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Extracapsular Proximal Femoral Fractures (Pertrochanteric Intertrochanteric and Fractures with Reverse Obliquity)

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Anatomical Fracture Location: Radiograph of Fracture Pattern

Extracapsular proximal femoral fractures constitute one of the most common fractures in the elderly population. They are distinguished by their anatomical location in relation to the joint capsule (fracture is located outside the capsule zone). Intertrochanteric, pertrochanteric, and reverse oblique fractures belong to the extracapsular group of injuries. In intertrochanteric fractures, the fracture line runs along the base of the femoral neck between the trochanters (Fig. 15.1). In pertrochanteric fractures, the fracture line involves both trochanters, and usually at least one of them is fractured or separated (Fig. 15.2). These injuries are more unstable compare to intertrochanteric fractures. In reverse oblique fractures, the major fracture line extends from the proximal/medial to distal/lateral intertrochanteric

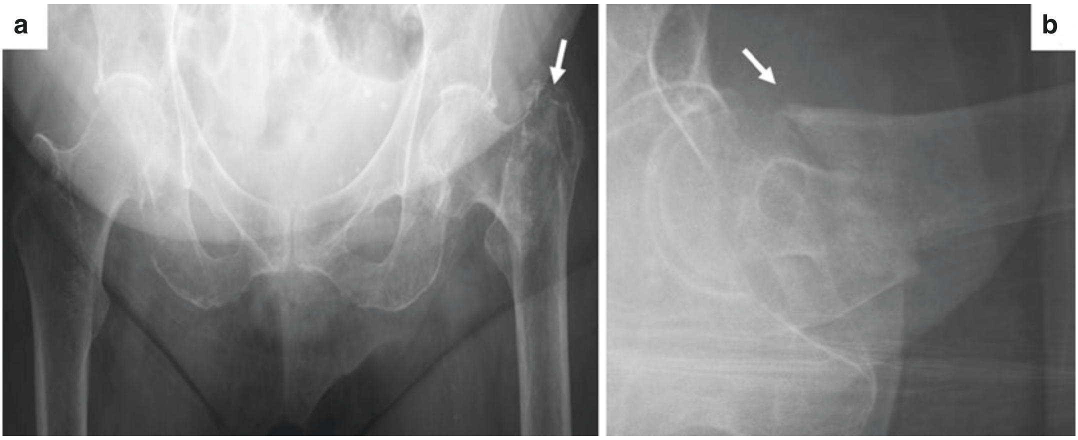

Fig. 15.1 (**a**) AP pelvis and (**b**) lateral left hip radiograph demonstrating (arrows) an intertrochanteric fracture pattern

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region (Fig. 15.3). Tendency toward medial displacement of the femoral shaft due to hip adductor pulling is a characteristic feature in this subgroup of injuries.

The main problem in the extracapsular proximal femoral fractures is the mechanical factor, not the biological: they are subject to great forces corresponding to the muscles that tend to displace the fragments. Callus formation is common in these fractures; nonconsolidations are rare, due to the absence of synovial fluid and the abundant blood supply. Our goal is therefore not only that the fracture consolidates but that it does so in the most anatomical and functional position possible.

There are many classifications of extracapsular proximal femoral fractures, but none is used predominantly. The most important thing is to define if they are stable or not.

Evans classification divides extracapsular proximal femoral fractures into stable and unstable patterns [1, 2]. The distinction between both groups is based on the integrity of the posteromedial cortex area. This classification also includes the reverse obliquity fracture pattern, in which there is possibility of medial displacement of the distal fragment.

Fig. 15.2 AP pelvic radiograph showing a left pertrochanteric fracture

All other classification systems for intertrochanteric fractures, including the AO/OTA, are variations of the Evans classification.

The AO classification describes the bone involved, the anatomical site, and the morphology of the fracture [3]. It is also the classification system most used in scientific articles.

Brief Preoperative Planning

Plain radiographs are essential imaging studies to classify the fracture pattern and carry out the appropriate preoperative planning in terms of reduction maneuvers and implant selection.

A normal radiograph does not rule out the presence of a hip fracture; 8% of patients suffering from hip pain have a hidden fracture. When a fracture is suspected and plain radiographs are inconclusive, magnetic resonance imaging (MRI) or CT scan can be requested to confirm the diagnosis. Almost all fractures of the proximal femur, if not all, should be surgically stabilized to avoid further displacement and ongoing painful stimuli and to facilitate early mobilization and weight-bearing. Conservative treatment is only considered in patients unable to walk, in those who present a clinical situation too serious to withstand an intervention, or in patients who refuse intervention.

