

Hip instability and microinstability

Overview

- Hip arthrodesis is uncommonly used and can be used to treat advanced hip degeneration, often posttraumatic, in a very specific patient population [1].
- Hip arthrodesis is indicated for patients younger than 30 years with a high activity level, severe pain and stiffness, and normal adjacent joints [1].
- Hip arthrodesis is contraindicated in patients with disease of the adjacent joints (lumbar spine, contralateral hip, ipsilateral knee), major limb-length discrepancy greater than 2.0 cm, or active infection [1].
- The preferred position for hip arthrodesis is 25° to 30° of hip flexion, 0° to 5° of adduction, and 5° to 10° of external rotation [1].
- Hip arthrodesis achieves lasting pain relief and satisfactory clinical results in most patients [1].
- The survivorship of hip arthrodesis can be limited by symptomatic degenerative disease of the adjacent joints, including the lumbar spine, contralateral hip, and ipsilateral knee [1].
- Low back pain and osteoarthritis of the ipsilateral knee are the most common problems following hip arthrodesis [1].
- Conversion of hip fusion to total hip arthroplasty is occasionally needed, with good clinical results seen in most patients [1].
- Cam impingement refers to femoral-based deformities, such as an aspherical femoral head or reduced head-neck offset, that result in repetitive abutment of the acetabular rim and femoral head-neck junction [1].
- Pincer impingement describes acetabular-based deformities, such as acetabular retroversion or acetabular protrusio, that create abnormal abutment of the acetabular rim and femoral head-neck junction [1].
- Patients with acetabular labral disease commonly present with groin pain that is worsened by prolonged sitting, walking, running, or pivoting [1].
- Hip osteotomy surgery is contraindicated in patients with major restriction of hip motion and/or advanced joint deterioration [1].
- Surgical hip dislocation with trochanteric osteotomy is based on preserving the blood supply to the femoral head via the deep branch of the medial femoral circumflex artery [1].
- External hip snapping is caused by the iliotibial band and is produced with hip flexion [1].

- Internal hip snapping is caused by the iliopsoas tendon and is produced with hip extension from a flexed position [1].
- The advantages of the periacetabular osteotomy (PAO) include one surgical incision, maintenance of the posterior column, preservation of blood supply to the acetabulum, and the ability to perform major multiplanar acetabular corrections [1].
- Overcorrection or retroversion of the acetabulum with a PAO can produce secondary femoroacetabular impingement (FAI) [1].
- Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) can be used to assess articular cartilage glycosaminoglycan (GAG) content in acetabular dysplasia, where low GAG content has been associated with PAO failure [1].
- Hip arthroscopy indications address pathology in the central, peripheral, and peritrochanteric compartments of the hip joint [4].
- Central compartment pathology treated by hip arthroscopy includes labral tears, loose bodies, ligamentum teres tears, chondral defects, and pincer lesions associated with FAI [4].
- Peripheral compartment pathology treated by hip arthroscopy includes cam lesions associated with FAI, capsular laxity associated with hip instability, loose bodies, and recalcitrant internal snapping hip secondary to chronic iliopsoas bursitis [4].
- Peritrochanteric compartment pathology treated by hip arthroscopy includes recalcitrant trochanteric bursitis, tears of the gluteus medius and minimus, and painful external snapping hip [4].
- Iatrogenic chondrolabral injury is the most reported complication in one systematic review of hip arthroscopy [4].
- Neurapraxia is a common but transient complication following hip arthroscopy, with an incidence approaching 50% in one series [4].
- The lateral femoral cutaneous nerve (LFCN) is the most commonly involved nerve in neurapraxia following hip arthroscopy [4].
- Permanent nerve injury following hip arthroscopy is less than 5% [4].
- Inadequate resection in FAI surgery, more commonly on the femoral side, is the most common reason for revision hip preservation surgery [4].
- Deficient anterolateral acetabular coverage of the femoral head is the dominant deformity in developmental hip dysplasia, resulting in structural hip instability and acetabular rim overload [7].
- Female patients with developmental hip dysplasia generally present with acetabular labral tears and rim cartilage lesions [7].
- The long-term prognosis for the symptomatic hip with moderate dysplasia (lateral center-edge angle $<15^\circ$) treated nonsurgically is very poor [7].
- A reconstructive acetabular osteotomy is the treatment of choice for developmental hip dysplasia [7].
- The Bernese PAO is a mainstay of surgical treatment for acetabular reorientation in developmental hip dysplasia [7].

- The Bernese PAO is increasingly combined with hip arthroscopy in a single setting when labral pathology is present, with hip arthroscopy performed first [7].
- The reported survival of the Bernese PAO is 60% at 20-year follow-up [7].
- Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) assessment of the glycosaminoglycan (GAG) content of the articular cartilage is predictive of outcome after PAO, with low GAG content associated with an increased risk of failure [7].
- Salvage osteotomies, such as the Chiari osteotomy, rely on the articulation of the femoral head with metaplastic fibrocartilage rather than articular hyaline cartilage [7].
- Patients with spinal deformity, those who have undergone spinal fusion, or those with a fixed spinopelvic alignment have a marked increase in the risk of instability following total hip arthroplasty [20].
- The previously well-accepted notion of a consistent or fixed “safe zone” for acetabular cup positioning has been questioned in favor of a patient-specific approach considering pelvic tilt, spinopelvic relationships, and lumbar spine rigidity [20].

