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TECHNICAL NOTE • HIP - FRACTURES

Reduction techniques for difficult subtrochanteric fractures

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Abstract

Subtrochanteric fractures can result from high-energy trauma in young patients or from a fall or minor trauma in the elderly. Intramedullary nails are currently the most commonly used implants for the stabilization of these fractures. However, the anesthetic procedure for the patients, the surgical reduction and osteosynthesis for the fractures are challenging. The anesthetic management of orthopedic trauma patients should be based upon various parameters that must be evaluated before the implementation of any anesthetic technique. Surgery- and patient-related characteristics and possible comorbidities must be considered during the pre-anesthetic evaluation. Adequate fracture reduction and proper nail entry point are critical. Understanding of the deforming forces acting on various fracture patterns and knowledge of surgical reduction techniques are essential in obtaining successful outcomes. This article discusses the intraoperative reduction techniques for subtrochanteric fractures in adults and summarizes tips and tricks that the readers may find useful and educative.

Keywords Hip fractures · Subtrochanteric · Reduction techniques · Anesthesia

Introduction

The subtrochanteric region of the femur extends 5 cm distally from the inferior border of the lesser trochanter. The fractures of this area can occur as a result of high-energy trauma in a younger population but are also common as a result of a fall or minor trauma in the elderly because of osteopenia. The intramedullary nails that are currently most commonly used for the stabilization of these fractures seem to be superior compared to the extramedullary implants such as the sliding hip screw; intramedullary nails are therefore considered the gold standard for the treatment of most subtrochanteric hip fractures in adults [1–8]. However, the surgical reduction and nailing of these fractures are challenging. Adequate fracture reduction and proper nail entry point are critical. 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 article discusses the intraoperative reduction techniques for subtrochanteric fractures in adults and summarizes tips and tricks in a comprehensive review that the readers may find interesting and enjoyable.

Operating table and instruments

In preference, most patients with subtrochanteric fractures to be treated with an antegrade intramedullary nail should be positioned supine on a radiolucent traction table. The traction table is the best assistant for the orthopedic surgeon, allowing to perform the procedure in static environment. Surgeons, who are familiar with the leg free technique, prefer standard operating tables commenting on the laborious setup and the technical difficulties in the precise manipulation of the lower limb during the operation [9, 10].

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However, although the preoperative setup with the traction table requires additional time, intraoperative fluoroscopy guidance is easier with stable traction without the need for a dedicated assistant to hold traction exclusively throughout the procedure.

The standard nailing set and the large fragment reduction instruments should be available for the nailing of subtrochanteric fractures. The latter should include large bone clamps, mallet, Hohmann retractors and ball-spike pushers or bone hooks. If the fracture pattern is more complex, Schanz pins and cerclage wires should also be available.

Patient positioning

The operation is performed with the patient under general, neuraxial anesthesia and/or peripheral nerve blockade and sedation after appropriate pre-anesthetic evaluation. Antibiotic prophylaxis administered approximately 30 min prior to the surgical incision. 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 opposite to the fractured side and stabilized with a thoracic belt or a post in order not to obstruct the incision, entry point, guide wire insertion and reaming of the femur, thus avoiding to enlarge the proximal incision [11]. The opposite leg is placed in flexion and abduction in a foot plate or boom holder to make enough room for the C-arm. The fractured leg is tied securely in a foot plate and the leg is placed in adduction, while longitudinal traction is applied through the leg holder. Care is given for the proper and secure tying of the foot to the foot plate in order to avoid skin abrasions or accidental loosening of the foot during the operation. We do not recommend skeletal traction using a Steinmann pin in the distal femoral condyles because it increases surgical complexity and trauma and it may interfere with the distal locking screw if a long nail is to be used.

After traction is applied, the foot is put to neutral or slight external rotation position, and fracture position/reduction is evaluated by fluoroscopy in anteroposterior (AP) and lateral views. If reduction is considered acceptable, the surgeon may proceed with skin sterilization and 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. If reduction is not acceptable, usually the distal fracture fragment is in posterior translation; in this scenario, to facilitate reduction and osteosynthesis, a crutch may be positioned under the distal fracture fragment to elevate the fragment and obtain bone apposition (Fig. 1a–c). If horizontal pelvic tilt is observed that increases external rotation of the proximal fracture fragment, the surgeon should correct with sand bags or sheets

