

# Knee osteoarthritis

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## Overview

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### ARTHROSCOPIC MANAGEMENT

- Performing arthroscopy for the treatment of early-stage osteoarthritis of the knee may help delay the need for knee arthroplasty, but proper patient selection is imperative [2].
- Arthroscopic débridement allows assessment of the joint and affords the ability to débride the meniscus, loose articular cartilage, and synovium, as well as to remove any loose bodies [2].
- Arthroscopy enables visualization of the entire joint and may aid in future decision making regarding osteotomy versus unicompartmental knee arthroplasty versus total knee arthroplasty [2].
- Arthroscopic indications include mild to moderate arthritis with minimal malalignment and mechanical symptoms consistent with a loose body, meniscus tear, synovitis, or painful osteophytes [2].
- Arthroscopic procedures are contraindicated in the knee with advanced arthritis, especially when varus or valgus malalignment is present [2].
- The literature lacks well-designed studies to evaluate the efficacy of arthroscopic procedures for knee osteoarthritis [2].
- Some studies have demonstrated improvement in short-term outcomes with arthroscopic procedures, while most demonstrate equivalent outcomes to nonsurgical treatment at mid to long-term follow-up [2].
- Arthroscopic lavage and débridement of the arthritic knee is controversial but effective when properly indicated [2].
- Indications for arthroscopic lavage and débridement are limited to specific mechanical symptoms caused by loose bone, cartilage flaps or particles, meniscal tears, or synovial impingement [2].
- Irrigation during arthroscopic lavage dilutes the joint fluid, which reduces the concentration of degradative enzymes [2].
- Removal of loose cartilage, meniscus, and/or synovium during débridement reduces mechanical symptoms and removes a source of irritation to the synovial tissue [2].
- Diseased cartilage is removed or stabilized using a shaver, laser, or radiofrequency probe during chondroplasty [2].

- The potential for thermal damage when using a laser or radiofrequency probe has resulted in decreased use of these techniques [2].
- In abrasion arthroplasty, an arthroscopic shaver is used to débride cartilage defects and penetrate the subchondral bone plate to cause bleeding [2].
- The goal of abrasion arthroplasty is formation of a blood clot, which undergoes metaplasia to become fibrocartilage; the process is estimated to take 8 weeks [2].
- Fibrocartilage is primarily composed of type I collagen as opposed to the type II collagen of normal hyaline cartilage [2].
- In subchondral drilling or microfracture, cartilage defects are débrided to a stable rim, and the resulting exposed subchondral bone is penetrated with a small drill or awl [2].
- The goal of subchondral drilling or microfracture is to create bleeding bone, which produces a blood clot and subsequent fibrocartilage [2].
- Some studies have demonstrated by 2 years post-operatively that the fibrocartilage cap is significantly degraded or no longer present [2].

## OSTEOTOMY

- Osteotomy of the knee is effective in treating arthritis because of a varus or valgus malalignment and can delay the need for total knee arthroplasty [57].
- Osteotomy of the knee is frequently combined with cartilage restoration procedures to provide a better mechanical environment for the biologic repair [57].
- Osteotomy of the knee is ideal for the young, active patient with isolated medial or lateral compartment disease because it realigns the limb and reduces stresses on the articular cartilage of the diseased compartment [57].
- Medial compartment arthritis in the varus malaligned limb is treated with a valgus-producing high tibial osteotomy [57].
- Techniques for valgus-producing high tibial osteotomy include lateral closing wedge, medial opening wedge, and dome osteotomy [57].
- Drawbacks of lateral closing wedge high tibial osteotomy include the need for concomitant fibular osteotomy, higher risk of peroneal nerve injury, and injury or disruption of the proximal tibiofibular joint [57].
- Drawbacks of medial opening wedge high tibial osteotomy include the need for bone graft and risk of collapse, nonunion, or loss of correction [57].
- One technique for valgus-producing high tibial osteotomy has not been shown to be superior to the other in terms of patient outcome or longevity [57].
- Slight overcorrection of the varus deformity to 8° to 10° of valgus has produced good results in high tibial osteotomy [57].
- There is increasing consensus that individualization of the amount of correction depending on the extent of arthritis and patient age may be appropriate, but no clinical studies are available [57].

- Lateral compartment arthritis in the valgus malaligned limb is usually treated with a varus-producing distal femoral osteotomy to avoid an oblique joint line [57].
- The osteotomy for valgus malalignment is performed through the distal femur because the lateral femoral condyle is typically hypoplastic leading to excessive distal femoral valgus [57].
- The goal of varus-producing distal femoral osteotomy is to correct the deformity to 0° (neutral) to 2° of valgus [57].
- Some authors argue that for small corrections in valgus knees the osteotomy should be performed on the tibial side, but this technique can lead to an oblique joint line and has not been validated in clinical studies [57].
- Contraindications for valgus-producing high tibial osteotomy include lateral compartment arthritis, patellofemoral arthritis, inability to accept cosmetic appearance of leg, greater than 15° flexion contracture, range of motion less than 90°, and loss of lateral meniscus [57].
- Contraindications for varus-producing distal femoral osteotomy include medial compartment arthritis, greater than 15° flexion contracture, range of motion less than 90°, loss of medial meniscus, and patellofemoral arthritis [57].
- Complications of knee osteotomy include compartment syndrome, peroneal nerve palsy, nonunion or malunion, undercorrection or overcorrection, and patella baja [57].
- Peroneal nerve palsy is more common in high tibial osteotomy [57].
- Valgus-producing high tibial osteotomy has been successful in approximately 50% to 85% of patients at 10 years [57].
- Varus-producing distal femoral osteotomy has been successful in up to 87% of patients at 10 years [57].
- Total knee arthroplasty after osteotomy is technically challenging because of previous incisions, scar tissue, retained hardware, tibial abnormalities, and femoral abnormalities [57].
- Patella baja and increased need for lateral release are common after total knee arthroplasty following osteotomy [57].
- Survivorship of total knee arthroplasty does not seem to be affected by prior osteotomy; several studies have shown excellent long-term results [57].
- An osteotomy of the distal femur or proximal tibia may be performed in isolation, or as a concomitant procedure, to correct malalignment, off-load a single compartment, or improve knee joint stability [59].
- Long-leg standing radiographs assist with determining the mechanical axis, thus degree of corrective osteotomy [59].
- Long-leg standing radiographs can correct sagittal or coronal plane malalignment [59].
- Distal femoral varus osteotomy is a treatment option for symptomatic valgus malalignment, including isolated lateral compartment osteoarthritis in a young, active patient [59].
- Medial closing wedge distal femoral osteotomy is indicated when the angle of correction is more than 17.5 degrees or in cases of limb-length discrepancy [59].
- Reported results for distal femoral varus osteotomy include a 20% major complication rate and a 64% 10-year survival rate [59].

