

Hip arthroscopy

Overview

- Hip arthroscopy is used for the diagnosis and treatment of hip joint pathology [1].
- A 23-point arthroscopic examination of the hip involves specific basic setup, portal placement, and surgical technique [1].
- Peritrochanteric access is utilized for gluteus medius repair [1].
- Hip arthroscopy can be performed using a supine approach [1].
- Surgical indications for hip arthroscopy have been defined [1].
- Hip arthroscopy for labral pathology has been analyzed prospectively with 10-year follow-up [1].
- Complications in hip arthroscopy have been documented in 1054 cases [1].
- A systematic approach exists for the plain radiographic evaluation of the young adult hip [1].
- Clinical examination of the hip joint is performed in athletes [1].
- Femoroacetabular impingement is identified as a cause for osteoarthritis of the hip [1].
- A geographic zone method is used to describe intra-articular pathology in hip arthroscopy [1].
- Clinical outcomes for hip arthroscopy for labral tears have been reviewed with a 4.8-year mean follow-up [1].
- Arthroscopic labral repair in the hip involves specific surgical techniques and has been reviewed in the literature [1].
- Current indications, treatment options, and management issues for hip arthroscopy have been addressed [1].
- Current concepts and recent advances in arthroscopic surgery of the hip have been discussed [1].
- The influence of femoroacetabular impingement on results of hip arthroscopy in patients with early osteoarthritis has been studied [1].
- An arthroscopic classification for the acetabular labral tear has been established [1].
- Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement has been compared [1].

- The effect of the size of resection in the surgical treatment of femoroacetabular impingement has been evaluated [1].
- Indications, outcomes, and complications of hip arthroscopy have been reviewed [1].
- The role of labral lesions in the development of early degenerative hip disease has been examined [1].
- The relationship between watershed labral lesions and early arthritis of the hip has been investigated [1].
- The relationship between diagnosis and outcome in arthroscopy of the hip has been analyzed [1].
- Femoroacetabular impingement has been described in orthopaedic surgery literature [1].
- Arthroscopy for the treatment of femoroacetabular impingement in the athlete has been discussed [1].
- Early outcomes after hip arthroscopy for femoroacetabular impingement in the athletic adolescent patient have been reported [1].
- A cadaveric assessment of the safe zone for hip arthroscopy regarding central, peripheral, and lateral compartment portal placement has been conducted [1].
- Arthroscopy of the hip in children and adolescents has been addressed [1].
- The anatomy, histologic features, and vascularity of the adult acetabular labrum have been described [1].
- Current techniques and spectrum of disease for hip arthroscopy in the athletic patient have been reviewed [1].
- Indications, positioning, portals, basic techniques, and complications for beginning hip arthroscopy have been outlined [1].
- Arthroscopic psoas tenotomy has been described [1].

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 [19].
- The hemipelvis comprises three bones: the ilium, ischium, and pubis, which unite at the triradiate cartilage within the concave acetabulum [19].
- The shape and depth of the acetabulum are formed by the appearance of ossification centers around the end of the first decade of life, with complete fusion occurring around 18 to 19 years of age [19].
- The ilium is a large flat bone that forms the majority of the coxal bone [19].
- The iliac crest terminates anteriorly at the anterior superior iliac spine (ASIS) and posteriorly at the posterior superior iliac spine (PSIS) [19].
- The anterior and posterior inferior iliac spines (AIIS and PIIS) are located inferior to the ASIS and PSIS [19].
- The greater sciatic notch is located directly below the PIIS and serves as the passage for the large sciatic nerve exiting the pelvis [19].