Anatomy & Pathophysiology

BONY ANATOMY

- The hip is a multiaxial joint formed by the articulation between the pelvis and femur, connecting the axial skeleton and the lower extremity [25].
- The hemipelvis comprises three bones: the ilium, ischium, and pubis, which unite at the triradiate cartilage within the concave acetabulum [25].
- The acetabulum comprises an articular crescent-moon-shaped lunate surface and a nonarticular central fossa that serves as the attachment point for the ligamentum teres [25].
- The acetabulum is incomplete inferiorly, forming a notch through which vital blood vessels and nerves pass to supply the joint [25].
- The femoral head forms two-thirds of a sphere, with a small depression at its center from which the ligamentum teres extends to connect to the acetabular notch [25].
- The neck-shaft angle of the femur averages 125°, placing the head and neck more perpendicular to the acetabulum in a neutral position [25].
- Normal version, defined as the head-neck angle in the frontal plane, averages 15 to 20° [25].
- The angular projection of the femoral head and neck in relation to the obliquely placed acetabulum allows for rotary movements at the hip and prevents impingement [25].
- The mean femoral neck-shaft angle in the adult is 130° ± 7° [30].
- The mean anteversion of the femoral neck is 10° ± 7° [30].
- The weakest area in the femoral neck is located in the Ward triangle [30].
- The calcar femorale is a medial area of dense trabecular bone that transfers stress from the femoral shaft to the inferior portion of the femoral neck [30].

CQ HAND + UPPER LIMB

SOFT TISSUE ANATOMY

- The acetabular labrum is a fibrocartilaginous ring attached to the rim of the acetabulum that extends the articulating surface area and increases femoral head coverage [25].
- The labrum is triangular in cross section, which contributes to its ability to create a pressurized seal of the central compartment of the hip during loading [25].
- Only the external one-third of the labrum contains blood vessels, leaving the majority of the structure avascular and limiting its healing ability following injury [25].
- The labrum is highly innervated, with the presence of both mechanoreceptors and nociceptors [25].
- The labrum is absent in the area of the inferior acetabular notch, where the transverse acetabular ligament serves as the continuation of the labrum [25].
- The hip is surrounded by a dense fibrous capsule extending from the periphery of the acetabulum to the intertrochanteric line of the femoral neck [25].
- The capsule enhances joint stability by preventing translation of the femoral head in the acetabulum [25].
- The iliofemoral ligament is Y-shaped, originates at the anterior inferior iliac spine, and inserts at the intertrochanteric line [26].
- The iliofemoral ligament becomes taut in full extension, preventing anterior dislocation and hyperextension of the hip [26].
- The pubofemoral ligament attaches to the inferior and medial part of the capsule and may cause a hip adduction contracture [26].
- The ischiofemoral ligament reinforces the posterior capsule and provides a check to internal rotation of the hip [26].
- The twisted orientation of the hip ligaments provides a screw mechanism for the hip in full extension [26].
- The ligamentum teres originates in the cotyloid fossa and attaches on the fovea of the femoral head [26].
- The iliofemoral ligament is the strongest ligament in the body [22].
- The hip joint capsule is tight in extension and internal rotation, and relaxed in flexion and external rotation [22].
- The labrum deepens the acetabulum, increases coverage of the femoral head, and plays a role in shock absorption, joint lubrication, and pressure distribution [17].
- The most critical role of the labrum is the creation of a negative pressure seal with the femoral head, which aids in joint stability [17].
- Removal of the labrum leads to a shift in the femoral contact point toward the acetabular rim, a decrease in intra-articular fluid pressurization, and a loss of lateral restraint to femoral head motion [17].
- Removal of the labrum increases contact stresses between the articular cartilage of the femoral head and the acetabulum by 92% [17].
- The zona orbicularis is a circumferential structure that forms a collar around the base of the femoral neck and is thought to resist hip distraction [64].

- The ligamentum teres appears to play a secondary role to other soft-tissue restraints, having been shown to restrict the motion of the femoral head [64].
- Isolated tears of the ligamentum teres have been found in hip dysplasia, in which it may play a more prominent role in stabilization [64].

VASCULAR ANATOMY

- From birth to approximately 4 years of age, the major blood supply to the femoral head comes from the medial and lateral femoral circumflex arteries, with major contributions from the artery of the ligamentum teres [32].
- From the age of 4 years to adulthood, the posterosuperior and posteroinferior retinacular arteries from the medial circumflex artery are the major blood supply to the femoral head [32].
- In adulthood, the major blood supply to the femoral head is from the medial femoral circumflex and lateral epiphyseal arteries [32].
- The medial femoral circumflex artery is the main blood supply to the femoral head [30].
- The artery of the ligamentum teres arises from either the obturator or medial femoral circumflex artery and does not provide sufficient blood supply to maintain the viability of the femoral head [30].
- Fractures that disrupt the ascending blood flow to the lateral epiphyseal vessel have an increased risk of osteonecrosis [30].

PATHOPHYSIOLOGY OF INSTABILITY

- Hip stability is based primarily on bony architecture, with soft-tissue structures serving as secondary stabilizers [22].
- The degree of acetabular coverage and the femoral and acetabular version are key determinants of hip stability [64].
- In the setting of diminished acetabular coverage and alterations in normal version, the hip joint increasingly relies on soft-tissue structures to maintain stability [64].
- Hip microinstability refers to the femoral head micromotion within the acetabulum, which is a prolonged phenomenon that leads to cartilage damage and eventually osteoarthritis of the hip [11].
- Hip microinstability is characterized by a progressive onset with pain, disability, and a feeling of giving way in the hip [13].
- Damage to the hip capsule may cause instability of the hip; however, loss of the seal between the labrum and the femoral head may cause increased movement of the femoral head or microinstability [13].
- Acetabular dysplasia is defined as the presence of a lateral center-edge angle (LCEA) of $<25^\circ$ on the AP pelvic radiograph, whereas an LCEA between 20° and 25° is considered borderline dysplasia [52].
- The association between hip dysplasia and hip microinstability originates from the undercoverage of the femoral head by a relatively shallow acetabular rim [52].
- Lack of acetabular coverage can lead to excessive femoral head micromotion against the acetabulum, resulting in hip microinstability [52].

