16 Subtrochanteric Femoral Fractures

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Anatomical Fracture Location and Radiograph of Fracture Pattern

The subtrochanteric region of the femur is defined as the area which extends 5 cm distally from the inferior border of the lesser trochanter. Intramedullary devices (ID) remain the primary choice of fixation for the stabilization of these complex fractures [1–6]. Good fracture reduction and appropriate nail entry point are critical for the successful surgical treatment of these complex fractures. Understanding of the deforming forces acting on various fracture patterns and the ability to use proper surgical technique are essential in obtaining successful outcomes. This chapter reviews on the latest reduction instruments and techniques for the treatment of adult subtrochanteric fractures.

Preoperative Planning

Acquisition of good-quality radiographs (AP/lateral) to assess well the degree of comminution and extension of fracture lines distally is fundamental (Fig. 16.1a, b). Good visualization of the knee joint is also important for planning the distal locking of the intramedullary implant selected to stabilize the fracture. Ensure that the patient has been assessed per ATLS guidelines, particularly the young patient to avoid missing the presence of other associated injuries.

Our preference for most closed subtrochanteric fractures treated with an antegrade femoral nail is the supine position on a radiolucent traction table. The traction table is the best "assistant" for the surgeon, giving the ability to perform the procedure in static environment. Some surgeons, who are familiar with the leg-free technique, may prefer standard operating radiolucent table. These surgeons find many disadvantages with the use of the traction table, such as the laborious setup and the fact that there are technical difficulties in the precise manipulation of the lower limb during the operation [7, 8]. On the other hand, although the preoperative setup with the traction table requires additional time, easier intraoperative fluoroscopy is accomplished with the stable traction. Also, the leg-free technique requires a dedicated assistant to hold traction exclusively during the procedure.

An in-house femoral cephalomedullary nailing system with or without the option of using an antirotation screw should be available for the procedure with adequate inventory of different lengths and diameter of nails available. At induction prophylactic antibiotics should be administered as per local hospital protocol. Spinal or general anesthesia can be performed.

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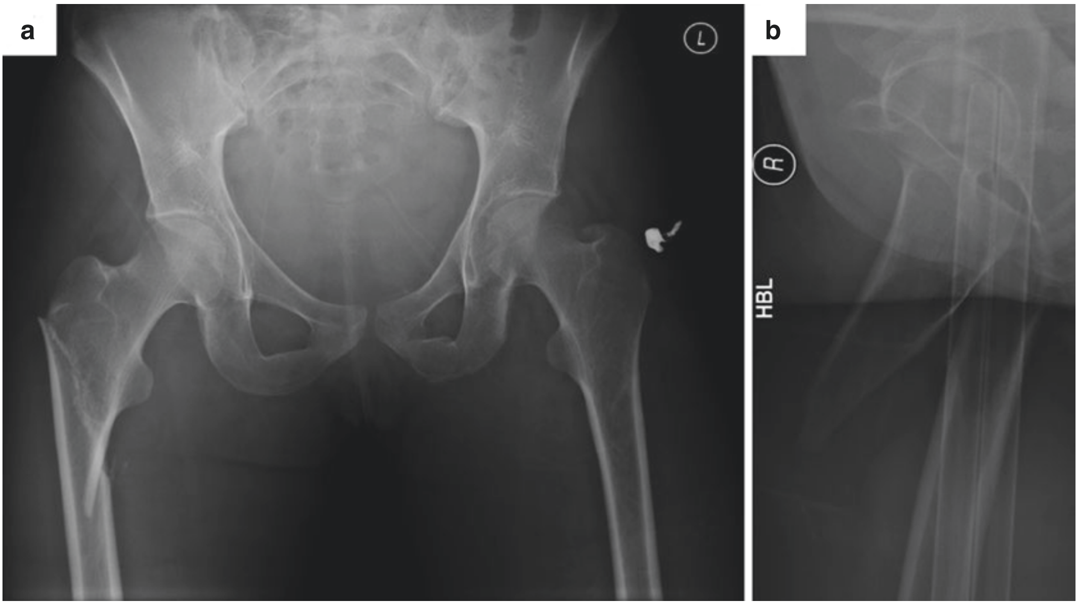

Fig. 16.1 Acquisition of good-quality radiographs (**a**) AP; (**b**) lateral views to assess well the degree of comminution and extension of fracture lines distally are fundamental. Note on the lateral view (**b**) the position of the proximal segment being flexed, abducted, and externally rotated

Patient Setup in Theater

The patient is placed supine on the traction table. The ipsilateral arm must be secured across the patient's body with a wide paper tape or in an arm hang. The upper trunk should be angled away from the fractured side in order to allow easy access for the preparation of the entry point for guide wire insertion and unobstructed reaming of the femur and subsequent nail insertion [9]. The unaffected leg is placed in flexion and abduction using the appropriate leg holding device attached to the table in order to allow easy acquisition of the lateral hip view using the C-arm.

