SURGICAL TECHNIQUES

CLOSED CEPHALOMEDULLARY NAILING WITH
PATIENT IN LATERAL DECUBITUS POSITION
FOR REPAIR OF PERITROCHANTERIC
FEMORAL FRACTURE

Matthew Sloan, MD, MS, Arvind von Keudell, MD, Kempland C. Walley, BSc, Michael C. Nasr, MD, Edward K. Rodriguez, MD, PhD

Published outcomes of this procedure can be found at: *J Trauma*. 2010 Jan;68(1):231-5

Introduction

Closed repair of peritrochanteric fractures with cephalomedullary nail fixation with the patient in the lateral decubitus position on a flat table with manual traction may allow improved fracture reduction and fixation in comparison with what is possible in a supine setup.

Three primary positioning strategies have been described for fixation of peritrochanteric femoral fractures: supine on a fracture table, supine on a flat radiolucent table, and the lateral decubitus position on a flat radiolucent table.

Advantages of a supine position on a fracture table include the ability to operate without an assistant, sustained longitudinal traction, and circumferential access to the injured lower limb. Disadvantages of this setup include difficulty determining the starting point, inability to accommodate obese patients, and many complications that are particular to the fracture table such as pudendal nerve injury, skin slough from the perineal post, and compartment syndrome of the uninjured lower limb¹⁻³.

Advantages of supine positioning on a flat radiolucent table for treating peritrochanteric femoral fractures are decreased operative time and increased versatility for treating a patient with multiple injuries. Disadvantages include difficulty obtaining lateral radiographic images and maintaining alignment over the course of the surgery⁴⁻⁶.

Advantages of cephalomedullary nail fixation of intertrochanteric and subtrochanteric fractures of the femur with the patient in the lateral decubitus position include easier access to trochanteric and piriformis fossa entry points. The above-mentioned complications associated specifically with a fracture table are also avoided. Conversion to an open approach may be easier, without substantial changes in patient positioning for most approaches to the hip and proximal part of the femur. Access to the injured limb for imaging and manipulation from both sides of the operating table are also easier, and may facilitate the management of obese patients. The lateral decubitus position allows soft tissue to

Disclosure: The authors indicated that no external funding was received for any aspect of this work. On the **Disclosure of Potential Conflicts of Interest** forms, which are provided with the online version of the article, 1 or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work.

fall away from the surgical field by the force of gravity, which can improve visualization, especially in obese patients with excessive soft tissue. The view of the peritrochanteric area is similar to that in a total hip arthroplasty performed with the patient in the lateral position, which aids in reduction by allowing an expanded view of the surgical field. During treatment of subtrochanteric hip fractures, the ability to freely manipulate the limb may aid in the reduction of the flexion deformity induced by the iliopsoas muscles⁷.

After the patient is placed in the lateral decubitus position on a radiolucent operating table, the fracture is reduced with traction, manipulation, and use of accessory devices as needed. The medullary canal entry point is determined radiographically, and then the canal is opened and reamed. The appropriate nail length is determined. The nail is then inserted and guidewires for the proximal cephalic lag screw are inserted under fluoroscopic guidance. The appropriate length and position for the lag screw are determined, and the lag screw is inserted. The distal interlocking screw-hole is drilled and measured through the aiming guide, and the distal interlocking screw is inserted. The wounds are closed, sterile dressings are applied, and anesthesia is withdrawn.

Indications & Contraindications

Indications

- Stable intertrochanteric hip fracture
- Unstable intertrochanteric hip fracture
- Peritrochanteric hip fracture
- Basal neck fracture
- Nonunion
- Malunion
- Subtrochanteric hip fracture

Contraindications

- Surgery unsafe due to patient's medical condition
- Femoral head fracture
- Femoral neck fracture
- Prior implant in place

Step 1: Operating Room Preparation

Perform sterile preparation, have the patient brought to the operating room, induce anesthesia, and place the patient in the lateral decubitus position before sterile draping.