- Microinstability may cause an overload on the acetabular structures, leading to compensatory labral hypertrophy and sometimes rim fractures [52].
- A lower center-edge angle or larger Tönnis angle increased the risk for severe cartilage damage to the femoral head [52].
- Patients with an LCEA of 25° were 3.57 times more likely to have severe cartilage damage to the femoral head [52].
- Labral hypertrophy is a biomechanical consequence of acetabular dysplasia, thought to be a compensatory mechanism to achieve adequate coverage of the femoral head [52].
- Femoroacetabular impingement (FAI) can contribute to the development of hip microinstability due to the altered relationship between the femoral head and acetabulum [52].
- Pincer and/or cam impingement can lead to levering of the femoral head posteriorly, resulting in hip microinstability and, in extreme cases, posterior hip dislocation [52].
- Capsular stretching can result from inherent tissue laxity or anatomic stretching due to pathologic motion of its bony attachment sites, such as in hips with FAI or dysplasia [61].
- The capsulotomy performed during hip arthroscopy disrupts the fibers of the iliofemoral ligament [61].
- The iliofemoral ligament resists external rotation in hip flexion and both external and internal rotation in hip extension [61].
- The pubofemoral ligament resists external rotation in extension or abduction [61].
- The ischiofemoral ligament resists internal rotation in flexion or extension [61].
- Damage to any aspect of the capsular complex may result in increased microinstability [61].
- Capsular laxity leads to microinstability, demonstrated by a significant increase in femoral head translation when incisions are made in the capsule complex [61].
- Cyclical stretching of the capsule results in a significant increase in femoral head displacement [61].
- Sports with repetitive torsional movements can produce soft-tissue attenuation because of repetitive microtrauma to the capsule and ligaments [64].
- Atraumatic hip instability can occur in patients with congenital soft-tissue deficiency or laxity, such as Ehlers-Danlos syndrome, Marfan syndrome, and Down syndrome [64].
- A large cam-based deformity in FAI can cause impingement that levers the femoral head posteriorly, causing a posterior contrecoup cartilage lesion, with posterior subluxation and instability [64].
- Hip microinstability can occur in athletes with mild osseous hip dysplasia superimposed on ligamentous laxity during sports requiring high degrees of hip motion [64].
- Secondary iliopsoas tendinitis can develop in patients with hip microinstability due to strain on the iliopsoas as it attempts to stabilize the anterior hip joint [64].
- The shallow hip socket in acetabular dysplasia results in high articular cartilage contact stresses near the superolateral rim of the acetabulum, with concurrent labral tears and progressive lateral subluxation of the femoral head [65].
- Any alteration to joint morphology or function can place the hip at risk for pathology [3].

Clinical Presentation

HIP MICROINSTABILITY

- Hip microinstability is defined as femoral head micromotion within the acetabulum, a prolonged phenomenon that leads to cartilage damage and eventually osteoarthritis of the hip [11].
- Patients with hip microinstability commonly present with pain of progressive onset [11].
- Hip microinstability is often seen in athletes who require extreme range of motion, such as dancers [11].
- The diagnosis of hip microinstability is described as difficult because signs and symptoms may be subtle, and there is no definitive preoperative diagnostic test, examination finding, or imaging modality that is pathognomic for the condition [6].
- Patients with hip microinstability often describe hip or groin pain that has increased over time [15].
- Most patients with hip microinstability report a feeling of instability or giving way in the hip [15].
- The description of giving way during activity is a critical factor in the diagnosis of hip microinstability [15].
- Athletes who participate in sports that include hyperextension may be more likely to have hip microinstability [15].
- Patients with hip dysplasia or connective tissue disorders, with or without a history of previous joint dislocation, are especially prone to hip microinstability [15].
- In patients presenting for revision arthroscopy with persistent pain and significant delay in achieving postoperative milestones, defects in the capsule or a compromised seal between the femoral head and labrum resulting in microinstability should be suspected [15].
- Hip microinstability is not well defined and lacks a clear diagnostic algorithm, leading to frequent missed or underdiagnosed cases [11].
- Motion of the femur relative to the acetabulum is the result of absolute biomechanical force acting on the hip joint, affected by bones (acetabulum, femur) and soft tissues (labrum, capsule, ligamentum teres, muscles) [11].

FEMOROACETABULAR IMPINGEMENT (FAI)

- Patients with symptomatic FAI frequently present with activity-related groin pain that is exacerbated by hip flexion activities [5].
- Patients with symptomatic FAI report difficulty with prolonged sitting, walking, running, or pivoting [5].
- The onset of symptoms in FAI is often insidious or follows minor trauma [5].
- Mechanical symptoms secondary to labral and articular cartilage disease are common in FAI presentations [5].
- Patients with FAI exhibit restricted hip internal rotation in 90° of flexion [5].
- The impingement test (flexion, adduction, internal rotation) elicits pain in patients with FAI, but the test is not specific for FAI [5].

- Cam impingement refers to femoral-based deformities (aspherical femoral head or reduced head-neck offset) that result in repetitive abutment of the acetabular rim and femoral head-neck junction [1].
- Pincer impingement describes acetabular-based deformities (acetabular retroversion, acetabular protrusio) that create abnormal abutment of the acetabular rim and femoral head-neck junction [1].

