Retrograde Versus Antegrade Intramedullary Nailing of Gunshot Diaphyseal Femur Fractures

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Abstract

Background The use of retrograde nailing for gunshot wound femur fractures is controversial due to concerns of knee sepsis after this procedure since the knee is entered to introduce the nail into the canal.

Questions/purposes We compared retrograde and antegrade nailing for gunshot femur fractures to determine whether (1) knee sepsis or other adverse events were more likely to complicate procedures using retrograde nails, (2) there were differences in surgical time or blood loss, and (3) there were differences in radiographic union.

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Methods We retrospectively reviewed our prospective trauma database from 1999 to 2012 for patients with a diagnosis of gunshot and femur fracture. We performed a detailed review of medical records and radiographs for those patients with OTA Classification Type 32 femur fractures secondary to gunshot injury treated with either retrograde or antegrade femoral nailing. Eighty-one patients were treated with intramedullary nailing (53 retrograde and 28 antegrade). We reviewed elements of the operative treatment (procedure, anesthesia time, operative time, and estimated blood loss) for all 81 patients. For clinical and radiographic review, followup was adequate for 43 and 25 patients with retrograde and antegrade nailing, respectively. Minimum followup was 3 months for both groups (retrograde: mean, 41 months; range, 3–148 months; antegrade: 26 months; range, 3–112 months).

Results No patients in either group developed knee sepsis. No significant differences were found between groups with regard to operative time, blood loss, or radiographic union.

Conclusions With the numbers available, immediate retrograde nailing appears as safe and effective as antegrade nailing for gunshot femur fractures. Immediate retrograde nailing is as safe as antegrade nailing for gunshot femur fractures.

Level of Evidence Level III, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Approximately 60,000 to 80,000 nonfatal gunshot wounds per year are treated in the United States, often concentrated in urban trauma centers [3]. Outcomes for patients with gunshot injury are associated with a significant loss in work

days, medical costs, and disability. Femur fractures are the most common long bone fractures seen with gunshot injury [3]. Immediate antegrade intramedullary (IM) nailing for treatment of gunshot femur fractures with minimal soft tissue disruption has become an accepted practice [13].

The use of retrograde IM nailing for the treatment of diaphyseal femur fractures has become an accepted practice over the last 18 years [5–7, 10–12]. Initially, a gunshot fracture was considered a relative contraindication for treatment using retrograde IM nailing due to concerns about the possibility of knee sepsis [8, 9]. Knee sepsis, either directly from the entry point itself or via communication from the open medullary canal after nail insertion, was thought to be a possible means of contamination.

Two recent retrospective clinical case series reviewed the clinical outcomes of patients with gunshot femur fractures treated with retrograde nails. One study of 15 patients with supracondylar femur fractures (defined as high velocity or low velocity) treated with a short IM nail reviewed the outcomes an average of 14 months after injury [9]. A second retrospective review was performed on 73 patients with 74 low-velocity gunshot femur fractures [2]. Average followup for 35 of these patients was 7 months. All patients in that series were treated with a long retrograde nail. There were no cases of knee sepsis in either series.

These small case series raise the question of whether retrograde IM nailing indeed can be used safely in some gunshot femur fractures. Other investigations comparing retrograde to antegrade nailing of femur fractures not associated with gunshot injury have been performed to ascertain the best care for patients with this injury. Although comparison of antegrade and retrograde nailing has been performed for other mechanisms of injury of femur fractures [7, 11, 12], this comparison has not been done for gunshot femur fractures.

We compared retrograde versus antegrade nailing for gunshot femur fractures to determine whether (1) knee sepsis or other adverse events were more likely to complicate procedures that used the retrograde nail, (2) there were discernible differences in surgical time or blood loss between approaches, and (3) there were differences in radiographic union between approaches.

Patients and Methods

Study Cohort

The study was approved by the institutional review board at the sponsoring institution. We performed a retrospective review of the trauma registry for our inner-city Level I trauma center from 1999 to 2012 for the diagnoses of

gunshot and femur fracture. Inclusion criteria for the study were patients with a diaphyseal femur fracture (OTA Classification Type 32) secondary to a handgun wound (identified as handgun injury by chart or radiographic review) and definitive fracture fixation of either antegrade or retrograde IM nailing. Exclusion criteria for this study were patients with proximal or distal femur fractures (OTA 31 or 33), extensive soft tissue injury requiring flap closure, shotgun blast injuries, incomplete records, and patients who had treatment with other methods for definitive fixation.