CQ HAND + UPPER LIMB

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- The ischium is a small L-shaped bone that forms the posteroinferior margin of the pelvis [19].
- The ischial tuberosity is the thickened portion of the ischial body and serves as a large attachment site for multiple muscle groups [19].
- The pubis consists of a body and two rami that connect superiorly to the ilium and inferiorly to the ischium to form the obturator foramen [19].
- The obturator foramen serves as a conduit for arteries and nerves and is covered by a strong membrane providing surface area for muscle attachments [19].
- The hemipelvises unite anteriorly at the pubic symphyses and articulate posteriorly with the sacral ala to form the sacroiliac joint [19].
- 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 [19].
- The acetabulum is incomplete inferiorly, forming a notch through which vital blood vessels and nerves pass to supply the joint [19].
- The femoral head forms two-thirds of a sphere, with a small depression at its center from which the ligamentum teres extends [19].
- The femoral neck connects the head to the shaft, with the long axis of head and neck projecting superomedially at an angle to that of the obliquely oriented shaft [19].
- The neck-shaft angle averages 125° [19].
- Normal version, defined as the head-neck angle in the frontal plane, averages 15 to 20° [19].
- The greater and lesser trochanters are located at the junction of the neck and shaft, connected by the intertrochanteric line anteriorly and the intertrochanteric crest posteriorly [19].
- The mean femoral neck-shaft angle in the adult is $130^{\circ} \pm 7^{\circ}$ [24].
- The mean anteversion of the femoral neck is $10^{\circ} \pm 7^{\circ}$ [24].
- The two prime trabecular groups of the proximal femur are the principal tensile group and the principal compressive group [24].
- Secondary compressive and tensile trabecular groups also exist in the proximal femur [24].
- The weakest area in the femoral neck is located in the Ward triangle [24].
- 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 [24].

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 [19].
- 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 [19].
- 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 [19].

- The labrum is highly innervated, with the presence of both mechanoreceptors and nociceptors [19].
- The labrum is absent in the area of the inferior acetabular notch, where the transverse acetabular ligament serves as the continuation of the labrum [19].
- The ligamentum teres arises from the apex of the cotyloid notch and attaches to the fovea of the femoral head [16].
- The ligamentum teres transmits an arterial branch of the posterior division of the obturator artery to the femoral head, which is less significant in adults [16].
- The hip is surrounded by a dense fibrous capsule extending from the periphery of the acetabulum to the intertrochanteric line of the femoral neck [19].
- The capsule enhances joint stability by preventing translation of the femoral head in the acetabulum [19].
- The iliofemoral ligament is Y-shaped and is the thickest and strongest of the three main hip ligaments [19].
- The medial portion of the iliofemoral ligament connects the anterior inferior iliac spine to the anterior intertrochanteric line [19].
- The lateral portion of the iliofemoral ligament originates slightly superior to the medial arm and attaches to the anterior greater trochanter [19].
- The iliofemoral ligament functions to limit external rotation, while its lateral arm limits extension of the joint [19].
- The ischiofemoral ligament extends from the ischial margin of the acetabulum to the greater trochanter of the femur and restricts internal rotation motion [19].
- The pubofemoral ligament extends from the obturator crest of the pubic bone to the femoral neck and acts to limit abduction of the joint [19].
- Deep fibers from all three ligaments merge to form the zona orbicularis, which circumvents the femoral neck [19].
- The hip capsule attaches anteriorly and posteriorly along the periphery of the acetabulum outside the labrum [20].
- Inferiorly, the hip capsule is attached to the acetabular labrum [20].
- The capsule is attached to the femur anteriorly along the intertrochanteric crest [20].
- On the posterior side, the capsule attaches only partially, such that the basicervical region of the femoral neck and the intertrochanteric region of the femur are not intracapsular [20].
- The iliofemoral ligament becomes taut in full extension, preventing anterior dislocation and hyperextension of the hip [20].
- The twisted orientation of the hip ligaments provides a screw mechanism for the hip in full extension [20].
- The sacrospinous and sacrotuberous ligaments create the boundaries of the greater and lesser sciatic foramina [20].
- The piriformis muscle and the sciatic nerve exit from the greater sciatic foramen [20].
- The short external rotator muscles exit from the lesser sciatic foramen [20].
- The primary hip flexor muscles are the iliopsoas, rectus femoris, and sartorius muscles [23].