HIP DYSPLASIA

- In adolescent hip dysplasia, lateral hip pain is most often attributed to decreased hip abductor muscle strength [47].
- Deep anterior groin pain in adolescent hip dysplasia generally indicates pain originating from the joint itself [47].
- Joint-related pain in dysplasia can occur from joint overload, edge-loading of the acetabulum, labral irritation or injury, or labral chondral injury [47].
- Lateral hip pain in dysplasia is often the initial symptom, occurring later in the day as fatigue develops due to altered biomechanics [47].
- Deep groin pain in dysplasia occurs later, is reported to be more common, is activity-related, and improves when activity restriction is instituted [47].
- Physical examination for adolescent hip dysplasia should include observation of ambulation to assess for an antalgic gait or a subtle Trendelenburg gait [47].
- The impingement test (flexion, internal rotation, and adduction) is used in the physical examination of adolescent hip dysplasia to determine the likelihood of true symptomatic labral pathology [47].
- Patients with late-presenting acetabular dysplasia complain of aching pain in the groin or lateral hip that is worse with exertion and long periods of walking or standing [63].
- Patients with late-presenting acetabular dysplasia may limp when tired or uncomfortable [63].
- Physical findings in late-presenting acetabular dysplasia are usually minimal, potentially including a Trendelenburg limp, a delayed Trendelenburg sign, or discomfort at the extremes of hip motion [63].
- Signs of snapping or popping in late-presenting acetabular dysplasia may be caused by a tear in the labrum [63].
- Pain in late-presenting acetabular dysplasia is exacerbated when the hip is maximally flexed, internally rotated, and adducted (impingement test) [63].

GENERAL HIP PAIN EVALUATION

- Anterior groin pain is most associated with intra-articular pathologies, including labral tears, degenerative changes, synovial pathologies, loose bodies, and osteonecrosis [48].
- Anterior groin pain can also result from extra-articular conditions such as hip flexor strains, iliopsoas snapping syndrome, or femoral stress fractures [48].
- Pain along the lateral thigh is often associated with greater trochanteric bursitis, iliotibial band syndrome, or abductor tendon tears or tendinitis [48].

- Pain in the posterior region of the hip and pelvis could result from muscle pathologies such as piriformis syndrome and hamstring muscle tears, or referred pain from the sacroiliac joint or low back [48].
- A thorough history is essential to differentiating between common causes of hip pain, as many conditions present with similar symptoms [3].
- Clinical examination tests and imaging findings should be used to confirm a suspected clinical diagnosis of hip pathology [3].

PEDIATRIC HIP INSTABILITY (DDH)

- In the neonatal period, the key clinical finding for developmental dysplasia of the hip (DDH) is instability of the hip [16].
- Hip clicks are nonspecific physical findings in the evaluation of DDH [16].
- Asymmetric skin folds are an unreliable and nonspecific finding in the evaluation of DDH [16].
- In infants older than 6 months with DDH, common findings are asymmetric hip abduction and apparent limb shortening in unilateral dislocations [16].
- Toddlers with DDH may present with restricted motion accompanied by a limb-length discrepancy, a limp, or a waddling gait [16].
- Toddlers with bilateral hip dislocations often present with hyperlordosis of the lumbar spine [16].
- Adolescents with DDH may manifest fatigue and pain in the hip, thigh, or knee in addition to signs and symptoms seen in younger children [16].
- The Galeazzi test is positive when the knee on the involved side is lower than the contralateral knee, indicating unilateral subluxation or dislocation of the hip [16].
- The Barlow test is positive when the hip on the affected side subluxates or dislocates upon application of a gentle posterolateral force with the hip flexed and adducted [16].
- The Ortolani test is positive when a dislocated hip is reducible, often accompanied by a palpable clunk as the femoral head reduces into the acetabulum [16].
- A decrease in abduction is the most sensitive test result for DDH on range of motion testing [16].
- Range of motion may be normal in children younger than 6 months with DDH if adductor contractures have not yet developed [16].
- The neonatal hip is a relatively unstable joint because the muscle is undeveloped, soft cartilaginous surfaces are easily deformed, and ligaments are lax [46].
- Exaggerated positioning in acute flexion and adduction in utero, especially in breech presentation, may cause excess stretching of the posterior hip capsule, rendering the joint unstable after delivery [46].
- In a subluxated hip, asymmetric pressure causes progressive flattening of the posterior and superior acetabular rim and medial femoral head [46].
- In a completely dislocated hip, dysplasia occurs because normal joint development requires concentric motion with normally mated joint surfaces [46].
- The shallow, deformed dysplastic joint surfaces predispose to further mechanical instability and the progression of the disorder [46].

- Asymmetric skin folds in DDH are not very reliable, frequently producing false-positive and false-negative results [46].
- The Galeazzi test is almost always useless in children younger than 1 year and is negative if dislocation is bilateral [46].
- Limited passive hip abduction (usually < 70 degrees from the midline) is a positive finding for dislocated hips, but the test may be normal in lax (dislocatable but not dislocated) hips [46].
- The Barlow test detects an unstable but located hip and is unsuitable for a dislocated hip [46].
- The Ortolani test detects hips that are already dislocated [46].
- If left untreated, muscles about the hip become contracted, and the acetabulum becomes more dysplastic and filled with fibrofatty tissue (pulvinar) [54].
- Potential obstructions to obtaining a concentric reduction in DDH include the iliopsoas tendon, pulvinar, hypertrophied ligamentum teres, contracted inferomedial hip capsule, transverse acetabular ligament, and inverted labrum [54].
- The teratologic form of DDH is the most severe and usually necessitates early surgery, with a pseudoacetabulum present at or near birth [54].
- Teratologic hip dislocations commonly manifest in association with syndromes such as arthrogryposis and Larsen syndrome [54].
- Other clinical findings associated with DDH include asymmetric gluteal folds (less reliable), Trendelenburg stance (in older children), increased lumbar lordosis, and pelvic obliquity [54].
- Repeated examinations are important in infants because irritability can prevent proper evaluation [54].

