Review article

Treatment of recent trochanteric fracture in adults

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**ABSTRACT**

Recent trochanteric fracture is frequent in adults, and mainly affects elderly patients who risk loss of independence. Treatment is surgical, of various sorts. Open reduction internal fixation (ORIF) with intra- or extra-medullary implants is the most frequent attitude in these fractures, which usually heal easily. In elderly patients, arthroplasty is an alternative choice for some authors. These different treatment modalities are presented, focusing on technical details. Possible technical difficulties and the means of dealing with them are considered. Published results help in choosing the treatment most suitable for a particular type of fracture in a particular patient.

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1. Introduction

Recent trochanteric fracture in adults overwhelming affects elderly subjects. Frequency is increasing with population aging [1] despite the development of treatments for osteoporosis. Preventive measures based on anti-shock trousers have failed to demonstrate efficacy, due to poor compliance [2,3].

In elderly subjects, fracture entails a serious risk of loss of independence best reduced with surgery (usually conservative) that should be undertaken with minimal delay.

The two most widely used types of open reduction internal fixation (ORIF) are intra-medullary nailing and screw-plate fixation, often performed by trainee surgeons due to their frequency and reputed simplicity [4,5].

2. Definition

Trochanteric fracture involves the proximal femur between the cervical region and the shaft. Subtrochanteric fracture, with a fracture line running from an area within 5 cm distal to the lesser trochanter, is usually also included in the definition [6].

3. Classifications

There are numerous classifications of trochanteric fractures, based on fracture line location [7,8] and on displacement and the consequences for external reduction maneuvers [9]. Two classifications are particularly widely used:

- the Evans classification [10], modified by Jensen and Michaelsen [11], is based on fracture site stability and comprises 5 types, from non-displaced 2-fragment (Type I) to medially and posterolaterally comminuted fracture (Type V) (Fig. 1);
- The AO classification [12] comprises 3 groups:
  - 31A1: simple 2-fragment pertrochanteric
  - 31A2: multi-fragment pertrochanteric
  - 31A3: intertrochanteric, each subdivided into 3 subgroups (Figs. 2–3).

Both classifications have limited inter- and intra-observer reproducibility, although this is better in the AO classification at the level of the 3 principal groups [13].

4. Epidemiology

Trochanteric fracture mainly affects the elderly. Together with femoral neck fracture, it constitutes the category of proximal femoral fractures, for which more than 80,000 cases were reported in France in 2005.

In elderly subjects, trochanteric fracture results from bone fragility associated with frequent falls, induced by certain medical drugs such as hypnotics and also recent antihypertensive treatments [14].

5. Diagnosis

Classically, trochanteric fracture affects subjects aged >75 years, with a distinct female predominance.

It often follows a simple high fall, resulting in total lower-limb impotence. The classic deformity pattern of shortening, adduction and external rotation may not apply when there is no displacement.
6. Treatment objectives

In the elderly, there is a risk of general complications and especially of loss of independence and, in particular, of walking capacity.

The chosen treatment should allow verticalization and early seating, to avoid the serious complications associated with decubitus.

Treatment should involve as little shock, surgery time and blood loss as possible so as not to impair recovery.

Ideally, it should allow resumption of unrestricted weight-bearing, which is the best guarantee of conserving walking capacity.

Whatever the treatment, associated measures comprise pre- and post-operative pain management, prevention of venous thromboembolism, dietary supplementation if necessary, and muscle exercise.

7. Treatments

7.1. Functional treatment

Functional treatment of trochanteric fracture is reserved to strictly non-displaced fractures in cooperative patients. It comprises non-weight-bearing for the fractured limb and limited hip flexion awaiting radiologic fusion. The main risk is of secondary displacement. Elderly patients are not ideal candidates, due to the serious risk of loss of independence. In case of absolute anesthesiological or surgical contra-indication, functional treatment may be the only option in a situation of obligatory therapeutic abstention, but with a mortality rate exceeding that of surgery.

7.2. Conservative treatment

Conservative management was codified by Böhler, specifying traction time (10–14 weeks) and direction according to fracture line location and fragment displacement.

Due to the long decubitus required, conservative treatment is nowadays exceptional, reserved to rare cases of anesthesiological contra-indication.
7.3. Surgical treatment

Surgical treatment is the rule. It should be performed as quickly as possible after stabilization of vital functions [16,17].

7.3.1. ORIF

7.3.1.1. Patient positioning. Positioning seeks to achieve at least partial fracture site reduction. ORIF is greatly helped if the fracture site is already reduced before the procedure. These initial reduction techniques are performed closed or semi-open, under fluoroscopy.

Whenever the type of ORIF (intra-medullary nailing or screw-plate), installation is on a traction table. Transosseous traction is not usually required; traction using a shoe of appropriate size is enough. Dorsal decubitus has the advantage of simplicity and good hemodynamic and ventilatory tolerance in patients whose general health status may be poor; some teams, however, prefer lateral decubitus, which provides good control of rotation.