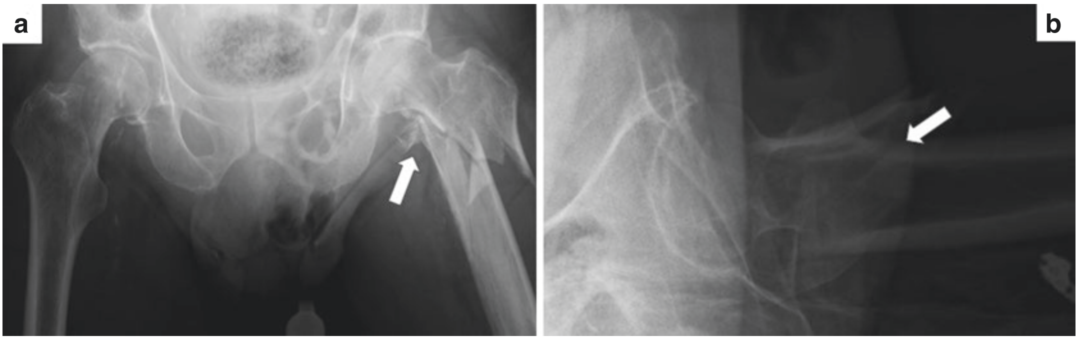

Fig. 15.3 (**a**) AP pelvic radiograph and (**b**) lateral left hip showing (arrows) a reverse oblique fracture pattern

Treatment goals are to restore the preoperative functional status and to decrease mortality and morbidity and length of hospital stay [4, 5].

Surgical fixation of intertrochanteric fractures is based on restoring the normal alignment angle between the neck and the shaft of the femur and allowing controlled collapse in both stable and unstable fractures. Regardless of the method and device used, the main technical factors that eliminate the complications of surgical treatment are restoration of alignment and correct insertion of the appropriate implant selected to stabilize the fracture. The most frequent complications reported are loss of reduction, migration of implants leading to cutout, malunion, nonunion, and avascular necrosis of the femoral head [6].

For stable intertrochanteric fractures, dynamic hip screw (DHS) continues to be the most common implant of osteosynthesis used. It allows the controlled collapse of the fracture that increases bone contact and decreases the failure of the implant. It favors impaction while at the same time it increases the intrinsic stability of the fracture.

Its advantages are easy to place, familiarity of the surgeons with their use, wide availability, high success rates, low rate of complications, and low cost.

On the other hand, the disadvantages are open technique, increased bleeding, higher failure rates in unstable fracture patterns, and excessive subsidence causing shortening of the limb. The most common angle of the DHS used is 135°. However, implants at 150° are biomechanically superior but may be associated with higher cutout risk. A variant of DHS is the dynamic helical hip system (DHHS) [7]. The spiral sheet being used here improves the rotational stability of the femoral head fragment. Another of the advantages described is that the removal of bone tissue is less with the spiral blade than with the traditional hip screw.

Cephalomedullary devices are the choice of implants for pertrochanteric, reverse oblique, and in general terms unstable fracture patterns. Their theoretical advantages in comparison to extramedullary implants are mainly biological and mechanical. From the biological point of view, intramedullary osteosynthesis respects the periosteal vascularization and does not disturb the fracture hematoma. From the mechanical point of view, the lever arm at the level of the proximal end of the femur is shorter than that generated with extramedullary methods, thereby decreasing the risk of implant failure. The most obvious biomechanical advantage of the intramedullary nail is its load sharing property. Its advantages are percutaneous insertion, greater resistance to varus, and reduced risk to subsidence and shortening. Its disadvantages are possibility of peri-implant fracture (short nails), higher incidence of nail migration, and higher cost.

When a cephalomedullary implant is selected, the lag screw should be placed in the central area of the head and reach the subchondral bone. The measurement of the tip-apex distance (TAD) (>25 mm) can predict failure of fixation particularly in the osteoporotic bone [8].

Total hip arthroplasty (THA) would only be recommended in pathological fractures, in patients with very symptomatic anterior coxarthrosis, and potentially in patients with rheumatoid arthritis who suffer an unstable fracture, since they have a higher risk of avascular necrosis and pseudoarthrosis. The surgical technique is more demanding: it is often necessary to use revision components, such as femoral stems with calcar replacement, bipolar heads, and double-mobility cups, trying to provide an increase in mounting stability due to the high risk of dislocation [9].

Patient Setup in Theater

Following general or spinal anesthesia, the patient is placed in supine position on the fracture table and closed reduction of the fracture is recommended by traction and rotation of the affected extremity. The unaffected leg using an appropriate device attached to the fracture table is abducted and flexed as far as possible to make room for the image intensifier (Fig. 15.4).