Investigations

CLINICAL EXAMINATION

- A thorough history is essential to differentiating between common causes of hip pain [3].
- Clinical examination tests and imaging findings should be used to confirm a suspected clinical diagnosis [3].
- Patients with symptomatic femoroacetabular impingement (FAI) frequently present with activity-related groin pain exacerbated by hip flexion activities [5].
- Patients with symptomatic FAI may experience difficulty with prolonged sitting, walking, running, or pivoting [5].
- Mechanical symptoms secondary to labral and articular cartilage disease are common in FAI [5].
- The impingement test (flexion, adduction, internal rotation) elicits pain in patients with FAI but is not specific for the condition [5].
- The impingement test involves hip flexion to 90 degrees followed by adduction and internal rotation to yield a pain response [44].
- The roll test involves rolling the leg into internal and external rotation while the patient is supine, where the leg may feel stiff or occasionally grab [44].

- The Stinchfield test involves active straight-leg raise of approximately 20 cm against mild resistance, eliciting pain in the anterior hip [44].
- The Patrick test involves positioning the leg in a figure-of-four position to elicit pain in the anterior or posterior hip region [44].
- Pain located over the posterior pelvis during hip examination indicates referred pain from L5 to S1 facets or the sacroiliac joint, not the hip joint [44].

RADIOGRAPHY

- Conventional radiographs remain critical in the initial imaging evaluation of the hip [10].
- A complete hip series usually includes an anterior-posterior (AP) pelvis, a centered AP hip, a lateral view (frog-leg, cross-table, Dunn 45° or 90°), and a false-profile (Lequesne) view [10].
- The AP pelvis view is used to assess acetabular anatomy, including version, acetabular coverage, and femoral head sphericity [5].
- Lateral views, most commonly the 45° Dunn view and frog-leg lateral, are used to assess femoral head sphericity and head-neck offset [5].
- The femoral head-neck junction morphology is often assessed using the alpha angle [10].
- Some studies indicate that radiographs, particularly the Dunn 45° view, may be more accurate for determining the alpha angle measurement than CT or MRI [10].
- The “crossover” sign on an AP pelvis radiograph indicates acetabular retroversion related to lateralization of the anterior acetabular wall relative to the posterior acetabular wall [10].
- An optimal AP pelvis image requires the sacrococcygeal joint to be between 3 and 5 cm above the superior border of the symphysis pubis to avoid false-positive or false-negative crossover signs [10].
- The Tönnis angle is defined by the angle of the acetabular sourcil and a line parallel to the transverse pelvis axis, with values between 0° and 10° considered normal [10].
- The lateral center-edge angle of Wiberg is the angle between a line from the center of the femoral head perpendicular to the transverse pelvis axis and a second line from the center of the femoral head to the superolateral most point of the acetabulum [10].
- Center-edge angles of 20°–40° are considered normal, while angles from 20° to 25° are considered borderline [10].
- The femoral head extrusion index is defined by the length of the femoral head that lies beyond the acetabulum as a percentage of the total horizontal width of the femoral head, with values greater than 25% considered abnormal [10].
- Coxa profunda is diagnosed when the acetabular fossa line touches or is medial to the ilioischial line on an AP pelvis radiograph [10].
- A normal alpha angle is less than 50°–55°, while an abnormal alpha angle of 70° has been demonstrated in a patient with femoroacetabular impingement [10].
- Osteoarthritis of the hip can be categorized using the Kellgren-Lawrence classification, a 4-point grading system classified into doubtful, mild, moderate, and severe [10].

- Osteoarthritis of the hip can be categorized using the Tönnis classification, a 3-point grading system categorized into mild, moderate, and severe [10].
- Radiographic and clinical severity of osteoarthritis do not necessarily correlate, particularly if radiographs are non-weight-bearing or if false-profile views are not included [10].
- Plain radiographs are the first imaging studies obtained for patients presenting with hip pain and can determine the presence of fractures, degenerative changes, and abnormal joint morphology [36].
- Standard AP radiographs of the hip and pelvis are obtained to examine bony architecture, check for evidence of joint space narrowing or changes to bone quality, and quantify femoral head coverage [36].
- The Dunn view and frog leg view are appropriate to measure the alpha angle to determine the presence of impingement [36].

MAGNETIC RESONANCE IMAGING

- MRI is the modality of choice for patients suspected of soft tissue or intra-articular pathology, given its superior sensitivity and specificity [36].
- Conventional MRI is effective at identifying osteochondral injuries, muscletendinous pathologies, and inflammation [36].
- Magnetic resonance arthrography (MRA) is more appropriate than conventional MRI to determine injuries to the labrochondral structures and the ligamentum teres [36].
- MRA is used to identify the presence of loose bodies and synovial chondromatosis [36].
- The utility of MRA in the accurate detection and staging of articular cartilage lesions is reduced, with sensitivity reported to be less than 50% compared with arthroscopic findings [36].
- Recent advances in MRI techniques, such as delayed gadolinium-enhanced MR imaging and T2* mapping, allow for a more in-depth analysis of the structure of articular cartilage [36].
- Delayed gadolinium-enhanced MR imaging and T2* mapping were effective at detecting early changes to the articular cartilage surfaces of patients with hip dysplasia and femoroacetabular impingement [36].
- MRI provides information regarding the integrity of the acetabular labrum and articular cartilage [5].
- The anatomy of the proximal femur as well as the version of the acetabulum and femur may be assessed using MRI [5].
- The sensitivity of MRI to acetabular rim chondral lesions is limited [5].
- Noncontrast MRI at 3T is generally adequate for diagnosing intra-articular pathology [40].
- If 3T imaging is unavailable, MRA can be considered at 1.5T for increased diagnostic accuracy [40].
- A prospective study found similar accuracies between noncontrast 3T MRI and 1.5T MRA in femoroacetabular impingement [39].
- In a retrospective study evaluating noncontrast 3T MRI versus hip arthroscopy, accuracy for labral tears was 98% and for acetabular cartilage lesions was 90% [39].
- MRI is used when osteonecrosis is suspected [44].

