

High tibial osteotomy

Anatomy & Pathophysiology

COMPLICATIONS AND PATHOLOGY

- Recurrence of varus deformity is reported to occur in 5% to 30% of patients with proximal tibial osteotomy [1].
- Recurrence of varus deformity was the most common complication in Coventry's report of 213 proximal tibial osteotomies [1].
- Coventry attributed the recurrence of varus deformity to inadequate correction at the time of surgery [1].
- Overcorrection beyond the normal 5 degrees of anatomic valgus decreased the frequency of recurrent varus deformity [1].
- Peroneal nerve injury is most often related to fibular osteotomy performed in conjunction with proximal tibial osteotomy [1].
- The peroneal nerve is most at risk during osteotomy of the proximal fibula, where the nerve wraps around the neck of the fibula before dividing into deep and superficial branches [1].
- Popliteal artery injury is rare but devastating [1].
- At 90 degrees of flexion, the distance between the osteotomy blade and the popliteal artery averaged 10.6 mm in a cadaver study [1].
- Most patients develop significant patella baja after proximal tibial osteotomy [1].
- Shortening of the patellar tendon after prolonged immobilization is a factor that may cause patella baja [1].
- New bone formation at the site of the osteotomy in the area of the insertion of the patellar tendon is a factor that may cause patella baja [1].
- Fibrosis of the patellar tendon is a factor that may cause patella baja [1].
- The decrease in the height of the patella has no appreciable effect on the success or failure of the osteotomy or the need for subsequent total joint replacement [1].
- Patella baja is likely to make a subsequent total knee arthroplasty more technically demanding [1].

COMPARATIVE OUTCOMES

- A meta-analysis by Fu et al. showed better knee function in the arthroplasty group compared to high tibial osteotomy [1].
- A meta-analysis by Fu et al. showed no difference in knee score between the arthroplasty group and high tibial osteotomy [1].
- The 10-year survival rate for medial compartment arthroplasty reported by Pandit et al. was 91% [1].
- The 10-year survival rate for high tibial osteotomy was 60% [1].
- Unicompartmental arthroplasty is less stressful for the patient than total knee arthroplasty [1].
- Unicompartmental arthroplasty is more likely to be “forgotten” by the patient according to Zuiderbaan et al. [1].
- Patients with the varus morphotype may be better served with an osteotomy to unload the already overloaded medial compartment according to Becker and Hirschmann [1].
- Osteotomy may be preferred if the underlying cause is significant malalignment [1].
- Unicompartmental arthroplasty may be best suited for true medial compartment arthritis [1].
- Total knee arthroplasty may be the best choice if the problem is an undiagnosed early inflammatory arthritis [1].

Investigations

RADIOGRAPHIC EVALUATION

- Plain radiographs are appropriate initial imaging studies for most knee conditions because they allow the assessment of traumatic injury, arthritis, patellofemoral alignment, osteochondral injury, bone neoplasm, and surgical implants [7].
- Orthogonal views for knee imaging should include at least two perpendicular views: AP and lateral [7].
- Weight-bearing AP (extension) views are used to assess cartilage loss from the distal femur and tibial plateau [7].
- Weight-bearing PA (Rosenberg; flexion) views are used to assess cartilage loss from the posterior femur and tibial plateau [7].
- Patellofemoral views are used to assess patellofemoral alignment (tilt/subluxation), patellar and trochlear morphology, osteochondral injury, and patellofemoral arthritis [7].
- A notch view is used to assess posterior femoral cartilage, notch width, and osteophytes [7].
- Radiographs may identify subchondral sclerosis, joint space narrowing, subchondral cysts (variable), osteophytes (variable), and joint subluxation in osteoarthritis [7].
- Radiographs may identify joint space loss and peripheral bone erosion in inflammatory arthropathy [7].
- Radiographs may identify subchondral radiolucency, most common in the medial femoral condyle, in osteochondral defects [7].

- Radiographs may identify linear radiolucency or radiodensity, most common in the proximal medial tibia, in stress fractures [7].
- Radiographs may identify a mixed sclerotic pattern with a subchondral, epiphyseal, or metaphyseal location in osteonecrosis [7].
- Radiographs may identify malalignment, osteophytes, cysts, and joint space loss in patellofemoral disease [7].
- Radiographs can underestimate isolated chondral lesions but may demonstrate joint space narrowing, osteophytes, sclerosis, and cysts [9].
- Weight-bearing AP and lateral views and an axial view of the patellofemoral joint should be reviewed for articular cartilage evaluation [9].
- The ability to detect subtle narrowing or an isolated chondral defect on the flexion surface may be improved with a semiflexed PA view [9].
- Long leg alignment views are used to determine the mechanical axis [9].
- If the mechanical axis traverses the involved compartment (varus knees with medial compartment lesions or valgus knees with lateral compartment lesions), realignment may need to be considered as an initial procedure or as an adjunct to a cartilage restorative procedure [9].
- Radiographs are still the standard for initial evaluation of knee arthritis [13].
- Images for knee arthritis evaluation should include weight-bearing AP and lateral views [13].
- Images for knee arthritis evaluation should include a view of the weight-bearing knee flexed at 45-degree angle, imaged posterior to anterior [13].
- Images for knee arthritis evaluation should include a sunrise view (i.e., Merchant view) [13].
- Images for knee arthritis evaluation should include extension and flexion lateral views [13].
- A standing full-length AP radiograph from hip joint to ankle joint is used to evaluate limb alignment and knee deformity [13].
- A standing full-length AP radiograph is used to identify femoral and/or tibial bone deformity (developmental or traumatic) [13].
- The KL rating grades extent of OA based on review of AP knee radiograph [13].
- Primary features used for KL rating include osteophytes (periarticular and tibial spine) and joint space narrowing [13].
- KL Grade 0 indicates normal knee features with no OA [13].
- KL Grade 1 indicates OA possibly present [13].
- KL Grade 2 indicates OA present with minimal severity [13].
- KL Grade 3 indicates OA present with moderate severity [13].
- KL Grade 4 indicates OA present with severe severity [13].
- Knee arthroplasty is recommended when Grade 4 findings are present [13].