- The iliopsoas muscle has a large origin along the iliac crest, iliac fossa, sacra ala, iliolumbar ligaments, and sacroiliac ligaments [23].
- The iliopsoas also has origins along the bodies of the T12 through L4 thoracic lumbar vertebra, the transverse process of the first through fifth lumbar vertebra, and the intervertebral disks [23].
- The rectus femoris crosses the hip joint and the knee joint [23].
- The straight head of the rectus femoris originates from the AIIS, while the reflected head originates from the supra-acetabular tubercle at the superior-anterior edge of the acetabulum [23].
- The sartorius muscle originates on the ASIS, crosses the hip and knee joints, and inserts on the medial aspect of the tibia and the pes anserine complex [23].
- The tensor fasciae latae muscle originates laterally on the anterolateral edge of the iliac crest [23].
- The gluteus maximus and hamstring muscles are the most important hip joint extensors [23].
- The gluteus maximus originates from the sacrum, the coccyx, and the sacrotuberous ligaments [23].
- The hamstring muscles originate on the ischial tuberosity [23].
- The abductors of the hip are predominantly the gluteus medius and minimus muscles [23].
- The gluteus medius has three different components: anterior, middle, and posterior [23].
- The gluteus medius and minimus muscles function together to maintain and abduct the femur during the stance phase of gait [23].
- The adductor muscles of the hip include the adductor brevis, the adductor longus, the adductors magnus, the pectineus, and the gracilis [23].
- The external rotators of the hip include the obturator internus and externus, superior and inferior gemelli, quadratus femoris, and piriformis muscles [23].
- The piriformis forms the reference structure for the posterior part of the hip [23].
- The superior gluteal nerve and artery exit the pelvis above the piriformis muscle [23].
- The pudendal nerve, internal pudendal artery, nerve to the obturator internus, posterior femoral cutaneous nerve, sciatic nerve, inferior gluteal nerve, inferior gluteal artery, and nerve to the quadratus femoris exit the pelvis below the piriformis [23].
- In 10% of cases, the common peroneal component of the sciatic nerve can pass through the division in the piriformis [23].
- Most often, the sciatic nerve passes below the piriformis and is situated on top of the short external rotators [23].
- The most consistent internal rotators of the hip joint are the gluteus medius and tensor fascia latae muscles [23].

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 [26].

- 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 [26].
- In adulthood, the major blood supply to the femoral head is from the medial femoral circumflex and lateral epiphyseal arteries [26].
- The medial femoral circumflex artery is the main blood supply to the femoral head and terminates in the posterior aspect of the extracapsular arterial ring [24].
- The lateral femoral circumflex artery gives rise to the anterior aspect of the arterial ring [24].
- The superior and inferior gluteal arteries also contribute branches to the extracapsular arterial ring [24].
- The ascending cervical arteries originate from the extracapsular arterial ring and are divided into four distinct groups based on their anatomic relationship to the femoral neck: lateral, medial, posterior, and anterior [24].
- The lateral group of ascending branches is the main blood supply to the femoral head [24].
- The ascending branches give off multiple perforator vessels to the femoral neck and terminate in the subsynovial arterial ring located at the margin of the articular surface of the femoral head [24].
- The lateral epiphyseal artery penetrates the femoral head and is believed to be the dominant blood supply to the femoral head from this system [24].
- 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 [24].
- The common femoral artery arises from the external iliac artery as it passes underneath the inguinal ligament [26].
- The common femoral artery passes anterior and medial to the hip capsule [26].
- The profundus or deep femoral artery arises from the lateral aspect of the common femoral artery approximately 3.5 cm below the inguinal ligament [26].
- The lateral circumflex artery arises from the lateral side of the proximal profundus femoris artery [26].
- The medial circumflex artery most commonly comes from the posteromedial profundus femoris artery but may also come directly from the femoral artery [26].
- The superior gluteal vessels are branches of the posterior division of the internal iliac artery and are closest to the hip as they exit from the sciatic notch [26].
- The inferior gluteal vessels and internal vessels are branches of the anterior division of the internal iliac artery and exit the pelvis between the piriformis and coccygeus muscles [26].

PATHOPHYSIOLOGY

- Femoroacetabular impingement (FAI) is recognized as a common cause of hip dysfunction and secondary osteoarthritis [7].
- In FAI, distinct structural abnormalities produce repetitive impingement between the acetabulum and the femoral head-neck junction [7].
- Three types of FAI are recognized: cam, pincer, and combined cam/pincer [7].

