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Original Research Article

Closed intramedullary nailing of acute femoral shaft fracture: reduction with help of bone levers through a small incision without opening fracture site

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ABSTRACT

Background: Femoral shaft fractures are usually treated with intramedullary nailing. In this study, we report a modified closed surgical technique with reduction with bone levers through a small percutaneous stab incision without opening fracture site for this type of fracture.
Methods: From June 2015-January 2017, this technique was used on 43 patients with femoral shaft fractures. Patients were followed up postoperatively for clinical evaluation. The surgical technique involves a mini-percutaneous incision slightly distal to the fracture site, and fracture reduction is performed with bone levers without opening the fracture site.
Results: 39 patients were included in final assessment. 29 fractures (74.4%) healed in the first 6 month. 35 (89.7%) fractures were united by one year. 4 (10.3%) patients needed bone grafting. The functional results were considered excellent and good in 36 (92.3%) patients, 3 (7.7%) patients had poor results.
Conclusions: The advantages of this procedure include that no fracture site is opened, there is a shorter operation time, less radiation exposure and it is especially suitable for multiple trauma and obese patients.

Keywords: Fracture femur, Mini-open, Percutaneous nailing

INTRODUCTION

Closed intramedullary nailing, first reported by Hey Groves 1918 and later popularized by Kuntscher in 1940 is now the treatment of choice for most femoral shaft fractures.[1,2] Numerous studies have demonstrated predictable and rapid fracture union, with a low complication rate.[3] These superior results are primarily attributed to achieving a form of biological fixation of the femur by preserving the surrounding soft tissue and fracture hematoma that are vitally important for fracture healing.[4,5] Closed femoral nailing usually requires a fracture table and continuous traction for fracture reduction. Multiple radiation exposures are required for closed reduction and passage of guide wire in distal fragment. Use of bone levers for reduction results in early reduction and smooth passage of guide wire into distal fragment. This can lead to a decreased total operative time and less radiation exposure.[6,7]

Although a traditional, open intramedullary procedure has the advantages of being easily learned, producing good reduction, and having short operative time but it has complications such a high infection rate and a high rate of delayed union, compared with the closed nailing method.[8-12] We developed a closed intramedullary nailing technique with percutaneous stab fracture reduction with bone levers to obtain easy and quick internal fixation of acute femoral shaft fractures especially in obese and polytrauma patients and distal 1/3 femoral fractures in which there is marked sagging of distal fragment because of gravity and gastrocnemius muscle pull. This method has a predictable surgical time, easy and more convenient for less experienced newly qualified orthopaedic surgeon, only fewer instruments are required and decreased radiation exposure. It can be applied with regular facilities and with no specialized equipment.

METHODS

We performed 43 such intramedullary nailing procedures on 42 adults with acute femoral shaft fractures from June 2015 to January 2017. Patients were followed up every three monthly. The selection criteria for our study included patients with acute diaphyseal and distal 1/3 femoral fractures, obese patients and patients who had multiple system injuries. Exclusion criteria included pathological fractures, non-acute fractures, significant open fractures (Gustilo types 2 and 3). All fractures in our study group were stabilized within 48 hours whenever medically feasible. Medical records were reviewed to obtain the injury mechanism, associated injuries, other procedures performed during the same anesthesia, the operative time, amount of C-arm exposures and functional results. Functional outcomes were measured according to the classification proposed by Klemm and Borner regarding the motion of the hip and knee, and the fracture alignment (Table 1).[13] The preoperative radiographs were evaluated to determine the fracture location, patterns, and extent of communition. The postoperative radiographs were reviewed to measure the quality of reduction and the process of fracture healing.

Table 1: Functional results after fracture femur shaft (Klemm and Borner).

Excellent
Full hip and knee motion
No muscle atrophy
Normal radiological consolidation
Good
Minimal loss of hip and knee motion
Less than 2 cm muscle atrophy
Less than 5^0 axial deviation
Poor
Moderate (25%) loss of hip and knee motion
More than 2 cm muscle atrophy
Axial deviation 5^0 to 40^0

Surgical techniques

Step 1: Nail entry site approach

Under general or spinal anesthesia, patient was placed in the supine position on the operating fracture table. A 5cm skin incision is made from the tip of the greater trochanter proximally in line with the femoral shaft. Incise the fascia of the gluteus maximus in line with its fibers. Identify the subfascial plane of the gluteus maximus. Palpate the piriformis fossa. Entry is made with pointed awl under fluoroscopy. Pass a guide wire into the proximal canal until its tip is at the fracture site. Enlarge the proximal canal using a 9-mm reamer to allow easy passage of the guide rod.

Step 2: Near fracture site approach

Make a lateral, longitudinal skin incision approximately 2cm in length to allow the insertion of 1 or 2 bone levers at about 2 to 8cm distal to fracture site. The optimal location of the incision should be determined by carefully evaluating the preoperative radiographs and by image intensifier. After the incision is deepened into the fascia, the distal fragment is easily palpated through the defect. By these means, the bone is approached without extensive soft tissue dissection. The fracture site is never exposed (Figure 1).

