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Is staged management with immediate conversion of external fixation to retrograde intramedullary nailing for combat-related Gustilo Type III supracondylar femur fractures safe and reliable method?

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ABSTRACT

Introduction: Femur fractures due to bomb explosions and gunshots in battlefield require osseous stabilization as quickly as possible to expedite emergent conditions. İmmediate external fixation is the initial procedure as usual with planned early conversion to definitive treatment. The purpose of the current study is to determine the results of the early retrograde intramedullary nailing in combat-related injuries.

Material and methods: Eighteen patients with comminuted supracondylar femur fractures, initially treated with external fixation followed by planned conversion to retrograde intramedullary nailing in a one-stage procedure, were evaluated in a retrospective review to gather demographic, injury, management, and fracture-healing data for analysis.

Results: According to the system of Gustilo Anderson and Orthopedic Trauma Association, all fractures were open type III and 33-A3, respectively. The mean follow-up, operation time and union time were 1.8 years (range, 6 months to 2,6 years), 75 min (range, 60–100), and 3 months (range, 1.5–4), respectively. There was one complication of acute osteomyelitis which was successfully treated with antibiotic-load beams and aggressive bone debridement. No septic arthritis was observed.

Conclusions: We concluded that immediate retrograde intramedullary nailing in combat-related supracondylar femur fractures regardless of contamination even in Gustilo type III is a safe and reliable treatment method.

Introduction

Combat-related fractures, which are often complex injuries in terms of treatment and follow-up, mainly affect the limbs, predominantly the lower limbs [1,2]. Initial management of this patients should always follow principles and guidelines of the Advanced Trauma Life Support System (ATLSS). After life-saving interventions are done, extremity protective interventions are performed.

Combat-related injuries are considered high-energy traumas which usually cause serious bone fractures and soft-tissue defects. Gustilo Type III open femur fractures in conflict zones are initially stabilized with external fixation devices as usual [3]. Conversion to definitive treatment is often delayed secondary to patient's physical condition and medical instability [27]. However definitive treatment of open femur fractures with severe soft tissue disruption is still controversial and challenging for orthopedic surgeons.

Retrograde intramedullary nailing in supracondylar femur fractures is widely accepted practice over the last 20 years in orthopedic surgery [4,5]. On the other hand, knee septic arthritis is considered a devastating risk with the technique due to the intraarticular starting point [6,7]. Though some encouraging reports [9], Gustilo Type III fractures as often encountered in conflict areas have higher infection risk as well, and most of the authors regard it as a relative contraindication [5,6,8].

In this study, we postulated that treatment of the combat-related fractures of the supracondylar femur Gustilo type III by retrograde intramedullary nailing in troops is a safe and effective method. To our knowledge, this is the first study of results of the retrograde intramedullary nailing in patients who are poor candidates due to combat-related injuries.

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Material and methods

After Institutional Review Board approval, 18 patients with Gustilo Type III supracondylar femur fractures due to combat-related injuries from December 2015 to January 2018 were enrolled to the study. According to the Orthopedic Trauma Association classification system [31], all fractures are classified as 33-A3. All fractures were the result of blast trauma secondary to bomb or bomb explosion in combat zones. All patients were treated by conversion of the external fixation to retrograde intramedullary nail stabilization. The clinical and radiological data of the patients were compiled from the hospital's computerized trauma registries, medical records, telephone interviews, and a review of radiographs. In the supracondylar femur fractures with significant bone loss, distraction osteogenesis with external circular fixator was preferred. Therefore, these patients were excluded from the study population. All patients were troops and male with a mean age of 24.3 years (range 21–32 years), and all data was retrieved retrospectively.

All of the fractures had been stabilized with a standard unilateral half-pin external fixator, with at least two or three six-millimeter half-pins inserted into the proximal and distal femoral fragments and connected in a unilateral frame after fracture reduction as possible at 2nd level hospitals within the first twenty-four hours after the injury (Fig. 1). Also, soft tissue defects were closed to get a coverage on fracture site. Primarily closable wounds were sutured at the time of the initial debridement and application of the external fixator; other wounds were treated initially with vacuum-assisted closure procedure and were grafted during retrograde intramedullary nailing. Before definitive treatment, aggressive debridement and bedside irrigation was performed as an initial treatment for all cases either in emergency department or operating room.