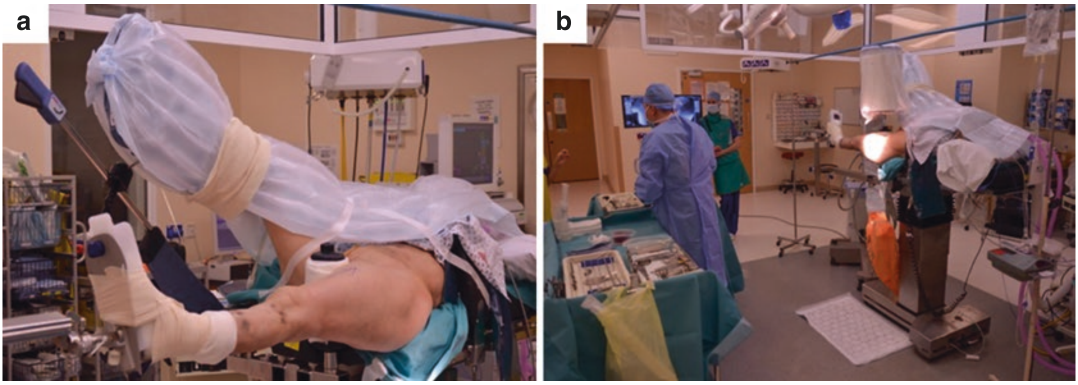

Fig. 15.4 Intraoperative pictures demonstrating (**a**) patient positioning on traction table (left affected extremity is placed on axial traction) and the right hip is flexed and abducted to allow easy access and fluoroscopic image acquisition during surgery; (**b**) image intensifier (II) in position for checking reduction prior to initiation of the procedure

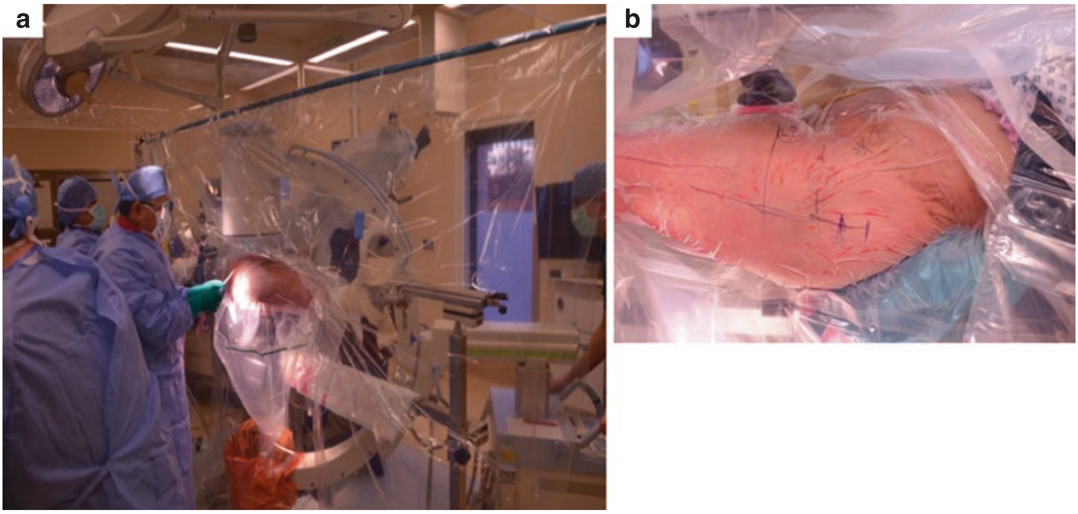

Fig. 15.5 (**a**) Intraoperative image with II in place checking the anatomical landmarks prior to skin incision; (**b**) anatomical landmarks have been marked on the skin prior to the skin incision for an intramedullary nailing procedure (greater trochanter (GT)). Incision will be made over the line extending proximally from the GT

Reduction should be achieved as anatomically as possible. If this is not achievable in a closed procedure, open reduction may be necessary. The skin all over the affected leg is prepared with usual antiseptic solutions (aqueous/alcoholic povidone-iodine). The patient is then prepared and draped as for standard proximal femoral procedures. When positioning the drapes, bear in mind that the incision will be proximal to the greater trochanter if an IM nail device has been selected to stabilize the fracture (Fig. 15.5).