- Review preoperative images (Fig. 1).
- Comply with sterile operating procedures.
- Induce general or spinal anesthesia.
- Prior to placing the patient in the lateral decubitus position, obtain an image of the contralateral femur with the patella facing directly anteriorly for assessment of the profile of the lesser trochanter. Save this image and use it later to assess appropriate rotational alignment on the injured side⁸.
- Place the patient in the lateral decubitus position on a radiolucent table using a positioning system such as a radiolucent beanbag or a peg board. Do not use metallic supports as they may interfere with imaging at the level of the hip. It is important to position the patient with the uninjured limb extended at the hip so that it does not interfere with the lateral radiograph.
- A large c-arm fluoroscopic unit is positioned across from the surgeon, who stands on the posterior side of the patient. Before the operation is started, trial anteroposterior and lateral views are obtained by rotating the c-arm over the patient toward the surgeon in order to compensate for physiologic anteversion of the femoral neck. As the femoral neck lies approximately 10° to 15° out of plane with a true lateral view, the c-arm is rotated over the patient to obtain that view. Note the degree of rotation needed to obtain the view of the femoral neck as it will coincide with the angle that will be required later to insert the lag screw properly into the femoral head with an ideal tip-to-apex distance⁷.

Fig. 1

Fig. 1 Preoperative anteroposterior views of the pelvis and left hip of a 79-year-old woman with a left displaced intertrochanteric hip fracture after a mechanical fall.

Step 2: Fracture Reduction

Reduce the fracture using manual traction and slight internal or external rotation; confirm anatomic reduction radiographically.

- The surgeon or assistant applies manual traction with slight external rotation on the involved lower limb, and the anatomic reduction is confirmed radiographically. Subtrochanteric and intertrochanteric fractures can typically be reduced by using traction with external rotation when the lesser trochanter is intact to counter expected shortening, flexion, and rotational forces from the iliopsoas.
- Accessories such as rolled towels under the medial part of the thigh or knee may be used to prevent valgus malreduction. For an apex-anterior fracture pattern, a tool such as a Cobb elevator inserted through an additional incision to push the apex posteriorly may aid in a challenging reduction. A similar technique may be employed with a bone hook to prevent varus malreduction by pulling the proximal fragment laterally. In the setting of a subtrochanteric fracture, a collinear reduction clamp or bone hook is often helpful to counter deforming forces and maintain fracture reduction (Video 1).
- A stack of towels is usually needed under the groin area to compensate for adduction of the femoral shaft secondary to gravity, which could result in some artificial valgus or a medialized shaft.
- Flexion of the limb may be required to bring the distal part of the shaft toward a flexed subtrochanteric proximal femoral segment.

Video 1 Manual fracture reduction and image confirmation.

Step 3: Nail Insertion

Determine the appropriate nail length, identify the nail entry point, open the femoral canal, insert a ball-tipped guide into the canal, insert the nail, and attach the aiming arm to the nail.

- For operations done with the patient in the lateral decubitus position, the trochanteric entry position is preferred. Prior to incision, identify the femoral shaft axis radiographically and mark it on the skin. Extend this line past the greater trochanter to aid with anterior-posterior positioning of the guidewire. Make a small incision proximal to the greater trochanter and dissect into the gluteus maximus fascia, separating the muscle until the tip of the greater trochanter is palpable. The ideal position is generally midline with the femoral neck, lateral to the tip of the greater trochanter, and lateral to the anatomic axis, but it will vary according to the lateral bend of the chosen implant. Irrespective of the implant that is chosen, the guidewire must be centered on the lateral view (Video 2).
- For a trochanteric entry nail, insert the guidewire manually or under power at approximately 6° lateral to the axis of the femoral shaft on anteroposterior view. This entry should allow the guidewire to cross the center of the canal just distal to the lesser trochanter. Insert the protective sleeve and trocar down to the entry point, and then remove the trocar.
- Confirm guidewire placement on anteroposterior and lateral views, insert the guidewire to approximately 15 cm, and then remove the protective sleeve from the guidewire.
- Pass a cannulated drill bit over the guidewire into the tissue protector until you reach bone and drill to the stop to open the canal. Then remove the drill bit and guidewire.
- It may be necessary to determine the femoral neck-shaft angle if you are selecting an implant that is available in various angles. This may be done preoperatively on the basis of the contralateral femoral neck-shaft angle. If devices with varying neck-shaft angles are not available, a fixed-angle cephalomedullary device (e.g., 130°) is sufficient.
- Obtain c-arm anteroposterior and lateral views to assess for adequate fracture reduction prior to choosing the nail length. If reduction is adequate and a long cephalomedullary device is preferred, measure the appropriate