COMPUTED TOMOGRAPHY

- Three-dimensional CT study provides enhanced bone detail [7].
- Imaging in the axial, sagittal, and coronal planes may help visualize fracture lines and displacement, osteolytic lesions around joint arthroplasty, and cortical disruption in cases of infection or neoplasia [7].
- Three-dimensional reconstructions may help with preoperative planning for complex intra-articular fractures, multiplanar osteotomy for limb malalignment, and reconstitution of bone loss in joint arthroplasty [7].
- Axial plane imaging of the hip and knee can help assess the rotational alignment of components of a total knee arthroplasty in cases of patellar maltracking [7].
- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty (TKA) planning [13].

MAGNETIC RESONANCE IMAGING

- Increasing strength of the magnetic field (measured in Tesla units) increases the resolution of images [7].
- An injected contrast agent (intravenous or intra-articular) may help delineate specific tissues of interest in MRI [7].
- MRI may identify the presence of edema, intra-articular fluid, disruption of ligament fibers, and an atypical ligament contour to suggest cruciate ligament injury [7].
- MRI can identify patterns of meniscal injury by location (anterior, midbody, posterior, peripheral, articular), pattern (horizontal, longitudinal, radial, complex), and displacement [7].
- MRI may identify the degree of articular cartilage injury (chondrosis, full-thickness cartilage loss), the presence of associated bone marrow edema, and the location (medial condyle, lateral condyle, trochlea, patella; anterior, posterior) [7].
- MRI may identify edema, avulsion, or discontinuity for the MCL/lateral collateral ligament (LCL) or associated posteromedial and posterolateral ligamentous complexes [7].
- MRI may be used to assess the continuity of the quadriceps or patellar tendon [7].
- MRI may be used to assess the margin of resection for a neoplasm, identify vascular malformation, or define the location of nerves or vessels relative to popliteal cysts [7].
- MRI can be used to evaluate articular cartilage morphology [9].
- MRI is grossly overused in the arthritic patient population [13].
- If the joint space is significantly narrowed on radiograph, then MRI is not indicated [13].
- MRI is used when osteonecrosis is suspected [13].
- MRI can be helpful in confirming MCL diagnosis and helping to rule out concomitant meniscal injury [3].
- MRI is useful for confirming MCL injury and identifying the site of injury [3].
- MRI is useful to detect the presence of meniscal and other injuries to the knee [3].
- Relative indications for an MRI include an uncertain ACL status despite multiple examinations, evaluation of a suspected meniscal tear, or preoperative evaluation for a planned MCL reconstruction or repair [3].

- MRI should be obtained as a useful adjunct to help diagnose posterolateral corner injuries in LCL injuries [14].
- MRI is often a useful adjunct for diagnosing posterolateral corner and LCL injuries in the severely injured knee [14].
- MRI findings can refocus the examination to the posterolateral structures when posterolateral injury can often go unnoticed during an initial evaluation [14].
- MRI can prove to be an extremely valuable adjunct in diagnosis when pain and guarding at the time of injury can often obscure posterolateral injury [14].

NUCLEAR MEDICINE

- Nuclear medicine involves labeled radionuclide injection followed by delayed imaging of gamma radiation [7].
- Areas of increased radionuclide concentration appear bright or “hot” in nuclear medicine imaging [7].
- Nuclear medicine provides a nonspecific study that does not define the etiology of an abnormality but rather the presence of an abnormality that may correlate with a clinical concern [7].
- Increased radionuclide activity in bone may be a normal postoperative finding for up to 6 to 12 months after a fracture repair or arthroplasty [7].
- Technetium-99 (Tc-99) is a radionuclide that may help identify infection, neoplasia, occult fracture, bone healing, active phases of heterotopic ossification, implant loosening, or failure of osseointegration [7].
- Gallium-67 (Ga-67) is a radionuclide that may help differentiate between aseptic and septic prosthetic loosening [7].
- 24 to 72 hours are needed for a complete Gallium-67 (Ga-67) study [7].