Closed Reduction Maneuvers

With the aid of the axial traction, disimpaction of the fragments can be achieved and any residual varus deformity can be corrected (Figs. 15.6 and 15.7). While maintaining traction, the leg is internally rotated 10°–15° to complete fracture reduction; the patella should have an either horizontally or slightly inward position. In stable fractures, these maneuvers should be sufficient. Alternatively, greater internal rotation and a degree of abduction to increase the degree of

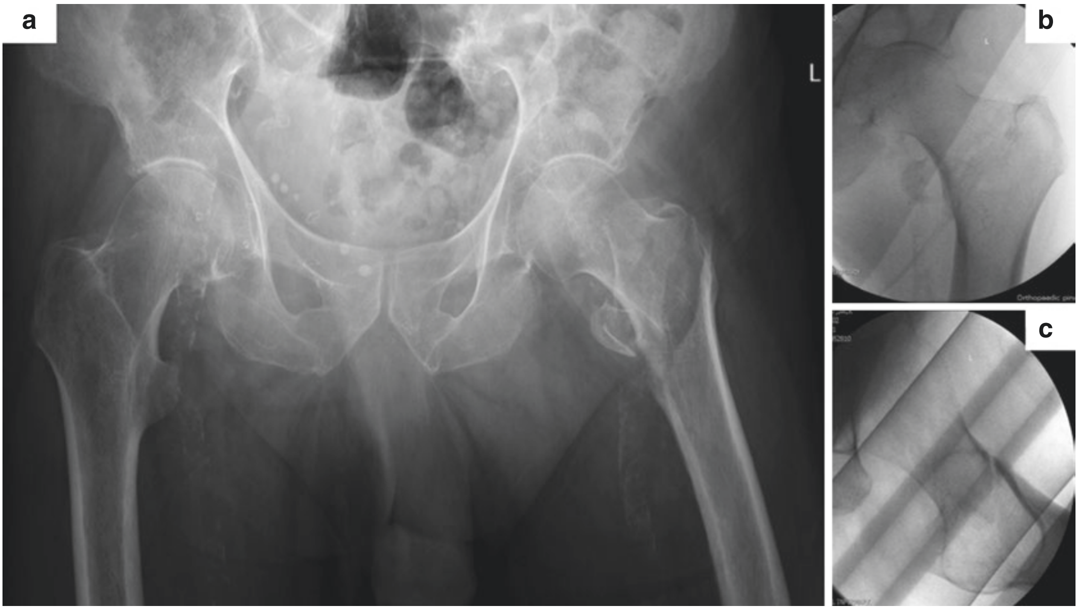

Fig. 15.6 (**a**) Preoperative AP pelvic radiograph showing a displaced left pertrochanteric hip fracture; (**b**) AP and (**b**) lateral fluoroscopic images demonstrating satisfactory closed reduction after application of axial traction and internal rotation