- Gadolinium-enhanced MRI arthrogram is useful when labral pathology is suspected, especially when associated with FAI [44].
- MRI may identify gluteus medius and gluteus minimus tears in patients with lateral hip pain and abductor weakness [44].
- MRI is helpful in identifying femoral neck stress fracture in athletes and predicting patients that may require surgical intervention [40].
- MRI is helpful in assessing complications of conventional and resurfacing hip arthroplasties, particularly those with metal-on-metal bearing systems [40].
- Major MRI findings that help predict histologic ALVAL scores include synovial thickening, synovitis, synovial volume, abductor disruption, and soft-tissue edema [40].
- In cases of suspected fracture with normal or equivocal plain radiographs, MRI is the current additional imaging modality recommended where there is uncertainty about the presence of an intracapsular fracture [42].
- MRI has been shown to be more accurate than bone scans in the early stages after injury for detecting occult hip fractures [42].
- MRI will demonstrate soft tissue problems that may be causing hip pain in the absence of a fracture [42].
- Dynamic MRI-positive enhancement integral color mapping (PEICM) can estimate femoral head perfusion preoperatively, with a nonunion rate of 0% in the normal perfusion group, 6.7% in the reduced perfusion group, and 50% in the absent perfusion group [42].

COMPUTED TOMOGRAPHY

- CT scans are effective for examining cortical and cancellous bone and can be used to create three-dimensional reconstructions of the hip for use in surgical planning [36].
- Measurements of femoral head coverage and acetabular and femoral impingement can be performed reliably using CT images [36].
- Low-dose CT with three-dimensional reformats is particularly useful in surgical planning of complex or borderline deformities [5].
- CT overcomes the limitations of radiography by providing three-dimensional assessment of bony morphology and, to some degree, assessment of soft-tissue abnormalities [27].
- Combined with arthrography, CT can evaluate chondrolabral abnormalities, specifically in patients with contraindications to MRI [27].
- CT is helpful in fracture evaluation, particularly in the setting of negative radiographs or for further defining fracture morphology in patients requiring surgical reduction [27].
- Three-dimensional CT with pelvic remodeling may be indicated for preoperative planning for reconstruction associated with dysplasia surgery, femoroacetabular impingement, posttraumatic arthritis, or other complex primary total hip arthroplasty [44].
- The multiplanar and 3D capabilities of CT make it an invaluable tool for assessing bone morphology, but at higher cost and radiation dose [40].

- 3D volume renderings are useful to aid in preoperative planning in FAI and subspine impingement [40].
- Multidetector CT scanning reported 100% specificity and sensitivity for the diagnosis of hip fracture in a series of 209 patients with negative plain radiographs [42].
- In a series of 78 CT scans, CT scanning yielded a sensitivity of 86% and specificity of 98% for occult hip fractures [42].
- Studies comparing CT and MRI for occult hip fractures have come out in favor of MRI scanning [42].

ULTRASONOGRAPHY

- Ultrasonography provides real-time dynamic assessment of the hip and is useful in diagnosing soft-tissue abnormalities about the hip joint [27].
- Ultrasonography is particularly useful in providing real-time guidance during diagnostic and therapeutic procedures [27].
- Although ultrasonography is a valuable tool to examine pediatric hip conditions, its utility in evaluating the adult hip is limited [36].
- Ultrasonography can be an effective modality to identify musculotendinous disruptions, effusions associated with intra-articular pathology, or inflammatory conditions, such as bursitis [36].
- Ultrasonography is increasingly used for targeted injections into muscles, tendons, or intra-articularly around the hip for corticosteroids or biologic treatments [36].
- Ultrasonography allows bedside evaluation of the hip and can be used to guide interventions in the office setting [40].

Treatment

NON-OPERATIVE MANAGEMENT

- Patient education and counseling regarding activity modification is of primary concern following a diagnosis of hypermobility or microinstability to protect the hip region [6].
- Nonsurgical management of hip hypermobility or microinstability focuses on strengthening periarticular musculature, specifically the iliopsoas, gluteals, adductors, rotators, and core musculature [6].
- Strength of the abductor and external rotator groups is of particular importance for controlling lower extremity alignment during functional activities [6].
- Individuals with excessive hip external rotation range of motion have decreased strength of the hip internal rotators [6].
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- Flexibility exercises should be prescribed with caution only after end-feels have been assessed and are discouraged in patients with excessive range of motion [6].

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- Neuromuscular reeducation, including proprioceptive and perturbation training, may be beneficial for individuals with joint hypermobility [6].
- The first line of treatment for hip microinstability is physical therapy, which may include anti-inflammatory medication and activity modification [56].
- Physical therapy for hip microinstability focuses on core muscles and hip stabilizers, mainly the hip external rotators and abductors [56].
- Low back pathology should be ruled out before starting a physical therapy program for hip microinstability [56].
- Patients with hip microinstability are reevaluated after 6 to 8 weeks of physical therapy to determine if they are surgical candidates [56].
- A trial of conservative management, including anti-inflammatory medications, activity modification, physical therapy, and intra-articular injections, should be attempted prior to surgical management for hip dysplasia [50].
- Conservative means are unable to adequately correct osseous abnormalities in hip dysplasia [50].