nail length radiographically over a ball-tipped long guidewire inserted into the canal so that the tip of the nail resides centrally in the canal and 1 to 2 fingerbreadths above the proximal pole of the patella or as directed by the implant manufacturer.

- Measure the nail length from the proximal end of a radiographic ruler with the guidewire in good position at the desired insertion depth. It is important for the fracture to be adequately reduced at this time so that the nail length measurement is accurate.
- If appropriate, the nail diameter can be determined using radiographic ruler diameter tabs at the level of the femoral diaphysis.
- Repeat the radiographic assessment to confirm that fracture reduction has been maintained. Reaming is necessary when the preoperative radiographic assessment demonstrates a small-caliber canal. If this is the case, ream with steady pressure over the ball-tipped guidewire, drawing the reamer back often to clear the canal. Ream to a diameter at least 1.0 mm greater than the nail diameter. Continue reaming for 0.5 to 1.0 mm beyond the occurrence of cortical chatter at the level of the isthmus to avoid femoral canal fracture while providing adequate support to the nail⁹. For canal-nail mismatch or osteoporotic bone, additional reaming may be necessary beyond 1.0 mm. Remove the reamer, leaving the reaming rod in place.
- If available, a reaming rod measuring device can be used to confirm appropriate nail length when the reaming rod tip is at the desired depth.
- Assemble the nail with the aiming guide oriented laterally. Manually insert the nail into the opened canal.
- Check a fluoroscopic image to confirm that fracture reduction has been maintained and continue to push the nail across the fracture site. Use gentle but rapid hammer blows, stopping frequently to reassess progression across the fracture site. It is important that the patient has been positioned correctly, to allow adequate lateral imaging of the injured limb.

Video 2 Nail insertion: guidewire insertion, nail insertion assembly, measurements, canal opening, reaming, and nail insertion.

Step 4: Insertion of Cephalic Lag Screw

Attach the aiming arm to the insertion handle, pass a guidewire, drill over the guidewire to open the lateral cortex, and insert the cannulated screw with soft hammer blows.

- Attach the aiming arm to the insertion handle. A guidewire is used to confirm appropriate nail position (Video 3).
- Pass the trocar to the skin through the guide sleeve, make an incision, and dissect the fascia to allow passage of the guide sleeve to the lateral cortex. Then confirm placement and fracture reduction radiographically.
- Replace the trocar with the guidewire and insert it from the lateral cortex into the femoral head, respecting the proper tip-to-apex distance. Confirm that it is centered in the head and neck on anteroposterior and lateral views (Fig. 2). With the patella of the injured lower limb facing directly laterally, obtain an anteroposterior image to compare the profile of the lesser trochanter with the preoperative image of the contralateral limb, in order to assess rotational alignment.
- It is possible to penetrate the joint space on insertion of the guidewire into the femoral head. To avoid this, it is important to progress slowly toward the final position in the head, taking time to obtain anteroposterior and lateral views as you approach the cortex of the femoral head.
- A second guidewire is used for provisional fixation and rotational stability.
- Use the screw measuring device to determine appropriate screw length from the guidewire.
- Use a cannulated drill over the guidewire down to the stop to open the lateral cortex.
- Attach the cannulated screw or spiral blade to the insertion device, pass it through the guide sleeve, and then hold the insertion device and advance the screw or blade with soft hammer blows or a rotational motion as indicated by the system of choice.
- Insert a screwdriver through the nail. Then engage the rotational locking mechanism for the screw.
- The tip-apex distance is the sum of the distances from the tip of the screw to the apex of the femoral head on the anteroposterior and lateral views. It should be <25 mm to reduce the likelihood of screw cutout¹⁰⁻¹² (Fig. 3).