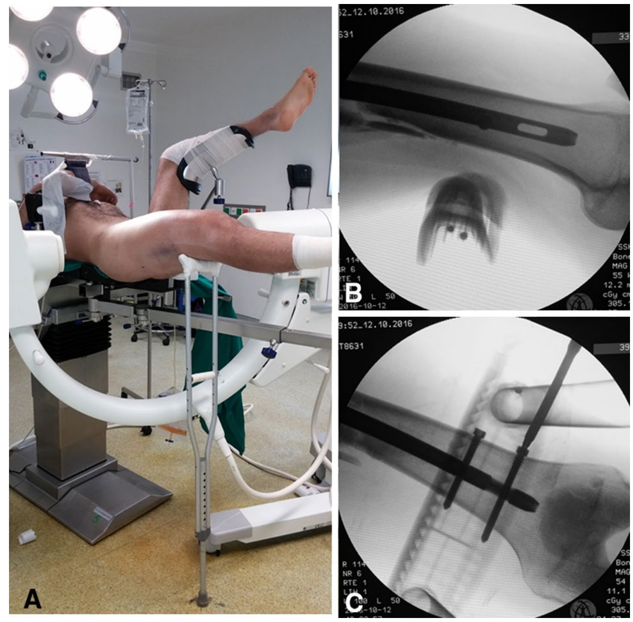


Fig. 1 **a** A crutch is positioned under the distal fracture fragment to facilitate reduction in a young patient with a comminuted subtrochanteric fracture extending to the femoral diaphysis. **b** Lateral and **c** AP intraoperative fluoroscopy views at distal locking of a long trochanteric hip nail

placed under the ipsilateral buttock or with adjustment with the fracture table itself [12].

Fracture patterns

The fracture pattern should be carefully assessed in the decision for the reduction technique. Usually, the proximal fragment under the contraction of the iliopsoas muscle is displaced in flexion, abduction and external rotation. The adductors pull the distal fragment of the femur toward the midline and in combination with the gravity force and externally rotate it. Shortening of the limb is caused by the combination of all muscle forces that are attached on the distal fragment [12]. The above deformity creates a pattern that is very difficult to be reduced during closed intramedullary nailing [13]. More complex fracture patterns may exist that further complicate reduction and osteosynthesis; fracture and separation of the greater trochanter from the proximal femur may complicate reduction and insertion of the optimal entry point for nailing [14]. In contrast, traverse fractures could be reduced easier using closed reduction methods, in contrast to spiral patterns that most of the time require open reduction methods. In the latter case, to avoid large approaches and protect the biology of the fracture site that promote fracture healing and reduce the risk for complications, minimal invasive techniques as described in this paper are recommended.

Closed reduction techniques

On the traction table, the fractured leg should be adducted approximately 10–15° to achieve the optimal entry point. A sandbag is placed under the ipsilateral buttock or the table is tilted to the opposite direction to eliminate external rotation of the proximal fragment [12]. Rotational alignment of the distal fragment is evaluated with the fluoroscopy and corrected by rotating the foot plate. The surgeon must remember that the hip is already internally rotated if a sandbag under the buttock is used or the fracture table is tilted to the opposite side; therefore, rotation of the leg cannot be estimated with the patella as a guide. If the distal fragment drops posteriorly, the foot plate should be elevated 2–3 cm (20–30°) [15], or a crutch could be positioned under the distal fragment at the respective height that is assessed by fracture reduction with the fluoroscopy [10, 16]. A mallet or a hammer can be used for indirect reduction in the subtrochanteric fracture; this applies an external force to the fracture fragment into proper reduction. The disadvantage of this technique is that the maneuver used for fracture reduction and guide wire passing must be repeated during reaming to avoid eccentric reaming that may result to improper reduction.

Once reduction is considered appropriate, a straight lateral incision of 4–5 cm is performed, starting 2 cm proximal to the greater trochanter in line with the axis of the femur. The tensor fascia lata and the abductor muscles are incised in line with the skin incision, the glutei are dissected bluntly and the greater trochanter is palpated. The optimal entry point must be located with the cannulated awl according to the specifications of the intramedullary nail to be used; almost all intramedullary hip nails are inserted through a greater trochanter entry point. We recommended the trochanteric entry point to be placed slightly more medial to the tip of the greater trochanter in the AP view and in the center of the greater trochanter in the lateral view [11, 17]. This avoids lateral insertion of the nail and varus reduction or high position of the head screw.

