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Prevention of Complications After Treatment of Proximal Femoral Fractures

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Abstract

Two factors are primarily responsible for complications after treatment of proximal femoral fractures. First, the strong deforming forces across the hip joint and proximal femur can make fracture reduction difficult. Second, the placement of the implant affects fracture healing and outcome more dramatically than in other areas of the body. In subtrochanteric fractures, the use of appropriate reduction and stabilization techniques can prevent varus malreduction and subsequent failure of the fixation device. In intertrochanteric fractures, lag screw cutout can be prevented by correct implant positioning. In femoral neck fractures, nonunion can be avoided by careful attention to reduction and hardware positioning.

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Most complications after treatment of fractures of the proximal femur are preventable. Reduction and stabilization techniques and correct implant positioning are important in preventing complications.

Failure of Fixation in Subtrochanteric Fractures

Etiology

A fracture of the subtrochanteric region of the femur is inherently unstable if posteromedial comminution exists.[1] The tremendous compressive stresses along the posteromedial aspect of the proximal femur are coupled with extremely powerful deforming forces across the hip joint, affecting the hip flexors, hip abductors and adductors, and quadriceps and leading to flexion, abduction, and external rotation of the proximal segment. Fracture reduction and implant choice must take into account the lack of stability if the posteromedial buttress is incompetent and must counteract the deforming forces to prevent loss of reduction and subsequent implant failure.

Accurate reduction of the proximal femur is critical in restoring hip mechanics and protecting the implant from the stresses that create a predisposition to fatigue failure. The goal of reduction is to restore the neck-shaft angle to approximately 130° to 135°. The fracture must be reduced in both the AP and lateral planes to allow an appropriate load transfer. Malreduction, particularly varus malreduction, increases the moment arm across the proximal femur and increases the likelihood of implant failure (Figure 1).

Fractures with a subtrochanteric component are mainly cortical. The subtrochanteric region has watershed vascularity, and the combination of a tenuous blood supply and powerful stresses increases the risk of delayed fracture union and fixation failure.

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Figure 1 An AP radiograph of the proximal femur showing varus malreduction of a subtrochanteric femoral fracture, which creates a predisposition to implant fatigue failure.

Figure 2 A meticulous biologic dissection of a subtrochanteric femoral fracture with preservation of the muscle pedicles facilitates rapid healing without a bone graft, despite the extensile exposure.

Surgical Technique

Although a fracture table often is helpful in surgically reducing a femoral fracture, its use can hinder the reduction of a subtrochanteric fracture, particularly if the patient is supine and distal limb traction and a perineal post are used. A perineal post provides countertraction, but it also tends to create a varus-producing force at the level of the fracture. When the leg is adducted to improve access to the proximal femur for nail entry, the adduction causes the fracture to drape across the post, resulting in varus malalignment that is accentuated with further traction.

A flat-top radiolucent table can be used instead of a standard fracture table, with the patient in the lateral position to allow the entire distal limb to be draped free and the distal segment to be manipulated to help achieve reduction. Often a provisional reduction can be achieved by simply flexing and abducting the distal segment and temporarily stabilizing it with a clamp while traction is applied to help restore the length of the limb and fine-tune the reduction. With the limb in the lateral position, the soft tissues fall away from the lateral hip, and access to the proximal femur for nail entry is easier than in the supine position. In addition, simple elevation of the distal limb allows gravity to counteract the varus alignment of the proximal segment.

The use of a limited open or percutaneous technique to minimize muscle stripping and preserve the tenuous blood supply can improve the healing of a subtrochanteric fracture (Figure 2). A percutaneous standard or lobster claw reduction clamp can be carefully placed or fluoroscopically guided to counteract the deforming forces on the proximal femur. The reduction maneuvers also can be simplified by using a percutaneous anterolateral ball spike pusher to correct flexion and abduction or a unicortical Schanz pin to control the proximal segment.

Implant Selection and Placement

A fracture fixation implant in the proximal femur must be capable of withstanding significant varus forces for several months. If fracture comminution prevents load sharing, the implant must be able to survive cyclic loading and prevent fatigue failure. Intramedullary nails, particularly cephalomedullary nails, are biomechanically superior in unstable proximal femoral fractures because they reduce the moment arm at the proximal femur.[2] Compared with plates, which are applied to the lateral surface of the femur, intramedullary nails usually require a smaller surgical exposure. However, the use of an intramedullary device can lead to varus malalignment if the reduction is not maintained during reaming. It is critical that the reduction also be maintained during nail placement and securing of all locking screws.