- Cam impingement involves femoral-based abnormalities such as aspherical femoral head, reduced head-neck offset, or femoral retroversion, resulting in repetitive abutment of the acetabular rim and femoral head-neck junction [7].
- Pincer impingement involves acetabular-based disorders such as acetabular retroversion, global overcoverage, or acetabular protrusio, creating abnormal abutment of the acetabular rim and femoral head-neck junction [7].
- Combined cam/pincer deformities are common in FAI [7].
- Impingement abnormalities can cause labral tears, degeneration, or ossification [7].
- Impingement abnormalities can cause acetabular cartilage delamination [7].
- Impingement abnormalities can cause secondary osteoarthritis [7].
- The acetabular labrum plays a role in shock absorption, joint lubrication, and pressure distribution [41].
- The most critical role of the acetabular labrum is the creation of a negative pressure seal with the femoral head, which aids in joint stability [41].
- Removal of the labrum leads to a shift in the femoral contact point toward the acetabular rim [41].
- Removal of the labrum leads to a decrease in intra-articular fluid pressurization [41].
- Removal of the labrum leads to a loss of lateral restraint to femoral head motion [41].
- Removal of the labrum increases contact stresses between the articular cartilage of the femoral head and the acetabulum by 92% [41].
- 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 [27].
- Motion of the femur relative to the acetabulum is the result of the absolute biomechanical force acting on the hip joint, affected by bones and soft tissues [27].
- FAI-related damage to the labrum and loss of the seal between the labrum and the femoral head might generate hip microinstability [39].
- Current evidence supports that the hip capsule is the structure mainly implicated in hip microinstability [39].
- Hip dysplasia predisposes patients to premature joint degeneration because joint loading forces are concentrated at the edge of the dysplastic acetabulum and labrum, leading to chondrolabral damage [42].
- Extra-articular abnormalities including abnormal femoral torsion have been found to exacerbate or cause impingement or instability [42].
- Chondrolabral damage occurs quickly in patients who acquire a deformity, as may be seen in those with slipped capital femoral epiphysis [42].
- Even in the absence of symptoms, chondrolabral junction damage may occur in the presence of osseous deformity [42].
- Iliopsoas impingement on the anterior hip joint is a mechanism for labral tears, characterized by a tear on the anterior acetabulum directly beneath where the iliopsoas tendon crosses the hip joint [41].

- Traction injury of sufficient energy can tear the labrum in association with avulsions of the rectus femoris [41].
- Sports that require a great deal of hip torsion can lead to capsule attenuation and laxity secondary to repetitive microtrauma [41].
- Attenuation of the capsule leads to microinstability of the joint, in which the femoral head subluxates anteriorly and rides on the anterior superior labrum [41].
- Microinstability can occur in patients with collagen disorders such as Ehlers-Danlos syndrome, Marfan syndrome, and Down syndrome [41].
- Degenerative labral tears are analogous to degenerative meniscus tears in the knee and are frequently associated with diffuse articular changes in an arthritic joint [41].
- Degenerative labral tears are thought to be extremely common in the aging hip and likely occur early in the arthritic process [41].
- Patients with FAI demonstrate decreased hip flexion and extension strength compared with reference persons and their contralateral hip [3].
- Hip strength deficits are common in patients presenting with unilateral symptomatic FAI and occurred most commonly in hip abduction and flexion

Clinical Presentation

HISTORY AND SYMPTOMS

- Patients with symptomatic femoroacetabular impingement (FAI) frequently present with activity-related groin pain that is exacerbated by hip flexion activities [7].
- Patients with symptomatic FAI report difficulty with prolonged sitting, walking, running, or pivoting [7].
- The onset of symptoms in symptomatic FAI is often insidious or follows minor trauma [7].
- Mechanical symptoms secondary to labral and articular cartilage disease are common in symptomatic FAI [7].
- Anterior groin pain is most associated with intra-articular pathologies, including labral tears, degenerative changes, synovial pathologies, loose bodies, and osteonecrosis [47].
- Anterior groin pain can also result from extra-articular conditions such as hip flexor strains, iliopsoas snapping syndrome, or femoral stress fractures [47].
- Pain along the lateral thigh is often associated with greater trochanteric bursitis, iliotibial band syndrome, or abductor tendon tears or tendinitis [47].
- Posterior hip and pelvic pain can result from muscle pathologies such as piriformis syndrome and hamstring muscle tears, or referred pain from the sacroiliac joint or low back [47].
- In adolescent hip dysplasia, lateral hip pain is often the initial symptom, occurring later in the day as fatigue develops due to altered biomechanics [49].

- Deep anterior groin pain in adolescent hip dysplasia indicates pain originating from the joint itself, such as joint overload, edge-loading of the acetabulum, or labral irritation [49].
- Patients with hip microinstability often describe hip or groin pain that has increased over time and report a feeling of instability or giving way in the hip during activity [48].
- Athletes participating in sports that include hyperextension are more likely to have hip microinstability, especially those with hip dysplasia or connective tissue disorders [48].
- Patients with acetabular dysplasia presenting in adolescence complain of aching pain in the groin or lateral hip that is worse with exertion and long periods of walking or standing [44].
- Symptoms in patients with late-presenting acetabular dysplasia usually increase steadily in frequency and severity over a relatively short time [44].

