



Subtrochanteric femur fractures: current review of management

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- Subtrochanteric (ST) femur fractures are proximal femur fractures, which are often difficult to manage effectively because of their deforming anatomical forces.
- Operative management of ST fractures is the mainstay of treatment, with the two primary surgical implant options being intramedullary (IM) nails and extramedullary plates.
- Of these, IM nails have a biologic and biomechanical superiority, and have become the gold standard for ST femur fractures.
- The orthopaedic surgeon should become familiar and facile with several reduction techniques to create anatomical alignment in all unique ST fracture patterns.
- This article presents a comprehensive and current review of the epidemiology, anatomy, biomechanics, clinical presentation, diagnosis, and management of subtrochanteric femur fractures.

Keywords: femur; intramedullary nail; reduction techniques; subtrochanteric fracture

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Introduction

Subtrochanteric (ST) femur fractures are defined as fractures of the proximal femur that occur within 5 cm of the lesser trochanter.¹ Overall, the incidence of these fractures has been estimated to be approximately 15–20 per 100,000 individuals.² The age distribution for these fractures has a bimodal distribution: individuals younger than 40 years old account for approximately 20% of ST fractures, while individuals older than 50 years account for over 2/3 of ST fractures.³ At younger ages, the incidence of these fractures appears to be nearly equal between male and female; however, with increasing age, the incidence among females increases disproportionately to males.³ Additional ST fracture risk factors include patients

undergoing treatment of osteoporosis with bisphosphonates, low total bone mineral density, and chronic diseases such as diabetes mellitus.⁴

Anatomy

To properly diagnose and treat ST fractures, orthopaedic surgeons must have a comprehensive understanding of the relevant anatomy. The ST area comprises the meta-diaphyseal proximal femur within 5 cm distal to the lesser trochanter. The femoral calcar provides significant structural integrity to the proximal femur. It is the dense posteromedial bone that extends from distal to the lesser trochanter to the posteroinferior femoral neck. Biomechanically, the calcar can experience greater than 1000 Newtons of force upon standing and during gait.⁵ The subtrochanteric region also experiences secondary forces from the numerous muscular attachments found in the area, which increase stress around the proximal femur and hip.⁶ These muscular attachments include the hip abductors, adductors, short external rotators, and iliopsoas.

Biomechanics

Multiple deforming forces act on both the proximal and distal fragments of these fractures to create a characteristic deformity. On the proximal fragment, the gluteus medius and gluteus minimus cause abduction, the iliopsoas causes flexion, and the short external rotators (piriformis, obturator internus, quadratus femoris, and the superior and inferior gemelli) cause external rotation. On the distal fragment, the gracilis and adductor muscles cause an adduction and shortening force (Fig. 1). The culmination of these forces results in the characteristic deformity seen in ST femur fractures of abduction, external rotation, and flexion of the proximal segment and adduction of the distal segment – overall generating a typical fracture pattern of varus and procurvatum. These anatomical deforming

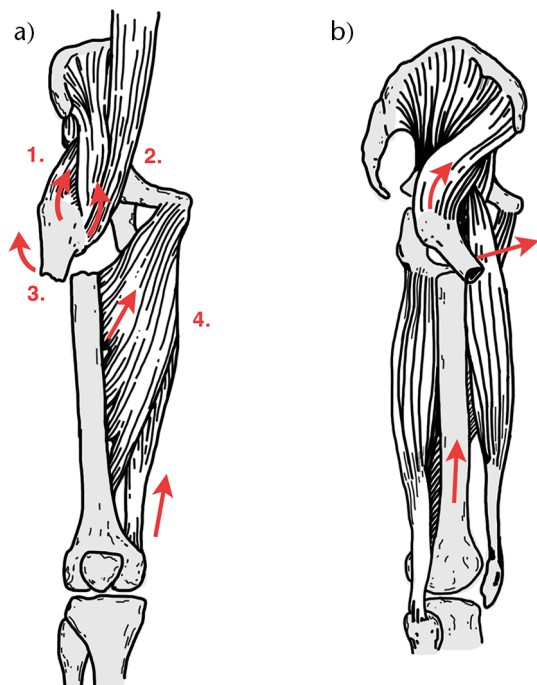


Fig. 1 The deforming forces (red arrows) of the proximal and distal fragments in subtrochanteric fractures in the coronal (A) and sagittal (B) planes. The proximal fragment is abducted by the gluteus medius and minimus (1), flexed by the iliopsoas (2), and externally rotated by short external rotators (3). The distal fragment is adducted and shortened by the adductors and gracilis (4).

forces can present difficulties when attempting to reduce ST fractures intraoperatively.