Fixed-angle plates are designed to accommodate the anatomy of the proximal femur and withstand the forces placed on it, although a meticulous soft-tissue technique is required to preserve the femur's vascularity and healing ability. The acceptable implants include a 95° blade plate and a condylar screw construct, as well as the newer locking proximal femoral plates.[3] Regardless of the choice of implant, the neck-shaft angle must be preserved to prevent varus malalignment, and a biologically friendly surgical technique must be used. These are absolute requirements for successful treatment of an unstable subtrochanteric femoral fracture (Figure 3).

Salvage Procedures

If fixation of a subtrochanteric fracture leads to varus collapse, a valgus osteotomy with autogenous bone grafting can be performed as a salvage procedure. It is critical to restore the neck-shaft angle to prevent further varus deformity and resulting hardware failure. The valgus osteotomy

Figure 3 An AP radiograph of the proximal femur showing restoration of the neck-shaft angle and stabilization with a fixed angle device, which lessens the risk of implant fatigue failure.

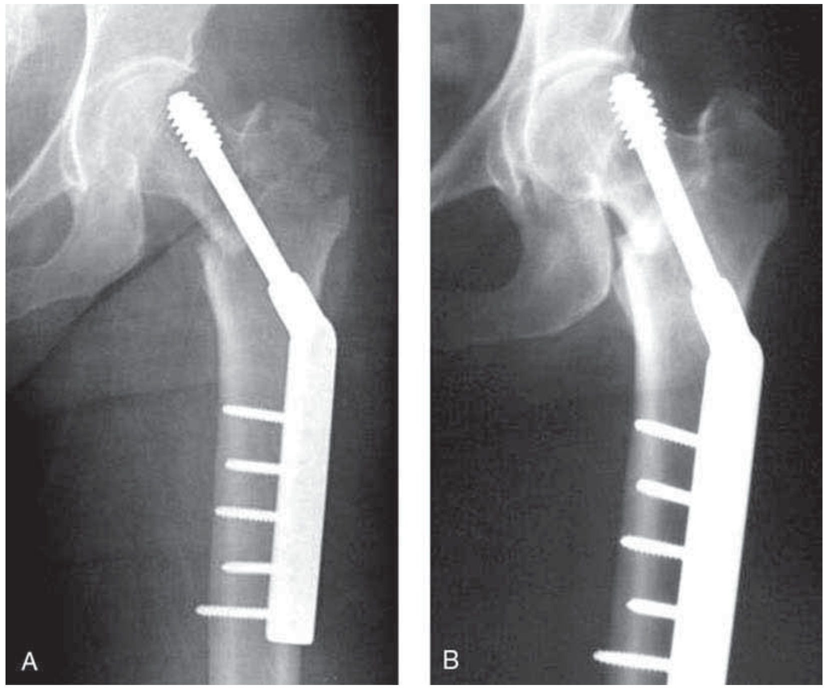

Figure 4 AP radiographs of the proximal femur showing lag screw cutout caused by unstable fracture reduction and improper implant positioning. **A,** Malpositioned lag screw. **B,** Cutout from the femoral head.

can be stabilized with a 95° blade plate or a fixed-angle locking proximal femoral plate. Necrotic bone must be completely resected, possibly resulting in shortening of the femur. The use of cancellous autograft can improve the likelihood that the procedure will be successful. A step-cut osteotomy can provide additional stability at the nonunion site, and the additional shortening that results may be necessary to accomplish healing of the nonunion. The combination of neck-shaft angle restoration, rigid fixation (with or without a step-cut osteotomy), and autogenous grafting can counteract the extreme stresses in the subtrochanteric region and the tenuous watershed blood supply, which are the factors most commonly responsible for failure of fixation.