There were 88 patients with OTA Type 32 fractures (Fig. 1). Seven patients were excluded because their injuries had been caused by shotgun or centerfire rifle injuries. This adjustment left 81 patients eligible for inclusion in this study. Seventy-three of the patients were male and eight were female. Fractures occurred on the right side in 42 patients and on the left side in 39 patients. Injury films were adequate in 52 of the fractures for classification. OTA classification of the fracture pattern was comminuted in 42 fractures (32C3; Fig. 2) and spiral in eight (32 C1). Two additional fractures were simple perforations of the cortex, without apparent propagation, something not described in the OTA classification scheme (Fig. 3). Retrograde nails were used in 53 patients and antegrade nails in 28 patients (Table 1). Despite attempts to contact all patients, 10 patients in the retrograde nailing group and four patients in the antegrade nailing group were excluded because they had insufficient records and were lost to followup; thus, followup was adequate for 43 of 53 (81%) patients with retrograde nailing and 25 of 28 (89%) with antegrade nailing. There was no difference between groups with regard to the number of patients available for followup ($p = 0.21$). Minimum followup was 3 months for both groups of patients with adequate followup (retrograde: mean, 41 months; range, 3–148 months; antegrade: 26 months; range, 3–112 months; $p = 0.1$). We reviewed the entire cohort (81 patients) for operative parameters (procedure, anesthesia time, operative time, and estimated blood loss) and the cohort with adequate followup (68 patients) for clinical and radiographic parameters.

Records Review

We reviewed records to determine mechanism of injury, history of injury, physical examination to include extremity nerve and vascular status, and clinical and radiographic followup. Temporizing measures, such as a skeletal traction pin, or temporary external fixation were noted. Operative records (operative report, nursing notes, and anesthesia records) were reviewed for anesthetic time, operative time, procedure(s) performed, intraoperative

Fig. 1 A flowchart shows the patient selection process in this study.

Fig. 2 A radiograph shows a comminuted fracture (OTA Type 32C).

complications, and blood loss. Outpatient followup notes were reviewed to determine progress of healing, ambulatory status, and postoperative complications (infection, thromboembolic phenomena, nerve injury, vascular injury, and malunion). Knee sepsis, our main outcome measure, was considered positive if (1) a knee aspiration was done with positive culture results or (2) a patient was returned to the operating room for knee irrigation and débridement.

Radiographic Review

We also reviewed imaging studies (orthogonal radiographs and CT scan, where indicated) to confirm that a patient had

Fig. 3A–B (A) AP and (B) lateral radiographs show a simple perforation fracture (arrow).

Table 1. Patient demographics and operative data

Variable	Retrograde group (n = 53)	Antegrade group (n = 28)	p value
Male/female (number of patients)	48/5	24/4	
Age (years)*	30.5 (17–61)	33.6 (17–68)	0.24
Right side (number of patients)	25	14	
Left side (number of patients)	28	14	
Operative time (minutes)*	167 (73–405)	164 (95–260)	0.7
Anesthetic time (minutes)*	234 (109–525)	231 (120–365)	0.85
Estimated blood loss (mL)	223 mL (50–900)	364 mL (75–1500)	0.06

* Values are expressed as mean, with range in parentheses.

a gunshot wound to the femoral shaft determined by the fracture pattern and ascertain whether fracture healing had occurred. CT scans were not routinely obtained for patients with gunshot femur fractures. They were obtained (1) as part of the initial evaluation by the general surgery trauma service or (2) later in the course of treatment to help determine nonunion. For inclusion, initial radiographs and subsequent radiographs up to the point of demonstrating fracture union needed to be available for review. Fractures were classified by the OTA classification system. Fracture healing was also documented, and those patients who had delayed union beyond 6 months were considered to have nonunions. A union was defined as bridging callus on three of four sides on two orthogonal radiographic views, with minimal tenderness to palpation or pain on standing. Alternatively, delayed union was defined by the absence of progressive fracture healing for 3 consecutive months after the injury.

Wound Care Protocol

The wounds were addressed in the emergency department by applying a sterile dressing until the patient's injury could be stabilized in the operating room. Patients underwent excision and incision (débridement) of entry and exit wounds locally at the level of skin and subcutaneous tissue before fracture stabilization. The wound tracts were not formally explored for bullets or bullet fragments unless they were superficial and easily removed without further damaging the surrounding soft tissues. Wounds were not closed primarily. More extensive soft tissue injuries required a greater amount of soft tissue treatment, including excision of nonviable tissue. All patients received intravenous antibiotics (first-generation cephalosporin in both groups) on presentation to the emergency department and for 48 hours after operative intervention.

Bullet and Bullet Fragments

The bullet and fragments were removed if easily accessible in the wound or if superficially under the skin and could easily be removed by a small counter incision. Fragments in the fracture site or medullary canal were removed at the surgeon's discretion.