- Medial opening or lateral closing wedge high tibial osteotomies are utilized to correct varus malalignment or medial compartment overload [59].
- High tibial osteotomy may be used in conjunction with osteochondral resurfacing, meniscal repair, or knee instability procedures [59].
- Contraindications for high tibial osteotomy include severe osteoarthritis (stage III–IV), limited knee range of motion (<120 degrees), soft tissue compromise, and age less than 65 years [59].

## KNEE ARTHRODESIS

- When the knee is not amenable to reconstruction, arthrodesis is usually the last option available to the surgeon to obtain a painless, stable knee [60].
- Successful fusion is achieved in more than 90% of patients undergoing knee arthrodesis [60].
- The most common indication for knee arthrodesis is the nonreconstructable total knee arthroplasty that has failed, usually because of infection and loss of the extensor mechanism [60].
- Less common indications for knee arthrodesis include septic arthritis, osteomyelitis, posttraumatic arthritis in a young manual laborer, painful ankylosis, neuropathic knee (Charcot joint), and paralytic deformity [60].
- Contraindications for knee arthrodesis include bilateral knee involvement and ipsilateral hip arthrodesis [60].
- Surgical techniques for knee arthrodesis include external fixation, plates, intramedullary rods, and combined modalities [60].
- If the limb-length discrepancy is less than 2 cm, the knee is placed in 5° to 7° of valgus and 15° of flexion during arthrodesis [60].
- If the limb-length discrepancy is 2 to 4 cm, the knee is placed in extension to enable ground clearance during arthrodesis [60].
- If the limb-length discrepancy is greater than 4 cm, bone grafting or a prosthetic spacer to limit gait abnormalities can be considered during arthrodesis [60].
- Complications of knee arthrodesis include painful nonunion (most common), infection, deep vein thrombosis, peroneal nerve palsy, and wound dehiscence [60].
- Long-term complications of knee arthrodesis include hip, spine, and ankle pain because of the altered gait pattern [60].

## Anatomy & Pathophysiology

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### BONY ANATOMY

- The knee joint consists of the distal femur, proximal tibia, and patella [10].
- The medial femoral condyle is larger and projects farther posteriorly and distally than the lateral femoral condyle [20].

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- The lateral femoral condyle projects farther anteriorly and is wider in the medial-lateral direction than the medial femoral condyle [20].
- The tibial articular surface slopes 7° to 10° in the sagittal plane [20].
- The posterior slope of the medial tibial plateau averages 10.7° and the lateral plateau averages 7.2° [24].
- The medial tibial plateau is larger than the lateral plateau and is concave in both frontal and sagittal planes [20].
- The lateral tibial plateau is smaller, more circular, concave in the frontal plane, and convex in the sagittal plane [20].
- The patella is the largest sesamoid bone in the body with a mean thickness of 2.5 cm [20].
- The patellar articular surface is the thickest in the body, measuring approximately 5 mm in the midportion and 2 mm on the sides [20].
- The patella contains a vertical central ridge separating the broader lateral facet from the medial facet, plus a smaller odd facet [20].
- The medial compartment has a larger surface area than the lateral compartment [24].

## LIGAMENTS

- The anterior cruciate ligament (ACL) is composed of 90% type I collagen and 10% type III collagen [20].
- The ACL has a mean length of 33 mm and a mean midsubstance width of 11 mm [20].
- The ACL femoral attachment is a semicircular area on the posteromedial aspect of the lateral femoral condyle [20].
- The ACL tibial attachment is a broad, irregular, oval-shaped area between the medial and lateral tibial spinous processes [20].
- The posterior cruciate ligament (PCL) has a mean length of 38 mm and a mean width of 13 mm [24].
- The PCL femoral attachment is a broad, crescent-shaped area on the anterolateral aspect of the medial femoral condyle [24].
- The PCL tibial insertion is located 10 to 15 mm distal to the joint line on the posterior central sulcus [24].
- The ACL anteromedial bundle is tight in knee flexion and the posterolateral bundle is tight in knee extension [24].
- The PCL anterolateral bundle is tight in knee flexion and the posteromedial bundle is tight in knee extension [24].
- The medial collateral ligament (MCL) originates on the femoral sulcus approximately 3.2 cm proximal and 4.8 cm posterior to the articular surface of the femur [24].
- The adductor tubercle is a prominence on the medial condyle proximal to the MCL origin and serves as the insertion site for the adductor magnus muscle [24].
- The Gerdy tubercle is located 2 to 3 cm lateral to the tibial tuberosity and is the insertion site of the iliotibial band [20].
- The fibular head is located a mean of 1.5 cm distal to the joint line, with a range of 6 to 32 mm [24].

