



Femoral Osteotomy

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AUTHOR INFORMATION

Author: Austin T Fragomen, MD, Instructor of Orthopedic Surgery, Weill Medical College of Cornell University; Consulting Surgeon, Department of Orthopedic Surgery, Limb Lengthening and Reconstruction Svc, Hospital for Special Surgery

Coauthor(s): S Robert Rozbruch, MD, Assistant Professor of Orthopedic Surgery, Weill Medical College of Cornell University; Consulting Surgeon, Department of Orthopedic Surgery, Limb Lengthening and Reconstruction Svc, Hospital for Special Surgery

Austin T Fragomen, MD, is a member of the following medical societies: American Academy of Orthopaedic Surgeons, and Arthroscopy Association of North America

Editor(s): Steven I Rabin, MD, Clinical Associate Professor, Loyola University Medical Center; Chair, Department of Orthopedic Surgery, Dreyer Medical Clinic; Francisco Talavera, PharmD, PhD, Senior Pharmacy Editor, eMedicine; B Sonny Bal, MD, Assistant Professor, Department of Orthopedic Surgery, University of Missouri School of Medicine; Dinesh Patel, MD, Assistant Clinical Professor of Orthopedic Surgery, Harvard Medical School; Chief of Arthroscopic Surgery, Department of Orthopedic Surgery, Massachusetts General Hospital; and William L Jaffe, MD, Clinical Professor of Orthopedic Surgery, New York University School of Medicine; Vice Chairman, Department of Orthopedic Surgery, Hospital for Joint Diseases

INTRODUCTION

Proximal femoral osteotomy is currently commonly used for adults in the treatment of hip fracture nonunions and malunions and in cases of congenital and acquired hip deformities.

History of the Procedure: Proximal femoral osteotomy was a technique used in adults in the early part of the 20th century for the treatment of hip dysplasia and osteoarthritis. Varus and valgus- producing osteotomies were aimed at maximizing joint congruity and redistributing the weightbearing load across the femoral head to a less affected area. Historically, the best results were obtained in patients with long-standing deformities, including Perthes osteonecrosis, coxa vara, and developmental dysplasia. Modern periacetabular osteotomies and joint arthroplasty techniques have narrowed the indications for this once common procedure. Proximal femoral osteotomy continues to find application in adults for the treatment of hip fracture nonunions and malunions and in cases of congenital and acquired hip deformities.

Problem: In young patients with symptomatic hip disease, total joint arthroplasty has traditionally been a suboptimal solution. Problems with accelerated bearing wear and premature implant loosening leading to early revision surgery are well documented in this patient population. Intertrochanteric osteotomy has some use in providing temporary relief of pain in this challenging group of patients. While newer bearing materials with

improved wear properties may improve the longevity of total joints in young patients, data to support this position are yet lacking.

Patients with deformity of the proximal femur typically develop arthritis over time due to abnormal joint wear from malalignment. Deformities typically include a varus or valgus neckshaft angle, rotational malalignments, and leg-length discrepancy in any combination. These deformities can be acquired, as in the case of proximal femur fracture malunions and nonunions, or developmental, as in the cases of fibrous dysplasia, coxa vara, and developmental dysplasia.

Regardless of the etiology, these patients with femoral deformity are at an increased risk for the development of pain and arthritis in the affected hip. Once arthritis has begun, the problem is further aggravated by the mechanical malalignment from the femoral deformity. Standard hip replacement techniques and prostheses are usually unsuitable for deformed proximal femora, thus increasing the complexity of the procedure, surgical risks, and possibly the longevity of the reconstructed joint.

The benefits of early proximal femoral osteotomy to correct deformity are two-fold. One, in the deformed hip prior to the onset of arthritic changes, the realignment often reduces symptoms, prevents further joint degeneration. In the deformed hip with arthritic changes, restoration of normal alignment can often decrease pain and improves function. Moreover, if the relief of symptoms is incomplete and the patient later requires hip replacement surgery, then the arthroplasty procedure is simplified by restoration of the anatomy.

