement. In patients with type 3a and 3b open femur shaft fracture, if the patient is polytraumatized, closed unreamed IM nailing should be carried out on the same day following irrigation and debridement. If the patient has isolated type 3a and type 3b, he/she should be placed in traction for 10 days after the irrigation and debridement and closed IM nailing should be implemented after the healing of the soft tissue. The treatment option for the Type 3c fractures is the external fixator.[8]

There are different approaches to the timing of the intervention. Charnley (1961), Smith (1964) and Evans (1978) suggested that the postponement of the operation decreased the delayed bone union and nonunion rates. AO group prefers early osteosynthesis in order to prevent the complications.[18]

As the complication rates are high in the polytraumatized patients, surgeons are forced to early stabilization. Johnson and his colleagues conducted a study in 1985 on polytraumatized patients with femur shaft fractures and determined that the fracture stabilization within the first 24 hours decreased 5 times the incidence of ARDS development. 1990 Philips et al. confirmed these findings.[3]

In the polytraumatized patients, although Pape showed in 1993 that lung functions were deteriorated if the reamed technique was used, even they did not have pulmonary trauma, the functions improved within 48 hours. Lung functions were not affected, if the unreamed technique was applied. These results indicated that unreamed nailing had a less deteriorating effect on lungs and decreased the risk of ARDS development in the patients with existing pulmonary trauma.[13]

In polytraumatized patients (ISS is greater than 18), several studies confirmed that immediate stabilization was required within the first 24 hours. As the patient needs supportive treatment before the fracture stabilization, the acid-base equilibrium should be corrected, coagulopathy should be prevented and Hemoglobin levels over 10 should be assured. In addition, it should be taken into consideration that time-wasting examinations may increase the complication rates.

Although during the drilling of the medulla, IM pressure may be significantly increased, endosteal blood flow may be impaired and cortical thermal necrosis may develop, success rates are comparable in respect of bone healing. Nevertheless, as the unreamed nails cause fewer complications, the preference tends gradually to shift towards unreamed systems.

The interruption of the medullary artery, which perfuses at least 2/3 of the femur shaft, worried the objectors of the IM nailing in the femur shaft fractures. However, if enough space is preserved between the IM nail and the cortex for revascularization, the blood flow normalizes within 6-8 weeks.[15,19]

In the study of Whiteside, periosteal tissues play the most important role in the revascularization and their damage prevents the formation of the periosteal callus. According to the Khilander, endosteal circulation renews itself very fast.[19]

According to the Browner, in the polytraumatized patients, femur shaft fractures, type 1 and 2 open fractures, ipsilateral femur and tibia fractures and isolated femur fractures should be intramedullary nailed without delay.[2]

Creation of an opening at the distal fragment during the drilling procedure may decrease the pressure.

As results are significantly affected by the open and closed IM nailing, the open technique should not be chosen if not really necessary.

Browner collected the data of the patients reported in the literature and published the infection rate as 0.4% and the nonunion rate as 1%. In cases operated with the open technique, the infection rate increased to 3.5% and the infection and nonunion rates increased to 17.7% and 2.1% respectively after the nailing was performed within the first 24 hours in open femur fractures.[2]

In our series, 17 of the 21 femur shaft fractures were treated with the closed technique and 4 with the open technique (One of these cases, who had a previously operated femur fracture and was operated with the open technique due to the implant insufficiency and another one was operated with open technique because biopsy was needed from the fracture line with mini-incision due to the pathological fracture).

Winquist recommends static nailing in type 2 and comminuted fractures.[7]

The results of the mechanic stability tests showed that, the most torsion-resistant nails were unreamed R-T nails in femur shaft fractures and subtrochanteric fractures and it was demonstrated that they provided 50% of the normal femoral strength. This rate drops to 3% with the reamed IM nails.[5]

Although the number of the distal screw is still under discussion, two screws provide more stable osteosynthesis. Whereas rarely encountered, the risk of nail break is increased if the proximal one of the distal

holes left empty.[29] We inserted double screws to the distal segment in 11 cases and a single screw in 8 cases. We did not encounter screw break in our patients. Patients, who were treated with single screw insertion to the distal, had at least 50% cortical contact and were cases with prolonged operation duration. The reason for the absence of the screw break in our limited series was that the screw did not have to bear much load in patients with cortical contact. In comminuted fractures, if the contact is small at the fracture line, one screw would be insufficient, as it has to bear all the load.[20]

In our series, we did not insert any off-target distal screw. In his study, Wiss reported the off-target distal screwing failure as 3.7.[21]

IM nails have the advantage of sharing the load compared to the compression plates. If the shape of the fracture is axially stable, load can be applied at an early stage. Although early load application may cause breaking or loosening of the plate, IM nailing enables fast bone healing, as load is applied to the bone.[2]

Methods like cerclage, which were recommended for the unstable fractures in the articles published before 1990 has only historical value and should not be implemented, as there is no stability problem anymore with the 2nd generation nails inserted with the appropriate technique.[5]

Regarding the closed technique nailing, bone healing rates of 97%, 100% and 97% were reported by Wiss, Keogh and Thoresen respectively. In our series, which contained a limited number of patients and had a high percentage of pathological fractures, the same rate was 90%.[9,21]

Several investigators like Thoresen, Wiss and others do not apply load on the extremity before the development of the bridging callus or the 3rd months after the IM nailing, they use full load starting from the 1st month after the dynamic nailing.[9,21]

According to the Wiss, bridging callus develops in the 8th week and cortical bridging in the 26th week.[21]

According to Brumback and Straumbough removal of locked IM nails or dynamization are not necessary. If necessary, there should be at least 1 year between the time of trauma and the removal.[13]

In polytraumatized patients, Brumback prefers supine position for the operation and recommends to bring the hip in adduction in order to detect the nail hole more easily. He prefers the lateral position in obese patients.[7]

We operated all patients on the traction table in supine position and we did not observe any neural injury related to the stretching.

The duration of the radioactive exposure during the operation was reported as 3.43 minutes by Kempf and as approx. 12.6 minutes by Levin.[22,23] We did not measure the duration of the fluoroscopy during our operations.

Dodenhoff et al. conducted a study with 80 patients and determined in 30% of them heterotopic ossification; the same rate was 10% in our study.[12]

CONCLUSION

Femur shaft fractures occur mostly in males in their active ages and with high-energy traumas. They cause serious morbidity.

The closed technique should be insistently recommended. The closed technique is superior to the open technique in all outcome parameters.

It should not be implemented if there is not sufficient experience and there are not adequate technical facilities available, as this technique is difficult to master and open to immediate complications.

2 screws should be absolutely inserted into the distal. Although a single screw can prevent the rotation, it cannot prevent the lateral angulation.

The best effort should be given to the nailing within the first 24 hours in polytraumatized patients.

Prophylaxis with indomethacin should be considered in the postoperative period in order to prevent the risk of heterotopic ossification in patients, especially with cranial trauma.

Locked IM nails are superior to other techniques in every step of the treatment. It is the ideal treatment method regarding the early application of the load, anatomic arrangement, early rehabilitation of the knee and hip, prevention of the angulation in the fracture line, shortness and rotation.

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