Figure 1: a) bone levers used for reduction. b) a small stab incision used to manipulate fracture with bone lever.

Step 3: Fracture reduction

Insert the guide wire until the tip is 1cm proximal to the distal end of the proximal canal. Reduce the fracture by manipulation with bone levers and pass the guide wire into the main distal fragment. This is usually easy in most fractures and can be done within several minutes. When lever is passed just near the fracture site an upward and laterally directed force is applied to lever depending upon fracture displacements and distal fragment is aligned to proximal fragment and guide wire is easily passed in distal fragment (Figure 2). No manipulation of distal fragment with hands or reamers is required and it decreases radiation exposure and operative time. An accurate reduction is also not needed at this time. Next ream the entire femur over the guide rod in 1mm increments until the desired diameter and stable reduction is achieved. Preservation of reaming material around the fracture site is also achieved with this technique.

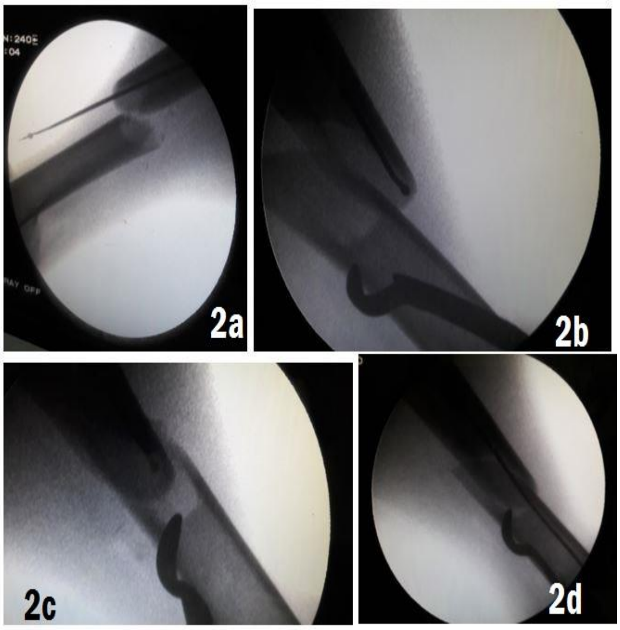

Figure 2: a) guide wire missing the distal fragment due to improper reduction. b) bone lever introduced distal to fracture site to manipulate fracture into reduction. c) reduction achieved. d) guide wire crossed into the distal fragment.

Step 4: Nail insertion

Determine the length of the nail either preoperatively by measuring the opposite femur or by intraoperative measurement of the guide wire. Drive the selected nail into the canal manually with simultaneous traction of the distal femur with fracture table. Insert the proximal screws, and check for any gap at fracture site and correct rotation of the limb before distal locking.

Step 5: Distal locking

Distal locking must be done regularly. When a C-arm fluoroscope is available, a good image of the distal femur should be obtained in a lateral position. Distal locking is always completed with the guide of the image intensifier.

RESULTS

One patient expired of multiple systems injuries, and 3 other patients were lost to follow-up, leaving 39 fractures in 43 patients included in this study for final assessment. There were 30 men and 13 women. The average age was 37.5 years (range 19-63) years.

The majority of fractures were caused by motor vehicle accident 55.8% (24/43), hit by motor vehicle 25.6% (11/43), fall from height 14% (6/43), and assault4.6% (2/43) (Table 2). Ten patients had associated injuries, requiring additional surgeries during the same anesthesia (Table 3).

Table 2: Mechanisms of injury.

Mechanism of injury	Number	Percentage
Motor vehicle accident	24	55.8
Hit by vehicle	11	25.6
Fall	6	14.0
Assault	2	4.6

Table 3: Associated injuries.

Associated injury	No. of associated
Head injury	2
Chest injury	2
Abdominal injury	3
Spinal fracture	1
Tibial fracture	2

Most surgical procedures were begun within 5 days after admission to the emergency department. 14 (32.6%) patients were operated within 48hrs of injury, 21 (48.8%) within 48hrs and 5 days and 8 (18.6%) within 5 to 10 days (Table 4). Surgeries were done via spinal anesthesia in 40 patients. The mean operation time was 94 minutes (range 60-110) minutes (Table 5).

Table 4: Timing of surgical stabilization of fracture.

Time after injury	No. of fractures	(%)
< 48 h	14	32.6
Within 5 days	21	48.8
Within 10 days	8	18.6

Table 5: Operation time of the procedure.