## MENISCI

- The menisci are C-shaped fibrocartilaginous disks that provide shock absorption, increase joint congruency, enhance stability, and aid in synovial fluid distribution [10].
- The medial meniscus is firmly attached to the joint capsule along its entire peripheral edge [10].
- The lateral meniscus is attached to the anterior and posterior capsule but has a region posterolaterally where it is not firmly attached [10].
- The medial meniscus has less mobility than the lateral meniscus and is more susceptible to tearing when trapped between the femoral condyle and tibial plateau [10].
- The lateral meniscus is larger than the medial meniscus and carries a greater share of lateral compartment pressure [10].
- Menisci consist of type I collagen fibers arranged obliquely, radially, and vertically [24].
- Vascular supply to the menisci penetrates 20% to 30% of the peripheral medial meniscus and 10% to 25% of the peripheral lateral meniscus [24].
- The medial meniscus is crescent-shaped and attaches more anteriorly and posteriorly than the lateral meniscus [24].
- The lateral meniscus is circular in shape and covers a larger proportion of the tibial plateau [24].
- Meniscal root tears completely disrupt circumferential fibers, resulting in loss of hoop stresses and increased contact forces [16].
- Meniscal root tears are functionally equivalent to a total meniscectomy [16].

## VASCULAR AND NERVE ANATOMY

- The blood supply to the knee is formed from an anastomosis of the descending geniculate artery, superior and inferior geniculate arteries, middle geniculate artery, and anterior tibial recurrent arteries [20].
- The middle geniculate artery supplies both the anterior and posterior cruciate ligaments [20].
- The knee is innervated by branches of the femoral nerve (L2, L3, L4), obturator nerve (L2, L3, L4), and sciatic nerve (L4, L5, S1, S2) [20].
- The posterior articular branch of the tibial nerve is the largest nerve providing innervation to the intra-articular knee [20].
- The infrapatellar branch of the saphenous nerve innervates the skin over the anterior knee and proximal tibia [20].

## KINEMATICS AND BIOMECHANICS

- The knee is a hinge joint that incorporates gliding and rolling motions [21].
- The “screw-home” mechanism involves tibial external rotation of 5 degrees in the final 15 degrees of extension [21].
- The greatest range of motion occurs in the sagittal plane at approximately 160° [36].
- Knee rotation ranges from 45° in external rotation to 30° in internal rotation [36].

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- Range of motion in the frontal plane reaches a maximum of 10° for both abduction and adduction [36].
- During walking, knee range of motion reaches approximately 70° in the sagittal plane, 15° in the frontal plane, and 10° in the transverse plane [36].
- The normal instant center of the knee joint follows a semicircular path related to tibiofemoral surfaces and crossing ligaments [36].
- Rupture of cruciate ligaments or disruption of the tibiofemoral surface causes a major change in the path of the instant center [36].
- The crossed four-bar linkage system describes the basic element of knee motion, with cruciate ligaments acting as the central pivot and menisci providing peripheral force control [37].
- In full extension, the lateral femoral condyle sits slightly more anterior than the medial femoral condyle on the tibial plateau [37].
- The popliteus muscle initiates flexion by pulling the lateral femoral condyle backward while the medial femoral condyle slides forward, resulting in tibial internal rotation [37].

## OSTEOARTHRITIS PATHOPHYSIOLOGY

- Primary changes of osteoarthritis include loss of articular cartilage, remodeling of subchondral bone, and formation of osteophytes [7].
- Osteoarthritis involves all tissues forming the synovial joint, including articular cartilage, subchondral bone, metaphyseal bone, synovium, ligaments, joint capsule, and muscles [7].
- Osteoarthritis is the leading cause of disability and impaired quality of life in developed countries in patients older than 65 years [7].
- The prevalence of osteoarthritis is expected to increase 66% to 100% by 2030 [7].
- The knee is the most commonly affected joint, with 12% of adults older than 60 years diagnosed with knee osteoarthritis [7].
- Inflammation does not appear to be a major component of osteoarthritis in most patients [7].
- Advancing age is perhaps the most important risk factor for osteoarthritis [7].
- Female sex and loss of estrogen over time increase the risk of osteoarthritis [7].
- Obesity is a risk factor for osteoarthritis [7].
- Osteoarthritis is not simply the result of mechanical wear from joint use [7].
- At a cellular level, osteoarthritis results from deterioration in the ability of chondrocytes to maintain and restore articular cartilage [7].
- Chondrocytes undergo age-related telomere erosion and increased expression of the senescence marker  $\beta$ -galactosidase [7].
- Varus thrust overloads the medial compartment, accelerates cartilage degeneration, and increases the adductor moment of force [4].
- Valgus thrust overloads the lateral compartment and accelerates cartilage degeneration in the lateral compartment [4].

- The mechanical limb line (Mikulicz line) extends from the femoral head center to the ankle center [15].
- The farther the Mikulicz line is from the knee center, the greater the mechanical load to the affected knee compartment [15].
- Restorative knee osteotomies correct distal femoral and/or proximal tibial deformities to realign the Mikulicz line to pass through the knee center [15].
- The mechanical lateral distal femoral angle (mLDFA) is neutral at 90 degrees [15].
- An mLDFA greater than 90 degrees is defined as varus mechanical distal femoral alignment [15].
- An mLDFA less than 90 degrees is defined as valgus mechanical distal femoral alignment [15].