Fig. 2

Fig. 3

Video 3 Lag-screw or spiral blade insertion: measurements, lateral cortex opening, and screw or blade insertion.

Fig. 2 Intraoperative anteroposterior view showing the lag-screw guidewire position with a bone hook used to restore the femoral neck-shaft angle. The distal guidewire tip has reached subcortical bone and is well-centered in the femoral neck.

Fig. 3 Intraoperative anteroposterior view showing placement of the spiral blade over the guidewire into the femoral head.

Step 5: Insertion of Distal Interlocking Screw

Confirm fracture reduction on anteroposterior and lateral views, drill through the lateral cortex of the femur for the distal interlocking screw, measure the screw length, insert the screw, and remove the aiming arm if one was used.

- Obtain anteroposterior and lateral views to confirm fracture reduction.
- Insert the trocar assembly through the aiming arm for the distal locking screw and then make an incision to allow the trocar to pass to bone. Alternatively, obtain perfect circles on radiographs (Video 4).
- Remove the trocar and then use a calibrated drill to pass through both cortices.
- Read the length of the interlocking screw from the drill bit; press the drill sleeve to bone for an accurate reading.
- Insert the interlocking screw through the protective sleeve with a screwdriver (Fig. 4).
- Remove the sleeve and aiming arm.
- Remove the connecting screw and insertion handle from the nail.

Fig. 4

Video 4 Insertion of distal interlocking screw: aiming, cortical drilling, and insertion.

Fig. 4 Intraoperative anteroposterior view showing placement of the distal interlocking screw with the aiming guide.

Step 6: Final Radiographic Imaging

Obtain anteroposterior and lateral views to confirm maintenance of fracture reduction and appropriate placement and length of the nail and cephalic and distal locking screws.

- Obtain anteroposterior and lateral views to assess fracture reduction, nail placement and length, and the position and length of the cephalic and distal locking screws (Video 5 and Figs. 5 through 8).

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Video 5 Final anteroposterior and lateral views of the fracture reduction and the positions of the nail, spiral blade, and distal interlock screw.

Fig. 5 Intraoperative anteroposterior view showing the final position of the proximal part of the nail and the spiral blade.

Fig. 6 Intraoperative anteroposterior view showing the final position of the distal part of the nail and the distal interlocking screw.

Fig. 7 Intraoperative lateral view showing the final position of the proximal part of the nail and the spiral blade, with the blade well-centered in the femoral neck.

Fig. 8 Postoperative anteroposterior view of the pelvis showing the position of the proximal part of the nail and the spiral blade at the first follow-up visit. This patient had a new right intertrochanteric fracture from a mechanical fall.

Step 7: Wound Closure

Irrigate and close the wounds, and apply operative dressings.

- Irrigate all wounds.
- Close the wounds in deep and superficial layers.
- Apply sterile dressings to all surgical wounds.

Results

Intramedullary device technology has been altered to address the complication of periprosthetic fracture at the distal tip that made earlier intramedullary fixation less appealing compared with extramedullary fixation for stable fracture patterns. A previous study indicated that newer-generation intramedullary devices may have lower complication rates than historic controls¹³.

Additionally, use of an intramedullary device for repair of intertrochanteric fractures raises the possibility of performing a closed procedure with the patient in the lateral decubitus position. This position allows improved access to trochanteric and piriformis fossa entry points, simpler conversion to open approaches without repositioning the patient, and easier access to the injured limb for imaging and manipulation by a surgical assistant from both sides of the operating table, which may be particularly beneficial for obese patients.