There was no standardized protocol for antibiotic type, dose and duration of use as this was instructor dependent, however classical usage of 1 st generation cephalosporin 4×1 g/d, gentamicin sulfate 2×80 mg/d and metronidazole 2×500 mg/d for 5 days was administered as soon as the patients were reached to emergency department.

A one-stage conversion procedure, including removal of external fixator and retrograde nailing of femur, was considered as soon as possible without any delay if the general status of the patient permits. After removal of the external fixator, soft tissue pin tracks debridement and the curettage of the bone holes were performed before retrograde nailing. Trigen Meta-nail (Smith and Nephew) was used in all patients. During the procedures, the patients were placed supine on fracture table and folded support placed beneath the fracture where the knee was flexed comfortably.

Postoperative management with regard to weight-bearing and the range of motion of the extremity was individualized according to the configuration of the fracture and stability, and associated injuries. Pin-track care was done by cleaning the sites once a day with an antiseptic solution of povidone iodine. Patients were advised to restrict-weight on the fractured femur until the callus formation in at least three cortexes was noted on follow-up radiographs.

The clinical follow-up criteria were recorded as knee range of motion level, complication level regarding the need for additional operations, and walking level with full weight-bearing as early as possible. Radiological criteria were the evidence of the callus formation in any of one cortex, limb length discrepancy and angular deformity in the control x-rays.

Baseline demographic and clinical variables for our study group are presented in Table 1, with salient features summarized as follows.

Results

The mean duration of follow-up was 1.8 years (range 6 months-2,6 years). The mean operative time for the procedure was 75 min (range 60–100 min), with minimal blood loss, with no need for

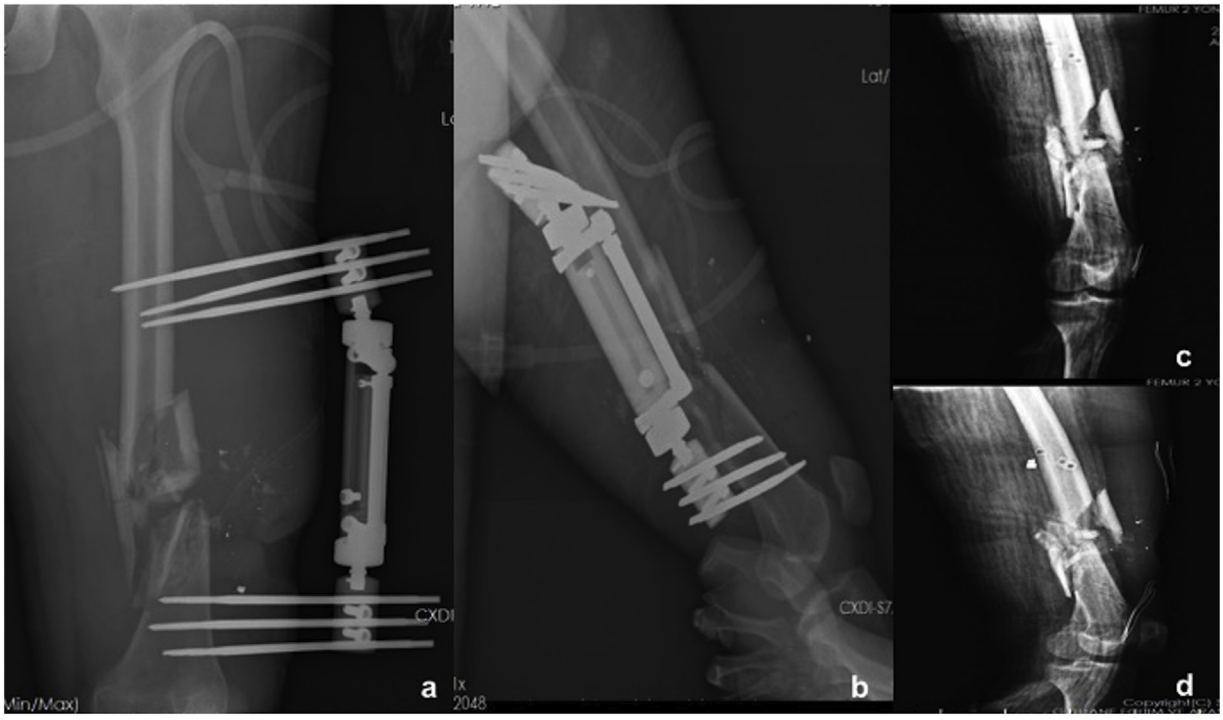

Fig. 1. A 22 year-old troop injured by bomb explosion a) AP graphy after immediate fixation with unilateral external fixator at 2nd level hospital b) Lateral graphy c,d) AP and lateral femur graphies of the same patients in operating room after removal of the external fixator and just before the retrograde intramedullary nailing.