It is essential to check that AP and lateral views can easily be taken by the electroradiological operator at any time. When possible, use of two fluoroscopes allows simultaneous AP and lateral control of reduction.

Once the patient is positioned in traction along the axis of the limb, reduction is checked, comparing morphology to that of the healthy hip on AP pelvic view.

If the fractured femur is in varus relative to the healthy side, axial traction should be increased; if it is in valgus, traction should be relaxed.

Once femoral morphology has been satisfactorily restored frontally, the lateral view is controlled. Lateral reduction can be adjusted by rotating the limb, starting with the patella at the zenith. As there is often posterior comminution, reduction is often achieved in internal rotation, which should, however, be moderate due to the risk of malunion in internal rotation, which would greatly hinder recovery of walking capacity [18]. Certain fractures are reduced in external rotation, as the pelvic and trochanteric muscles conserve their external rotational action on the proximal fragment; these are what are called “extradigital” fractures [19].

Thus simple limb positioning on the fracture table can adjust varus/varus frontally and rotation laterally (Figs. 4–6). It cannot, however, reduce displacement of fragments in sagittal translation or flexion of the proximal with respect to the distal fragment: these displacements require peroperative action directly on the fragments themselves. Such complementary reduction should be performed before creating the entry points for the fixation material. Quality of reduction and appropriate implant positioning determine the final result [20].

7.3.1.2. Reduction-aid techniques. Various reduction-aid techniques can be used.

Posterior support: this can be used to avoid posterior translation of the distal fragment in subtrochanteric or trochanteric-diaphyseal fracture, especially in obese patients (Figs. 7 and 8).

A Wagner raspatory on the anterior side of the neck reduces proximal fragment flexion caused, notably, by non-compensated psoas-iliac muscle traction (Figs. 9 and 10).
Open reduction with positioning of a bone-holding forceps may be necessary in subtrochanteric fracture with muscle incarceration within the fracture site [21] (Figs. 11 and 12).

Temporary cerclage can prevent reduction loss during osteosynthesis.

Precise reduction facilitates the location of the intra-medullary nail entry point, enabling reaming to prepare the nail lodge, reducing the risk of correction loss when the nail is introduced [22].

The advantages of anatomic reduction outweigh the harmful impact of local devascularization on fusion [23]. Optimal reduction is also important with screw-plates, to locate the entry point of the cervical screw and align the plate with the lateral side of the proximal shaft.

7.3.1.3. Types of internal fixation. Rather than contrasting open versus closed techniques, we shall distinguish internal fixation according to the extra- versus intra-medullary position of the material.

7.3.1.3.1. Extra-medullary material.
7.3.1.3.1.1. Blade- and nail-plates. Historically, blade-plates and nail-plates were the first types of internal fixation.

After reduction, implantation used a lateral approach, raising the vastus lateralis.

Material angulation varied according to fracture line type: 130° in pertrochanteric fracture and 95° in intertrochanteric fracture with horizontal line or subtrochanteric fracture.

Blade or nail position was determined using K-wires under fluoroscopy.

For 130° blades, a minimum 10 mm distance between the end of the blade and the contour of the femoral head was aimed at, to ensure against initial protrusion.

The monoblock design of these implants had the advantage of maintaining correct reduction. In case of comminution, fracture site

A K-wire in the proximal fragment reduces rotation disorder, especially excessive external rotation of the proximal fragment. Without prior correction, there is a major risk of malpositioning the entry point of an intra-medullary nail and of excessive femoral anteversion.
impaction along the blade or nail, however, entailed a serious risk of material penetrating the joint.

7.3.1.3.2. Screw-plates. Screw-plates encountered great success, due to their ease of implantation and the possibility of controlled sliding of the cervical screw, inducing fracture site impaction to promote fusion with a reduced risk of joint penetration by the material.

The technique is as follows:

- after fracture site reduction, a lateral subtrochanteric approach is performed, raising the vastus lateralis;
- femoral neck anteversion is estimated, and a cervical guide-wire is placed in a central position frontally and laterally using a guide angled according to the plate used (130°, 135° or 140°, depending on the model) under fluoroscopy. In subtrochanteric fracture, an angle of 95° is used [24];
- screw length should take account of the possibility of compression of the site;
- the trajectory of the cervical screw and of the plate barrel is prepared using a triple reamer;
- a temporary anti-rotation wire may be fitted if necessary before inserting the cervical screw;
- a flat section on the screw and plate avoids one rotating with respect to the other;
- the fracture site can be compressed peroperatively; otherwise, compression is ensured by the dynamic assembly;
- a supplementary cervical screw may be positioned in parallel proximal to the first screw, to neutralize rotation force;
- in complex fracture, a lateral greater trochanter support plate may be associated, allowing extra screws for fixation.