In a study of repairs of peritrochanteric and diaphyseal femoral fractures with the patient in the lateral decubitus position⁷, the results were similar to reported outcomes of such repairs done with the patients in the traditional supine positioning. In this series of 100 peritrochanteric and 58 diaphyseal femoral fractures, there were 3 rotational malreductions that required surgical correction. Of these, 2 were noted intraoperatively and fixed immediately. The third case was noted postoperatively and required a return to the operating room. One limb-length discrepancy was noted and required a return to the operating room for surgical correction. The patient with the limb-length discrepancy had multiple injuries with bilateral comminuted femoral fracture.

Lag-screw cutout occurred in 3 patients, all of whom had a tip-apex distance of <25 mm. Two of these patients underwent conversion to a hemiarthroplasty, and 1 middle-aged patient had a conversion to a total hip arthroplasty. One nonunion occurred in a middle-aged patient who had a complex fracture pattern that included a proximal femoral fracture and a subtrochanteric component as well as a displaced basicervical segment. This patient underwent surgical revision of the nonunion 7 months after the initial surgery. One nail failed and was revised to a similar cephalomedullary device. The rates of these complications are all similar to the complications rates (2%, 8.5%, 7.2%, and 1.1% for malrotation, angulation of >5° at union, additional surgery needed to achieve union, and nonunion, respectively) in patients treated in the supine position¹⁴⁻¹⁶.

Pitfalls & Challenges

- Nails that are large proximally—i.e., those with a ≥ 17 -mm diameter—may displace a proximal fragment in a subtrochanteric fracture into varus if the lateral cortex is not reamed properly. Atypical femoral stress fractures with a prominent lateral cortex may also displace into varus if the lateral cortex is not well reamed. Proper reaming can be achieved by advancing the entry reamer while medial pressure is applied to the lateral cortex against the reamer with a ball-tipped pushing tool.
- Use a bone hook to lift and correct fracture alignment into proper alignment from valgus or varus deformity.
- Remove the ball-tipped guidewire prior to placing the cephalic screw. If this is not done, the threaded guide pin will go too anterior or posterior in the head.
- If using a radiographic ruler to estimate the nail diameter, realize that the ruler is not in the same plane as the femur and adjust the estimate accordingly. The ruler will likely be magnified relative to the femur given its more proximal position in relation to the x-ray source.

- If the fracture line runs through the desired nail entry point, do not drill through the fracture; instead, remove bone medial to the entry point to avoid fracture displacement. This may necessitate selection of a different implant for piriformis entry.
- The screw connecting the nail to the insertion handle must be properly tightened; otherwise, the lag screw may not align properly through the aiming guide.
- The lag-screw guide sleeve should not be overtightened into the lateral cortex. If it is, the aim may deviate from the proper alignment.
- If repositioning of the nail is necessary, always use the insertion handle to make these adjustments. Pulling on the guide sleeve or drill can cause the aim to deviate from proper alignment.

Matthew Sloan, MD, MS
 Arvind von Keudell, MD
 Kempland C. Walley, BSc
 Michael C. Nasr, MD
 Edward K. Rodriguez, MD, PhD
 Hospitals of the University of Pennsylvania, Philadelphia, Pennsylvania
 Department of Orthopedics, Beth Israel Deaconess Medical Center, Boston, Massachusetts
 E-mail address for M. Sloan: Matthew.sloan@uphs.upenn.edu