The affected limb is placed in slight adduction, while longitudinal traction is applied with the patient's foot secured into the special designed boot (Fig. 16.2). Great care must be given for tying securely the foot to the fracture boot in order to avoid skin abrasions or accidental loosening of the foot. We do not prefer the use of a Steinmann pin in the distal femoral condyles as a method of applying traction in these fractures, for the reason that it may interfere with the distal locking of the nail.

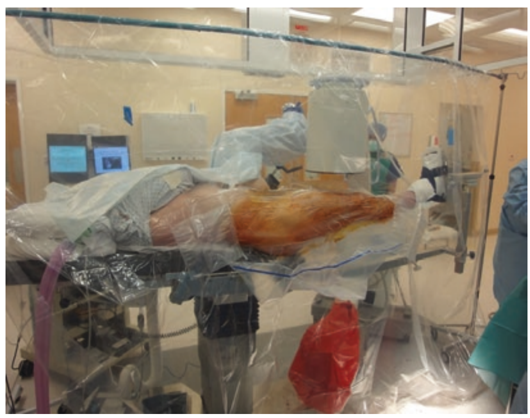

Fig. 16.2 Patient positioning. The affected limb is placed in slight adduction, while longitudinal traction is applied with the patient's foot secured into the special designed boot

Traction is applied to the affected limb, and the reduction is checked by fluoroscopy in true anteroposterior (AP) and true lateral (in line with the femoral neck anteversion) fluoroscopic views. If a closed acceptable reduction has been achieved, the surgeon can proceed for the draping with a sterile curtain hung from above (if available) or with the traditional method where the anterior and lateral aspects of the hip and the leg are draped free.

Closed Reduction Maneuvers

The fracture pattern plays a significant role in the decision-making for the reduction technique. Usually, the proximal fragment under the contraction of the iliopsoas muscle is being flexed, abducted, and externally rotated (Fig. 16.1b). On the other hand, the adductors pull the distal fragment of the femur toward the midline and, in combination with the gravity force, externally rotate it. Sandbags or sheets can be applied under the affected buttock to eliminate the external rotation of the proximal fragment.

The shortening of the limb is being caused by the combination of all the muscle forces that are attached on the distal fragment [10]. The above described deformity creates a pattern that is very difficult to be reduced during the insertion of the nail [11]. Furthermore, more complex fracture patterns may exist, including the separation of the greater trochanter from the rest of the proximal femur which could lead to even more difficulties to the reduction and additionally to the estimation of the optimal entry point for the nailing procedure [12]. The authors prefer to try at first closed reduction. Traverse fractures could be reduced easier using closed reduction methods, in contrast to spiral patterns that most of the time the open reduction using minimal invasive techniques is mandatory.

The rotational alignment can be checked by rotating the fracture table boot extension device. The surgeon must remember that the hip is already internally rotated if a sandbag under the buttock is used. Due to this fact, the internal rotation cannot be estimated with the patella as a guide. If the distal fragment has a posterior sag, the fracture boot could be elevated 20–30° [13]. This particular action will help the distal fragment to be aligned easier. The same result could be occurred with the aid of a crutch placed under the distal fragment, just below the fracture site, correcting and supporting the posterior sag [14]. When proper reduction is achieved, the crutch should not be removed from this position during the nailing. Proper care must be taken in order to provide sterile condition throughout the operation, if this technique is used [7].

Other instruments such as a mallet could be used for the indirect reduction of a subtrochanteric fracture. The use of this device applies indirect forces to the bone fragments via the soft tissues and it could assist to achieve reduction.

In complex subtrochanteric fractures or in those that closed reduction was not adequate, minimal invasive techniques may be used according to the surgeon preference.