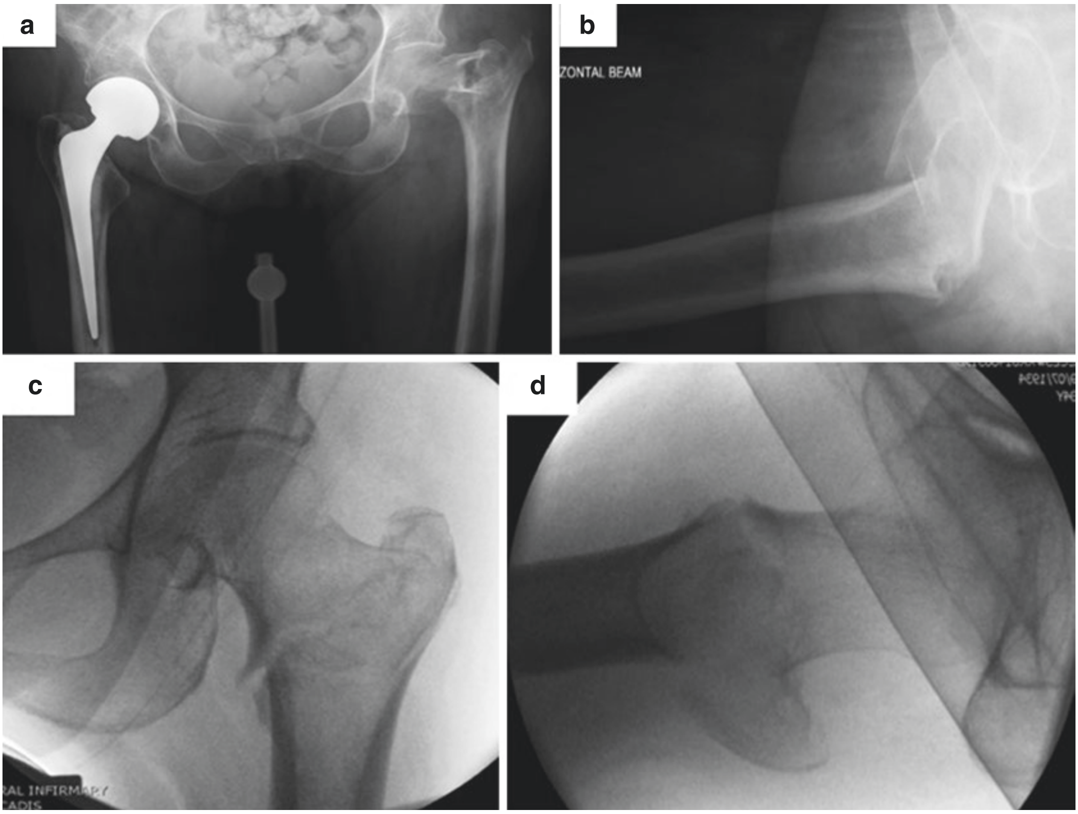

Fig. 15.7 Preoperative (**a**) AP pelvic and (**b**) lateral radiographs demonstrating a left displaced pertrochanteric hip fracture. (**c**) AP and (**d**) lateral fluoroscopic images of the left hip showing improved alignment after closed reduction

valgus might be necessary. Remember that acceptable reduction on both the AP and lateral planes is essential. Consequently, fluoroscopic imaging confirming reduction in both planes is required. Acceptable reduction is considered: between 5° of varus and 20° of valgus in the AP plane in respect to the contralateral hip and less than 10° of difference in the axial plane. A slight valgus of the fracture is acceptable and, in some cases, even convenient. In contrast, a varus reduction often results in a failure of osteosynthesis and should be avoided.

Regarding the patient's positioning, there are a number of differences to keep in mind regarding the use of a DHS and IM nailing technique. In IM nailing procedures, it is necessary to try to place the leg to be operated on a 5°–10° of adduction; Moreover, the trunk has to be tilted to the contralateral side to facilitate access to the greater trochanter.

Reduction Instruments

Reduction instruments that could be useful for open reduction procedures includes threaded K-wires, Steinmann pins, T-handle, Hohmann elevators, bone hooks, reduction clamps, cerclage wire, and ball-spike pusher.

Surgical Approach

The location of the incision depends on the selected fixation device. In the case of the intramedullary nail, the tip of the greater trochanter may be located and a horizontal skin incision of approximately 2–3 cm in length is made proximally to the greater trochanter, in line with the axis of the femur (Fig. 15.8). This is somewhat slightly posterior to what one might expect. In obese patients, a sufficiently wide incision should be made to allow the use of the insertion handle without excessive pressure of the soft tissues in the proximal area of the wound and for easy identification and appropriate selection of the entry point. A small incision is deepened through the fascia lata, splitting the gluteal muscle approximately 1–2 cm immediately above the tip of the greater trochanter and thus exposing its tip. Correct placement of the nail entry point is a crucial step of the technique and should be controlled in both projections using fluoroscopy. In the AP plane, the entry point should be located slightly medial to the tip of the greater trochanter; if it is more lateral, it can lead to excessive milling of the lateral cortex, weakening it, and a varus displacement of the fracture when the nail is inserted. In the lateral projection, the entry point should follow the axis of the femoral shaft, that is, between the anterior third and the posterior two-thirds of the greater trochanter.

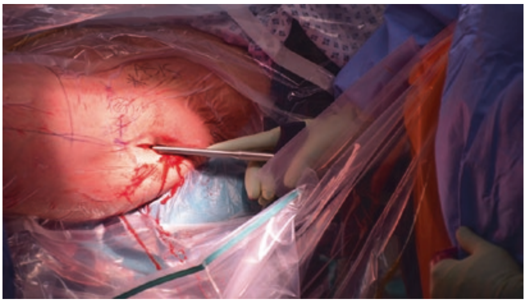

Fig. 15.8 Intraoperative image showing application of an awl for preparation of the entry point prior to the intramedullary nailing procedure

The lateral approach of the proximal femur used for the sliding hip screw must be in line with the axis of the femoral neck, but exposure of the femoral shaft must also accommodate the length of the selected side plate. It is a direct lateral approach in which the fascia lata is separated and the vastus lateralis is incised (or a flap is raised) to allow direct exposure of the lateral femoral cortex. For muscular patients or for increased proximal femoral shaft exposure, the vastus lateralis can be reflected anteriorly by adding an anterior transverse extension to the incision. Beginning proximally and posteriorly, the muscle mass is elevated from the femur and reflected anteriorly. The first perforating vessels lie on the lateral femur, approximately 5 cm below the vastus lateralis ridge (inferior border of greater trochanter). They should be identified and ligated or coagulated.