Screw-plates may be fitted on a minimally invasive approach (Fig. 13), limiting blood loss [25].

Locking the distal diaphyseal screws has been recommended to improve stability in case of osteoporosis, with encouraging experimental results [26]. There is, however, a risk of perforation of the head and of fracture of material in case of varization of the fracture site, due to the lack of play between plate and screws [27].

7.3.1.3.2. Intra-medullary material.

7.3.1.3.2.1. Ender’s flexible nailing. Flexible nailing, following Ender, was very much in fashion in the 1970s and 1980s.

Introducing a small-diameter elastic nail very remotely from the fracture site, in the medial side of the distal femur, may still be indicated in case of pre-existing skin lesions in the trochanteric region.

With the surgeon between the lower limbs, the patient is positioned with both lower limbs in abduction, enabling the site to be valgized to facilitate nailing. A large enough metaphyseal bone window allows 3 precurved nails to be introduced.

Although the use of locking nails limits sliding and the occurrence of skin problems at the knee [28], weight-bearing is not allowed and there is a high rate of malunion in external rotation. For these reasons, this technique has been abandoned in favor of more rigid internal fixation.

7.3.1.3.2.2. Intra-medullary nailing. Intra-medullary nailing is an effective attitude in trochanteric fracture [29]. With the optimization of positioning instrumentation, favoring minimally invasive insertion, and the mechanical advantage inherent to intra-medullary material in complex fracture, nailing has become increasingly widespread compared to screw-plate fixation [30,31].

After reduction, the introduction area is located under fluoroscopy. Laterally, introduction follows the long axis of the femoral shaft, so that the trochanteric entry point can be determined only after reduction.

To optimize access to the summit of the greater trochanter, the lower limb must not be placed in adduction, varizing the fracture site; rather, the trunk should be inclined laterally on the side opposite the fracture (Fig. 14) and the position maintained by a lateral thoracic support. In obese patients, the incision is then shifted proximally.

The angle of the nail is adapted to the morphology of the proximal femur, and the entry point is determined according to the specifications for the particular nail.

There is a risk of over-reaming the lateral part of the proximal femur, especially when the guide is lateral to the fracture site. To avoid such eccentric reaming, a slight hyper-reduction in valgus during reaming prevents the trochanter being weakened laterally and thus prevents varus displacement when introducing the nail [32].

The metaphyseal and proximal diaphyseal region must be reamed sufficiently, at least 2 mm more than the diameter of the nail, to avoid the nail, which is straight whereas the proximal femur is curved, becoming stuck when it descends.

The descent of the nail determines the subsequent position of the cervical screw.
On AP view:

• giving the screw a low position delays joint breakage in case of varization of the fracture site;
• positioning the screw in the center of the femoral head provides a more solid bone anchorage while allowing the distance between the end of the screw and the apex of the head to be reduced, to improve stability [33] (Figs. 15–16).

On lateral view:

o ideally, the screw is centered in the femoral neck and epiphysis, maximizing before cut-out [34];
o excentric lateral positioning could trigger rotation of the proximal fragment, leading eventually to perforation of the femoral head [35].

If the fracture line is at the base of the head, fitting an anti-rotation wire before inserting the cervical screw reduces the risk of proximal fragment rotation.

The cervical screw needs to be long enough and go far enough into the epiphysis (“combined tip-apex distance”: the sum of the distance measured frontally and laterally, <25 mm), while keeping a safety margin of at least 5 mm between the top of the screw and the projection of the femoral head on AP and lateral views [36].

The lateral end of the cervical screw should go slightly beyond the lateral cortex of the femur, so as subsequently to be able to slide.

There are various specificities to different manufacturers’ models: the cervical screw may have the form of an “anti-rotation blade”, intended to provide better epiphyseal anchorage in porotic bone [37].

Associating a blocking system prevents the screw or blade rotating with respect to the nail, without preventing sliding, thereby allowing compression of the fracture site. Without such locking, there is a risk of post-operative intrapelvic migration of cervical material [38,39] (Figs. 17–19).

Distal locking of short intra-medullary nails is performed using the nail-holder device.

A short nail may be used in pertrochanteric fracture detaching the lesser trochanter if the fracture line does not extend more than 5 cm distally to the lesser trochanter and the patient is not morbibly obese.

For more distant fracture lines and subtrochanteric fracture and in morbidly obese patients, a long nail is required. In that case, distal targeting classically uses the “round holes” technique. Distal locking aids (e.g., the Distal Targeting Device, StrykerTM), intended to reduce the radiation involved in distal targeting, have recently been assessed.