Classification

Numerous classification systems have been developed for ST femur fractures. The Russell-Taylor classification is based on involvement of the lesser trochanter and fracture extension into the piriformis fossa.⁷ Prior to the development of a trochanteric entry nail, this was historically used to differentiate fractures amenable to intramedullary (IM) nailing versus those requiring a lateral fixed-angle device. A Russell-Taylor type I fracture has no piriformis fossa extension and would therefore be amenable to fixation via a piriformis entry IM nail. The AO/OTA classification has utility in its universality and is primarily used in the discussion of research.⁸ It should be noted that there does not yet appear to be an ideal classification system that guides treatment and establishes prognosis with satisfactory interobserver reproducibility.

It is important to identify two specific ST femur fracture patterns that alter management – reverse obliquity fractures and atypical fractures. Reverse obliquity fractures

are intertrochanteric or subtrochanteric (depending on the proximal extent of the fracture) injuries that have a primary fracture line from proximal and medial to distal and lateral. Reverse fractures have a tendency of medial shaft migration and high implant failure when treated operatively with a sliding hip screw, and they are most appropriately treated with an IM nail.^{9,10} Atypical fracture patterns are associated with bisphosphonate use.^{4,6,11} For atypical femur fractures, the importance in recognizing the underlying primary risk factor stems from the high incidence of bilateral atypical femur fractures, the need to prevent completion of the fracture in the setting of lateral insufficiency with prophylactic fixation, and the recommendation to discontinue bisphosphonates with transition to another agent.¹¹ Common radiologic features of atypical ST femur fractures have been divided into major and minor criteria by the American Society for Bone and Mineral Research. Four of the five major criteria are required to define a fracture as atypical, while minor criteria may or may not be present based on the individual case. Major criteria include low-impact trauma, minimal comminution, fractures originating at the lateral cortex with transverse orientation, lateral cortical thickening, and a medial spike associated with complete fractures.¹²

Clinical evaluation/presentation

Patients with ST femur fractures present in a bimodal distribution. Subtrochanteric fractures in young patients are typically the result of high-energy trauma such as a motor vehicle collision or fall from height. This mechanism is often associated with other traumatic injuries and should be comprehensively evaluated by a trauma team through the Advanced Trauma Life Support system. Subtrochanteric fractures in elderly patients are typically the result of low-energy trauma, which often presents as an isolated injury. These individuals should undergo a thorough history to assess for comorbid medical conditions and medication history with specific attention to bisphosphonate usage and duration.

Physical examination of the affected limb will typically reveal a shortened and externally rotated lower extremity. Patients will complain of hip and/or thigh pain, along with an inability to bear weight, and pain with hip motion. While these fractures are normally closed injuries, a skin examination should be performed, as a high degree of flexion of the proximal segment may threaten the overlying skin. Physical examination should include assessment of the competence of surrounding neurovascular structures. A complete skeletal survey should be performed to assess for concomitant orthopaedic injuries. After ruling out other ipsilateral lower extremity injuries, patients may be placed into traction, as this will restore fracture length and improve preoperative pain scores.¹³