PHYSICAL EXAMINATION

- Patients with FAI exhibit restricted hip internal rotation in 90° of flexion [7].
- The impingement test (flexion, adduction, internal rotation) elicits pain in patients with FAI, but the test is not specific for FAI [7].
- A thorough history and physical examination are essential to differentiate between common causes of hip pain, as many conditions present with similar symptoms [5].
- Assessing the onset, duration, and location of symptoms, along with exacerbating and alleviating factors, is important for determining the cause of hip pain [47].
- Identifying changes to activity type or training regime helps differentiate between hip conditions when there is no known precipitating event [47].
- Documenting family history of hip conditions is important because certain genetic conditions, such as Ehlers-Danlos syndrome, can affect the hip [47].
- In adolescent hip dysplasia, physical examination should include observation of ambulation to assess for an antalgic gait or a subtle Trendelenburg gait [49].
- The impingement test in adolescent hip dysplasia assesses pain with flexion, internal rotation, and adduction to determine the likelihood of symptomatic labral pathology [49].
- Patients with late-presenting acetabular dysplasia may exhibit a Trendelenburg limp or a delayed Trendelenburg sign [44].
- Signs of snapping or popping in late-presenting acetabular dysplasia may be caused by a tear in the labrum [44].
- Persons with chronic hip joint pain exhibit reduced hip muscle strength [3].
- Hip strength deficits in patients with symptomatic FAI and labral tears occur most commonly in hip abduction and flexion [3].
- Strength deficits in hip flexion are associated with decreased function, loss of motion, and larger labral tears in patients with FAI and labral tears [3].
- Persons with FAI syndrome exhibit altered pelvifemoral coordination during weightbearing and non-weightbearing tasks [3].

- Impaired hip muscle strength is common in patients with FAI syndrome [3].

IMAGING

- The AP pelvis view is used to assess acetabular anatomy, including version, acetabular coverage, and femoral head sphericity [7].
- Lateral views, most commonly the 45° Dunn view and frog-leg lateral, are used to assess femoral head sphericity and head-neck offset [7].
- MRI or magnetic resonance arthrography provides information regarding the integrity of the acetabular labrum and articular cartilage [7].
- MRI or magnetic resonance arthrography can assess the anatomy of the proximal femur as well as the version of the acetabulum and femur [7].
- Sensitivity of MRI or magnetic resonance arthrography to acetabular rim chondral lesions is limited [7].
- Low-dose CT with three-dimensional reformats is particularly useful in surgical planning of complex or borderline deformities [7].
- Imaging findings should complement clinical examination findings to provide the most accurate diagnosis of hip pain [5].
- Gadolinium-enhanced MRI arthrography may demonstrate labral pathology in patients with late-presenting acetabular dysplasia [44].
- The false-profile radiograph is used to assess anterior acetabular coverage using the ventral center-edge angle, which should be more than 25 degrees [44].
- The abduction-internal rotation view is used to determine whether the hip reduces concentrically, a prerequisite for a rotational acetabular osteotomy [49].
- A 45° or 90° Dunn lateral view is used to determine the presence of cam morphology, an asphericity of the femoral head-neck junction [49].
- The alpha angle is measured by placing a best-fit circle over the femoral head and determining the angle subtended by a line from the center of the head along the femoral neck axis and a line from the center of the femoral head to the point where the anterosuperior head-neck junction exits from the best-fit circle [49].
- An alpha angle greater than 42° suggests some femoral head-neck offset deformity [49].
- CT scans are used to determine femoral and acetabular version, evaluate for possible cam morphology, and assess overall acetabular morphology, but are not a routine study for most cases of adolescent hip dysplasia [49].
- The incidence of labral pathology in patients with hip dysplasia is reported to occur in two-thirds of patients [49].
- The incidence of labral pathology in asymptomatic young adults is approximately 40% [49].
- Other findings in adult hip dysplasia include acetabular cartilage lesions in 69% and combined labral/cartilage lesions in 59%, most commonly seen on the anterior and superolateral acetabulum [49].

- Chondrolabral damage was found in 80% of asymptomatic volunteers and 57% of symptomatic patients with FAI, indicating degenerative changes exist in the absence of symptoms [11].
- Progressive degenerative changes on MRI were demonstrated in young athletes with limited internal rotation in flexion ($<10^\circ$) and radiographic findings of FAI compared with those with normal internal rotation [11].
- Abnormal femoral version ($<10^\circ$ or $>25^\circ$) was found in 52% of symptomatic patients, with severe abnormalities in 17% [11].
- Cam deformities above 55° were found in only 31% of hips in asymptomatic adults evaluated with pelvic CT scans [11].