7.3.1.3.3. Improving epiphyseal bone anchorage. Intra-osseous acrylic cement may improve epiphyseal anchorage. After an experimental validation phase [40,41], acrylic cement was successfully associated to treat unstable trochanteric fracture in severe osteoporosis, using screw-plates or intra-medullary nails [42,43].

7.3.1.3.4. External fixation. External fixation represents an interesting alternative for stabilizing type 31A1 or 31A2 fracture in fragile patients, as it involves little shock.

The various assemblies available all begin with reduction on the fracture table, followed by fitting two series of pins: one oblique at 130° to the diaphyseal axis with epiphyseal fixation, and one using bicortical diaphyseal pins.

The most frequent complication is infection on the pins, with an incidence of 7% for standard pins [44]. With the advent of hydroxyapatite-coated pins, this complication has almost completely disappeared [45].

In case of non-union, revision using internal fixation entails a risk of infection.

7.3.1.4. Hip replacement. Some teams prefer hip replacement, especially in unstable fracture in elderly patients who remain able to walk, in whom internal fixation anchorage may be problematic. The rate of early mechanical failure in ORIF at advanced stages on the Singh classification is indeed an indication for hip replacement, as in cervical fracture [46–49].

Mortality seems no higher after hip replacement than after ORIF [50,51]. Comparative studies between the two are, however, few, and no definite conclusion can be drawn [47,52].

Pre-operative planning and landmarking (lesser trochanter, greater trochanter, trochanteric fossa, femoral expansion of gluteus maximus, etc.) allows lower-limb length to be almost equalized.

All approaches are feasible. In case of continuity between the gluteus medius and vastus lateralis caused by a fracture detaching the greater trochanter, a transcortical approach provides excellent access to both acetabulum and femur, but requires painstaking reconstruction, repositioning the greater trochanter by cerclages or a trochanteric hook plate.

Implants may be cephalic, bipolar or total, using standard or revision femoral components. Large heads, bipolar heads or dual mobility sockets provide extra stability, which is useful because of the risk of dislocation [51] (Fig. 20).

8. Clinical forms and therapeutic specificities

8.1. Fracture in young subjects

In young subjects, trochanteric fracture results from violent trauma, and is usually displaced. Muscle incarceration in the
fracture site is not unusual and hinders reduction by isolated external maneuver.

In young subjects, the greater frequency of material ablation and the room taken up proximally by intra-medullary nails may justify more frequent resort to screw-plates, especially in stable fractures.

8.2. Fracture of pathological bone

The proximal femur, and the metaphyseal region in particular, is a common location for bone metastasis. Absence of apparent trauma, presence of osteolysis and isolated lesser trochanteric fracture suggest tumor, especially metastatic or myelomatous in elderly subjects.

Depending on expected survival and tumor location and extension, treatment may comprise resection of the affected area and implantation of a mega-prosthesis or, if survival is more limited, internal fixation by intra-medullary nailing to reinforce the femur all the way down [53], possibly associating acrylic cement.

8.3. Fracture in osteoarthritic hip

Osteoarthritis is an argument for hip replacement. Total hip replacement is a logical attitude in case of trochanteric fracture
associated with symptomatic osteoarthritis and a sufficient pre-operative Parker score. A dual mobility socket reduces the risk of post-operative instability in this particular indication [51]. In patients with a very low-pre-operative Parker score, on the other hand, ORIF is sufficient, allowing nursing care and avoiding the problems of decubitus.

9. Associated measures

In trochanteric fracture, ORIF is performed under antibiotic prophylaxis. Thromboprophylaxis is initiated post-operatively if there is no hemorrhagic syndrome. A suction drain is reserved to wide approaches. Weight-bearing up to the pain threshold is allowed post-operatively after intra-medullary nailing or in stable fracture managed by screw-plate. Only touch weight-bearing is allowed if the assembly seems less secure in unstable fracture.

In elderly patients, hardware is not ablated except in case of infectious or mechanical complications or of prosthesis replacement.

10. Treatment results

In trochanteric fracture, ORIF shortens the affected limb by a mean 11 mm at fusion, and more in unstable fractures. For a given type of fracture, there is less shortening with intra-medullary nailing than with a screw-plate [54].

Intra-medullary nailing is increasingly used, but seems to give better results than screw-plates only in subtrochanteric fracture [55] (Figs. 19 and 20).

Reduction defect in varus is to be avoided, using direct manoeuvres if needed, as it is more often associated with defective fusion. Depending on the assessment criteria, functional results do not significantly differ between hip replacement and ORIF [56].

In elderly subjects, prognosis for trochanteric fracture is poor, with 6-month mortality exceeding 25% and lowered walking scores and Parker independence scores for survivors [57].

11. Conclusion

Treatment of trochanteric fracture is well codified. Risk of failure increases with imperfect reduction, poor implant positioning and advanced osteoporosis. The development of ORIF simulation, which is still in its early stages, should reduce the rate of technical error [58].

Disclosure of interest

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