Operative time	No. of fractures	Percentage (%)
< 60 min	11	28.2
60-90 min	19	48.7
> 90 min	9	23.1

In 36 fractures were treated with a static locking nail and 7 fractures with dynamic locking. Reduction and passage of the guide wire usually did not take more than 10 minutes in any case. There were no major intraoperative problems except in 2 patients, in whom further communition of the fracture occurred during surgery due to inadvertent forceful reaming. Nonetheless, the good results were not affected by the complications. No patient in this study required a conversion to a formal open reduction. Fracture healing was uneventful in the majority of cases in the first 6 months; 29 fractures (74.4%) healed in the first 6 month. By final follow up at one year 35 (89.7%) fractures were united. In 4 (10.3%) patients, there was little evidence of fracture union at one year and were treated with open bone grafting; these 4 fractures, healed last in this study. Complications in the form of limb shortening of more than 2cm occurred in 1 (2.6%) patient.

There were 2 (5.2%) superficial infections they were treated with debridement and antibiotics. No deep tissue infection occurred that required nail removal (Table 6). The functional results were considered excellent and good in 36 (92.3%) patients, 3 (7.7%) patients had poor results (Table 7). The relatively high rate of poor function was attributed to a particular group of patients with significant associated injuries. The mean hospital stay of our patients was 14 days. Most patients without a life-threatening injury were discharged after 5-to 7 days.

Table 6: Complications.

Complication	No. of fractures	%
Non-union	4	10.3
Limb shortening (>2cm)	1	2.6
Superficial infection	2	5.2

Table 7: functional results.

Result	Number	Percentage
Excellent	17	43.6
Good	19	48.7
Poor	3	7.7

DISCUSSION

Closed nailing allows the original hematoma to remain intact. An important point to emphasize is that closed reaming of the intramedullary canal deposits bone graft material at the fracture site.[3,14,15] On the contrary, open reduction and internal fixation of the fractured femur require stripping of the periosteum and subsequent reduction of the blood supply at the fracture site. This often results in extensive soft tissue damage and increased blood loss and raises concerns of fracture nonunion and infection. Therefore, the open technique is not recommended as a routine procedure in most cases. Nonetheless, because it requires no special equipment and achieves quick stabilization, some authors advocate open nailing for polytrauma patients.[8,16] The primary advantage of the closed fixation method compared to open fixation is that the bony structure can be restored with an intact soft tissue envelope. Many published studies have demonstrated superior results of closed femoral nailing, such as reliable fracture healing and a low infection rate.[17]

To obtain closed reduction using a fracture table may prolong the procedure using conventional method and cause many complications, and the need to transfer patients usually seriously limits the care of patients with polytrauma. Faced with polytrauma patients when rapid fixation is essential, these techniques prolong the procedure and put the patient at additional risk.[18-20] Realizing the benefits, limitations, and potential complications of various methods of femoral nailing, we prefer to use the method described herein, especially for polytrauma and obese patients and distal femoral fractures. In our method the fracture site was not exposed, and fracture healing was not compromised by the technique. In a recent and the largest study of closed, reamed femoral nailing, Wolinsky et al reported a union rate of 93.6% after initial nailing and an overall union rate of 98.9% after an additional procedure.[21] We demonstrated a comparable union rate (97.3%) to that of closed methods.

Furthermore, there were only 2 superficial infections in our study, and the small amount of blood loss associated with this approach was well tolerated. The disadvantages of open reduction are minimized by use of our new technique which is without opening fracture site. The use of only 1 or 2 levers to reduce the fracture through a stab percutaneous incision is important. In our experience, because an accurate reduction is not required for passage of the guide rod into the distal canal, an incision that is as small as 2.5cm often suffices for this purpose.

A satisfactory reduction is usually achieved later with a larger reamer. In this way, we preserve the surrounding soft tissues, and the reamed fragments of bone collected in the flutes of the reamers also remain around the fracture site as bone graft material. More importantly with this approach, acute nailing also helps avoid multiple c-arm exposures to hands and helps in early reduction. One advantage of the technique is that the time needed to complete the entire procedure is short, a benefit that is crucial for emergency surgery. In experienced hands, our technique can be performed within 1hour. Hajek et al discussed the use of 1 or 2 distal screws in the treatment of femoral shaft fractures in a biomechanical and clinical study.[22]

In an emergency procedure, we believe that single distal locking is particularly useful and can be performed without increased morbidity with help of C-arm. Our technique reduces the radiation exposure to a great extent. Although the precise risk is still unknown, the increased use of fluoroscopy has raised concerns about the dosage of applied radiation and its potential harmful effects, both to surgeons and patients.[23]

CONCLUSION

Closed intramedullary nailing will continue to be the gold standard treatment for acute femoral shaft fractures. However, with careful patient selection and a proper surgical technique, our stab percutaneous intramedullary nailing technique can be as safe and effective as the closed method.

The union rate is high, and the complication rate is low. The procedure is quick with no need to transfer the patient, and it requires no specialized equipment. It is an ideal choice of surgery for patients with distal 1/3 femoral fractures, obese patients and polytrauma patients.

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