Investigations

GENERAL PRINCIPLES

- Imaging findings should complement clinical examination findings to provide the most accurate diagnosis of hip pathology [5].
- A thorough history is essential to differentiating between common causes of hip pain [5].
- Clinical examination tests and imaging findings should be used to confirm a suspected clinical diagnosis [5].
- Conventional radiographs remain critical in the initial imaging evaluation of the hip [10].
- Conventional radiographs have long been the initial imaging modality for pathologies including fractures, developmental dysplasia of the hip (DDH), femoroacetabular impingement (FAI), and osteoarthritis [21].
- Plain radiographs are the first imaging studies obtained for patients presenting with hip pain [30].
- The type of radiographic imaging performed is dependent upon the suspected pathology [30].

RADIOGRAPHY

- A complete hip series usually consists of 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].
- 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 [30].
- The Dunn view and frog leg view are appropriate to measure the alpha angle to determine the presence of impingement [30].
- Acetabular morphology is assessed on AP pelvis radiographs, including acetabular overcoverage and undercoverage [10].
- Specific views of the hip are used to detect abnormalities of the femoral head-neck junction seen with FAI [10].
- The femoral head-neck junction morphology is often assessed using the alpha angle [10].
- Some studies have shown that radiographs, in particular the Dunn 45° view, may be more accurate for determining the alpha angle measurement than CT or MRI [10].

- The AP pelvis radiograph should be performed with the lower extremities in approximately 15° of internal rotation and centered over the pelvis [10].
- Coxa profunda is diagnosed when the fossa line touches or is medial to the ilioischial line [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 [10].
- Femoral head extrusion index values greater than 25% are considered abnormal [10].
- The Tönnis angle is defined by the angle of the acetabular sourcil and a line parallel to the transverse pelvis axis [10].
- Tönnis angles between 0° and 10° are considered normal [10].
- The lateral center-edge angle, or 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 [10].
- Center-edge angles from 20° to 25° are considered borderline [10].
- The “crossover” sign on AP pelvis radiographs indicates acetabular retroversion related to lateralization of the anterior acetabular wall relative to the posterior acetabular wall [10].
- An optimal AP pelvis image is required for the “crossover” sign, as pelvic tilt or rotation may lead to false-positive and false-negative results [10].
- For neutral pelvic tilt, the sacrococcygeal joint should be between 3 and 5 cm above the superior border of the symphysis pubis [10].
- Osteoarthritis of the hip can be categorized using the Kellgren-Lawrence or Tönnis classifications [10].
- The Kellgren-Lawrence classification is a 4-point grading system classified into doubtful, mild, moderate, and severe [10].
- The Tönnis classification is a 3-point grading system categorized into mild, moderate, and severe [10].
- Radiographic and clinical severity do not necessarily correlate, particularly if the radiographs are non-weight-bearing or if false-profile views are not included [10].
- Radiographs remain integral to the assessment of fractures and can be supplemented with CT to further investigate suspected occult fractures, define fracture morphology, and assist in preoperative planning [10].
- Radiographs can serially assess hardware positioning and evaluate symptomatic hardware related to open reduction and internal fixation and total hip arthroplasty [10].
- Anteroposterior (AP) and lateral radiographs are required for the identification of femoral neck fractures [36].
- In the majority of cases, the diagnosis of a femoral neck fracture is clear on the AP radiograph [36].
- The lateral radiograph may be difficult to acquire due to pain but is useful in determining whether the fracture is present and whether it is displaced [36].
- In equivocal cases, the lateral radiograph can help determine whether the fracture is displaced, which is usually essential to determine the choice of treatment [36].

- Full-length AP and lateral femur films are standard for femoral neck fracture evaluation [36].