## OSTEONECROSIS PATHOPHYSIOLOGY

- Spontaneous osteonecrosis of the knee (SPONK) is more common in women older than 55 years [5].
- In 99% of patients, SPONK involves only one joint and only one condyle, typically the epiphysis of the medial femoral condyle [5].
- Some evidence suggests SPONK lesions represent microfractures [5].
- Secondary osteonecrosis of the knee typically involves more than one compartment or even the metaphyseal bone [5].
- Approximately 80% of secondary osteonecrosis cases have bilateral involvement [5].
- Patients with secondary osteonecrosis are typically women with a 3:1 ratio to men, usually younger than 55 years [5].
- Secondary osteonecrosis progresses to advanced osteoarthritis in 80% of patients treated nonsurgically [5].
- SPONK pathomechanics begin with mechanical stress overload of bone due to the Mikulicz line over the medial compartment and increased adductor moment of force [9].
- Osteoporosis and meniscal tissue loss contribute to SPONK by causing point loading of bone [9].
- The second step in SPONK pathomechanics is microfracture (fatigue) of subchondral bone from accumulated cyclic overload [9].
- The third step in SPONK pathomechanics is fluid build-up into the subchondral bone region, increasing intraosseous pressure and disrupting blood flow to the watershed region of the distal condyle [9].
- The fourth step in SPONK pathomechanics is remodeling of necrotic bone, where resorption exceeding repair leads to bone collapse and cartilage deformation [9].
- SPONK radiographic appearance shows a sclerotic halo around a lucent area of collapse, distinct from the crescent sign seen in secondary osteonecrosis [9].
- Secondary osteonecrosis pathomechanics begin with intraosseous vascular occlusion due to coagulopathy, lipid emboli, immune complexes, steroid cytotoxicity, or adipose cell enlargement [56].
- The second step in secondary osteonecrosis pathomechanics is bone cell necrosis [56].
- The third step in secondary osteonecrosis pathomechanics is remodeling of necrotic bone, leading to collapse and joint degeneration when necrotic bone is adjacent to the joint [56].

- The crescent sign in secondary osteonecrosis is a radiographic hallmark indicating the space between the cartilage layer and resorbed epiphyseal joint [56].
- The crescent sign portends joint surface demise because shear forces tear cartilage, creating flaps that rapidly progress to joint degeneration [56].
- Corticosteroids are the highest risk factor for secondary osteonecrosis, accounting for 90% of cases [56].
- Alcohol use is the second highest risk factor for secondary osteonecrosis [56].
- Approximately 70 to 90% of patients with secondary knee osteonecrosis have hip involvement [56].

## Clinical Presentation

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### HISTORY AND SYMPTOMS

- Pain in knee osteoarthritis is often exacerbated with activity and relieved by rest [7].
- Patients may describe a deep aching pain with decreased range of motion and swelling [7].
- Pain is aggravated by stairs, inclines, and transition from sit to stand [4].
- Bowing deformity and instability are seen later in the clinical presentation of knee osteoarthritis [4].
- Knee thrust is a later finding in the clinical presentation of knee osteoarthritis [4].
- Varus thrust indicates ligament stretch-out on the convex side and overloads the medial compartment [4].
- Valgus thrust indicates ligament stretch-out on the convex side and overloads the lateral compartment [4].
- A patient who does not have temporary relief from an intra-articular injection should be evaluated for other pathology external to the knee joint [14].
- Catching or locking, instability in the coronal and/or sagittal plane, or an effusion can signal the presence of a mechanical pathology warranting surgical treatment [14].
- Patients with knee osteoarthritis have an altered gait and increased energy cost [7].
- Atrophy in muscles crossing the affected joint is often present in chronic knee osteoarthritis [7].
- Spontaneous osteonecrosis of the knee presents with sudden onset of medial knee pain, frequently with a limp [9].
- In spontaneous osteonecrosis of the knee, acute pain lasts 6 to 8 weeks and is located over the femoral condyle [9].
- Spontaneous osteonecrosis of the knee is associated with mild to moderate effusion and loss of knee range [9].

### PHYSICAL EXAMINATION

- Physical examination of the knee in osteoarthritis often reveals restricted range of motion, crepitus, tenderness along the joint line, an effusion, and some degree of deformity [7].
- Patellar tracking and ligament stability should be assessed during the physical examination of the knee [7].
- Varus or valgus alignment should be noted during the physical examination of the knee [7].

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- Gait abnormalities should be noted during the physical examination of the knee [7].
- The lumbar spine and hips should be examined because pathology in one of these locations can present as referred pain to the knee [14].
- The lower extremities should be examined for evidence of muscular atrophy or weakness, with particular attention to hip abductor and quadriceps strength [14].
- Distal sensation and vascular perfusion (peripheral pulses) should be assessed in all patients with symptomatic knee osteoarthritis [14].
- Knee alignment should be assessed in both supine and standing positions, as bearing weight may change the knee's alignment dynamically [43].
- Inspection of the knee can reveal skin abnormalities, evidence of trauma, malalignment, and swelling [43].
- Palpation of the peripatellar tissue can reveal the presence of effusion and/or synovitis [43].
- Blocks to motion during range of motion testing can be pain-related or mechanical [43].
- When active and passive ranges of motion differ, the clinician must differentiate between pain-related, mechanical, or neuromuscular causes [43].
- Hip range of motion should be examined and may reveal resultant knee pain, indicating the possibility of referred pain from intra-articular hip pathology [43].

## IMAGING

- Weight-bearing radiographs are the most sensitive for confirming the diagnosis of knee osteoarthritis [7].
- Radiographic studies help confirm the clinical diagnosis of a joint disorder determined using the patient's history and physical examination [3].
- Plain radiographs are appropriate initial imaging studies for most knee conditions [3].
- Weight-bearing AP and lateral views are standard initial radiographic images for knee evaluation [4].
- A view of the weight-bearing knee flexed at 45-degree angle, imaged posterior to anterior, is a standard initial radiographic image for knee evaluation [4].
- A sunrise view (Merchant view) is a standard initial radiographic image for knee evaluation [4].
- Extension and flexion lateral views are standard initial radiographic images for knee evaluation [4].
- A standing full-length AP radiograph from hip joint to ankle joint is used to evaluate limb alignment and knee deformity [4].
- A standing PA view obtained with the patient's knee in 45° of flexion often is preferred over the standard standing AP view for evaluating knee osteoarthritis [14].
- The 45° flexion PA view allows better evaluation of the posterior femoral condyles and earlier detection of subtle joint-space loss than the AP view [14].
- Additional radiographs for knee osteoarthritis should include a lateral view of the affected side and a Merchant or sunrise view of the patellofemoral joint [14].
- Radiography may identify subchondral sclerosis, joint space narrowing, subchondral cysts, osteophytes, and joint subluxation in osteoarthritis [3].