Frequency: Proximal femoral osteotomy is commonly used in the treatment of nonunions of hip fractures. Both femoral neck and intertrochanteric fracture nonunions respond positively to valgus-producing realignment osteotomies. Malunions of hip fractures, including intertrochanteric type and unreduced slipped capital femoral epiphysis (SCFE), are other common indications for osteotomy. Infrequently, proximal femoral osteotomy is performed in adults for the treatment of hip arthritis and osteonecrosis.

Pathophysiology:

Femoral neck nonunion

In femoral neck nonunion, the fracture fails to heal despite an adequate blood supply. Weightbearing forces across a vertically oriented fracture line produce shear stresses at the fracture site that favor the production of fibrous tissue. Valgus intertrochanteric osteotomy reorients the fracture site into a more horizontal position. Axial loading in this situation encourages osteogenesis and fracture union (see Images 1-3).

Intertrochanteric nonunion

Intertrochanteric hip fractures typically do not disturb the blood supply to the femoral head and tend to heal predictably. Nonunions of this common fracture pattern are usually the result of a combination of varus malalignment and inadequate stability of fixation. Treatment is aimed at correcting the varus neck-shaft angle to a neutral or slight valgus orientation and improving the stability at the fracture site often with a fixed-angle device (see Images 4-6).

Intertrochanteric malunion

When the fracture collapses into varus angulation and then goes on to bony union, a malunion results. The hallmark of this malunion is a varus neck-shaft angle with shortening of the ipsilateral femur, shortening of the abductor musculature or lever arm, and often trochanteric-pelvic abutment and a Trendelenburg gait with poor hip motion. This patient is at an increased risk for the development of hip arthritis. Intertrochanteric osteotomy serves to realign the hip joint, restore normal abductor mechanics, and reestablish equal leg lengths.

SCFE malunion

SCFE is a common fracture variant seen in the adolescent population. In many cases, in situ pinning of the displaced fracture is indicated, since this reduces the risk of osteonecrosis of the femoral head. If a displaced slipped epiphysis heals in situ, a fracture malunion can result. After remodeling, this malunion is characterized

by coxa vara, femoral shortening, and retroversion of the femoral neck with a significant loss of hip motion. A valgus-producing proximal femoral osteotomy can correct the varus and reestablish normal rotation, both of which reorient the femoral head in the acetabulum, offering possible protection from the development of arthritis. This procedure also equalizes limb length and abductor tension, thereby normalizing gait.

Fibrous dysplasia

A shepherd's crook deformity of the proximal femur has long been associated with fibrous dysplasia. Repeated microfractures of the femoral neck lead to progressive displacement and healing of the femur in varus. Significant shortening of the femur, trochanteric-pelvic abutment, and shortening of the abductor lever arm occur concomitantly. Rotational deformity may also be present.

Patients report limb shortening, hip stiffness, and an inability to abduct the lower extremity, which can be particularly troublesome for women of childbearing age. Pain may be present as well. These patients are at risk for progression of the deformity, fracture of the femoral neck, and joint degeneration. Valgus-producing proximal femoral osteotomy serves to prevent progression of the deformity and the development of a fracture, reestablish a more normal femoral headacetabular relationship, lengthen the extremity, tension the abductors, and greatly improve hip abduction.

Developmental dysplasia of the hip

Adults with hip dysplasia often have both acetabular and femoral deformity. The femoral neck assumes a valgus and anteverted orientation, while the acetabulum is shallow with varying degrees of uncovering of the femoral head, ranging from mild to subluxed to a frank dislocation. In select patients, surgery is indicated to improve femoral head coverage or better reduce the hip joint. A varus-producing proximal femoral osteotomy with derotation of the anteverted neck improves femoral head orientation. Often, this is combined with a periacetabular osteotomy to improve superolateral and anterior head coverage.

Osteoarthritis and osteonecrosis

The goal of the femoral osteotomy procedure is to alter the contact point across the articular cartilage during weight bearing. When arthritic change occurs without deformity, then a valgus-extension osteotomy moves the contact point of weight bearing forces to a new location on the femoral head, alleviating the pressure across the degenerated area of articular cartilage. This area of damaged cartilage has been shown to undergo a reparative process through which new collagen is created (see Images 7-8).