When the optimal position of the awl is confirmed with the fluoroscopy, the tipped guide wire is advanced through the awl to the proximal fragment. We recommend the guide wire to be pre-bended slightly at its distal part to facilitate advancement through the fracture fragments. The guide wire should be advanced to the distal fragment, approximately to the proximal pole of the patella. The final position of the guide wire is assessed with the fluoroscopy; the tip of the guide wire should be viewed in the middle of the femoral condyles in both the AP and lateral views. Then, reaming should start. Do not ream until you ensure adequate contact with the greater trochanter at the entry point, as this may lead to lateral enlargement of the pilot hole [11].

Minimally invasive reduction techniques

In complex subtrochanteric fractures and in those that close reduction was not feasible or acceptable, open reduction techniques should be used. In this case, to preserve the fracture biology minimally invasive reduction techniques are recommended.

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 applied with the power drill in respective fragments and used with a T-handle as joysticks giving the surgeon the ability to manipulate the fracture fragments for optimal reduction and advancement of the guide wire [18]. Reduction in the fracture and application of the Schanz pins should be assessed with the fluoroscopy before the reaming process (Fig. 2a–c). This technique is almost atraumatic and allows maintenance of the reduction during reaming of the intramedullary canal and nailing [19].

Instruments such as a ball-spike pusher, a bone hook, or Hohmann retractors can be used for direct reduction in the fracture through a stab incision to the skin and blunt dissection through the fascia at the fracture site. Positioning of the instrument must be strategically chosen in order to allow for proper fragment manipulation (Fig. 3a–c). If a ball spike is used, a small unicortical hole to the bone with a 2.7-mm drill is recommended to avoid slip and displacement of the instrument. In typical subtrochanteric

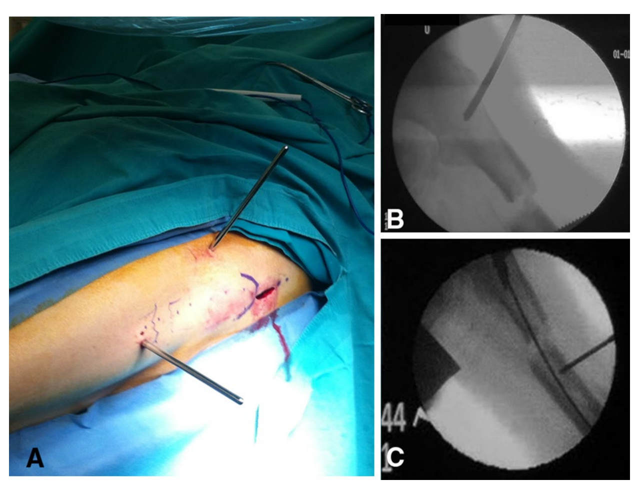


Fig. 2 **a** Minimally invasive reduction in a transverse subtrochanteric fracture with percutaneous Schanz pins. **b** A Schanz pin is inserted to the proximal fragment and **c** another pin to the distal fragment to facilitate reduction

fractures, in which the distal fragment is adducted, lateral traction of the distal fragment with a bone hook may be helpful for reduction. In this particular scenario, a bigger incision of about 3–4 cm is necessary, 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 (Fig. 4a, b). Similarly, a hook may be used for reduction in the proximal fragment followed by stabilization with a reduction bone clamp (Fig. 5a–c). In complex comminuted fractures, through the same incision, manipulation of the fracture fragments can be done with strong forceps (Fig. 6a, b).