Table 1
Demographics and baseline characteristics of the patients.

n	18 patients
Age	24.3 (range 21–32 years)
Side	10 left, 8 right
Follow-up	1.8 years (range 6 months- 2,6 years)
Gender	18 male
Surgery time	75 minutes (range 60–100 min)
Trauma type	Bomb explosion
Classification (Gustilo-Anderson)	Type III

blood transfusion in any of the cases. The operations were performed immediately in all patients after the injury. The mean time between injury and definitive IM nail fixation was 4.3 days (range; 2–7 days) and 3.6 days (range; 1–6 days) between initial debridement and definitive IM nail fixation.

The criteria for the fracture healing was union in at least three cortexes on lateral and anteroposterior x-rays. Of the eighteen fractures available for follow-up until union, all healed at a mean period of 3 months (range 1.5–4 months) without any complication. Moreover, walking without pain was accepted as clinical bony union.

No septic arthritis was observed, Conversion from external fixator to retrograde intramedullary nailing was performed as a one-stage procedure in all patients which means the procedure is applied under the same anesthesia but with separate preparation and draping procedures. In 17 of 18, there is no evidence of pin-track infection as well as any fewer on injured skin postoperatively. However, one patient had serious drainage at injury site, which was considered as osteomyelitis due to huge anterior wall defect on fracture site where the intramedullary nail has not enough coverage of soft tissues. Microbiological culture revealed that there was a reproduction of Serratia. Systemic sensitive antibiotic treatment with serial aggressive debridements and local vancomycin-impregnated beads for about 2 months suppressed the infection (Fig. 2).

Knee range of motion was examined by an independent examiner in comparison to the contralateral healthy side using a goniometer. 90° flexion was regained at 3 weeks, while 110° flexion and full extension was observed at 2 months postoperatively. At the time of final follow-up, the mean range of flexion of the knee was 120° (range 110° to 140°) in all patients (Figs. 3 and 4). The patients were allowed full-weight bearing after a mean period of 3 months (range, 2.5–4 months).

Antero-posterior and lateral radiographies were obtained preoperatively, and at 1,2,3 and 6 months postoperatively. Shortness and angulations were evaluated radiologically as the mean leg-length discrepancy at the time of full-weight bearing was 1,7 cm (range, 1–3 cm.), the mean angulation was 7° (range, 5–10°) on coronal plane and 10° (range, 7–13°) on sagittal plane which were considered within acceptable limits.