OPERATIVE MANAGEMENT: HIP ARTHROSCOPY

- Hip arthroscopy can be used to treat microinstability by reestablishing the labral-femoral head seal and addressing capsular looseness or damage [13].
- During hip arthroscopy for microinstability, labral tears, cartilage defects, and ligamentum teres pathologies are addressed [56].
- The labral-femoral head seal should be reestablished following labral repair and verified by visualization on dynamic examination [56].
- A probe is used during hip arthroscopy to test the tightness and anatomic integrity of the capsule [56].
- Thermal capsulorrhaphy may be used to shrink redundant capsule if it is felt to be loose during examination [56].
- Absorbable sutures may be used to plicate the capsule if it is felt to be loose during examination [56].
- The hip capsule should be repaired following arthroscopy to avoid instability due to the capsulotomy [56].
- Care should be taken when performing an intraportal capsulotomy to preserve as much of the inferior femoral ligament (IFL) as possible [56].
- At least 50% of the IFL is damaged when performing subspine trimming using a transverse interportal capsulotomy [56].
- Capsular reconstruction should be considered in patients who previously underwent hip arthroscopy and present with symptomatic defects on the hip capsule [56].
- Capsular reconstruction aims to restore capsule integrity, prevent adhesion formation, and improve joint stability [56].
- Capsular reconstruction is a technically demanding procedure that requires advanced skills in hip arthroscopy [56].

- Patients undergoing capsular reconstruction should be informed about the complexity of the procedure and the need for prolonged physical therapy [56].
- The acetabular labrum should be repaired or reconstructed whenever possible to preserve its function, especially the negative suction seal function [14].
- Appropriate capsular management, including capsular repair and plication in indicated cases, is a key step in preserving or establishing hip stability [14].
- Ligamentum teres reconstruction in instability cases may prove to be a useful adjunct along with capsular plication but is still unproved [14].
- Hip arthroscopy is performed on a traction table by carefully distracting the joint with the minimum force required to avoid traction injuries [50].
- The leading cause of failure after hip arthroscopy for FAI is inadequate bony resection of cam or pincer deformities [50].
- Excessive resection has been proposed as a potential reason for failure after hip arthroscopy [50].
- When bony deformity is excessive, difficult to access, or multiple procedures are to be performed, surgical hip dislocation becomes the procedure of choice over arthroscopy [50].

OPERATIVE MANAGEMENT: OSTEOTOMY AND OPEN PROCEDURES

- A reconstructive acetabular osteotomy is the treatment of choice for symptomatic hip dysplasia with deficient acetabular coverage [7].
- The Bernese periacetabular osteotomy (PAO) is a mainstay of surgical treatment for acetabular reorientation [7].
- PAO is increasingly combined with hip arthroscopy in a single setting when labral pathology is present, with hip arthroscopy performed first [7].
- Advantages of the PAO include a single surgical incision, preservation of blood supply to the acetabulum, maintenance of posterior column integrity, and the ability to perform major multidimensional acetabular corrections [7].
- Disadvantages of the PAO include anterior overcorrection producing acetabular retroversion and secondary FAI, intra-articular fracture, and neurovascular injury [7].
- Reported survival of PAO is 60% at 20-year follow-up [7].
- Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) assessment of glycosaminoglycan content is predictive of outcome after PAO, with low GAG content associated with increased risk of failure [7].
- Surgical hip dislocation provides near 360° access to the acetabulum and femoral head without compromising the blood supply to the femoral head [50].
- Benefits of surgical hip dislocation over arthroscopy include greater visualization, better access to global deformity, thorough dynamic examination, treatment of extra-articular impingement, ability to perform osteochondral transplantation, and treatment of complex deformities [50].
- Iatrogenic osteonecrosis of the femoral head can occur during surgical hip dislocation if perforator vessels are injured [50].

- Complications of surgical hip dislocation include trochanteric nonunion, fracture, infection, and heterotopic ossification [50].
- Hip arthrodesis is used to treat advanced hip degeneration, often posttraumatic, in a specific patient population [1].
- Indications for hip arthrodesis include age younger than 30 years, high activity level, severe pain and stiffness, and normal adjacent joints [1].
- Contraindications for hip arthrodesis include disease of adjacent joints, major limb-length discrepancy greater than 2.0 cm, and active infection [1].
- Survivorship of hip arthrodesis can be limited by symptomatic degenerative disease of adjacent joints, including the lumbar spine, contralateral hip, and ipsilateral knee [1].
- Conversion of hip fusion to total hip arthroplasty is occasionally needed [1].
- Rehabilitation after conversion of hip fusion to total hip arthroplasty is prolonged due to profound hip abductor weakness and associated limp [1].

OPERATIVE MANAGEMENT: TOTAL HIP ARTHROPLASTY CONSIDERATIONS

- Acetabular implant orientation targets for stability are 30° to 50° abduction and 5° to 25° anteversion [8].
- High abduction combined with high anteversion is associated with anterior instability with hip extension [8].
- Low abduction combined with low anteversion is associated with posterior instability with hip flexion [8].
- Combined acetabular and femoral implant anteversion targets are 35° to 40° for females and 30° to 35° for males [8].
- Decreased femoral offset and inadequate leg length restoration can result in femoral neck impingement and decreased abductor mechanism efficiency [8].
- Female sex is associated with an increased dislocation rate in total hip arthroplasty [8].
- Spinal fusion or limited lumbar spine mobility increases the risk of dislocation in total hip arthroplasty [8].
- Increased femoral head size greater than 36 mm is associated with a substantial reduction in dislocation rates [8].
- Increased femoral head size greater than 36 mm is associated with an increased incidence of groin pain [8].
- Increased femoral head size greater than 36 mm is associated with higher polyethylene wear rates among younger and more active patients [8].
- Patients with spinal deformity, spinal fusion, or fixed spinopelvic alignment have a marked increase in the risk of instability in total hip arthroplasty [20].
- The concept of a consistent or fixed “safe zone” for acetabular cup positioning has been questioned in favor of patient-specific positioning based on pelvic tilt and spinopelvic relationships [20].