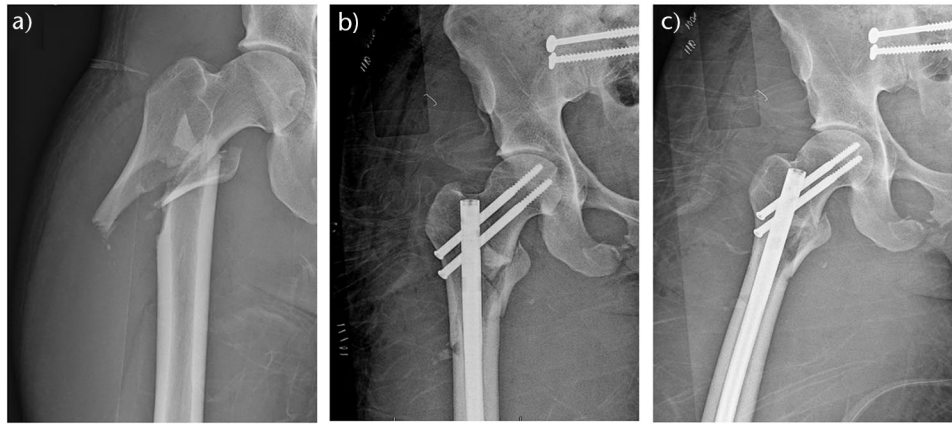


Fig. 2 Preoperative (A) anteroposterior (AP) and immediate postoperative AP (B) and lateral (C) radiographs of a right subtrochanteric femur fracture with intertrochanteric extension that was treated with a piriformis entry reconstruction nail.

Radiographic evaluation

An appropriate radiographic series allows for proper fracture identification and classification, which aids in pre-operative planning. Recommended initial radiographic imaging of a patient with suspected ST fracture should include an anteroposterior pelvis, as well as orthogonal femur and knee radiographs. Contralateral femur films may be useful to estimate femoral version, particularly with comminuted fractures that lack cortical reads to judge anatomical reduction. Computed tomography (CT) scans, although not always necessary, are often obtained as part of the initial trauma evaluation. They should be carefully reviewed, as they allow for a more thorough assessment of fracture morphology, including potential proximal fracture extension, which could influence preoperative planning, fracture reduction methods, and implant choice.¹ Typical radiographic findings for ST fractures include abduction, external rotation, and flexion of the proximal segment with adduction of the distal segment.

Treatment

Non-operative management of ST fractures is not usually a viable option. Without surgical reduction and fixation, patients have a high risk of symptomatic malunion or non-union; but more importantly, they are unable to mobilize, resulting in a higher mortality risk.¹⁴ The few candidates to consider for non-operative treatment include those who have an unacceptably high mortality risk from anaesthesia, or those who are in hospice care and have minimal hip discomfort. However, due to the benefits of decreased pain and increased mobility, all individuals involved in the medical decision-making process should have a thorough discussion prior to proceeding with non-operative management.¹⁵

Operative management of ST fractures can be broadly broken down into two major categories: intramedullary (IM) nailing and extramedullary plating (Fig. 2; Table 1). Of these, the IM nail has become the gold standard of treatment for numerous reasons – decreased hospital length of stay, blood loss, and overall operative time; immediate weight-bearing; and improved functional outcomes.^{21,22} Recent data from the Swedish registry show that the overwhelming majority (1989/2288, or 87%) of ST fractures are being treated with IM nails.²³ Intramedullary nails provide a biomechanical advantage with increased stiffness, rigidity, and a shorter moment arm, which translates to a stronger construct and decreased strain experienced by the implant.²⁴ Nail entry point and construct design can affect fracture reduction and stability; therefore, the surgeon should understand the modifiable variables that can improve surgical outcomes.

Regarding nail entry point, the surgeon has the choice between a piriformis or trochanteric entry point. The incision for both entry portals should be made proximal and in line with the curved axis of the femoral canal to avoid the superior gluteal nerve.²⁵ This posterior incision also allows for passage of the entry wire in a posterior to anterior direction, in line with the anatomical bow of the femur, which reduces the risk of sagittal plane eccentric reaming of the proximal fragment. The piriformis entry portal has an inherent advantage in that it is a straight nail that is in line with the coronal axis of the femoral intramedullary canal.^{26,27} This collinear advantage results in a decreased risk of varus malreduction and decreased risk of eccentric medial cortex reaming.^{28,29,30,31} However, the piriformis starting point is more challenging in obese patients, and there is an increased risk for anterior cortical blowout with excessive anterior placement.³² The greater trochanter is the alternative entry portal for treating ST fractures with IM nails. Although the trochanteric portal may minimally