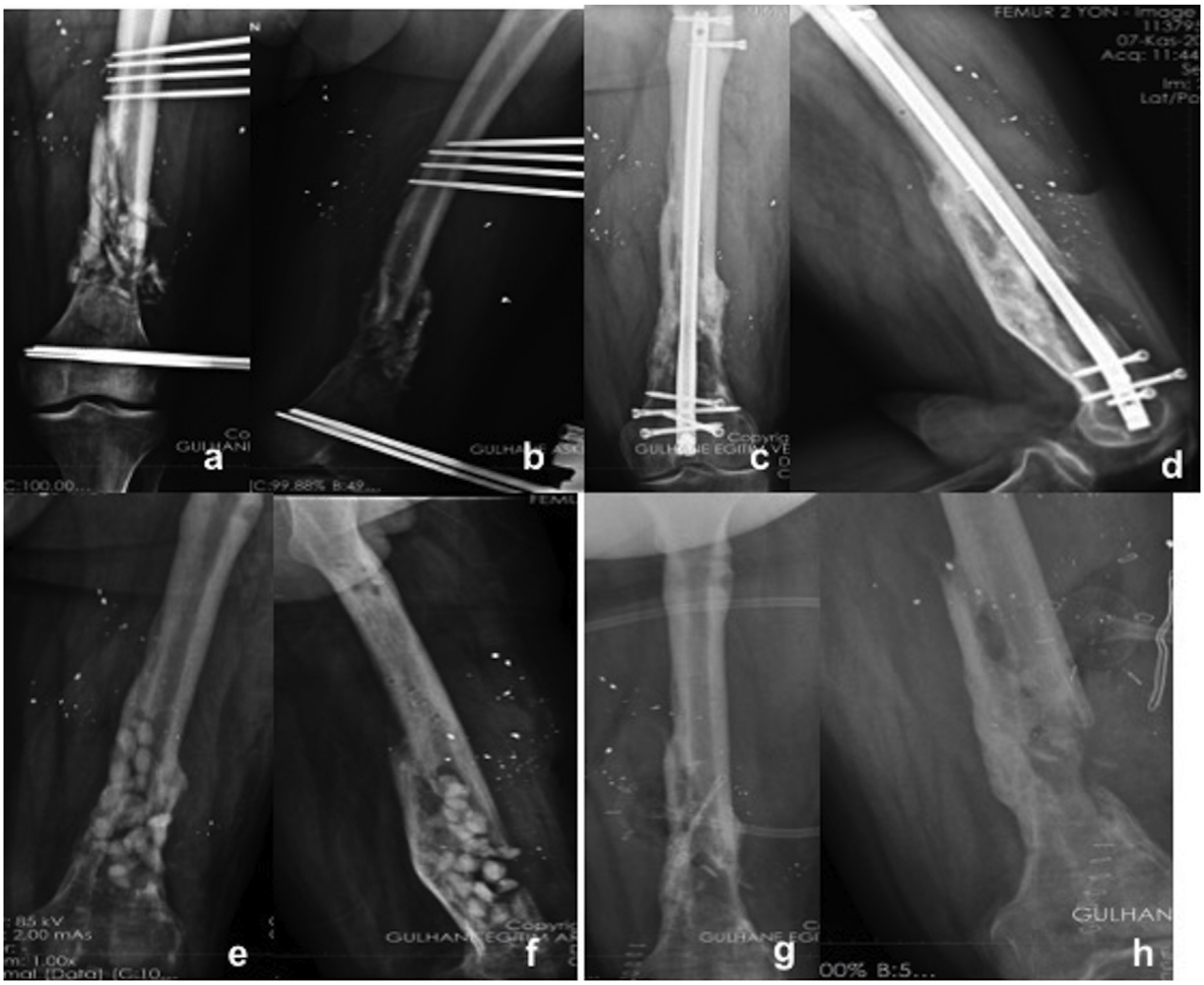

Fig. 2. A 28-year injured by bomb explosion. a,b) AP and lateral graphies of the comminuted fractured femur after initial fixation c,d) İmmediate retrograde femoral nailing was performed after transportation to our clinic e,f) Removal of the nail due to serious drainage on injured site after union and vancomycin-impregnated beads were put into the cavity after debridement of the bone g,h) At the time of final follow-up graphies of the femur.

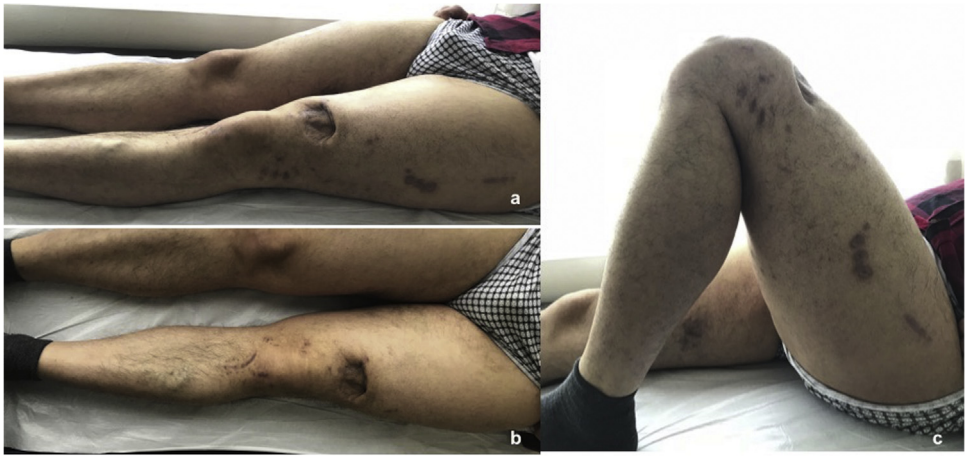

Fig. 3. Clinical pictures of a 24-year-old troop a) Lateral view of the fully extension of the injured extremity and knee b) Superior view of the injured extremity and c) Lateral view of the 140° flexion of the knee of the injured extremity.