Lag Screw Cutout in Intertrochanteric Fractures

The intertrochanteric femoral fracture is one of the most common fractures treated by orthopaedic surgeons, and the incidence of this injury is likely to increase as the population ages and longevity increases. The most common complication associated with this fracture is lag screw cutout, which usually can be prevented.[4]

Etiology

Most implants designed for intertrochanteric fracture fixation allow for shortening and impaction. Thus, deformity or malunion is accepted in return for predictable fracture healing. However, the presence of osteoporotic bone in the femoral head increases the likelihood of fixation failure if the position of the implant is compromised in any way. Implant position has proved to be the factor that best predicts the risk of lag screw cutout in intertrochanteric fracture treatment[4] (Figure 4). Therefore, efforts to prevent lag screw cutout focus on appropriate implant positioning.

Surgical Technique

Achieving a stable reduction is essential for decreasing the risk of cutout or other failure. To obtain a stable reduction that is as nearly anatomic as possible, a closed reduction using a fracture table can be performed before open reduction. Most intertrochanteric fractures can be reduced using gentle axial traction and internal rotation, and this procedure facilitates appropriate implant positioning. Using a proximal thigh support can help overcome posterior angulation or sag in a relatively unstable fracture, and a medially directed force applied to the lateral aspect of the femur can help correct proximal varus malalignment.

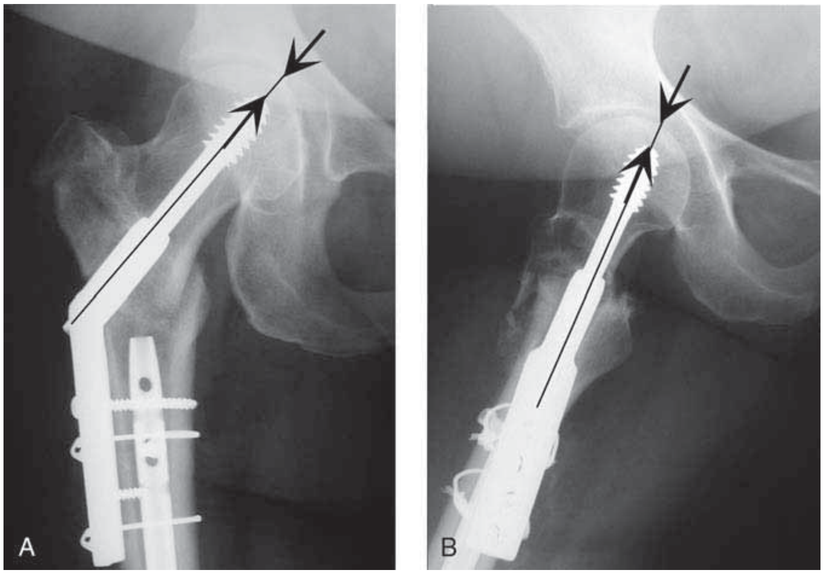

Figure 5 The distances from the tip of the implant to the apex of the femoral head on an AP **(A)** and a lateral **(B)** radiograph are combined to determine the tip-apex distance. Cutout failure generally is unlikely if the tip-apex distance is less than 25 mm.

Implant Selection and Placement

An intertrochanteric fracture is most commonly stabilized using a sliding or cephalomedullary hip screw.[5] Regardless of the implant used, the position of the lag screw is critical for allowing the fracture to heal without cutout or other failure. The lag screw must be placed in the subchondral bone at the center of the femoral head, as seen on both AP and lateral radiographs. The correct lag screw positioning is determined by the tip-apex distance, which is the sum of the distance from the tip of the lag screw to the apex of the femoral head as measured on both AP and lateral projections[4] (Figure 5). The ideal tip-apex distance is less than 25 mm. This measurement of implant placement is the most accurate predictor of the risk of cutout,[4] and therefore appropriate positioning of the lag screw is the highest priority in intertrochanteric fracture fixation.

Salvage Procedures

After a lag screw cutout, the fracture sometimes collapses into a more stable position and heals. Hardware removal may alleviate the patient's symptoms, including hip pain and limited hip range of motion. If severe joint destruction has not occurred, further surgery may not be required. If the fracture has not healed, the nonunion or malunion must be surgically treated with fracture takedown and repair.[6] A fixed-angle device may be required for stability after failure of a sliding or cephalomedullary hip screw. Autogenous bone grafting may increase the likelihood of success, particularly if a cavitary defect exists in the femoral head or neck. As in subtrochanteric fracture fixation, correction of varus and restoration of the neck-shaft angle improves the likelihood of a successful outcome.