Table 1. Current evidence on subtrochanteric femur fractures

Study	Study type	No. of patients	Fracture type and observation	Results
Freigang et al ¹⁶	Retrospective radiomorphometric case control study	61	Subtrochanteric femur fractures; uncomplicated healing within 6 months postoperatively vs. delayed union	At 6 months 29/61 (47.5%) rated healed, 32/61 (52.5%) rated delayed union. In total 9/61 (14.8%) required revision. At 12 months 48/61 (78.7%) rated healed without further intervention.
Xie et al ¹⁷	Meta-analysis	625	Subtrochanteric femur fractures; outcomes of intramedullary fixation vs. extramedullary fixation	Intramedullary fixation achieved shorter operation time, less intraoperative blood loss, shorter length of incision, and shorter length of stay. No significant difference for union time, rate of infection, rate of refracture, and rate of nonunion.
Horner et al ¹⁸	Prospective study	644	Subtrochanteric and Intertrochanteric femur fracture; implant-related complications and mortality	Implant-related complication 9.9%. Most common complications included peri-implant fracture (4.2%), proximal thigh pain requiring implant extraction (2.0%), and lag-screw cutout (1.1%). 30-day mortality 9.5%.
Zhang et al ¹⁹	Randomized controlled trial	180	Comminuted subtrochanteric femur fracture; compare the efficacy and safety of the proximal femoral anatomical locking compression plate vs. proximal femoral nail antitorotation	Femur intramedullary nail resulted in better recovery of hip function good and excellent Harris hip scores ($p < .05$). There was no significant difference in complication rate ($p > .05$).
Hoskins et al ²⁰	Retrospective review	134	Subtrochanteric fractures; Cerclage wire use improved fracture displacement (3.2 mm vs. 8.8 mm), angulation and quality of reduction ($p < 0.05$).	Open reduction and the use of cerclage did not produce a negative effect in terms of fracture union.

decrease soft tissue dissection due to its more superficial location, it does violate the abductor insertion. In addition, the trochanteric entry point carries a greater concern for varus malreduction and presents a high degree of variability based on individual patient trochanteric anatomy.^{33,34} Overall, the entry point decision should be made on an individualized basis, taking into consideration relevant patient anatomy, surgeon preference, fracture characteristics, and extension of the fracture pattern.

When treating ST femur fractures, the ideal nail is an antegrade, statically and distally locked cephalomedullary nail that allows for added proximal fixation in the femoral neck and head. A large cephalomedullary screw or helical blade can be utilized; however, these provide more utility in intertrochanteric fractures by providing compression at the fracture site. Alternatively, using two smaller diameter reconstruction-style screws decreases the bone removal in the femoral neck and head, while still providing adequate proximal fixation. Additional advantageous nail characteristics are a larger proximal diameter and full-length nails. This strengthens the construct by improving rotational and axial stability and decreases the risk of post-implant fractures when compared to the use of short nails.³⁵ The use of two distal interlocking screws has been demonstrated to provide greater rotational and axial stability than one.³⁶

The second major category of operative fixation for ST fractures is the use of locking or fixed-angle extramedullary plates. Placement of fixed-angle blade plates presents a high degree of technical difficulty. This factor, coupled with decreased rates of union, increased operative time, increased time until weight-bearing, and increased infection rates compared to IM nailing has led to a decreased use of fixed-angle plates.^{15,37} Using a locking plate compared to

a fixed-angle blade plate has demonstrated better biomechanical properties. However, this construct was shown by Collinge et al to result in failed fixation, malalignment/malunion, deep infection, or a combination of these factors in over 40% of patients. Of these patients, over 1/3 underwent a secondary revision surgery.³⁸ There is utility, however, in extramedullary plating, particularly when using a small fragment plate for provision fixation when open reduction is required. Malunion rates have been reported to drop from 27% to 0% when using this provisional plating technique.²¹

Reduction strategies and techniques

Due to the deforming forces in ST fractures, several techniques can be considered to achieve proper anatomic reduction. These reduction techniques include the use of clamps, a ball spike pusher with a bone hook, percutaneous Schanz pin joysticks, a femoral distractor, a finger reduction tool, blocking wires or screws, and cerclage wiring.^{39,40,41} Positioning of the patient prior to reduction should be based on the surgeon’s familiarity and preference, as each carries distinct advantages and disadvantages. The lateral decubitus position can allow for easier entry portal access via adduction of the ipsilateral leg in more obese patients, for example. This position also allows for easier reduction of the distal fragment. The supine position is familiar to most surgeons, is superior in the case of polytrauma by providing access to other extremities, and is protective of an injured spine.

