

No Evidence of Infection After Retrograde Nailing of Supracondylar Femur Fracture in Gunshot Wounds

Oguz Poyanli, MD, Koray Unay, MD, Kaya Akan, MD, Melih Guven, MD, and Korhan Ozkan, MD

Background: The aim of the study was to determine whether osteomyelitis of the femur or septic arthritis of the knee develops after retrograde intramedullary nailing of the femur performed within 7 days of supracondylar femur fracture, secondary to gunshot wounds, without skin defects.

Methods: Fifteen patients with a mean age of 27.8 years (range, 18–52 years), with supracondylar fractures of the femur due to gunshot wounds and without skin defects. Retrograde intramedullary nails were inserted through the intercondylar notch of the femur. We evaluated whether osteomyelitis of the femur or ipsilateral septic arthritis of the knee joint developed postoperatively.

Results: None of the patients who were followed up for a mean period of 11.7 months (range, 9–16 months) showed evidence of ipsilateral septic arthritis of the knee or osteomyelitis of the femur.

Conclusion: Retrograde intramedullary nailing of the femur can be performed in patients with supracondylar fractures of the femur due to gunshot wounds, and without skin defects, in the first 7 days after the trauma. Neither osteomyelitis of the femur nor septic arthritis of the knee develops in these patients.

Key Words: Osteomyelitis, Septic arthritis, Gunshot, Nailing, Femur, Retrograde.

(*J Trauma*. 2010;68: 970–974)

Internal fixation techniques for the treatment of open fractures are controversial because of the high risk of infection.^{1–5} The patterns of trauma associated with gunshot wounds are very different to those seen for open fractures due to other causes. The size of the skin injury at the time of trauma is important. In serious injuries, skin grafting or flapping can be required. However, there are some cases that do not require such interventions.⁶

In open fractures of the long bones, the use of external fixation is recommended as an option.^{5,7,8} For fractures that are too close to the joint, external fixation techniques are difficult to perform due to technical problems. An alternative method for the treatment of supracondylar fractures of the femur is that of retrograde locked femoral nailing. Open fractures that result from gunshot wounds are different from open fractures caused by other mechanisms.^{9–11} Moreover,

the open fracture site and the knee joint are brought in contact during the application of retrograde intramedullary nails through the intercondylar notch of the femur. In this case, there is a risk of septic arthritis of the knee.^{12,13}

We hypothesized that locked retrograde intramedullary nailing could be performed within 7 days of injury with no increase in the risk of deep infection in patients with supracondylar femur fractures secondary to gunshot wounds, without any skin defect, and vascular injury requiring a repair after the trauma.

PATIENTS AND METHODS

The records of the patients from 1998 to 1999 from the military hospital that 1st author worked in and from our institution from 1999 to 2005 were evaluated retrospectively. The clinical, radiologic, and laboratory data of the cases with a gunshot wound, open femur fracture without a skin defect were gathered.

The inclusion criteria in this paragraph were as follows:

1. The necessity of all patients to have been hospitalized in the above-mentioned clinics and the periods
2. The follow-up period for at least 12 months
3. To have a supracondylar femoral fracture
4. To have an open fracture
5. To have an etiology of gunshot wound
6. To have been operated in the first week of the initial injury

The exclusion criterion was to have a defect large enough to prevent skin coverage and bone coverage or major neurovascular damage.

For all cases, debridement had been performed with elliptical excision of skin edges with removal of foreign debris and limited debridement of bone fragments. All the debridements had been performed within the first 24 hours after injuries. The tibial-tubercle traction had been used in the interim. A standard antibiotherapy protocol (cefazolin sodium 4 × 1 g/d, gentamicin sulfate 2 × 80 mg/d, and metronidazole 2 × 500 mg/d, intravenously for 3 days) had been ordered for the patients after they were wounded.

The follow-up criteria for supracondylar femoral fractures: isometric quadriceps, knee range of motion, and non-weight bearing exercises with two crutches are encouraged as early as possible. The criterion for commencement of isotonic quadriceps exercises and weight bearing was the evidence of callus formation in any of one cortex in the control X-rays. The full weight bearing was permitted if the patient lacked pain at the fracture site, and there were callus formation in at

Submitted for publication December 17, 2008.