Arthroplasty must be considered if the cutout has led to severe destruction of the hip joint. If the fracture has healed, a total hip arthroplasty may alleviate the patient's symptoms. However, if the fracture has not united, a calcar-replacing arthroplasty can be considered. Another option is a long-stem prosthesis to achieve diaphyseal stability, possibly supplemented with an autogenous bone graft to facilitate fracture healing. The choice of a salvage procedure is determined by individual patient and fracture characteristics. The goal is restoration of function with minimal further morbidity.

Nonunion of Femoral Neck Fractures

Etiology

Femoral neck nonunion most commonly occurs in physiologically young patients, for whom open reduction and internal fixation is the standard treatment.[7] In older patients who are less physiologically robust, nonunion is less frequent because a displaced fracture is commonly treated with hemiarthroplasty or total hip arthroplasty.

The risk of nonunion is greatest after a high-energy injury, which tends to produce significant displacement, with damage to the retinacular vessels supplying the femoral head and neck. These fractures frequently have a vertical orientation and are thus predisposed to varus angulation and inferior translation (Figure 6). If an anatomic reduction is not obtained, the shear forces across the femoral neck fracture can lead to fixation failure and fracture nonunion. Collapse and shortening can result, increasing the shear forces in the fracture plane and the risk of nonunion or implant failure.

Surgical Techniques

Preventing nonunion of a femoral neck fracture requires attention to

Figure 6 An AP radiograph of the proximal femur showing fixation failure of a high-energy femoral neck fracture, with resulting varus collapse and inferior translation.

both anatomic reduction and fixation. The nature of the fracture must be identified through presurgical imaging studies, including an internal rotation radiograph. CT or MRI is used if the fracture is not displaced. Adequate intrasurgical imaging of the fracture is critical for anatomic reduction and can be accomplished with c-arm fluoroscopy. AP and true lateral radiographs are needed, and an internal rotation radiograph can further facilitate the reduction.

An anatomic closed reduction must be confirmed through radiographic imaging in two planes, with recognition that failure is exponentially more likely if the reduction is not anatomic. If the surgeon decides to proceed with open reduction, several surgical approaches are available. A traditional Watson-Jones lateral approach facilitates implant placement; however, exposure and reduction of the fracture can be difficult in a large or obese patient. The anterior Smith-Petersen approach provides excellent exposure of the fracture and allows clamp placement directly perpendicular to the fracture plane, although the placement of lateral hardware can be challenging from an anterior approach. A recently described technique includes an anterior approach for reduction, with a percutaneous or limited-open lateral approach for hardware placement.[8] This combined-approach technique is recommended because it allows an anatomic reduction under direct observation as well as hardware placement through an accessory approach.

Implant Selection and Placement

Implant selection and placement are critical for maintaining an anatomic reduction. The acceptable implants include a sliding hip screw construct with or without a derotation screw, and a cannulated screw. A sliding hip screw construct should be applied with a tip-apex distance of less than 25 mm. If necessary, a derotation screw (usually a cannulated 6.5- to 8.0-mm screw) can be placed superior to the lag screw in the subchondral bone of the femoral head. The lag screw for the sliding hip screw must be placed slightly inferior to the location determined by the ideal tip-apex distance to allow the derotation screw to be placed superiorly. The derotation screw is believed to reduce the risk of rotation that can occur with a single lag screw placed in the femoral head.[9]

Cannulated screws also can be placed using a percutaneous or limited-open approach. The position of the cannulated screws is important,[10] because the construct will be unstable unless the fixation includes buttressing of the inferior and posterior femoral neck or is stout enough to withstand shear forces when the hip is loaded. Unstable fixation predisposes the fracture to varus deformity, posterior collapse, and shortening, which in turn create unacceptable shear forces at the fracture site and thus increase the risk of nonunion or implant failure. To achieve the most predictable outcome, an inferior calcar screw and a posterior femoral neck screw must be accurately placed as close as possible (2 to 3 mm) to the posteroinferior cortex (Figure 7). The inferior calcar and posterior neck screws will buttress the femoral neck and the reduction to prevent deformity and failure. A third screw is usually placed anterosuperior in the femoral neck. Screw divergence is desirable to lessen the risk of shortening and displacement. With either a cannulated screw or sliding hip screw, an accessory lag screw can be placed from the lateral trochanter perpendicular across the vertical femoral neck fracture to provide resistance to shear forces. This adjunctive screw must be carefully placed to prevent interference with other hardware.