For many ST fractures, the use of clamps can be considered to assist in maintaining reduction (Fig. 3). The use of this technique has demonstrated excellent reductions and a high union rate.⁴² For simpler two-segment

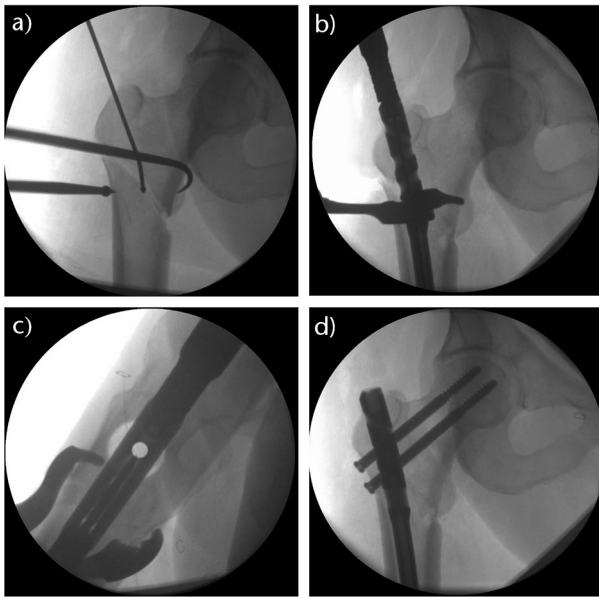


Fig. 3 Use of a ball spike pusher to medialize the distal fracture fragment while simultaneously pulling the proximal fragment with a bone hook to address the varus fracture deformity (A). After the guidewire was placed, a clamp was utilized to maintain the reduction in the coronal (B) and sagittal (C) planes. Anatomical reduction was achieved and the subtrochanteric femur fracture was fixed with a trochanteric entry reconstruction nail (D).

ST fractures, devices such as percutaneous Schanz pin joysticks or the ball spike pusher and bone hook can be utilized to align the fragments and allow for proper placement of a guide wire.⁴³ Schanz pins can also be coupled with a femoral distractor to establish length and to lock the reduction into place once proper alignment has been achieved. Another tool that can be of significant use for two-segment ST fractures is the finger reduction tool (Fig. 4). While length is typically improved with longitudinal traction, varus malalignment typically persists despite traction due to the proximal insertion of the abductors and the distal insertion of the adductors. In this case, passing a finger reduction tool can be utilized to gain control of the proximal fragment and correct the varus malalignment. Improper starting point or path of the guide wire can result in eccentric reaming, potentially resulting in cortical blowout or malreduction of a previously aligned reduction. For more complex fracture patterns with comminution or those with distal extension, blocking wires or screws can be placed on the concavity of the deformity in the proximal segment to maintain reduction and stiffen the construct (Fig. 5).²⁴ Although there is concern for disruption of the femoral blood supply, the use of percutaneous cerclage wiring has also been shown to be an effective and safe reduction method.^{40,41}