Open Reduction Maneuvers

If an acceptable closed reduction is not achieved, we can take advantage of making an open reduction to improve the reduction. A proximal fragment displaced in flexion by the effect of the iliopsoas muscle can be reduced by a periosteal elevator, a Cobb, or a Hohmann elevator placed on the anterior aspect of the femoral neck. If there is rotational malalignment, adjustment can be achieved with the introduction of a Kirschner wire allowing reduction maneuvers to take place and subsequently maintenance of reduction with the insertion of an additional K-wire stabilizing both the neck and the femoral shaft fragments. Figures 15.9 and 15.10 demonstrate reduction tips.

Implant Insertion

The mechanical effectiveness of internal fixation is determined by five independent variables: (a) bone quality, (b) fragment geometry, (c) quality of reduction, (d) implant selection, and (e) implant placement. All of these parameters are controlled by the surgeon. Implant placement in the biomechanically ideal position for the individual patient is probably the most important of the five variables.

The next step for DHS implants is the introduction of the guide wire of the cervical-cephalic screw, taking into account that the entry point for an angled 135° plate is usually located in the center of the lesser trochanter. This step is important because it will define the posterior position of the screw in the femoral head (lateral projection). There are authors who defend, in the AP projection, the centered placement of the screw in the neck and close to the subchondral region of the femoral head; others place it closer to the cortical lower neck for better screw anchorage. Finally, the lateral plate is inserted and is held in the femoral shaft with the insertion of usually four screws.

Following the opening of the correct entry point, proper proximal reaming is done to allow the introduction of the nail without producing displacement or separation of the fragments. The most recommendable placement of the cervical-cephalic screw is in the center of the head (in AP and lateral planes) or in any case somewhat lower in the AP projection. It is necessary to avoid superior positions or tip-apex distance (TAD) less than 25 mm or about 10 mm from the joint, in both planes (Fig. 15.11). It must

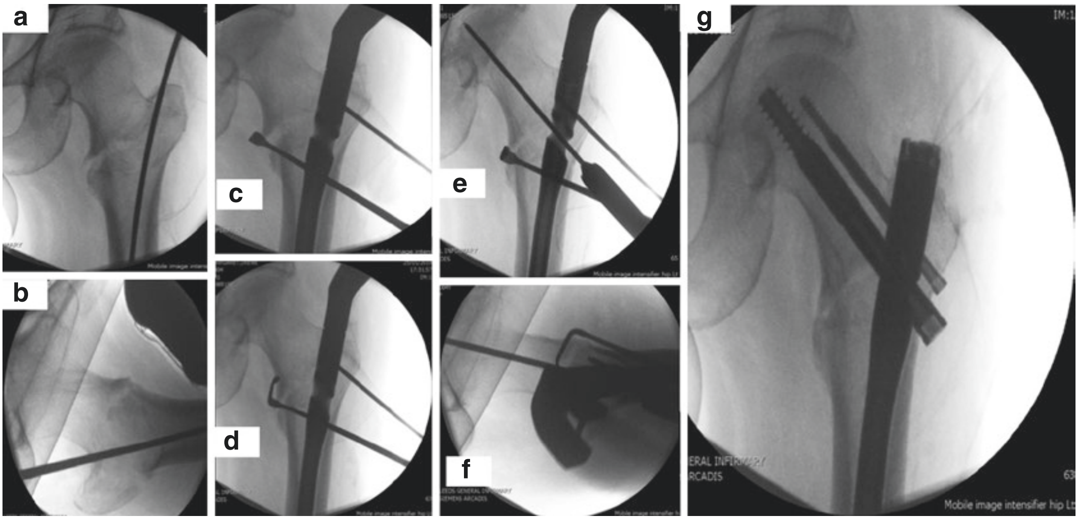

Fig. 15.9 Intraoperative fluoroscopic images demonstrating reduction maneuvers: (**a**) AP and (**b**) lateral images showing the presence of medial and anterior fracture gap and the insertion of guide wire; (**c**) AP image showing the insertion of a small langebeck over the medial neck area to improve the valgus alignment and to reduce the fracture gap by pulling; (**d**) AP image demonstrating improved reduction; (**e**) AP; (**f**) lateral images demonstrating insertion of guide wire in the center of the neck while reduction is maintained; (**g**) AP image showing insertion of a lag and anti-rotation screw in the femoral head with good reduction