Salvage Procedures

If fixation failure and subsequent nonunion occur, the choice of a salvage procedure is determined by the condition of the remaining hip joint. Total hip arthroplasty has the most predictably successful outcome if osteonecrosis is present in a femoral neck nonunion. If nonunion and hardware failure have not resulted in hip destruction, the salvage procedure must convert the shear forces at the vertical femoral neck fracture into compressive forces. This goal is best accomplished with a valgus intertrochanteric osteotomy, which allows conversion of the

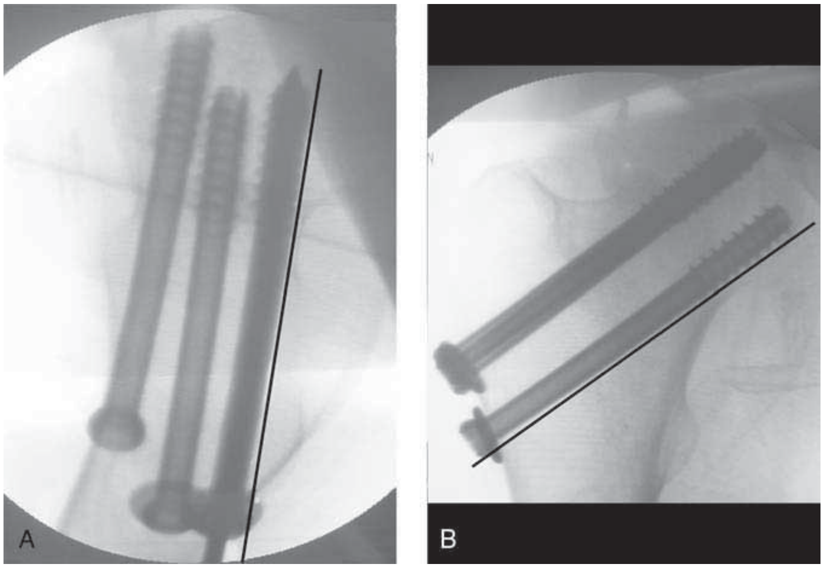

Figure 7 In these fluoroscopic images of the femoral neck, the lines drawn parallel to the posterior femoral neck screw **(A)** and inferior calcar screw **(B)** represent placement within 2 to 3 mm of the femoral neck cortex. The screws will buttress the femoral neck and prevent deformity and failure.

Figure 8 An AP radiograph of the proximal femur showing a valgus intertrochanteric osteotomy stabilized with an osteotomy blade plate, which has converted the shear force of the vertical femoral neck nonunion into a compressive force.

vertical femoral neck fracture to a more horizontal orientation.[11] Redirecting the fracture plane helps convert the forces at the femoral neck nonunion from shear to compressive and thereby promotes union (Figure 8). The osteotomy can reestablish some of the length of the collapsed femoral neck, although obligate external rotation frequently occurs with hip flexion. A proximal femoral blade plate is often used in such fractures to achieve stable fixation. This salvage technique generally results in fracture union, even of a long-standing nonunion. However, some patients develop osteonecrosis after a successful nonunion repair, and the proximal femoral deformity can make arthroplasty difficult.

Summary

Complications are predictable after fixation of proximal femoral fractures, although they can often be prevented by using appropriate surgical techniques for reduction and implant positioning. Preventing varus malalignment and using an implant capable of withstanding the stresses of the subtrochanteric region lessens the risk of fixation failure. A stable reduction with a tip-apex distance of less than 25 mm decreases the risk of cutout in fixation of an intertrochanteric femoral fracture. Anatomic reduction with placement of lag screws, derotation screws, or cannulated screws inferiorly along the calcar and posteriorly along the femoral neck minimizes the risk of femoral neck nonunion. If a complication occurs, a thorough understanding of salvage procedures is necessary.

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