- MRI is grossly overused in the arthritic patient population [4].
- If the joint space is significantly narrowed on radiograph, then MRI is not indicated for knee osteoarthritis [4].
- MRI is used when osteonecrosis is suspected in the knee [4].
- MRI may identify the degree of articular cartilage injury, the presence of associated bone marrow edema, and the location of the injury [3].
- Three-dimensional CT with remodeling is used for preoperative planning for reconstruction associated with dysplasia, post-trauma planning, and complex total knee arthroplasty planning [4].
- Three-dimensional CT reconstructions may help with preoperative planning for multiplanar osteotomy for limb malalignment and reconstitution of bone loss in joint arthroplasty [3].

## Investigations

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### PLAIN RADIOGRAPHY

- Imaging studies should include at least two perpendicular views: AP and lateral [3].
- Weight-bearing AP views in extension are used to assess cartilage loss from the distal femur and tibial plateau [3].
- Weight-bearing PA (Rosenberg; flexion) views are used to assess cartilage loss from the posterior femur and tibial plateau [3].
- Patellofemoral views are used to assess patellofemoral alignment, patellar and trochlear morphology, osteochondral injury, and patellofemoral arthritis [3].
- The notch view is used to assess posterior femoral cartilage, notch width, and osteophytes [3].
- Supine AP knee radiographs do not adequately estimate the joint space width needed to estimate the degree of osteoarthritis progression [41].
- Plain frontal radiographs of the knee may not accurately display the actual joint space due to different cartilage wear patterns, meniscal integrity, or variances in tibial slopes [41].
- A 45° standing flexion view was introduced by Rosenberg et al. to evaluate joint space [41].
- A fixed flexion view (FFV) technique has been introduced with improved reproducibility and good evaluation of the joint space [41].
- The Lyon Schuss view (LSV) requires fluoroscopic adjustment of the irradiation angle relative to the medial tibial plateau, which is more accurate for measuring the actual joint space width than FFV [41].
- The radiation exposure dose for the Lyon Schuss view is higher than for the fixed flexion view [41].
- Goniometer readings of long limb alignment or measured on an FFV correlated well with the angle measured on long limb radiographs [41].
- Radiographs are the standard for initial evaluation of knee arthritis [4].
- Images for knee arthritis evaluation should include weight-bearing AP and lateral views [4].

- Images for knee arthritis evaluation should include a view of the weight-bearing knee flexed at 45-degree angle, imaged posterior to anterior [4].
- Images for knee arthritis evaluation should include a sunrise view (Merchant view) [4].
- Images for knee arthritis evaluation should include extension and flexion lateral views [4].
- The Kellgren-Lawrence (KL) rating grades the extent of OA based on review of the AP knee radiograph [4].
- Primary features used for KL rating include osteophytes, joint space narrowing, subchondral sclerosis with or without subchondral cysts, and altered shape of periarticular bones [4].
- KL Grade 0 indicates normal knee features with no OA [4].
- KL Grade 1 indicates OA possibly present [4].
- KL Grade 2 indicates OA present with minimal severity [4].
- KL Grade 3 indicates OA present with moderate severity [4].
- KL Grade 4 indicates OA present with severe severity [4].
- Knee arthroplasty is recommended when Grade 4 findings are present [4].

## ADVANCED IMAGING

- Advanced radiographic imaging studies may help assess overall limb alignment and further delineate intra-articular and extra-articular soft tissues [3].
- MRI may identify the degree of articular cartilage injury, including chondrosis and full-thickness cartilage loss [3].
- MRI may identify the presence of associated bone marrow edema and the location of cartilage injury [3].
- MRI is the most useful study for differentiating osteonecrosis from other conditions such as osteochondritis dissecans, transient osteoporosis, bone bruises, or occult fractures [5].
- A serpentine lesion within a well-demarcated border is a specific finding on MRI for osteonecrosis [5].
- Bone edema on MRI is a common feature of OA, osteonecrosis, cartilage injury, and transient regional osteoporosis [5].
- If the joint space is significantly narrowed on radiograph, MRI is not indicated [4].
- MRI is used when osteonecrosis is suspected [4].
- Three-dimensional CT reconstructions may help with preoperative planning for complex intra-articular fractures, multiplanar osteotomy for limb malalignment, and reconstitution of bone loss in joint arthroplasty [3].
- Axial plane CT imaging of the knee can help assess the rotational alignment of components of a total knee arthroplasty in cases of patellar maltracking [3].
- Assessment of the joint must combine physical examination along with radiographic (including full-length alignment views) and MRI findings [13].
- Radiographic evaluations are essential when diagnosing an osteochondritis dissecans (OCD) lesion of the knee [40].

- Important aspects of OCD lesions may be better seen with MRI than with radiographs [40].