Clinical:

Adults present with deformity about the hip from any number of etiologies, including hip fracture nonunion or malunion including SCFE, congenital coxa vara, shepherd's crook deformity from fibrous dysplasia, excessive femoral anteversion, developmental dysplasia of the hip, congenital or acquired femoral shortening, and soft tissue contractures about the hip.

A thorough examination is crucial before undertaking any osteotomy procedure to correct a deformity, as deformities commonly lie in multiple planes. Hip, knee, and ankle are examined, looking for deformity and joint range of motion. Hip joint contractures may be resolved through the osteotomy. Rotational profile of the lower extremity, including hip internal and external rotation and thigh foot axis, is documented. Limb length discrepancy is measured using blocks and later with radiographs.

Previous incisions, skin quality, and any signs of previous sepsis should be carefully sought.

INDICATIONS

The bases for performing a proximal femoral osteotomy can vary. In the presence of deformity, the goal is to correct the deformity and in so doing, realign the hip and lower extremity. This may include frontal, sagittal, and rotational corrections and perhaps even lengthening through the osteotomy. Indications for proximal femoral osteotomy in adults include the following:

- **Nonunion of a femoral neck fracture**
- **Nonunion or malunion of an intertrochanteric hip fracture deformity**
 - **Rotational deformities, as in the case of severe femoral anteversion, SCFE, and developmental dysplasia of the hip**
 - **Frontal plane (varus/valgus) deformities, as in the case of congenital coxa vara, varus fracture malunion, and shepherd's crook deformity from fibrous dysplasia**
 - **Sagittal deformities, including flexion and extension deformity, either bony as infraction malunion or nonbony, as in hip flexion contracture of achondroplasia**
 - **Significant shortening or bone loss of the distal femur requiring a proximal lengthening**
- **Combinations of the above indications, as in intertrochanteric fracture malunion with varus, external rotation, and shortening deformity**
- **Simultaneous femoral osteotomy and total hip arthroplasty**
- **Hip osteoarthritis or osteonecrosis in the young, active patient**

RELEVANT ANATOMY AND CONTRAINDICATIONS

Relevant Anatomy: Proximal femoral osteotomy is a joint-sparing procedure that relies on maintaining the biological integrity of the femoral head. Preserving the blood supply to femoral head is of the utmost importance. In adults, the medial femoral circumflex artery is the predominant nutrient vessel supplying the femoral head. Proximal femoral osteotomy is performed via a lateral approach, reducing the chance of injury to this vessel.

Other relevant anatomy includes knowledge of the normal anatomy of the femur. Normal neck-shaft angle ranges from 124-136. The center of the femoral head lies at a similar height as the tip of the greater trochanter. A line connecting these 2 points makes an angle of 90 (range 85-95) with the mechanical axis of the femur.

Contraindications:

- The presence of infection may preclude the use of internal fixation; however, external fixation may be a viable option in such cases.
- Limitations of hip motion can make realignment unsuccessful without soft tissue releases or compensation through the osteotomy.
- Advanced osteoarthritis or osteonecrosis is a relative contraindication.
- Inflammatory arthritis can also be a contraindication.

WORKUP

Lab Studies:

- Obtain a white blood cell count, erythrocyte sedimentation rate, and C-reactive protein level if infection is suspected.
- If osteonecrosis is present, then an investigation of the etiology may be indicated.
- Routine preoperative blood work is indicated.

Imaging Studies:

- Radiography

- Standing anteroposterior pelvis radiographs to measure neck-shaft angle and assess the hip joint integrity
 - Cross-table lateral of the involved hip to assess sagittal deformity
 - Standing bipedal 51-inch radiograph including the top iliac crests to below ankle joints to assess deformity and leg length
- Bone scanning
- To assess for nonunion
 - To assess for infection
- CT scanning (helpful in some instances): Hip CT scanning can help confirm the presence of a nonunion.
- MRI: This can help assess for osteomyelitis and can evaluate the condition of the hip joint.

TREATMENT

Medical therapy: For painful hip arthritis, treatment includes nonsteroidal anti-inflammatory drugs, acetaminophen, and glucosamine/chondroitin. Caution should be exercised when prescribing any medication on a long-term basis. Bisphosphonates may have a role in optimizing patients for surgery who have metabolic bone disease.