Monocortical Schanz pins can be used through a stab incision to the skin in order to manipulate the fracture fragments. One or two Schanz pins can be used (only in one or in both fragments), giving the surgeon an excellent ability to manipulate the fracture achieving the optimal reduction [15]. In order to manipulate the Schanz pin, a T wrench must be available for application. The reduction of the fracture and the placement of the Schanz pins should be checked with the image intensifier before the beginning of the reaming. This technique is almost atraumatic and the main advantage is the maintenance of the reduction during the preparation of the intramedullary canal and the passage of the nail [16]. Other minimal invasive technique includes the insertion of blocking screws [17].

Reduction Instruments

The standard nailing set and the large fragment instruments set are used for the nailing of the subtrochanteric fracture. We consider that a common fracture reduction set should contain large bone clamps, pointed reduction forceps, mallet, Hohmann retractors, ball-spike pushers, and bone hooks (Fig. 16.3). If the fracture pattern is more complex, the surgeon should make sure that he or she will have available Schanz pins and cerclage wire.

Surgical Approach

Once the proper reduction is confirmed, a small lateral incision of 4–5 cm is performed 2 cm proximal to the greater trochanter centered to the axis of the femur (Fig. 16.4). The

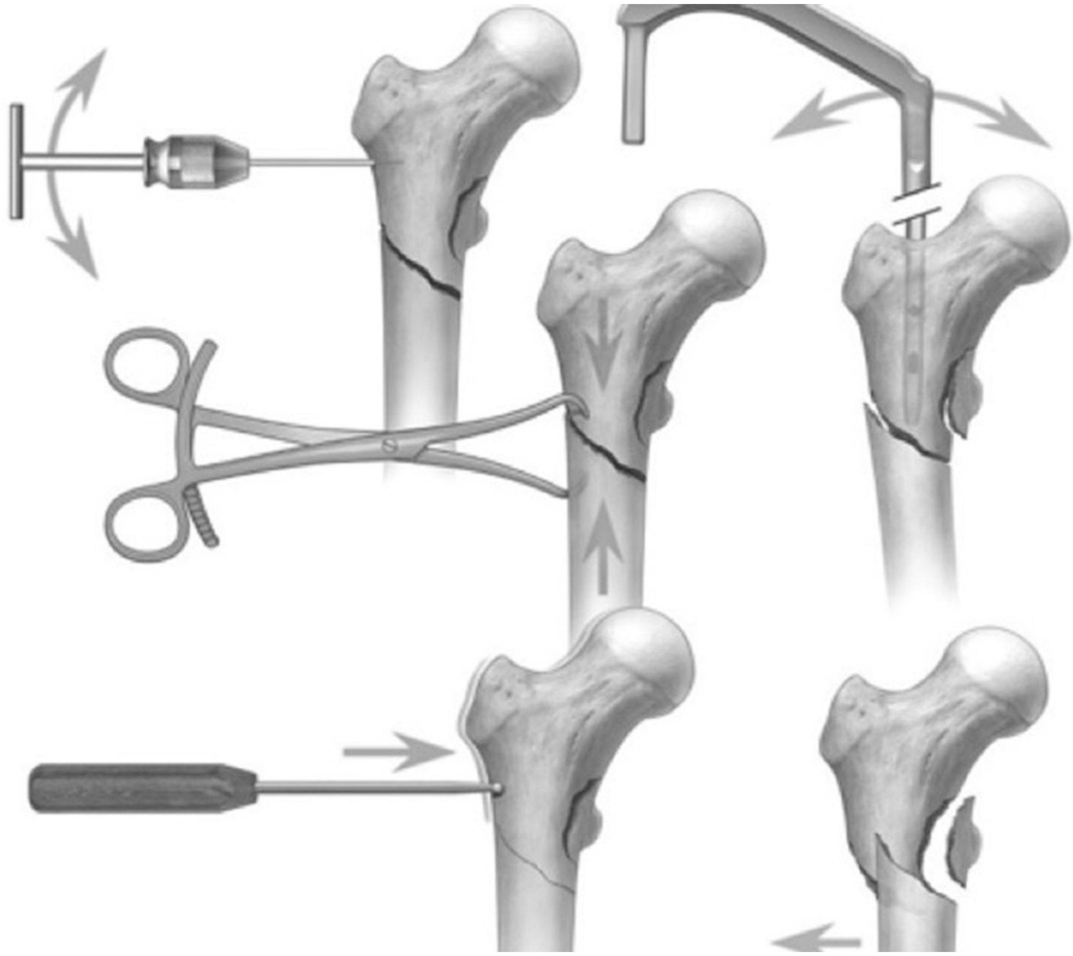

Fig. 16.3 Reduction tools include Schanz pins, large bone clamps, pointed reduction forceps, Hohmann retractors, ball-spike pushers, and bone hooks