Fracture Protocol

Whether a patient had received antegrade or retrograde nailing for gunshot femur fractures was determined by surgeon preference at the time. During the period of review, the surgeons at this institution considered the two methods equally safe and effective for treating femoral shaft fractures of all types, including gunshot wounds. Some patient factors, such as obesity or bilateral injury, were thought to be relative indications for retrograde nailing. The surgeons at this institution were involved in the development of the retrograde nailing technique during the 1990s before this review.

Patients who had antegrade nailing (Fig. 4) were placed on a fracture table. If an external fixator was used, this was removed at the beginning of surgery, and the pin sites were irrigated and curetted after skin preparation. Skin preparation was done with providone iodine solution and paint. The gunshot soft tissue injury was treated as described above. The IM nail was inserted after reduction of the fracture, gaining a trochanteric or piriformis entry point, inserting a guidewire, and reaming. All nails had interlocking screws placed proximal and distal to the fracture site.

Patients who had retrograde nailing (Fig. 5) were placed supine on a radiolucent fracture table. If the patient had a temporary external fixator placed before the IM nailing, it was removed at the beginning of surgery or after placement of the guidewire into the medullary canal. As before, the pin sites were cleaned and curetted after removal. The involved knee was flexed to about 30°, and an entry point was gained through the knee, either by parapatellar incision or through the patella ligament. Once an entry point was made, the canal was opened by entry reamer, followed by a guidewire, reaming, and insertion of the nail. Fracture site reduction was maintained throughout the procedure. Interlocking screws were placed proximal and distal to the fracture site in all patients.

Statistical Analyses

We performed statistical comparisons between the two groups using the Mann-Whitney U test for continuous data and Fisher's exact test for categorical data. Additionally, a post hoc power analysis was done to evaluate for a Type II error.

Results

Knee Sepsis and Other Complications

With the numbers available, no differences in complications rates were seen between groups. For our main end point, no patients in either group developed knee sepsis as defined by a positive culture on aspiration or a return to the operating room for irrigation and débridement of the knee. Two patients in the retrograde nailing group had superficial infection around the bullet tract. Both patients were treated with antibiotics, resulting in resolution of infection. None of the patients with antegrade nailing had superficial wound infection. Deep infections were noted in one patient each in the antegrade and retrograde nailing groups and were associated with large soft tissue injuries. The patient in the antegrade nailing group has been described above and the patient in the retrograde nailing group underwent débridement with irrigation and antibiotic therapy, resulting in control of infection with fracture healing. Two patients from the antegrade nailing group and four from the retrograde nailing group had associated vascular injury. One patient presented with compartment syndrome of the thigh. One patient has a 4-cm leg length discrepancy with an associated nonunion after retrograde nailing. Hardware failure was noted in one patient with antegrade nailing. The IM nail was found to have cut out of the insertion point at the greater trochanter. One patient with antegrade nailing

Fig. 4A–D (A) An AP radiograph shows a comminuted femoral shaft fracture. (B) AP and (C) lateral views demonstrate antegrade IM femoral nailing. (D) An AP radiograph of the fracture site shows healing at 9 months.

Fig. 5A–D (A) AP injury and (B) posttraction views show a spiral gunshot fracture. (C) AP and (D) lateral views demonstrate retrograde IM femoral nailing.

with cephalomedullary screws developed arthritis of the hip with destruction and absorption of the femoral head.

Operative Data

With the numbers available, no differences were apparent in parameters related to operative time or blood loss between the two approaches to femoral nailing (Table 1). The operative records showed the mean operating room time, including setup time, anesthesia time, and surgical time, was 231 minutes (range, 120–365 minutes) for antegrade nailing and 234 minutes (range, 109–525 minutes) for retrograde nailing ($p = 0.7$). The surgical times were 164 minutes (range, 95–260 minutes) and 167 minutes (range, 73–405 minutes), respectively, for the two procedures ($p = 0.96$). Mean estimated blood loss with antegrade nailing was 364 mL (range, 75–1500 mL) and 223 mL (range, 50–900 mL) with retrograde nailing ($p = 0.06$).

Fracture Union

With the numbers available, there were no differences in the likelihood of achieving fracture healing between the two techniques. Fracture healing occurred uneventfully in 22 of 25 patients (88%) with antegrade nailing and 40 of 43 patients (93%) with retrograde nailing. Nonunion or delayed union occurred with three patients (12%) with antegrade nailing and three patients (7%) with retrograde nailing (both $p = 0.26$). Of the three patients with antegrade nailing, two were successfully treated with dynamization of the nail, while one patient had an associated infection. The infected nonunion was treated in a staged fashion with irrigation and débridement, removal of the IM nail, and placement of antibiotic cement rod and beads, followed by open reduction and internal fixation, bone grafting, and placement of an internal bone stimulator. The patient went on to union and has not experienced any recurrence of infection to date. The three nonunions after retrograde nailing were treated initially with dynamization (between 4 and 6 months) and then exchange nailings (at 7, 8, and 9 months).