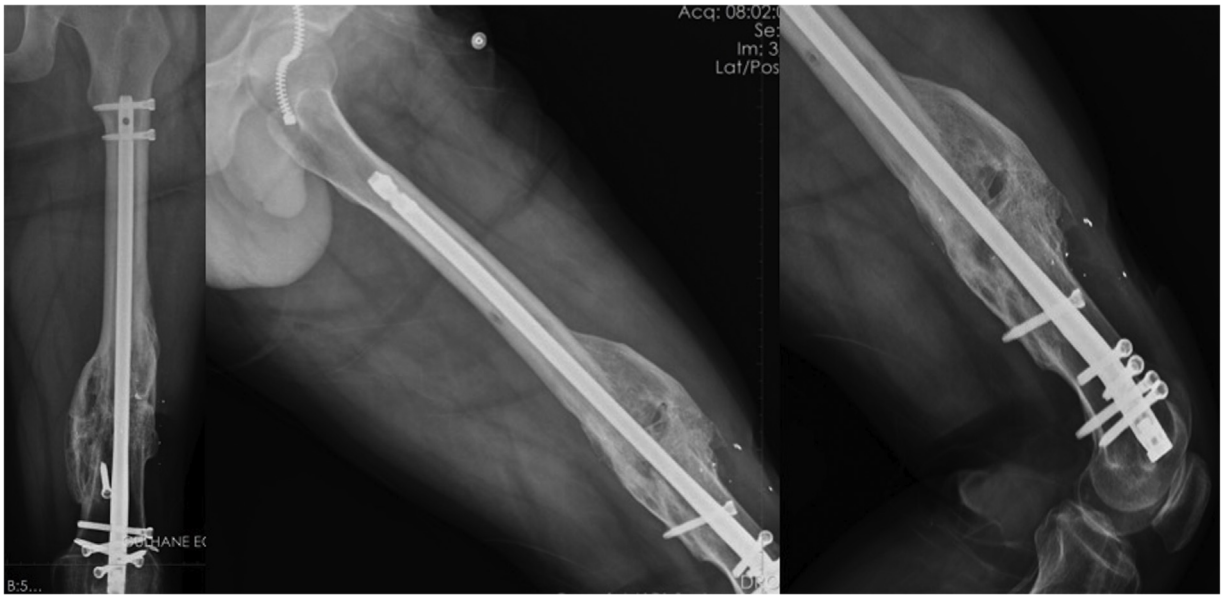

Fig. 4. AP and lateral graphies of the injured extremity of same patient. The hypertrophic callus formation at fracture site is observed.

Discussion

Gustilo-Anderson type III lower extremity injuries is an inherent risk for infection regardless of treatment options. Also, in ballistic injuries, due to grossly contaminated wounds, the infection risk is higher than the gunshot injuries which requires a delay for adequate soft-tissue healing and needs greater attention to wound care with appropriate debridements and mandate irrigations. Especially in wounded troops, the choice of treatment option becomes a complex problem with many irrigations, debridements and surgeries for soft tissue coverage [10].

Although gold standard for long bone fractures is locked intramedullary nail insertion, some surgeons stay away from this treatment because of high infection risk of internal fixation in open fractures [28,29]. Moreover, retrograde intramedullary nailing as a definitive treatment has higher potential infection risk in such injuries, where the treatment sometimes can be a potentially clinical drawback to the technique [6,7]. Even an osteomyelitis of femur has been occurred, the removal of the nail through the knee would be a devastating complication of joint infection [4].

There are not so many reports about the retrograde intramedullary nailing for gunshot femur fractures [9,11], moreover we are aware of no clinical case series after supracondylar femur fractures related with combat injuries. In a report, Poyanlı et. al. had neither osteomyelitis nor septic knee in open supracondylar gunshot fractures treated with retrograde intramedullary nailing, however the fractures did not have skin defects [9]. In a review combined of twenty-four articles, an overall rate of 0.18% acute knee sepsis after retrograde nail fixation for femoral shaft fractures was reported [6]. Similar to results of the review, an overall rate of 1.1% in 90, expected lower than 2% in 185, and 1.6% in 61 fractures were reported retrospectively [7,8,12].