MAGNETIC RESONANCE IMAGING (MRI)

- MRI is the modality of choice for patients suspected of soft tissue or intra-articular pathology, given its superior sensitivity and specificity [30].
- Conventional MRI is effective at identifying osteochondral injuries, musculotendinous pathologies, and inflammation [30].
- Magnetic resonance arthrography (MRA) is more appropriate to determine injuries to the labrochondral structures and the ligamentum teres and identify the presence of loose bodies and synovial chondromatosis [30].
- 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 [30].
- Recent advances in MRI imaging techniques, such as delayed gadolinium-enhanced MR imaging and T2* mapping, allow for a more in-depth analysis of the structure of articular cartilage [30].
- 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 [30].
- The anatomy of the proximal femur as well as the version of the acetabulum and femur may be assessed with MRI or MRA [7].
- Sensitivity to acetabular rim chondral lesions is limited with MRI or MRA [7].
- The soft-tissue contrast of MRI is superior to other imaging modalities in assessing both intra-articular and extra-articular hip pathology [21].
- Magnetic resonance arthrography (MRA) can further increase conspicuity of intra-articular lesions and is useful following hip preservation surgeries [21].
- Noncontrast MRI at 3T is generally adequate for diagnosing intra-articular pathology [34].
- If 3T imaging is unavailable, MRA can be considered at 1.5T for increased diagnostic accuracy [34].
- MRI is helpful in identifying femoral neck stress fracture in athletes and predicting patients that may require surgical intervention [34].
- MRI is helpful in assessing complications of conventional and resurfacing hip arthroplasties, particularly those with metal-on-metal bearing systems [34].
- Major MRI findings that help predict histologic ALVAL scores include synovial thickening, synovitis, synovial volume, abductor disruption, and soft-tissue edema [34].
- MRI is used when osteonecrosis is suspected [37].
- Gadolinium-enhanced MRI arthrogram is useful when labral pathology is suspected, especially when associated with FAI [37].
- MRI may identify gluteus medius and gluteus minimus tears in patients with lateral hip pain and abductor weakness [37].
- A prospective study comparing noncontrast 3T MRI to 1.5T MRA found similar accuracies between the two techniques for femoroacetabular impingement [33].

- In a retrospective study evaluating the accuracy of noncontrast 3T MRI versus hip arthroscopy, accuracy for labral tears was 98% and for acetabular cartilage lesions was 90% [33].
- MRI is the current additional imaging modality recommended where there is uncertainty about the presence of an intracapsular fracture [36].
- MRI has been shown to be more accurate than a bone scan in the early stages after injury for detecting occult hip fractures [36].
- MRI will demonstrate soft tissue problems that may be causing hip pain in the absence of a fracture [36].
- In cases of intense bone edema in the femoral neck demonstrated on MRI rather than a definite fracture, some authors have carried out a CT scan to aid in determining whether a fracture is present [36].
- Positron emission tomography/computed tomography (PET/CT) at 6 weeks could detect recovery of vascularity and predict the risk of vascular necrosis in femoral neck fractures [36].
- Dynamic MRI-positive enhancement integral color mapping (PEICM) can estimate femoral head perfusion preoperatively in undisplaced femoral neck fractures [36].
- In a study using dynamic MRI-PEICM, the nonunion rate was zero in the normal perfusion group, 6.7% in the reduced perfusion group, and 50% in the absent perfusion group [36].

COMPUTED TOMOGRAPHY (CT)

- 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 [30].
- Measurements of femoral head coverage and acetabular and femoral impingement can also be performed reliably using CT images [30].
- CT overcomes the limitations of radiography by providing three-dimensional assessment of bony morphology and, to some degree, assessment of soft-tissue abnormalities [21].
- Combined with arthrography, CT can evaluate chondrolabral abnormalities, specifically in patients with contraindications to MRI (ie, pacemakers) [21].
- CT is helpful in fracture evaluation, particularly in the setting of negative radiographs, or for further defining fracture morphology in patients requiring surgical reduction [21].
- Three-dimensional CT with pelvic remodeling may be indicated for preoperative planning for reconstruction associated with dysplasia surgery, femoroacetabular impingement (FAI), posttraumatic arthritis, or other complex primary total hip arthroplasty (THA) [37].
- The multiplanar and 3D capabilities of CT make it an invaluable tool for assessing bone morphology, but at higher cost and radiation dose [34].
- 3D volume renderings are useful to aid in preoperative planning in FAI and subspace impingement [34].
- CT scanning is a more accurate investigation than technetium bone scan for occult hip fractures but exposes the patient to further radiation [36].
- Thomas et al. reported 100% specificity and sensitivity for the use of multidetector CT scanning in diagnosis of hip fracture in a series of 209 patients with negative plain radiographs [36].

- Rehman et al. reported on 179 patients presenting with pelvic pain after trauma and imaging with CT missed no occult hip fracture [36].
- Sadozai et al. reported on 78 CT scans and reported CT scanning yielded sensitivity of 86% and specificity of 98% for occult hip fractures [36].
- Studies comparing CT and MRI for occult hip fractures have come out in favor of MRI scanning [36].