Accepted for publication July 10, 2009.

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From the Department of Orthopaedic and Traumatology (O.P., K.U., K.A., K.O.), Goztepe Research and Training Hospital, Istanbul, Turkey; and Department of Orthopaedic and Traumatology (M.G.), Medicine Faculty of Abant İzzet, Baysal University, Bolu, Turkey.

Address for reprints: Koray Unay, MD, Department of Orthopaedic and Traumatology, Goztepe Research and Training Hospital, Istanbul, Turkey; email: kunay69@yahoo.com.

DOI: 10.1097/TA.0b013e3181bb974b

least two cortexes at the control X-rays. If there was a doubt about osteomyelitis or septic arthritis, whole blood count, C-reactive protein, and sedimentation were requested. The leukocyte count and microbiological culture from the suprapatellar aspirate were performed for high suspicion of septic arthritis.

During the follow-up period, the following items had been recorded: type of trauma; Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification of the fracture; time of surgery; time point at which full-weight bearing was allowed; time point at which the fracture was accepted as union; total follow-up time; leg length discrepancy; range of motion of the knee joint; presence of osteomyelitis of the femur, and/or septic arthritis of the knee joint. The criterion for fracture healing was union in at least three cortexes on anterior-posterior and lateral radiographs. Drainage of pus at the sites of the wound, redness, swelling, and warmth, laboratory findings of leukocytosis, elevated C-reactive protein, and increased sedimentation rate had been determined as the follow-up criteria for osteomyelitis. A leukocyte count >50,000/mm³ or culture positivity of the aspirated knee joint fluid, along with redness, swelling, warmth, laboratory findings of leukocytosis, elevated C-reactive protein, and increased sedimentation rate had been determined as the follow-up criteria for septic arthritis.

RESULTS

This study included patients who were hospitalized in the military hospital in which the first author worked between 1998 and 1999 and patients who were hospitalized in our clinic between 1999 and 2005. In total, 63 patients with supracondylar femur fractures were enrolled; 26 of these patients had open fractures, and 15 of these had open fractures that did not require skin grafts or skin flaps, the trauma

being caused by gunshots. Eleven open fractures were excluded. Seven of them had an open supracondylar femur fractures caused by the reasons without gunshots, three of them had skin defects caused by gunshots, and one of the patient's surgery was performed at the 15th postinjured day because of the additional injuries on the other systems. Locked retrograde femoral nailing had been performed on these 15 patients, who had made up the study group.

All the patients were male, with mean age of 27.8 years (range, 18–52 years). Eight of the patients had been wounded by high-velocity gunshots during a military gunfight, and seven of them had been wounded by low-velocity gunshots during a civil clash. None of the patients had any neurovascular injury. The patients had been operated on after a mean period of 3.2 days (range, 2–7 days) after the injury, the delay being due to the general condition of the patient and technical limitations. In type AO/OTA-A2 and A3 fractures, locked retrograde intramedullary nailing had been performed percutaneously. For one type AO/OTA C2 fracture, open reduction and fixation of the intercondylar part of the fracture with a screw had been followed by locked retrograde intramedullary nailing. The mean follow-up period was 13.9 months (range, 12–19 months).

None of the patients had shown either osteomyelitis of the femur or ipsilateral septic arthritis of the knee during the follow-up period. All the fractures had healed without additional treatment. According to our chart review, one of the patients had had postoperative serous drainage at the site of the incision; however, there were no laboratory findings of leukocytosis, elevated C-reactive protein, or increased sedimentation rate. Microbiologic culture had shown that the drainage site was sterile. During the follow-up period, there had been no sign of osteomyelitis in this patient (Table 1, case 4). In two patients, knee aspirations had been performed