On the contrary, some authors concluded that severe open femoral fractures are a relative contraindication to retrograde nail fixation to avoid the surgical site infection and septic knee [6,8,13]. However, the ballistic fractures were not included in those studies, even those reports did not separate the complications regarding high or low-energy transfer. In a report from United Kingdom trauma center, infection rate of 60% has been reported for high-energy gunshot transfer injuries despite routine surgical intervention and antibiotic administration [14]. The rate of osteomyelitis

for Gustilo type III high energy femur fractures after osteosynthesis is reported to be 3.3%–4.2% [14–16]. In our study, although all fractures are high-energy open fractures (Gustilo type III) with an inadequate and contaminated soft-tissue coverage, the infection rate is slightly higher to literature with a deep infection rate of 1/18 (5%). However, the infection was seen at surgical site, not observed at knee joint which can be considered more innocent than the sepsis of knee, when the healing potential is thought. Though the removal of the nail via arthrotomy did not result with any sign or symptoms of the sepsis of knee. Also, in keeping with the general principles of management of osteomyelitis, aggressive debridements were performed periodically and vancomycin impregnated beads were placed into the medullary cavity at the last debridement showed regression clinically.

The mean union time for supracondylar fractures of the femur after retrograde nailing is reported to as the time between 3.4–4.8 months (range 1.3–15 months) in various studies [6,9,19,20,25,26]. Also, the union rate for the retrograde technique in distal femoral fractures has been reported as 96.5% (range 87–100%) in above-mentioned studies. In our study group, the mean union time for the fractures was 3 months, and the union rate was 100%, though the fractures were open and combat-related Gustilo Type III injuries in accordance with the literature.

Another possible complications after the treatment for distal femoral fractures are stiffness in knee joint due to insufficient reduction and rehabilitation, nonunion and deep pin-track infection. Especially definitive treatment of fractures of femur with external fixation until union is associated with high risk of those complications. In some series, nonunion in up to 20% of patients, deep pin-track infection in up to 20%, and knee stiffness in up to 45% have all been reported in contemporary series of fractures of the femur treated with external fixation [8,30]. Thus, conversion to retrograde intramedullary nailing before the development of complications related to long-term external fixation would be a good alternative for the management of those fractures of the femur in combat-related injuries. Furthermore, in some series, knee flexion range of 104.6° to 117° was reported eventually [9,19,21]. In our report, eventual result of 120° knee flexion was consistent with the literature, possibly because the patients were young and rehabilitation was started immediately after the operations.

On the other hand, the optimal treatment method for supracondylar femur fractures is still a challenging work in which the biological osteosynthesis has to be restored. Especially, the need for early mobilization of the troops after a high-energy trauma requires the optimal surgery with optimal implants. While minimally invasive approaches and plates are performed to get a stable construct with the aim of restoring the axis, length and rotation, intramedullary nailing has become an vigorous alternative in long bone fractures during the last 30 years where the proper fixation is often difficult [9]. Furthermore, open plate fixation and intramedullary nailing entail greater blood loss with increased operative time compared with external fixation or minimally invasive approaches, however retrograde nailing may afford shorter operative times and decreased blood loss as in our study group [8].

Implant failure in supracondylar femur fractures remains a great problem comparing to other fixation techniques. In a study, retrograde intramedullary nailing failure is reported up to 38% of cases [17], whereas implant failure after LISS plate osteosynthesis is reported up to 20% [18]. In a biomechanical comparative study between antegrade nailing, retrograde nailing and LISS plating, no significant difference was observed in axial and torsional stiffness. However retrograde nails have achieved the greatest axial stiffness, whereas the greatest torsional stiffness was observed in LISS plates [22]. Stabilizing the distal fragment against the axial and rotational forces is crucial in these injuries, so four interlocking screw fixation of the distal fragment may provide a great advantage to other implants. In our study, we have no failure with retrograde nailing technique in Gustilo type III distal femur fractures, which may mean that retrograde nailing in experienced hands can provide better alignment control than other implants in simple or complex distal femoral fractures [6,23,24].

As an eventual topic, the duration of the external fixation and when there is an increase in the infection risk after conversion to retrograde intramedullary nailing remains unknown. However, it is shown in our study that early conversion procedure provides the benefits of immediate femoral stabilization, regarding the lower infection rates, operation and union time.

The limitations of the study are as follow; the small number (only 18 cases) of population size, absence of control group and short follow up period.

Conclusions

Patients with combat-related Gustilo Type III supracondylar femur fractures were managed with a staged protocol consisting of external fixation and retrograde intramedullary nailing. To our knowledge, this is the first study to assess the clinical and radiological parameters after retrograde nailing technique in combat-related open fractures of distal femur. Our results show that retrograde intramedullary nailing seems to be a safe and effective treatment method for the stabilization of distal femur fractures, regardless of the fracture type, even in Gustilo type III combat-related injuries.

Conflict of interest

The authors declare no conflict of interest.

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