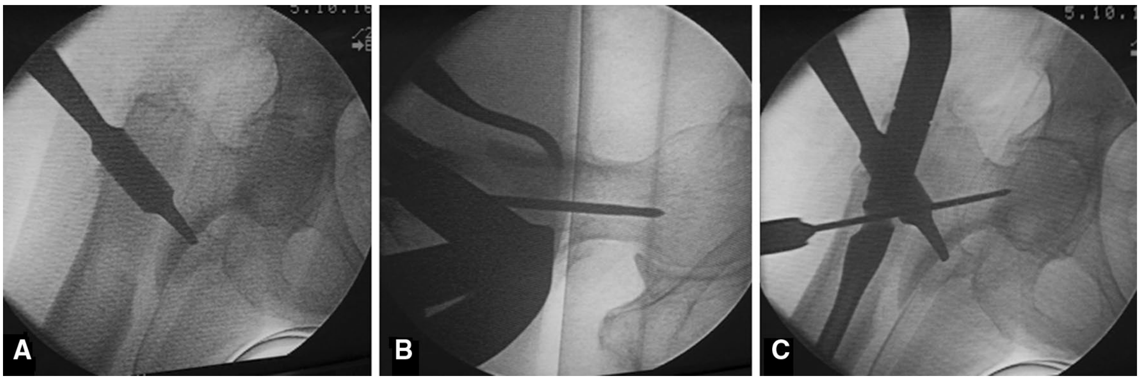
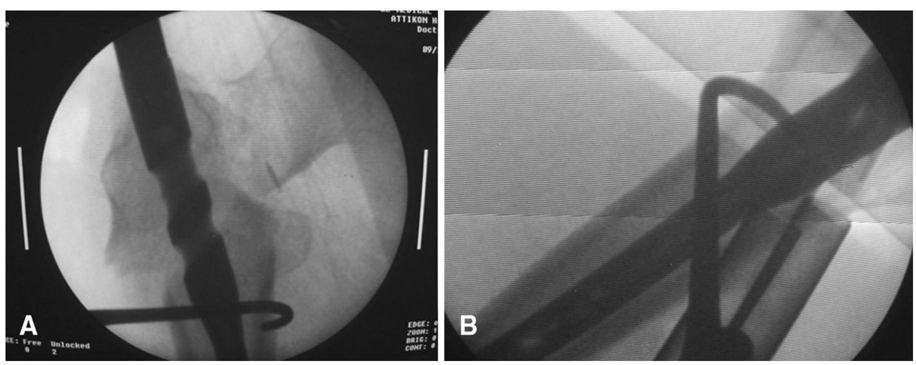


Fig. 3 **a** AP and **b** lateral fluoroscopy views show minimally invasive reduction in a pertrochanteric fracture with a Hohmann retractor. **c** The retractor was retained in place through the procedure

Fig. 4 **a** AP and **b** lateral fluoroscopy views show reduction in the distal fracture fragment of subtrochanteric fracture with a bone hook



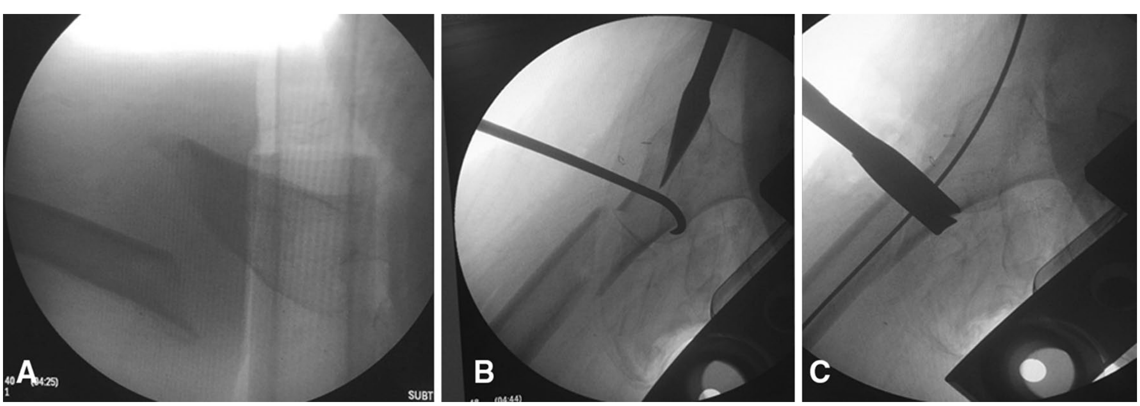


Fig. 5 **a** A displaced long oblique subtrochanteric fracture **b** reduced with a bone hook and **c** stabilized through the procedure of nailing with a reduction bone clamp

Fig. 6 **a** Manipulation and **b** reduction in a fracture fragment with a strong forceps

Open reduction techniques

Open reduction is occasionally necessary either for inability to obtain acceptable reduction or in cases of complex fractures. In the latter scenario, often it is recommended to start with an open reduction so that to achieve an optimal entry point, avoid malreduction and obtain fracture healing. The skin incision is centered at the fracture site with fluoroscopy guidance using a metallic instrument such as a forceps or a scissors. A straight incision of appropriate length is performed in line with the shaft of the femur centered at the fracture site. The incision can be extended proximally if the head screw can be inserted through the same incision. The fascia lata is incised, 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 hemorrhage from branches of the perforating vessels and prevents the denervation of the posterior fibers due to splitting of the muscle [12]. Then, the surgeon should be able to palpate the fracture and proceed with the reduction.