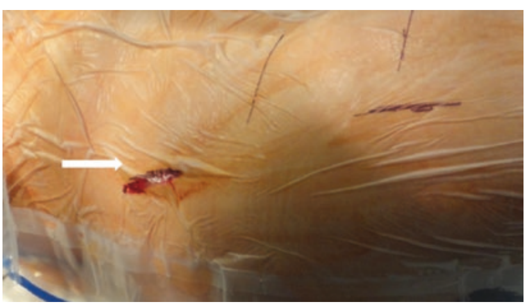

Fig. 16.4 A small lateral incision of 4–5 cm (arrow) is performed 2 cm proximal to the greater trochanter centered to the axis of the femur

tensor fascia lata and the abductor muscles are digitally split and the great trochanter should be palpated at this time. The entry point must be found according to the specification of the intramedullary device being used. We are familiar with the stryker gamma 3 IM nailing system, the Biomet Peritrochanteric Nail (PTN) System, and the Orthofix Veronail Trochanteric System; these devices demand the entry point to be placed on the greater trochanter. We suggest that the trochanteric entry point should be placed slightly more medial to the tip of the greater trochanter and centered on the lateral view (Fig. 16.5a, b). This entry point helps to avoid gradual enlargement of the entry point hole in the greater trochanter which leads to lateral placement of the nail and varus reduction or high position of the head screw [9, 15].

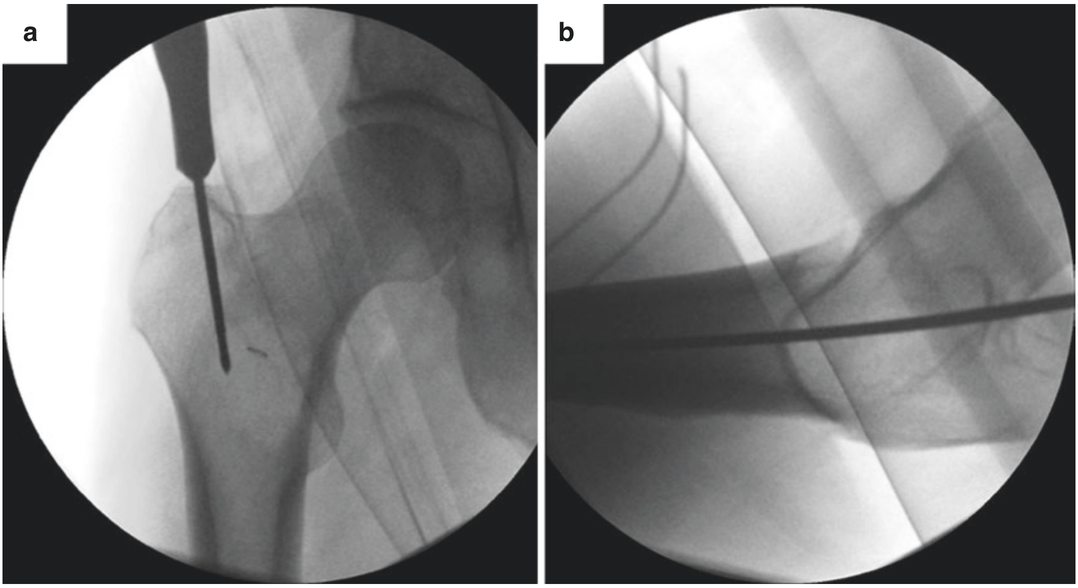

Fig. 16.5 Intraoperative fluoroscopic images demonstrating that the trochanteric entry point should be placed slightly more medial to the tip of the greater trochanter and centered on the lateral view

When the optimal entry point is confirmed using the image intensifier, the guide wire can be entered to the proximal fragment. A slightly prebended guide wire at its distal part is suggested. By bending it, it is easier for the surgeon to pass it through the fracture site. If the position of the guide wire is suboptimal, a reduction forceps (finger) can be used to correct its position (Fig. 16.6a–d). The final position of the guide wire should be checked using the C-arm in the AP and lateral views and it must be placed in the middle of the femoral condyles in both views. At this point the reaming procedure can be initiated. Do not ream until you ensure adequate contact to the entry point. This pitfall might lead to a lateral enlargement of the entry point [9].