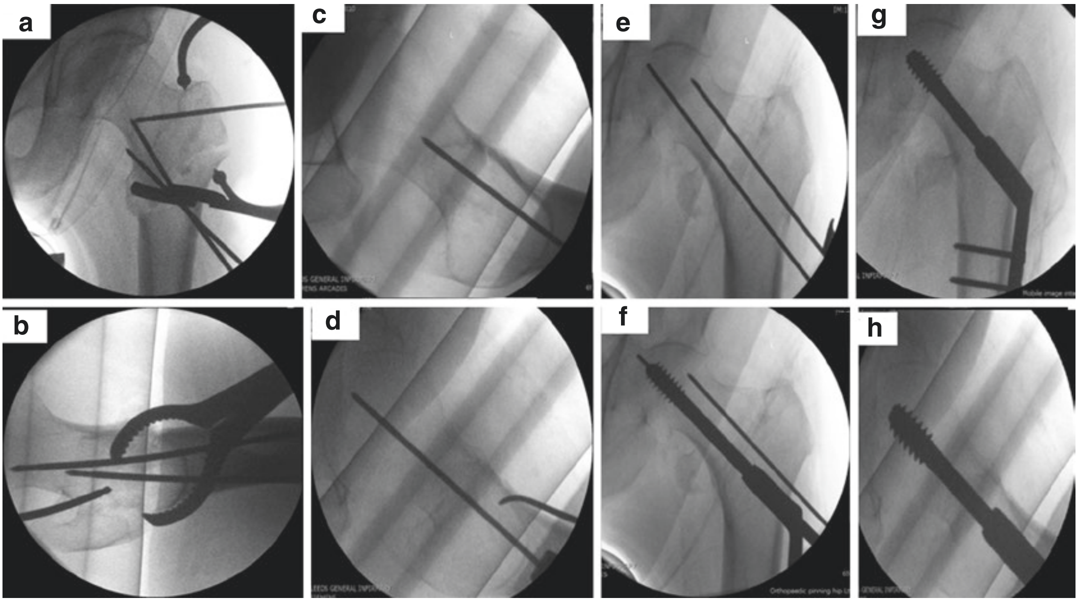

Fig. 15.10 Intraoperative fluoroscopic images demonstrating reduction maneuvers; (**a**) AP and (**b**) lateral images demonstrating reduction of a reverse oblique fracture pattern using a K-wire inserted parallel to the femoral shaft to correct the neck varus position; a pointed reduction forceps placed over the greater trochanter and the lateral femoral cortex for closing the gap; a reduction clamp placed anteroposteriorly controlling reduction in the lateral plane; insertion of two K-wires reducing the femoral shaft to the medial area of the femoral neck. A different case where (**c**) and (**d**) are in the lateral images, the application of a bone lever is placed on the anterior aspect of the femoral neck for maintenance of fracture reduction and advancement of the guide wire in the center of the femoral head. (**e**, **f**) AP images showing insertion of an anti-rotation guide wire to support the reduction achieved prior to reaming. (**g**) AP and (**h**) lateral images showing the insertion of DHS for stabilization of the fracture

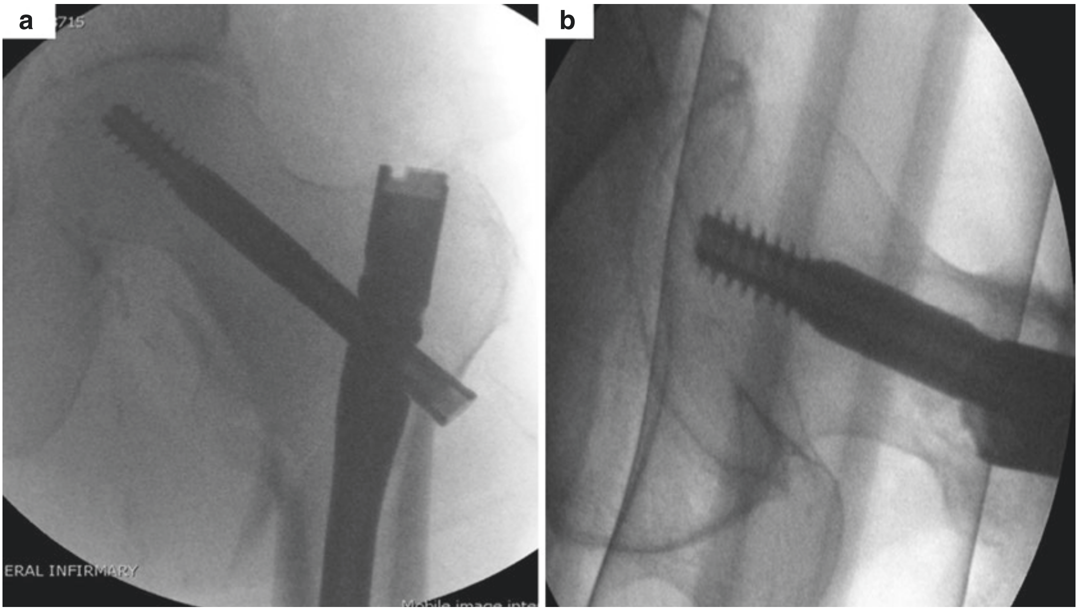

Fig. 15.11 Intraoperative (**a**) AP and (**b**) lateral images showing stabilization of a pertrochanteric fracture with a cephalomedullary nail. Note the central insertion of the lag screw on both planes of the fluoroscopic images

penetrate at least 1 cm into the subchondral bone (if not, it does not grip and acts as a stress accumulator (stress riser) being able to cause a subcapital fracture).