Surgical therapy: Alternatives to osteotomy in patients with arthritis include the following:

- **Total hip replacement: The age indication for hip arthroplasty continues to broaden for patients with coxarthrosis. This is in a large part due to the good results obtained through the use of alternative bearing surfaces. Hip arthroplasty has also been successful in the treatment of patients with femoral neck nonunions, developmental dysplasia of the hip, and fibrous dysplasia.**
- **Resurfacing procedures**
- **Hip arthroscopy**
- **Distraction arthroplasty hip joint: This has been successful in children with Perthes disease and may have a role in adults.**

Preoperative details:

- **Review all information from history, physical examination, and imaging studies.**
- **Correlate the radiographic measured degree of deformity with the clinical examination findings.**
- **Optimize the patient's range of motion and function; do not simply treat based on the radiograph findings.**
- **If using a blade plate, determine the optimal position for the blade in the femoral neck based on radiographic findings.**
- **Plan the level of osteotomy.**
- **Consider best approach with regard to skin condition.**
- **Have correct instrumentation available to remove old hardware.**
- **Obtain medical clearance and achieve patient optimization prior to surgery.**

- Involve the patient and the family in the decision-making process.
- Provide the patient with realistic expectations from the surgery.

Intraoperative details: Have the following items available in the room: the patient's radiographs, a goniometer, Steinman pins to judge rotation, C-arm fluoroscopy, and a broken hardware removal set. The operating table should be a fracture table or Jackson flat table with a bump under the ipsilateral buttock.

Internal fixation

The implant is typically a fixed-angle device (eg, 95 or 130 blade plate), and the procedure is performed through an open approach with an acute correction. One surgery is performed, but no postoperative adjustability is possible. Internal hardware is not ideal in cases of infection. The approach is lateral, centered over the proximal femur and greater trochanter.

If correcting rotation, place a Steinman pin into the proximal femur posteriorly, at the level of the lesser trochanter. Place a second pin into the distal femur at an angle that mimics the deformity such that when the deformity is corrected the pins will be parallel.

Place guide wire for the blade plate into the femoral neck and head in the predetermined ideal location. The seating chisel is advanced over the wire taking care to enter the bone at the ideal angle in the sagittal plane. Any planned flexion or extension would be set at this time. For valgus osteotomy, the blade plate can be inserted before completing the osteotomy while the bone is still stable. The plate is then used to help obtain the correction. For varus-producing osteotomies, the bone is cut before the blade plate is inserted (due to impingement of the plate on the femoral shaft), and the seating chisel is used to help reduce the proximal fragment.

The osteotomy is typically made at the level of the lesser trochanter. With a valgus-producing osteotomy, a small wedge of bone can be removed to improve bone contact at the osteotomy site. A compression device can be used, and the screws are then inserted through the plate. Wounds are closed in layers over a drain.

External fixation

An external fixator is also a fixed-angle device. It is mounted percutaneously and can be combined with a percutaneous osteotomy. An acute correction is typical. The fixator allows for postoperative adjustability, works well in presence of infection (no internal hardware), and allows for simultaneous lengthening through osteotomy.

However, the frame may be uncomfortable, a risk of pin tract infection exists, and a second surgery is required for frame removal.

External fixation is typically reserved for low intertrochanteric or subtrochanteric osteotomies.

When using external fixation, all half pins are inserted percutaneously. All half pins are predrilled and then hand inserted to reduce the risk of bone necrosis. The C-arm is used to establish orientation of the drill to ensure that the pins are ideally placed.

Two to three pins are used per segment to achieve stability. One half pin is placed centrally into the femoral neck and head. An additional 1 to 2 pins are placed above the level of the lesser trochanter. Three to 4 pins are placed in the shaft of the femur for stability.

If using Ilizarov-type rings, then one ring or ring block is attached to each segment to mimic the deformity. A percutaneous osteotomy is made, and the rings are manipulated to place the femur into the desired alignment. If the rings truly mimic the deformity, then the reduction is obtained by making the rings parallel. The rings are then fixed to one another. The same correction can be obtained using

a monolateral fixator. Again the frame is mounted in the deformed position and then acutely or gradually moved into the corrected position.