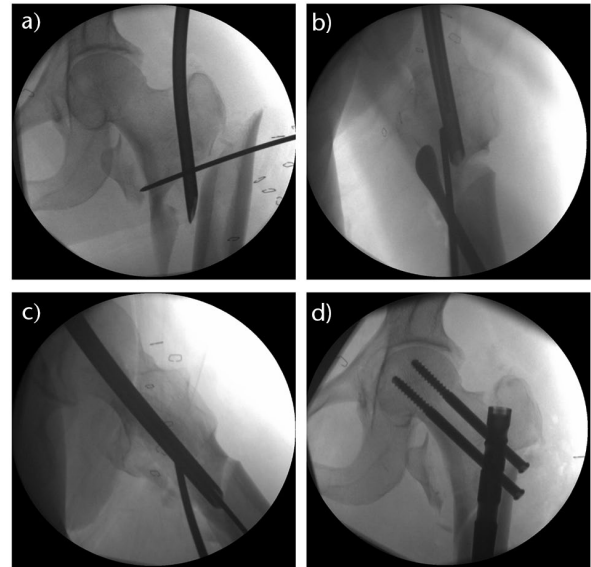


Fig. 4 Multiple reduction techniques were used to address this complex subtrochanteric femur fracture with intertrochanteric extension. The finger reduction tool was placed into the piriformis fossa entry portal to gain control of the proximal fragment (A). A Cobb periosteal elevator and a posterior blocking wire were utilized to correct the sagittal plane deformity (B). The finger reduction tool was then passed to the level of the distal fragment to allow for passage of the guidewire (C). Anatomical reduction was achieved and maintained with a piriformis entry reconstruction nail (D).

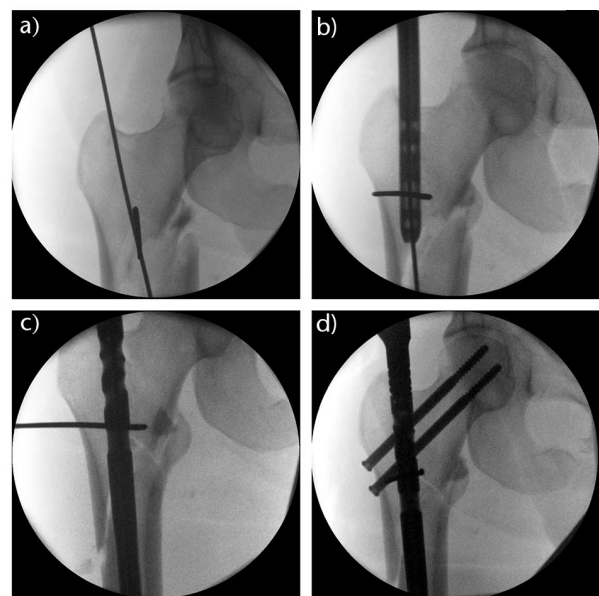


Fig. 5 A blocking wire was placed in the concavity of the deformity in the proximal fracture fragment just medial to the guidewire and was left in place during reaming to guide the reaming of the proximal fragment (A). As the nail was passed (B), the blocking wire effectively lateralized the distal segment (C) and created an anatomical reduction that was maintained with a piriformis entry reconstruction nail (D).

Complications

Operative complications for ST fractures are similar to the complications found in other proximal femur fractures, and include malunion, nonunion, infection, implant breakage, and mortality.⁴⁴ Mortality rates for ST fractures have been shown at 30 days, one year, and four years to be approximately 9.5%, 27%, and 60%, respectively.¹⁸ One of the most common complications of ST fracture fixation is that of a varus and procurvatum malunion or nonunion.⁴⁵ This risk is primarily linked to improper intraoperative anatomical reduction, so the effective use of reduction techniques should improve alignment and minimize union complications. Malunion, in particular, can be associated with rotational errors which may result in gait abnormalities and hip pain.¹ Rotational malalignment is particularly prevalent with the use of a traction table, as excessive internal rotation is often used for attempted fracture reduction. This is especially concerning in severely comminuted fractures.^{1,7} When healed in the typical ST malreduction pattern, excessive varus angulation and flexion of the proximal fragment can negatively alter the patient's gait mechanics. Symptomatic malunion may require a corrective osteotomy with instrumentation, and nonunion can be effectively managed with exchange of the implants with or without use of bone grafting.¹⁵ As with all surgical procedures, infection is a potential risk. Superficial infections can typically be managed with antibiotics alone. However, deep infections require surgical irrigation and debridement and possible implant removal. In the setting of an infected nonunion, the implants are removed and replaced with an antibiotic intramedullary implant, along with long-term intravenous (IV) or oral antibiotics.¹⁵

Conclusion

Subtrochanteric femur fractures are challenging orthopaedic injuries due to their complex and powerful deforming forces, which create significant difficulty in fracture reduction and implant fixation. As operative management remains the definitive treatment of choice for ST femur fractures, it is imperative to understand these forces and the techniques to properly reduce these fractures in order to improve alignment, stability, and patient outcomes.

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