Open Reduction Maneuvers and Implant Selection

Instruments like a ball-spike pusher, a bone hook, or a small Hoffman retractor can be used for direct reduction of the fracture. Through a stab incision to the skin and blunt dissection through the fascia, just above the fracture site, one of the above instruments can be utilized for the reduction of the fracture. The placement of the instrument must be strategically chosen in order to allow the proper skeletal manipulation. If a ball spike is used, a small unicortical hole to the bone with a drill of 2.7 mm is recommended to avoid the slippage of the instrument. In typical subtrochanteric fractures, in which the distal fragment is adducted, a bone hook may be helpful in the reduction. In this particular scenario, a bigger incision of about 3–4 cm is needed, and the hook should be passed posteriorly to the medial side of the distal fragment. Then, the surgeon can abduct and elevate the distal fragment achieving an adequate reduction and passage of the guide wire.

Direct open reduction must be used when close reductions maneuvers have failed to facilitate fracture reduction. Before the skin incision, it is recommended to mark the fracture site with an instrument (e.g., a Kocher's forceps) under the image intensifier avoiding wrong site of the skin incision. Once the fracture site has been located, a longitude incision of the skin to about 5 cm is performed in the lateral site of the femur, centered just proximal to the fracture site. We suggest proximal "extension" of the incision (i.e., if needed) in order the cephalic screw be placed through the same incision. The fascia lata is

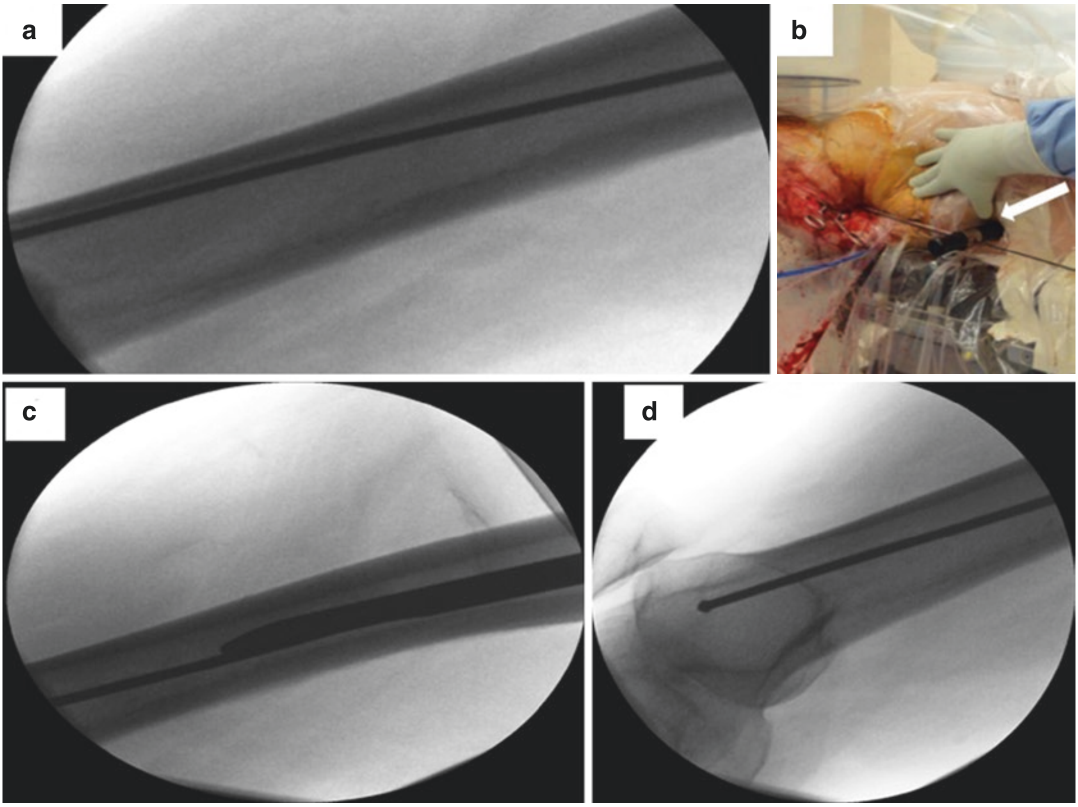

Fig. 16.6 (**a**) Lateral fluoroscopic image demonstrating an anterior-based guide wire. (**b**) Intraoperative image showing insertion of the finger forceps (arrow) to adjust the guide wire position. (**c**) Lateral fluoroscopic view demonstrating the advancement of the finger forceps and the central positioning of the guide wire. (**d**) Lateral fluoroscopic view showing more central positioning of the guide wire

opened lengthwise and the vastus lateralis muscle is exposed. In order to expose the femur, it is preferable to reflect the vastus lateralis from the intermuscular septum instead of splitting its muscle fibers.