Complications

HIP ARTHROSCOPY

- A systematic review of 92 studies involving more than 6,000 patients identified complications and reoperations during and after hip arthroscopy [3].
- Symptoms of nerve dysfunction after hip arthroscopy are considered an under-reported complication [4].
- Persistent structural disease is the most common cause of repeat hip preservation surgery [5].
- Femoral neck fracture is a reported complication following arthroscopic management of femoroacetabular impingement [6].
- Abdominal compartment syndrome has been reported as a complication following hip arthroscopy [7].
- Acute iatrogenic dislocation can occur following hip impingement arthroscopic surgery [8].
- Venous thromboembolic disease has an incidence following hip arthroscopy [9].
- Fatal pulmonary embolism has been reported in a polytraumatized patient following hip arthroscopy [10].
- Hip subluxation is a complication of arthroscopic debridement [33].
- Anterior dislocation of the hip can occur after arthroscopy in patients with capsular laxity [34].

TOTAL HIP ARTHROPLASTY

- Dislocation is the most common reason for revision surgery after arthroplasty within 2 years of injury [67].
- The dislocation rate after hemiarthroplasty is 2% to 3% [67].
- The incidence of dislocation following total hip arthroplasty (THA) has declined steadily, with rates reported as low as 6% in meta-analyses and 8% in recent randomized trials for femoral neck fractures [67].
- Use of a posterior approach increases the dislocation rate by a relative risk of 1.3 compared to other approaches [67].
- Changing from a posterolateral to a direct lateral approach reduced dislocation rates from 8% to 2% and from 13% to 4% in two prospective cohort studies [67].
- Parkinson's disease is associated with an increased risk of dislocation [67].
- Closed reduction of bipolar hemiarthroplasty implants carries a risk of dissociation of the bipolar head from the stem, which makes closed reduction impossible [67].
- Increased femoral head size (>36 mm) is associated with a clinical, substantial reduction in dislocation rates [8].
- Increased femoral head size (>36 mm) is associated with an increased incidence of groin pain [8].
- Increased femoral head size (>36 mm) is associated with higher polyethylene wear rates among younger and more active patients [8].
- Increased femoral head size (>36 mm) is associated with corrosion and loosening of the head-neck junction [8].
- Mechanical noise from hip implants has an incidence between 0.2% and 17.0% [8].

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- Audible mechanical noise from hip implants has not been associated with implant failure or revision [8].
- Fretting and crevice corrosion may occur in 2% or more femoral stem modular interfaces [8].
- Trunnionosis is diagnosed based on a serum cobalt level > 1 ppb and cobalt ions >>> chromium ions [8].
- Periprosthetic joint infection (PJI) risk is higher for patients with multiple surgical procedures [8].
- PJI risk is higher with uncontrolled diabetes, morbid obesity, inflammatory arthritis, malnutrition, smoking, and chronic immunosuppression [8].
- Longer index procedure surgical time increases the risk for operative field contamination [8].
- Allogeneic transfusion may independently increase periprosthetic infection [8].
- Periprosthetic osteolysis is a macrophage-initiated biologic response to submicron polyethylene wear debris [8].
- Aseptic loosening can result from osteolysis or osseointegration failure [8].
- Component subsidence in noncemented implants is most commonly associated with failure to obtain adequate initial implant stability [8].
- Higher loosening rates may occur with large femoral heads in noncemented components [8].
- A minimum of 35% ingrowth is required for acetabular fixation in noncemented components [8].
- Adverse reaction to metal debris (ARMD) can result in synovitis, acute lymphocyte vasculitis-associated lesions, and pseudotumor formation [8].
- Factors associated with increased metal particle generation include acetabular implant malposition, reduced or excessive clearance between the head and acetabulum, corrosion at modular junctions, smaller femoral head size (<46 mm) in hip resurfacing, and female sex [8].
- Decreased femoral offset and inadequate leg length restoration can result in femoral neck impingement against the pelvis or acetabular implant [8].
- Decreased femoral offset and inadequate leg length restoration can result in decreased abductor mechanism efficiency due to a reduced moment arm [8].
- Female sex is associated with an increased dislocation rate [8].
- Osteonecrosis and femoral neck fractures are associated with an increased dislocation rate [8].
- Spinal fusion or limited lumbar spine mobility is associated with an increased dislocation risk [8].
- Revision THA carries an increased dislocation risk compared to primary THA [8].
- High abduction combined with high anteversion results in anterior instability with hip extension [8].
- Low abduction combined with low anteversion results in posterior instability with hip flexion [8].

CEREBRAL PALSY HIP SURGERY

- A retrospective case-control series reported a 65% complication rate following bony hip surgery for cerebral palsy [66].
- In the same series, 26% of patients experienced multiple complications following bony hip surgery [66].
- Only 15% of complications following bony hip surgery for cerebral palsy required return-to-OR [66].

- An additional 2% of complications following bony hip surgery for cerebral palsy were life-threatening (Clavien-Dindo III-IV) [66].
- No perioperative deaths were reported in the retrospective case-control series of bony hip surgery for cerebral palsy [66].
- Complication rates for salvage procedures in late-presenting hip dislocations are 24% for femoral head resection, 33.3% for valgus-producing osteotomy, 35.3% for total hip arthroplasty, and 28.6% for shoulder prosthetic interposition [66].
- The complication rate for hip arthrodesis as a salvage procedure is 106.3% [66].

FEMORAL NECK FRACTURE OUTCOMES

- Between 15% and 20% of patients with femoral neck fractures will not return to their previous residence [68].
- Poor prognostic factors for return of mobility after displaced femoral neck fractures include increasing age, cognitive impairment, and any degree of impaired mobility before fracture [68].

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