The lateral approach to the subtrochanteric area of the femur generally is a safe approach. The surgeon should keep in mind that apart from the perforating arteries originating from the profunda femoris artery that are found posteromedial to the lateral femoral intermuscular septum, the other critical structures of the thigh, including the sciatic and femoral nerve, and the femoral artery and vein are located in a safe distance from the region [20]. Despite that, the surgeon should carefully position the instruments and handle the soft tissues with great care.

As the fracture has been exposed, a blunt Hohmann retractor can be placed to the anterior aspect of the femur elevating the vastus lateralis muscle and a second retractor to the posterior aspect of the femur elevating the bone fragment. In this way, the fracture is exposed and reduction can be performed with traction and rotation adjustment with the fluoroscopy. Reduction can be stabilized with reduction bone clamps (Fig. 7a–d); if the fracture is impacted, a bone hook can be used to mobilize the fragments before the application of the reduction clamp.

For long oblique fracture fragments without significant comminution, stainless-steel wires or cables can be used [21, 22]. We prefer a 2-mm wire or cable because it is easier to pass around the bone in a double-folded configuration (Fig. 8a, b). We also recommend that the wire should be passed from the posterior to the anterior side of the femur using a passer to avoid adjacent neurovascular injury. If a wire passer is not available, the soft tissues should be carefully detached from the bone with the use of a periosteal elevator and the cerclage can be passed around with the help of the surgeon's finger. Tightening of the wire should be used with the pull-twist technique. 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 to avoid breakage of the wire [23].

After successful intramedullary nailing and static locked, the wound is irrigated with saline and closed in layers. Application of a suction drain is generally not necessary, except in cases with open reduction through extended surgical approaches.

Anesthesia considerations

The anesthetic management for the orthopedic trauma patients presenting with subtrochanteric fractures should be based upon various parameters that must be evaluated before the implementation of any anesthetic procedure. Often, these patients are elderly with associated comorbidities. Surgery- and patient-related characteristics must be deliberated during the pre-anesthetic evaluation. Knowledge of the anatomy and innervation of the proximal

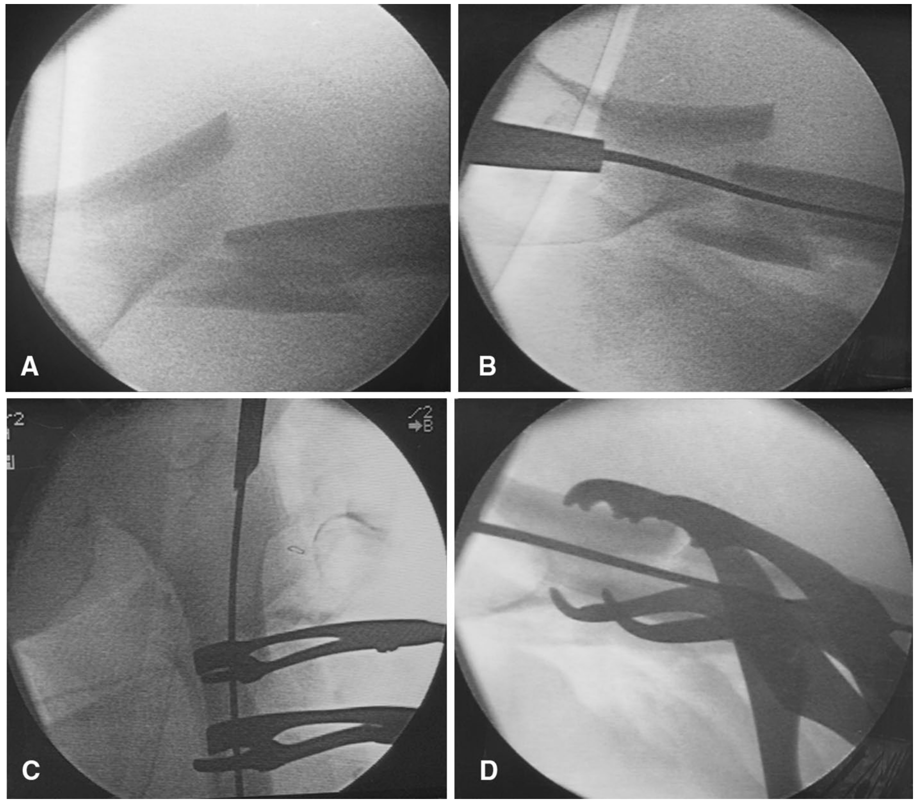


Fig. 7 **a** A displaced comminuted subtrochanteric fracture with **b** inadequate reduction. **c** AP and **d** lateral fluoroscopy views show optimal reduction with two reduction bone clamps