This maneuver decreases the bleeding from the branches of the perforating vessels and prevents the denervation of the posterior fibers due to splitting of the muscle. At this time, great care must be taken for the bleeding control, all the vessels must be carefully cauterized, and the larger ones should be ligated. If this step has been omitted, the perforated vessels are retracted into the muscle fibers and it would be very difficult to be found later, causing continuous bleeding [10].

It should be possible now to palpate the fracture and to proceed with the reduction.

The subtrochanteric area should be considered a quite safe anatomical region using the lateral approach that has been described earlier. The surgeon must keep in mind that apart from the perforating arteries of the deep artery of thigh which are found posteromedial to the lateral femoral intermuscular septum and the deep artery and vein of thigh, medial to the vastus medialis, the other critical structures of the lower limb such as the sciatic nerve and it's vessels and the femoral nerve, artery and vein are placed in a safe distance from the region of interest [18]. Despite that, the surgeon, as in every procedure must be careful in

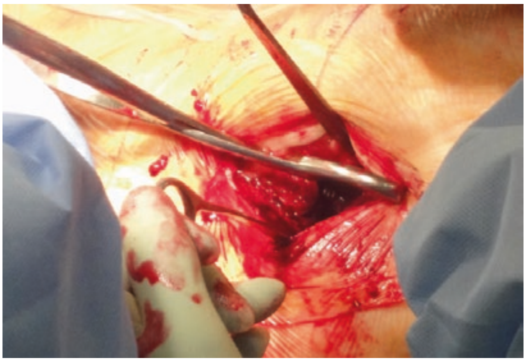

Fig. 16.7 Intraoperative picture demonstrating the insertion of a blunt Hohmann retractors over the anterior and posterior aspect of the femur following elevation of vastus lateralis at the level of the fracture for facilitation of fracture reduction with a large bone clamp

Fig. 16.8 Intraoperative picture demonstrating reduction of the fracture with a bone reduction clamp

the placement of the instruments, and great care should be given in the handling of the soft tissues.

As the fracture has been exposed, a blunt Hohmann retractor can be placed to the anterior aspect of the femur elevating vastus lateralis and a second one on the posterior side (Fig. 16.7). The fracture site is fully exposed and the amount of the traction and the rotational alignment can be readjusted with the aid of the image intensifier. If the fracture is impacted, a bone hook could be utilized to disimpact it before the application of the reduction clamp.

Alternatively, a reduction clamp can be applied (Fig. 16.8) or the cerclage wire technique can be used (a 2 mm wire). We find it easier and safer to pass the wire around the bone in a double-folded configuration. We recommend that the cerclage should be passed from the posterior to the anterior side of the femur and great care must be taken so as to avoid injury of the neurovascular structures. If a cerclage wire passer is not available, the soft tissues should be carefully detached from the bone with the use of a blunt instrument and the cerclage wire can be passed around with the help of the surgeon's finger or a curved artery forceps. When the wire is secured, it is recommended not to remove the reduction clamp during the reaming and until the final insertion of the nail [19].

Following successful reduction and appropriate preparation of the entry point, the guide wire now can be advanced distally. The nail length can be determined with the provided measuring device of the nailing system used. Reaming can be initiated and carried out 1.5 mm above the selected nail diameter. After reaming completion, the selected nail with the appropriate length and diameter size can be inserted. Optimum positioning of the cephalic screw must be achieved both on the AP and lateral radiographic planes (midline in both planes) (Fig. 16.9a–f). If an anti-rotation screw will be used, slightly inferior position of the lag screw is required (check nail design manufacturer's advice). Set screw mode (static or dynamic) depends on fracture pattern. In well-reduced transverse fractures, the set screw should be set in a static mode.