References

1. Brumback RJ, Ellison TS, Molligan H, Molligan DJ, Mahaffey S, Schmidhauser C. Pudendal nerve palsy complicating intramedullary nailing of the femur. *J Bone Joint Surg Am.* 1992 Dec;74(10):1450-5.
2. Callanan I, Choudhry V, Smith H. Perineal sloughing as a result of pressure necrosis from the traction post during prolonged bilateral femoral nailing. *Injury.* 1994 Sep;25(7):472.
3. Anglen J, Banovetz J. Compartment syndrome in the well leg resulting from fracture-table positioning. *Clin Orthop Relat Res.* 1994 Apr;301:239-42.
4. Karpos PA, McFerran MA, Johnson KD. Intramedullary nailing of acute femoral shaft fractures using manual traction without a fracture table. *J Orthop Trauma.* 1995 Feb;9(1):57-62.
5. McFerran MA, Johnson KD. Intramedullary nailing of acute femoral shaft fractures without a fracture table: technique of using a femoral distractor. *J Orthop Trauma.* 1992;6(3):271-8.
6. Stephen DJ, Kreder HJ, Schemitsch EH, Conlan LB, Wild L, McKee MD. Femoral intramedullary nailing: comparison of fracture-table and manual traction. a prospective, randomized study. *J Bone Joint Surg Am.* 2002 Sep;84(9):1514-21.
7. Bishop JA, Rodriguez EK. Closed intramedullary nailing of the femur in the lateral decubitus position. *J Trauma.* 2010 Jan;68(1):231-5.
8. Giannoudis PV, Pape HC, Schutz M. Antegrade nailing (subtrochanteric). AO Foundation. https://www2.aofoundation.org/wps/portal/!ut/p/a1/04_Sj9CPykssy0xPLMnMz0vMAFGjzOKN_A0M3D2DDbz9_UMMDRyDXQ3dw9wMDAwCTYEKlvEocDQnTr8BDuBoQEi_I35Uek5-EtipkY55ScYw6fPRRlppqUWpRXqlRUDhJJKSgmlrVQNVg_Lycr30_Pz0nFS95PxcVQNsWjLy0v0l1BV6hfkhkZU-aSGAwBJYqzy/dl5/d5/L0IDU0IKSWdrbUEhIS9JRFJBQUlpQ2dBek15cXchLzRKQ2hEb01kdEJnY2huQVZHRUEhL1o3XzJPMDBHsVMwS09PVDEwQVNFmudWRjAwMDYzLzAl/?showPage=redfix&bone=Femur&segment=Shaft&classification=32-A3&treatment=&method=CRIF+%28closed+reduction+internal+fixation%29&implantstype=Antegrade+nailing+%28subtrochanteric%29&approach=redfix_url=1285238479912. Accessed 2015 Dec 29.
9. Ricci WM, Gallagher B, Haidukewych GJ. Intramedullary nailing of femoral shaft fractures: current concepts. *J Am Acad Orthop Surg.* 2009 May;17(5):296-305.
10. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. *J Bone Joint Surg Am.* 1995 Jul;77(7):1058-64.
11. Kyle RF, Gustilo RB, Premer RF. Analysis of six hundred and twenty-two intertrochanteric hip fractures. *J Bone Joint Surg Am.* 1979 Mar;61(2):216-21.
12. Koval KJ, Zuckerman JD. Intertrochanteric fractures. In: Bucholz RW, Heckman JD, editors. *Rockwood and Green's fractures in adults*. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2001. p 1635-63.
13. Bienkowski P, Reindl R, Berry GK, Iakoub E, Harvey EJ. A new intramedullary nail device for the treatment of intertrochanteric hip fractures: Perioperative experience. *J Trauma.* 2006 Dec;61(6):1458-62.
14. Winquist RA, Hansen ST Jr, Clawson DK. Closed intramedullary nailing of femoral fractures. A report of five hundred and twenty cases. 1984. *J Bone Joint Surg Am.* 2001 Dec;83(12):1912.
15. Wolinsky PR, McCarty E, Shyr Y, Johnson K. Reamed intramedullary nailing of the femur: 551 cases. *J Trauma.* 1999 Mar;46(3):392-9.
16. Parker MJ, Handoll HH. Intramedullary nails for extracapsular hip fractures in adults. *Cochrane Database Syst Rev.* 2006;3:CD004961. Epub 2006 Jul 19.