Discussion

The use of retrograde IM nailing may have advantages over antegrade nailing for patients who are obese, are pregnant, have multiple injuries, or have more distal fractures [6, 7, 11–13]. To be able to use this device with gunshot femur

fractures may be an advantage in certain cases. We are aware of only two clinical case series of retrograde IM nailing for gunshot femur fractures [2, 9] but none comparing retrograde and antegrade nailing for patients with gunshot femur fractures. To our knowledge, our study is the first to compare the two groups with regard to the end points of knee sepsis and other complications, anesthetic and operative times, blood loss, and fracture union.

This study has several limitations. First, a limited sample size makes it difficult to be certain about any conclusions. There is the possibility of a Type II error within this study. Post hoc analysis of operating room and anesthesia times (assuming a Type I error of 5% and Type II error of 20%) would require a sample size of 448 for operating room time and 6074 for surgery time. To estimate blood loss, 41 patients would be required in each group, even excluding two outliers (1300 and 1500 mL, respectively, of patients with polytrauma) for blood loss in the antegrade group. Second, the followup for the patients was limited, though attempts were made to contact every patient for a return clinic visit. Third, the number of patients in the study is limited but larger than other series of gunshot femur fractures in the literature. No study compares a similar group of antegrade gunshot femur fractures. Fourth, the concern of selection bias favoring the retrograde nail group over the antegrade group is possible. During the early part of the period under review (1999–2003), the surgeons, who were developers of the retrograde IM nails, believed both techniques were equal in the treatment of femoral shaft fractures. After 2003, surgeons not involved with the development of the retrograde nailing techniques treated patients at our institution. Hence, more patients had retrograde nailing earlier in the review. Finally, because this was a retrospective study, we did not obtain knee scores or other functional outcomes data. Because knee ROM was not reliably recorded in the patient records, we could not use this end point.

Our retrospective comparison of antegrade and retrograde nailing of gunshot femur fractures showed similar results in the two groups with the end points of operative times, blood loss, fracture union, and knee sepsis. No patient had knee sepsis as defined by return to the operating room for irrigation and débridement or aspiration of a suspected knee infection with positive culture results. The data on patients with retrograde nailing are comparable to those of other published studies of retrograde femoral IM nailing for gunshot wounds.

Poyanli et al. [9] performed a retrospective review of 15 patients with supracondylar gunshot wounds treated with short retrograde nails for an average followup of 11.7 years. Eight of the patients had military rifle wounds, whereas seven were from handguns. The authors found that

all fractures healed, without knee sepsis or osteomyelitis of the bone.

Cannada et al. [2] retrospectively reviewed 73 patients with 74 gunshot femur fractures treated with reamed retrograde nailing at two institutions. Thirty-five patients (48%) were followed an average of 7 months after surgery, with no reported knee sepsis. Three of the patients were reported to have shortening of greater than 10 mm, and one patient had malunion of greater than 10° angulation. The authors reported one nonunion treated with nail dynamization.

Although a recent study by Bible et al. [1] did not involve gunshot wounds, it compared 34 retrograde nailings to 24 antegrade nailings in patients with ipsilateral traumatic knee arthrotomies requiring irrigation and débridement. There were no cases of knee sepsis in the retrograde nailing group and one in the antegrade nailing group, leading the authors to conclude retrograde nailing was a relatively safe technique, even in the presence of a traumatic knee arthrotomy.

Patients with osteomyelitis after retrograde nailing do pose a special problem. Removal of the infected nail would normally be through the knee, thus infecting the joint. Goren et al. [4] recommended trochanteric removal of the nail, using curved instruments to prevent contamination of the knee. The risk of osteomyelitis for low-velocity gunshot fractures is low, similar to that reported with Gustilo-Anderson Type 1 open fractures, so despite more extensive measures needed to remove a contaminated nail, there is relatively limited risk for the patient when compared with the benefits of retrograde IM nailing [11].

In summary, our study is the first to compare a series of patients with gunshot femur shaft fractures using antegrade and retrograde nailing techniques. Given the limitations of the study, we found use of retrograde nailing to be comparable to antegrade nailing with regard to knee sepsis. Though the number of patients is relatively large for gunshot femur fractures, there is the possibility of insufficient sample size for some of the end points. Even so, our data

are suitable for future inclusion in meta-analyses and systematic reviews on these topics.

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