## Treatment

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### NON-OPERATIVE MANAGEMENT

- A stepwise approach with graduated interventional treatment is recommended as pain and functional disability progress in knee osteoarthritis [15].
- Patient education programs are a strong recommendation for the management of knee osteoarthritis [15].
- Exercise, including supervised, unsupervised, and aquatic modalities, is a strong recommendation for the management of knee osteoarthritis [15].
- Self-management programs are a strong recommendation for the management of knee osteoarthritis [15].
- Topical NSAIDs are a strong recommendation for the management of knee osteoarthritis [15].
- Oral NSAIDs are a strong recommendation for the management of knee osteoarthritis [15].
- Oral acetaminophen is a strong recommendation for the management of knee osteoarthritis [15].
- Oral narcotics, including tramadol, are not recommended for the management of knee osteoarthritis [15].
- Lateral wedge insoles are not recommended for the management of knee osteoarthritis [15].
- Canes are a moderate recommendation for the management of knee osteoarthritis [15].
- Brace treatment is a moderate recommendation for the management of knee osteoarthritis [15].
- Neuromuscular training in combination with traditional exercise is a moderate recommendation for the management of knee osteoarthritis [15].
- Sustained weight loss is a moderate recommendation for the management of knee osteoarthritis [15].
- Intraarticular corticosteroids are a moderate recommendation for short-term relief in knee osteoarthritis [15].
- Arthroscopic partial meniscectomy is a moderate recommendation for meniscal tears in patients with concomitant mild to moderate osteoarthritis [15].
- Hyaluronic acid intraarticular injections are not recommended for the management of knee osteoarthritis [15].
- Arthroscopy with lavage and/or débridement is not recommended for the management of knee osteoarthritis [15].
- Supplements including turmeric, ginger extract, glucosamine, chondroitin, and vitamin D may be helpful for knee osteoarthritis [15].
- Manual therapy in addition to an exercise program may be used for knee osteoarthritis [15].
- Massage in addition to usual care may be used for knee osteoarthritis [15].
- FDA-approved laser treatment may be used for knee osteoarthritis [15].
- Acupuncture may improve pain and function in knee osteoarthritis [15].

- Transcutaneous electrical nerve stimulation may improve pain in knee osteoarthritis [15].
- Percutaneous electrical nerve stimulation may improve pain and function in knee osteoarthritis [15].
- Electromagnetic field therapy may improve pain in knee osteoarthritis [15].
- Extracorporeal shockwave therapy may be used for knee osteoarthritis [15].
- Platelet-rich plasma may reduce pain and improve function in knee osteoarthritis [15].
- Denervation therapy may reduce pain and improve function in knee osteoarthritis [15].
- High tibial osteotomy in properly indicated patients with unicompartmental knee osteoarthritis may improve pain and function [15].
- The utility and efficacy of dry needling for knee osteoarthritis is unclear [15].
- Free-floating interpositional devices, such as unispacers, are not recommended for knee osteoarthritis [15].
- Maintenance of a healthy body weight is effective for decreasing the severity of symptoms and slowing the progression of osteoarthritis of the knee [45].
- Obesity increases the likelihood of symptomatic knee osteoarthritis as much as threefold [45].
- Forces at the knee are magnified to three to seven times the actual body weight [45].
- The American Academy of Orthopaedic Surgeons recommends weight loss for patients with symptomatic knee osteoarthritis and a body mass index above 25 kg/m<sup>2</sup> [45].
- Patients who are overweight should strive to lose at least 5% of their current body weight and maintain the decreased weight with diet and exercise [45].
- Intra-articular corticosteroid injections are effective for symptomatic management of osteoarthritis of the knee [12].
- Oral supplementation with glucosamine and/or chondroitin sulfate has no benefit for management of symptomatic osteoarthritis of the knee [12].
- Nonsurgical treatment for spontaneous osteonecrosis of the knee includes analgesics, protected weight bearing, and physical therapy directed at quadriceps strengthening [5].
- Good results have been demonstrated with nonsurgical management of spontaneous osteonecrosis of the knee and postarthroscopic osteonecrosis [5].
- No evidence is available regarding the efficacy of bisphosphonates in osteonecrosis of the knee [5].
- Nonoperative treatment for spontaneous osteonecrosis of the knee is indicated when the lesion is less than 45% of condylar width [9].
- Nonoperative treatment for spontaneous osteonecrosis of the knee involves limited weight bearing for 6 to 8 weeks, analgesics, NSAIDs, and physical therapy to maintain knee range [9].

## ARTHROSCOPIC MANAGEMENT

- Some studies have demonstrated improvement in short-term outcomes with arthroscopic treatment, with most demonstrating equivalent outcomes to nonsurgical treatment at mid to long-term follow-up [2].
- Removal of loose cartilage, meniscus, and/or synovium during arthroscopy reduces mechanical symptoms and removes a source of irritation to the synovial tissue [2].

- The goal of abrasion arthroplasty is formation of a blood clot, which undergoes metaplasia to become fibrocartilage, a process estimated to take 8 weeks [2].
- In the absence of mechanical symptoms, knee arthroscopy with débridement is not effective in managing osteoarthritis of the knee [12].
- Arthroscopic knee débridement may provide relief from mechanical symptoms in carefully selected osteoarthritis patients but should not be offered as a first-line treatment in lieu of nonsurgical measures [13].
- Patients may continue to have pain because of underlying osteoarthritis, but mechanical symptoms are more reliably improved by arthroscopic débridement [13].
- Arthroscopy for spontaneous osteonecrosis of the knee is indicated only for mechanical symptoms of articular joint derangement [9].
- The MeTeOR trial found no statistically significant difference in patient-reported outcomes for pain and function at 6 or 12 months between physical therapy and arthroscopic partial meniscectomy for meniscal tear with concomitant osteoarthritis [49].
- An initial nonsurgical management strategy consisting of physical therapy with the option for later arthroscopic management in the absence of symptomatic relief is a sound approach for meniscal tear with concomitant knee osteoarthritis [49].

## CARTILAGE RESTORATION AND PRESERVATION

- Surgical options for treatment of focal cartilage injury include bone marrow stimulation techniques, osteochondral autograft or allograft transplantation, autologous cell-based therapy, and allograft therapies [13].
- Bone marrow stimulation techniques include microfracture and abrasion chondroplasty [13].
- Autologous cell-based therapy includes autologous chondrocyte implantation with or without a collagen membrane [13].
- Allograft therapies include particulated juvenile cartilage or acellular extracellular matrix [13].
- Correction of ligamentous instability and limb malalignment is paramount to the success of cartilage restoration procedures and meniscal transplantation [13].
- In the case of symptomatic meniscal deficiency, allograft meniscal transplantation can provide significant symptomatic relief and improvements in quality of life, although radiographic osteoarthritis may still progress [13].
- Surgical management of articular cartilage injuries should focus on removing inflammatory mediators and restoring the osteochondral unit [47].
- Surgical options for articular cartilage injuries include arthroscopic débridement, bone marrow stimulation, osteochondral autograft transfer, osteochondral allograft transplantation, autologous chondrocyte implantation, and various newer, emerging techniques [47].