TABLE 1. Parameters Measured at Diagnosis and at Follow-Up

Patient	Type of Trauma	AO/OTA Classification	Time of Surgery (d)	Time of Full-Weight Bearing (mo)	Time of Fracture Union (mo)	Follow-Up Time (mo)	Leg Length Discrepancy (cm)	Lack of Flexion of the Knee at Last Follow-Up (Comparison With the Contralateral Knee)	Lack of Extension of the Knee at Last Follow-Up
N1	HVGS	C2	3	4.5	5	13	—	25	5
N2	HVGS	A2	4	3	4	14	0.5	10	5
N3	HVGS	A3	7	3.5	4.5	13	1	5	—
N4	HVGS	A3	4	4	5	15	—	15	—
N5	HVGS	A3	5	3	6	17	0.5	10	5
N6	HVGS	A2	3	3.5	5	19	—	—	—
N7	HVGS	A3	2	4	5.5	12	1	5	—
N8	HVGS	A3	2	4	6.5	13	—	5	—
N9	LVGS	A2	2	3	4.5	12	—	—	5
N10	LVGS	A3	3	2.5	4	15	—	5	—
N11	LVGS	A2	3	3	4	13	0.5	10	—
N12	LVGS	Incomplete	4	2	3.5	12	—	—	5
N13	LVGS	A3	2	4	5.5	12	1	—	—
N14	LVGS	A3	3	3	4.5	13	—	5	—
N15	LVGS	A3	2	3.5	5	16	—	10	—

HVGS, high-velocity gunshot; LVGS, low-velocity gunshot.

after the detection of swollen knees during the postoperative follow-up. No redness or warmth had been noted for the patients' knees. The aspirated materials were serohemorrhagic. The cultures of these materials were both sterile. The leukocyte counts for the samples aspirated from these two patients were $9,800/\text{mm}^3$ and $11,300/\text{mm}^3$, respectively (Table 1, cases 8 and 11, respectively).

The clinical parameters measured at diagnosis and at follow-up of these patients are shown in Table 1. Postoperatively, the patients had been allowed full-weight bearing after a mean period of 3.4 months (range, 2.5–4.5 months). The fractures had been bonded after a mean period of 4.8 months (range, 3.5–6.5 months).

In one patient (Table 1, case 12), the fracture of the femur was partial. The axial cross-sections taken in the computerized tomography evaluation revealed that the circumference of the femur had been broken along more than 50% of an ~15-cm-long portion; this patient received prophylactic treatment with retrograde intramedullary nailing. The most severely comminuted fracture in our study group was that seen in a patient who had wounded himself with a military firearm, resulting in a fracture that extended to the intercondylar notch (Table 1, case 1). Anterior-posterior and lateral radiographies had been obtained preoperatively and at 13 months postoperatively. These images and the functional condition of the patient are shown in Figures 1–3.

DISCUSSION

We performed locked retrograde intramedullary femoral nailing on patients with supracondylar fractures of the femur due to gunshot wounds that did not require skin grafting or skin flaps, with surgery being performed within 7



Figure 1. Anterior-posterior (A) and lateral (B) femur radiographs of a patient with supracondylar fracture of the femur due to a gunshot.

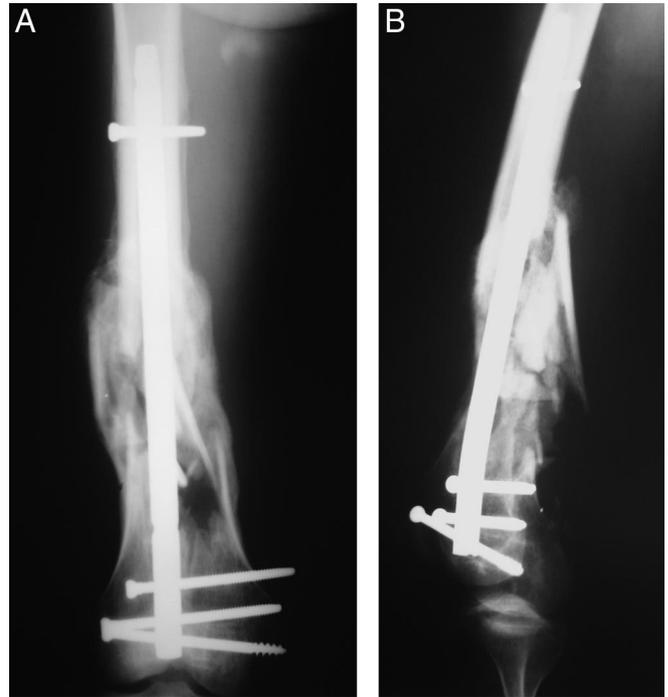


Figure 2. Anterior-posterior (A) and lateral (B) femur radiographs taken at 13 months postsurgery.