Summary of Tips and Tricks-Pitfalls

1. Use the tip-apex distance. The tip-apex distance is a useful intraoperative indicator of the depth and centralization of the compression screw in the femoral head, regardless of whether a nail or a plate is chosen to fix the fracture. The ideal position of the screw in both planes is about 10 mm from the subchondral bone: it has been shown that a distance less than 25 mm generally predicts a satisfactory result.
2. Assess the involvement of the lateral wall [10]. It is a factor determinant of fracture stability. If this wall is affected, it could cause medial translation of the femoral diaphysis and lateralization of the proximal fragment if a sliding screw is used. In these cases the use of DHS should be avoided and a nail must be used.
3. Take into account the anterior curvature of the femoral shaft. With aging, the diaphysis enlarges and the femoral arch increases. The radius of curvature in the diaphysis is at 114–120 cm; it is important to use nails with a radius of curvature of less than 200 cm. The use of too straight nails in an osteoporotic femur causes the nail to pinch or even perforate the anterior femoral metaphyseal cortex distally. If resistance is found during the insertion of the long intramedullary nail, a lateral X-ray of the distal femur has to be obtained, instead of trying to hit the nail with a hammer since an iatrogenic fracture can occur. Most intramedullary nails have gradually evolved into a more arched design.
4. Take into account the entry point of the nail. It is recommended a slightly medial entry point to the exact tip of the trochanter and to avoid as far as possible the lateral enlargement of this entrance hole. A placement of the nail in a more lateral position than what was intended can lead to proximal fragment malreduction or to a high position of the compression screw [11]. If the fracture line passes through the nail entry point, a medially directed force applied to the lateral trochanteric region (use a ball-spike pusher) helps preventing displacement of the greater trochanteric segment laterally during reaming.
5. Do not ream a nonreduced fracture. A misaligned intertrochanteric fracture cannot be reduced by simply passing an intramedullary nail through it. A closed reduction will be attempted and, if this is not possible, some form of percutaneous or mini-open reduction using a bone hook along the lesser trochanter or percutaneous levers without the need for denuding the periosteum or evacuation of the hematoma is advised.
6. Use caution in the nail insertion path. The use of the hammer is not recommended, as it can cause an iatrogenic fracture. It is safe to gently tap the insertion arch with mallet for final seating and fine-tune the intramedullary nail. The diversity of diameters at the distal end and the valgus angles at the proximal end of modern interlocking systems has reduced the frequency of iatrogenic femoral fractures. It is important to understand that if a hammer is needed to advance the nail, there is a problem (more reaming is required or there is compression of the anterior cortex due to discrepancy with the angle of the femur and the nail). The cause of the difficulty must be identified and corrected, since the intramedullary nail should pass manually.
7. Avoid varus angulation of the proximal fragment and use ratio between trochanter tip and femoral head center. Angulation varies the lever arm over the fixation because it makes the femoral neck more horizontal and, consequently, functionally longer when body weight is applied. This also causes the fixation of the femoral head to be higher than would be ideal and increases the risk of complications such as cutout. One way to assess the varus or valgus position during surgery is to examine the relationship between the tip of the greater trochanter and the center of the

femoral head, and these two points should be on the same plane. If the center of the head is distal to the tip of the greater trochanter, the reduction is in varus. If the center of the head is proximal to the greater trochanter, the reduction is in valgus.

8. When using nails, block them distally if the fracture shows axial or rotational instability. Most unstable fractures will require a long intramedullary nail. If we have doubts about the rotational or axial stability, we must add distal locking screws.
9. When nails are used to stabilize fractures with transverse or reverse oblique patterns, it is not uncommon for the fracture to be badly rotated or distracted. Fractures that are fixed in distraction have the risk of pseudoarthrosis and implant failure. The nail can be broken by its weakest point, which is the large hole intended for the compression screw. To eliminate distraction, the traction on the lower extremity should be released during surgery and before insertion of the distal locking screws and confirm bone-bone contact with fluoroscopy.
10. Use of methyl methacrylate (cement): Recent studies have demonstrated that the use of cement around the tip of the cephalic screw increases the grip of the implant to the bone [12]. This effect is even greater when the reduction or placement of the cephalic screw is suboptimal.

Conflict of Interest No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this chapter.

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