## OSTEOTOMY

- For isolated medial compartment degeneration, surgical options include medial opening wedge high tibial osteotomy, lateral closing wedge high tibial osteotomy, or unicompartmental knee arthroplasty [13].
- Lateral compartment osteoarthritis can be treated with lateral closing wedge distal femoral osteotomy, medial opening wedge distal femoral osteotomy, medial closing wedge high tibial osteotomy, or unicompartmental knee arthroplasty [13].
- High tibial osteotomy is indicated for spontaneous osteonecrosis of the knee when angular malalignment is present [5].
- Proximal tibial osteotomy is indicated for joint preservation in younger, active patients under 45 years with an occupation that makes arthroplasty less appropriate [9].
- Best results for proximal tibial osteotomy in spontaneous osteonecrosis of the knee are achieved when the lesion is less than 50% of femoral condylar width [9].
- A prospective study found that temporary relief with unloader bracing treatment could predict pain relief after valgus-producing high-tibial osteotomy [6].

## ARTHROPLASTY

- Total knee arthroplasty consistently provides substantial improvements in pain, function, and patient satisfaction with excellent survivorship after failure of conservative care for knee osteoarthritis [17].
- Total knee arthroplasty is a highly cost-effective surgical treatment and is the mainstay of surgical approaches for addressing advanced arthritis [17].
- The primary indication for total knee arthroplasty is to relieve pain caused by severe arthritis, with or without significant deformity [8].
- Radiographic findings must correlate with a clear clinical impression of knee arthritis before total knee arthroplasty is considered [8].
- Conservative treatment measures should be exhausted before surgery, including physical therapy, antiinflammatory medications, intraarticular injections, activity modifications, and the use of a cane for ambulation [8].
- Patients who do not have complete cartilage space loss before surgery tend to be less satisfied with their clinical result after total knee arthroplasty [8].
- Total knee arthroplasty is generally indicated in older patients with more sedentary lifestyles due to finite expected survival adversely affected by activity level [8].
- Total knee arthroplasty is clearly indicated in younger patients who have a significant functional impairment from osteoarthritis, systemic arthritis, or osteonecrosis with subchondral collapse of a femoral condyle [8].
- Severe pain from chondrocalcinosis and pseudogout in an elderly patient is an occasional indication for arthroplasty in the absence of complete cartilage space loss [8].
- Severe patellofemoral arthritis in an elderly patient may justify total knee arthroplasty because the expected outcome is better than that of patellectomy or patellofemoral replacement [8].

- Deformity can become the principal indication for arthroplasty in patients with moderate or severe arthritis when the progression of deformity threatens the expected outcome [8].
- As a flexion contracture progresses beyond 20 degrees, gait is significantly hampered and difficulty with regaining extension may warrant surgical intervention [8].
- As varus or valgus laxity becomes severe, a constrained condylar type of prosthesis may become necessary to prevent subsequent coronal plane instability [8].
- Intervening before severe laxity is present allows the use of a prosthesis that lacks coronal plane constraint and has a more favorable expected survivorship [8].
- Absolute contraindications to total knee arthroplasty include recent or current knee sepsis, a remote source of ongoing infection, extensor mechanism discontinuity or severe dysfunction, recurvatum deformity secondary to neuromuscular weakness, and the presence of a painless, well-functioning knee arthrodesis [8].
- Relative contraindications to total knee arthroplasty include medical conditions that compromise the patient's ability to withstand anesthesia, immunodeficiency, and the significant rehabilitation necessary to ensure a favorable functional outcome [8].
- A severely osteoarthritic ipsilateral hip joint should be considered for arthroplasty before the symptomatic osteoarthritic knee because rehabilitation is easier with a total hip arthroplasty and an osteoarthritic knee than with a total knee arthroplasty and an osteoarthritic hip joint [8].
- Other relative contraindications to total knee arthroplasty include significant atherosclerotic disease of the operative leg, skin conditions such as psoriasis within the operative field, venous stasis disease with recurrent cellulitis, neuropathic arthropathy, superobesity with a BMI of 45 or greater, recurrent urinary tract infections, and a history of infections in the proximity of the knee [8].
- Modifiable risk factors to consider before elective total knee arthroplasty include low vitamin D levels, metabolic syndrome, low albumin, neutropenia, superobesity, and a BMI less than 20 [8].
- Delaying primary total knee arthroplasty for up to 8 months while a patient works to improve a modifiable risk factor does not appear to worsen the outcome [8].
- A recent review noted an increasing rise in infection and other complications as obesity classification increased from severe to super-obese [8].
- Quality of life in super-obese individuals can be attained cost effectively and without a higher incidence of early aseptic loosening [8].
- Unicompartamental knee arthroplasty is an option for spontaneous osteonecrosis of the knee when a smaller total area of bone is involved [5].
- Total knee arthroplasty is indicated for spontaneous osteonecrosis of the knee for larger lesions or bone collapse that precludes the use of unicondylar knee arthroplasty [5].
- For secondary osteonecrosis, total knee arthroplasty is indicated when a large area is involved or in articular collapse or multiple compartment involvement [5].
- For spontaneous osteonecrosis of the knee, total knee arthroplasty is indicated for bone collapse, arthritis, and progressive pain [9].