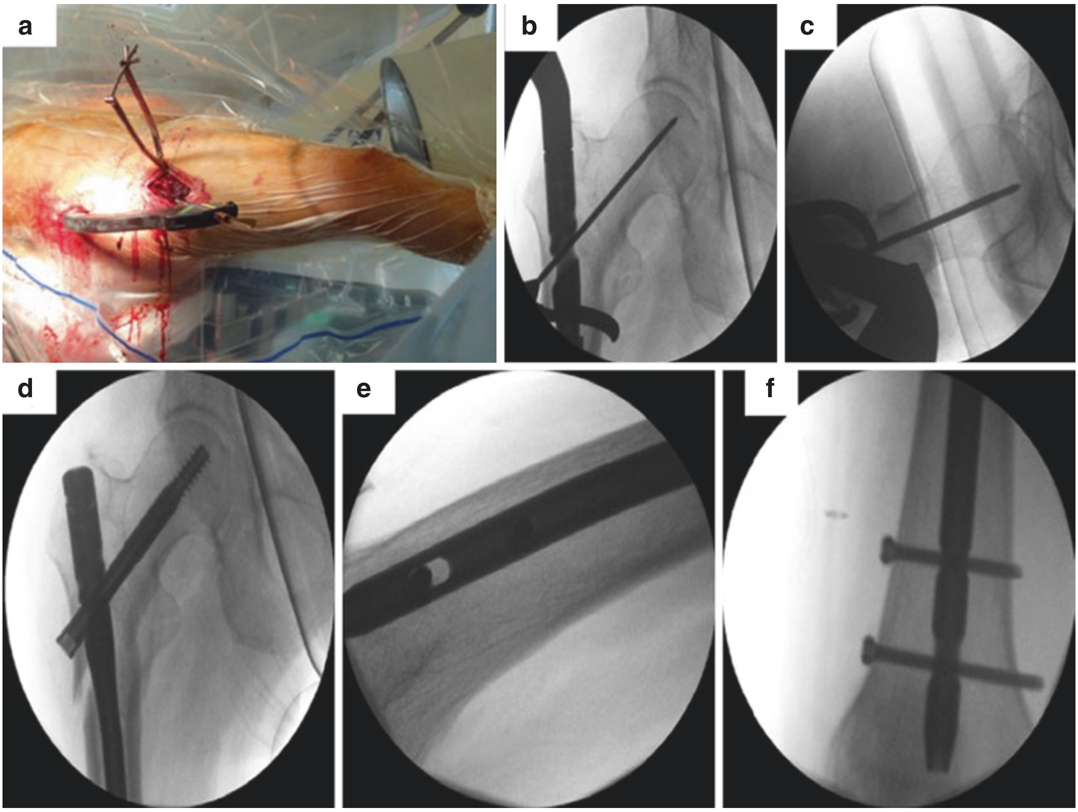

Fig. 16.9 (**a**) Intraoperative picture demonstrating the proximal jig attached to the nail for insertion of the guide wire to the femoral neck. Reduction has been maintained with the bone clamp. (**b**) AP fluoroscopic view showing positioning of the guide wire in the middle of the femoral neck. (**c**) Lateral fluoroscopic view showing positioning of the guide wire in the middle of the femoral neck. (**d**) AP fluoroscopic view showing positioning of the cephalomedullary screw in the middle of the femoral neck. (**e**) Lateral fluoroscopic view showing positioning of the nail in the middle of the distal femur. (**f**) AP fluoroscopic view showing the nail in the middle of distal femur with the insertion of two distal locking screws

Summary of Tips and Tricks-Pitfalls

Even with the use of the most sophisticated proximal intramedullary nail design, the reduction of these fractures remains of crucial importance and should obtained at all times. A skilled surgeon may treat the demanding unstable trochanteric fractures with any type of fixation device, as long as he or she remembers that the fixation device will never make up for surgical failures. Therefore, improvement of treatment of the unstable trochanteric fractures will predominantly be in the hands of surgeons, rather than in those of industry [20]. The surgeon must have the ability to use as many reduction techniques as he or she can (use of percutaneous joysticks, blocking screws, femoral distractor, open incision to clamp the fracture, cerclage wire) in order to avoid difficulties in the alignment of the fracture pattern and the implant insertion and pitfalls which dramatically increase the rate of complications and lead in poor outcomes.

Conflict of Interest The authors declare no conflict of interest in relation to the content of this chapter.

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