Postoperative details:

- **Drains are removed postoperative day 1.**
- **Partial weight bearing is typically allowed immediately.**
- **Wound care is routine.**
- **Showering and pin care protocols are surgeon specific. Typically showering begins after postoperative day 4.**

Follow-up care:

- **Office visit at 2 weeks to remove sutures**
- **Regular monthly visits with radiographs until bony union is observed**
- **A shoe lift may be indicated for limb length inequality, or a later limb-lengthening procedure may be planned if indicated.**

COMPLICATIONS

Major complications include infection, neurovascular injury, nonunion, inability to obtain or maintain a full correction, persistence of pain postoperatively, continued degeneration of hip articular cartilage. Other complications include deep vein thrombosis and painful hardware. With regard to external fixation, complications include pin site infection; fracture above or below the frame and fracture through a screw hole after frame removal, stiffness of adjacent joints, and septic arthritis if pins communicate with the joint.

OUTCOME AND PROGNOSIS

When proximal femoral osteotomy is used for the correction of congenital and acquired deformities and repair of hip fracture nonunion, results have been favorable. Hip range of motion, gait, pain, leg-length discrepancy, and patient satisfaction are improved. If arthritis develops, then future joint replacement is often facilitated. Simultaneous femoral osteotomy and total hip arthroplasty is a technically demanding procedure that has yielded acceptable results for complex hip reconstruction with deformity.

With regard to the use of proximal femoral osteotomy in the non-deformed hip with osteoarthritis, long-term followup reveals that many patients go on to require total hip arthroplasty. Some authors conclude that a place still exists for osteotomy in the treatment of hip osteoarthritis in younger patients. However, many have reported on the increased difficulty and higher complication rates associated with total hip arthroplasty performed in hips that have undergone previous intertrochanteric osteotomy procedures aimed at alleviating arthritic pain.

FUTURE AND CONTROVERSIES

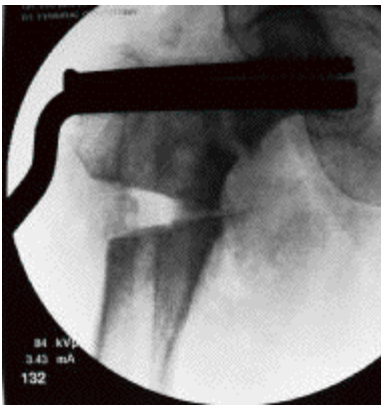
As newer prosthetic materials with reduced wear properties prove efficacious in total hip replacement surgery, the indications for arthroplasty may extend to younger and more active patients. Short-term follow-up of ceramic-on-ceramic total hip arthroplasty has demonstrated encouraging results. Such alternative bearings could reduce the need for proximal femoral osteotomy. However, osteotomy will continue to find applications in the correction of deformity in adult patients. Computer navigation promises to greatly advance the technical accuracy of all osteotomy procedures and will undoubtedly have a profound impact on how proximal femoral osteotomy is performed in the future.

PICTURES



Caption: Picture 1. This severe vertical fracture line through the femoral neck is a high risk for nonunion with simple pinning fixation.

Picture Type: X-RAY



Caption: Picture 2. The fracture is stabilized with a screw, and then a 95 blade is inserted. Proximal femoral osteotomy is created and a wedge removed.

Picture Type: X-RAY



Caption: Picture 3. Final image showing a valgus-producing osteotomy with improved orientation of the femoral neck fracture.

Picture Type: X-RAY



Caption: Picture 4. Painful nonunion of a peritrochanteric fracture in varus position with shortening and broken hardware.

Picture Type: X-RAY



Caption: Picture 5. Repair of nonunion with a 95 blade plate with restoration of normal alignment and equalization of limb length.

Picture Type: X-RAY



Caption: Picture 6. Osteonecrosis localized to a small area of the weightbearing portion of the femoral head.

Picture Type: X-RAY



Caption: Picture 7. Proximal femoral osteotomy was performed and the head was positioned into more valgus. In so doing, the affected portion of the femoral head is rotated away from the weightbearing area. External fixation was selected in this example.

Picture Type: X-RAY



Caption: Picture 8. Follow-up radiographs demonstrate a well-healed osteotomy with maintenance of the valgus positioning.

Picture Type: X-RAY

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NOTE:

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