Figure 3. Photographs of functional outcomes for the patients taken 13 months postsurgery (A) and (B).

days of the trauma. At the end of the postoperative follow-up period, none of the patients had had osteomyelitis of the femur or ipsilateral septic arthritis of the knee joint.

There are some limitations to this study. Our study group comprised 15 patients, which is an insufficient population size to achieve definitive results. However, this case study is considered to be a specific one because there is no information on this particular subject in the literature. We could not operate earlier on the patients due to technical limitations. For this reason, we had to limit our study to the first 7 days after trauma. Importantly, all the cases involved gunshot wounds, but none of the patients had skin defects.

Therefore, our results only relate to cases that are without skin defects.

Osteomyelitis may be present after osteosynthesis is performed for a fracture of the femur. The rate of osteomyelitis is reported to be 1.6% to 5.6%.^{5,14–17} Moreover, this rate has declined as a result of improvements in surgical techniques and therapies. For open fractures, especially in cases with Gustilo-type IIIC arterial injury, the infection rate is 3.3% to 4.2%.^{9,10,16,18} The infection rate for cases involving gunshot wounds is 2.6% to 20%.^{9,10,18,19–21} However, in this study, we did not observe osteomyelitis or septic arthritis in any of the patients who had supracondylar fractures of the femur but no skin defects and who underwent retrograde locked intramedullary nailing.

The implants used for fractures of the distal femur generally come in contact with the knee joint. Thus, migration of contaminating bacteria may occur from the open fracture site. The incidence of bacterial transmigration for retrograde locked intramedullary nails inserted in the knee is 0.18%.¹³ It has been reported that septic arthritis of the knee joint occurs more frequently in cases of open fracture.^{12,13} Septic arthritis concern with retrograde nailing is raised by establishing direct connection (through medullary cavity) between knee and open fracture site. Osteomyelitis concern is not unique to retrograde nailing but instead is concern with any open fracture regardless of fixation technique. In our study group, the fracture site was connected to the knee joint through the cannulated retrograde intramedullary nail. In two patients, effusions from the knee joints had been collected, and knee aspirations had been performed. However, there had been no sign of septic arthritis in either of these patients.

The mean union time for supracondylar fractures of the femur after the application of a retrograde intramedullary nail is reported to be between 3.4 months and 4.5 months.^{13,22,23} In our patient series, the mean period of healing was 4.8 months. Possible reasons for this discrepancy between our current results and the previously reported results are that (1) the fractures in our patients were all open fractures and (2) the small study size.

After retrograde intramedullary nailing of the distal fractures of the femur, a decrease in the range of motion of the knee joint may be observed.^{22,24,25} The most important reason for this is insufficient reduction in the sagittal plane. Another reason is insufficient rehabilitation of the patient. Forced range of motion exercises before complete healing of the fracture may be risky. Therefore, the time required for union is important. In the literature, eventual knee motion has been reported to be between 100-degree angle and 117-degree angle in some patient series with retrograde intramedullary nailing of the distal fractures of the femur.^{22,24,25} In our study group, there were relatively few problems related to the range of knee motion, possibly because the patients were young.²⁶

The complications in gunshot wounds differ according to the transferred energy.²⁷ Although low-velocity gunshot wounds necessitate minimal excision and cleansing, the skin edges and the wound surface together with necrotic tissues should be debrided in high velocity gunshot wounds.^{28,29} The

necessity for the amount of debridement may be similar among various studies.¹⁸ The rate of application of external fixators may be higher in high velocity gunshot wounds.¹⁸ All patients in our study had wound debridement without an external fixator.

In conclusion, of course osteomyelitis is a possible complication for all open fractures, but we performed retrograde intramedullary nailing of the femur in patients with supracondylar open fracture of the femur due to gunshot wounds but without skin defects. During the follow-up period, we found neither osteomyelitis of the femur nor septic arthritis of the knee joint in any of these patients. We think that the reason for this is the extent of the skin lesion is smaller than the other open fractures. To make such an exact conclusive statement, there is a need for a study with control group treated with early retrograde intramedullary nailing in gunshot wounds with skin defects.

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