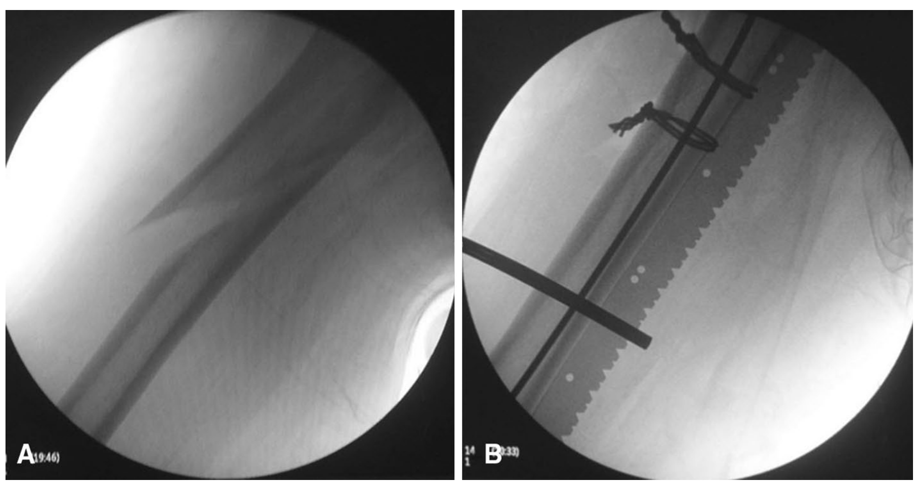


Fig. 8 **a** A long oblique subtrochanteric fracture **b** reduced with two double wires

femur and hip joint, the physiology of pain, and optimal training in up-to-date anesthetic procedures are paramount [24–26].

The anteromedial portion of the hip join receives innervation through the articular branches of the obturator nerve. Additionally, the anterior hip joint capsule is innervated by articular branches of the femoral nerve. The posterior part is innervated directly by the sciatic nerve and its branches (quadratus femoris and superior gluteal nerve) [27]. The proximal femur also receives complex innervation from branches of the femoral, sciatic and obturator nerve. Minor contribution of sacral nerves may exist at the posterior part of the proximal femur [28].

Anesthetic techniques for the patients with proximal femoral fractures include general anesthesia, neuraxial (spinal and/or epidural anesthesia) and peripheral nerve blockade. Compared to neuraxial anesthesia, general anesthesia is associated with longer hospitalization and possibly with increased in-hospital mortality [29]; conversely, neuraxial techniques have exhibited improved survival [30]. Additionally, peripheral nerve blocks, when they have employed, have led to supreme analgesia, reduced length of hospitalization and significant decrease in the incidence of delirium [31]. Femoral nerve/fascia iliaca compartment block alleviates pain in patients with hip and proximal femur fractures while positioning them for neuraxial or peripheral nerve blocks [32]. Performed preoperatively, fascia iliaca compartment block is effective in managing preoperative as well as postoperative pain with a high success rate [33]. It has been suggested, however, that lumbar plexus block may be a better option than femoral/fascia iliaca nerve blocks in that it anesthetizes the femoral, obturator and lateral femoral cutaneous nerves more consistently [34].

Conclusion

Reduction in subtrochanteric fractures is challenging, even with the use of the currently available sophisticated intramedullary hip nailing systems [35]. A skilled surgeon may treat these fractures with any type of fixation implants, with knowledge of the anatomy of the area and appropriate education and training in closed or minimally invasive reduction techniques. An experienced anesthesiologist with knowledge of current anesthetic procedures including general, neuraxial anesthesia and peripheral nerve blockade is paramount. In this way, intraoperative difficulties in fracture reduction and nailing and pitfalls that increase the rate of complications and lead to poor outcomes will be avoided [36–38].

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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