PHYSICAL EXAMINATION

- Physical examination along with radiographic or advanced imaging findings must be used concomitantly to determine the source of each patient’s symptoms and to determine appropriate surgical intervention when nonsurgical measures have failed [2].
- The physical examination for knee injury begins with observation of the patient’s gait [5].
- The uninjured knee is examined as a basis of comparison with the injured knee [5].
- Any swelling or effusion should be noted during physical examination [5].
- A small effusion will cause obliteration of the recesses on the medial and lateral aspects of the patellar tendon [5].
- With a larger effusion, diffuse swelling is present in the region of the suprapatellar pouch [5].
- A fluid wave can be palpated on the sides of the patella with a larger effusion [5].
- Active and then passive range of motion is tested carefully during physical examination [5].
- The knee is palpated to define areas of localized tenderness [5].

- The joint lines are located at the level of the inferior pole of the patella when the knee is flexed to 90 degrees [5].
- To determine varus and valgus stability, the patient's foot is held between the examiner's elbow and hip [5].
- Medial knee pain and instability at 30 degrees of flexion is diagnostic for MCL injury [3].
- Laxity to valgus stresses is assessed by the amount of medial joint space opening that occurs at 30 degrees of flexion [3].
- It is important to stress the knee at 30 degrees of flexion because with the knee in full extension the posterior capsule and PCL will stabilize the knee to valgus stress [3].
- Zero opening is considered normal for MCL injury grading [3].
- 1–4 mm of medial joint space opening indicates a grade I MCL injury [3].
- 5–9 mm of medial joint space opening indicates a grade II MCL injury [3].
- 10–15 mm of medial joint space opening indicates a complete or grade III MCL injury [3].
- Grade I and II MCL injuries typically have a firm end point to valgus stress [3].
- A grade III MCL injury tends to have a soft end point to valgus stress [3].
- Varus stress to the knee with opening at 30 degrees of flexion is diagnostic for an isolated LCL injury [14].
- The integrity of the LCL is assessed by placing a varus stress, with the knee in full extension and 30 degrees of flexion [14].
- Baseline varus opening is widely variable and should be compared to the contralateral leg [14].
- The average baseline for varus opening is 7 degrees [14].
- Exam findings with an isolated LCL injury should include varus laxity at 30 degrees of flexion and no instability in full extension [14].
- The dial test is the most useful test to evaluate for posterolateral instability [14].
- The dial test is performed at 30 and 90 degrees of flexion with a significant difference being an angle 5 degrees or greater than the contralateral leg [14].
- Injury to the posterolateral capsule alone is confirmed with greater external rotation at 30 degrees [14].
- An isolated PCL injury is confirmed with greater external rotation at 90 degrees [14].
- Injury to both posterolateral capsule and PCL is confirmed when there is greater rotation at 30 and 90 degrees compared to the uninjured leg [14].
- Patients commonly present with a history of a precipitating traumatic event or previous surgery for articular cartilage defects [9].
- An effusion, motion deficits, or limb malalignment may be observed in patients with articular cartilage defects [9].
- Knee stability should be compared with the normal side in patients with articular cartilage defects [9].
- Pain with weight bearing is a clinical presentation of knee arthritis [13].
- Pain with weight bearing is aggravated by stairs, inclines, and transition from sit to stand [13].
- Bowing deformity and instability are seen later in the clinical presentation of knee arthritis [13].

- Knee thrust is seen later in the clinical presentation of knee arthritis [13].
- A varus thrust indicates ligament stretch-out on the convex side of the thrust [13].
- A varus thrust overloads the medial compartment [13].
- A varus thrust accelerates cartilage degeneration in the medial compartment [13].
- A valgus thrust overloads the lateral compartment [13].
- A valgus thrust accelerates cartilage degeneration in the lateral compartment [13].

Complications

GENERAL COMPLICATIONS

- Reported complications of proximal tibial osteotomy include recurrence of deformity, peroneal nerve palsy, nonunion, infection, knee stiffness or instability, intraarticular fracture, deep vein thrombosis, compartment syndrome, patella infra, and osteonecrosis of the proximal fragment [1].
- Inadequate correction and recurrent varus deformity have been reported to occur in 5% to 30% of patients with proximal tibial osteotomy [1].
- Recurrence of a varus deformity was the most common complication in Coventry's report of 213 proximal tibial osteotomies [1].
- Coventry suggested that overcorrection beyond the normal 5 degrees of anatomic valgus decreased the frequency of recurrent varus deformity [1].

NEUROVASCULAR INJURY

- The peroneal nerve is most at risk with osteotomy of the proximal fibula, where the nerve wraps around the neck of the fibula before dividing into deep and superficial branches [1].
- A cadaver study demonstrated that at 90 degrees of flexion, the distance between the osteotomy blade and the popliteal artery averaged only 10.6 mm [1].
- Authors of a cadaver study recommended keeping something substantial between the proximal tibia and the popliteal artery, especially when using an oscillating power saw [1].

PATELLAR POSITION

- Factors that may cause patella baja include shortening of the patellar tendon after prolonged immobilization, new bone formation at the site of the osteotomy in the area of the insertion of the patellar tendon, and fibrosis of the patellar tendon [1].

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