- Results of total knee arthroplasty in spontaneous osteonecrosis of the knee are inferior to total knee arthroplasty in osteoarthritis [9].
- Patients undergoing total knee arthroplasty for spontaneous osteonecrosis of the knee report more pain and have a higher revision rate due to aseptic loosening [9].
- Unicompartmental knee arthroplasty is preferred over total knee arthroplasty for spontaneous osteonecrosis of the knee unless there is degenerative joint disease in the other compartments [9].
- For unicompartmental knee arthroplasty in spontaneous osteonecrosis of the knee, bone in the affected condyle must be able to support the implant and cement, and all necrotic bone must be removed [9].
- If bone in the affected condyle cannot support the implant and cement during unicompartmental knee arthroplasty for spontaneous osteonecrosis of the knee, the procedure should be converted to total knee arthroplasty [9].
- Total knee arthroplasty is effective at improving pain and function in patients with tricompartmental osteoarthritis using various surgical techniques leading to good outcomes [13].
- Total knee arthroplasty implant options include cruciate retaining, posterior stabilized, fixed or mobile bearing, and cemented or noncemented designs [13].
- Patient-specific instrumentation, computer navigation, and robotic-assisted technologies may marginally improve component position and limb alignment but require further studies of long-term clinical benefit and cost-effectiveness to determine their optimal role in total knee arthroplasty [13].
- Multiple total knee arthroplasty implant designs and surgical techniques have been successful in improving patient pain and function without any overwhelming evidence favoring one over the other [13].

## Complications

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### ARTHROSCOPIC MANAGEMENT

- The literature lacks well-designed studies to evaluate the efficacy of arthroscopic procedures for the treatment of early-stage osteoarthritis of the knee [2].
- Most studies demonstrate equivalent outcomes between arthroscopic treatment and nonsurgical treatment at mid to long-term follow-up [2].
- The potential for thermal damage when using a laser or radiofrequency probe for chondroplasty has resulted in decreased use of these techniques [2].
- Some studies have demonstrated that the fibrocartilage cap formed after subchondral drilling or microfracture is significantly degraded or no longer present by 2 years post-operatively [2].

### HIGH TIBIAL OSTEOTOMY (HTO)

- Patella baja due to scar contracture of the tendon is the most common complication of the open-wedge HTO technique [51].
- Collapse of the open wedge is a complication of the open-wedge HTO technique [51].

- Nonunion is a complication of the open-wedge HTO technique [51].
- Bone harvest site pain is a complication of the open-wedge HTO technique [51].
- Patella baja is the most common complication of the closed-wedge HTO technique [51].
- Loss of flexion and loss of posterior slope are complications of the closed-wedge HTO technique [51].
- Peroneal nerve palsy due to aberrant retractor placement is a complication of the closed-wedge HTO technique [51].
- The rate of conversion from HTO to total knee arthroplasty is 13% at 6 years according to a meta-analysis [51].
- Conversion from HTO to total knee arthroplasty requires longer operative time and more frequent use of revision implants [51].

### **DISTAL FEMORAL OSTEOTOMY (DFO)**

- Nonunion is a complication of distal femoral osteotomy [51].
- Loss of wedge correction is a complication of distal femoral osteotomy, most common in patients with osteoporotic bone [51].
- Residual patellofemoral maltracking is a complication of distal femoral osteotomy that may require patellofemoral realignment [51].

### **TOTAL KNEE ARTHROPLASTY (TKA)**

- Infection is the number one reason for revision total knee arthroplasty [55].
- Infection is the number one reason for revision within 2 years of index primary total knee arthroplasty [55].
- Aseptic mechanical implant loosening is the second most common reason for revision total knee arthroplasty [55].
- Malposition and/or malalignment of implants typically presents with knee stiffness and activity-related pain [55].
- Early wear presentation of polyethylene debris manifests as a warm knee and effusion with reactive synovitis [55].
- Late wear presentation of polyethylene debris manifests as osteolysis with bone resorption and retroprosthetic bone resorption creating excess bone strain and pain [55].
- Hypersensitivity typically presents with constant global pain, normal serum biomarkers, and negative aspiration studies [55].
- Patellofemoral complications occurred in 4% of patients with patellar resurfacing compared with 12% of patients in whom the patella was unresurfaced in a large retrospective study [58].
- Significant residual anterior knee pain was the most common complication in the unresurfaced patella group [58].

- A 5-year prospective, randomized study found that 25% of patients with unresurfaced patellas complained of anterior knee pain, whereas only 5% of patients with patellar resurfacing complained of anterior knee pain [58].
- Secondary resurfacing of the patella for residual anterior knee pain after TKA has a higher rate of complications, including patellar fracture and postoperative stiffness [58].
- Pain relief after secondary patellar resurfacing is inferior to what would be expected with primary resurfacing [58].
- Complications of resurfaced patellae account for most of the reoperations after TKA in many series [58].
- Patients who do not have complete cartilage space loss before surgery tend to be less satisfied with their clinical result after TKA [8].

### UNICOMPARTMENTAL KNEE ARTHROPLASTY (UKA)

- Long-term survivorship of unicompartmental knee arthroplasty is not comparable with total knee arthroplasty when measured by revision rates [51].
- In patients with a BMI greater than 40, the rate of increased clinical failure at 2 years is 29% for UKA versus 3% for TKA [51].

### KNEE DISLOCATION

- Infections following knee dislocation management have a reported rate of 12.5% [46].
- The reported incidence of heterotopic ossification following knee dislocation management is approximately 25% [46].
- Heterotopic ossification is more frequently found medially and posteriorly [46].
- PCL reconstruction is one independent risk factor for the development of heterotopic ossification [46].
- The incidence of posttraumatic arthritis in a retrospective long-term follow-up study of 44 multiligament reconstructions was 23% [46].
- A mean of 38% of patients (range, 5% to 71%) require surgical management of arthrofibrosis following knee dislocation [46].
- Recurrent instability after reconstruction has a mean incidence of approximately 40% [46].
- The incidence of pain following knee dislocation injuries has been reported from 25% to 68% [46].

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