ULTRASONOGRAPHY

- Ultrasonography provides real-time dynamic assessment of the hip and is useful in diagnosing soft-tissue abnormalities about the hip joint, and to a lesser degree, within the hip joint itself [21].
- Ultrasonography is particularly useful in providing real-time guidance during diagnostic and therapeutic procedures [21].
- Ultrasonography can be used at the time of clinical evaluation and provides real-time guidance during therapeutic and diagnostic procedures, which can be performed in the office setting [34].
- Although ultrasonography is a valuable tool to examine pediatric hip conditions, its utility in evaluating the adult hip is limited [30].
- Ultrasonography can be an effective modality to identify musculotendinous disruptions, effusions associated with intra-articular pathology, or inflammatory conditions, such as bursitis [30].
- Ultrasonography is also being increasingly used for targeted injections into muscles, tendons, or intra-articularly around the hip, for use with corticosteroids or biologic treatments emerging as a more recognized modality [30].

Treatment

INDICATIONS AND PATHOLOGY

- Hip arthroscopy indications address pathology in the central, peripheral, and peritrochanteric compartments of the hip joint [6].
- Central compartment pathology includes labral tears, loose bodies, ligamentum teres tears, chondral defects, and pincer lesions associated with femoroacetabular impingement (FAI) [6].
- Peripheral compartment pathology includes cam lesions associated with FAI, capsular laxity associated with hip instability, loose bodies, and recalcitrant internal snapping hip secondary to chronic iliopsoas bursitis [6].
- Peritrochanteric compartment pathology includes recalcitrant trochanteric bursitis, tears of the gluteus medius and minimus, and painful external snapping hip [6].
- Endoscopic techniques have been applied to proximal hamstring repairs and sciatic nerve decompression in the deep gluteal space [6].
- FAI is the most common indication for hip arthroscopy [6].

OPERATIVE TECHNIQUE AND ACCESS

- Hip arthroscopy is performed on a traction table by carefully distracting the joint with the minimum force required to avoid traction injuries [46].
- The anterolateral portal is typically the first portal established, located 2 cm anterior and 2 cm distal to the greater trochanter [6].
- The objective of the anterolateral portal is to enter the joint parallel to the sourcil without violating the labrum [6].
- The anterior portal is typically made next using a spinal needle for localization via an inside-out technique through the anterior triangle [6].
- The key landmark for the anterior portal is a line parallel to the femur extending distal from the anterior superior iliac spine [6].
- Remaining lateral to the line parallel to the femur minimizes risk to the femoral neurovascular bundle [6].
- Placing the anterior portal more laterally increases distance from the lateral femoral cutaneous nerve (LFCN) [6].
- The distal anterolateral portal is typically 4 to 5 cm distal to the anterolateral portal and provides a safe trajectory for anchor placement in the acetabulum [6].
- The Dienst portal is placed a few centimeters proximal to the anterolateral portal and offers a different trajectory into the central and peripheral compartments [6].
- The trochanteric space can be accessed via the anterolateral portal and a posterolateral portal located 2 cm posterior and 2 cm distal to the greater trochanter [6].
- A third portal distal to the vastus ridge insertion of the vastus lateralis provides a viewing angle for gluteus medius and minimus repairs [6].
- Fluoroscopy facilitates joint access for guidance and proper osseous resection during acetabuloplasty or femoroplasty [46].
- Modern surgical techniques allow for labral repair, débridement, near-circumferential labral reconstruction, acetabuloplasty, femoroplasty, subspine resection, and heterotopic ossification excision [46].
- Cartilage restoration techniques used in hip arthroscopy include microfracture, abrasion chondroplasty, and cartilage transplantation [46].
- A trend to close the hip capsule has surfaced in recent years due to the role of the capsule in conferring stability [46].

OUTCOMES AND EFFICACY

- Patients with FAI syndrome have significantly better hip-related quality of life at 12 months with hip arthroscopy compared to conservative care, exceeding the minimal clinically important difference [3].
- An individual physiotherapy treatment and rehabilitation program may augment improvements in patient-reported outcomes following arthroscopy for FAI syndrome [3].

- Overall outcomes after hip arthroscopy are consistently very good, with pain relief, functional improvement, and return to prior level of activity or play on par with surgeries for other joints in similar patient populations [46].
- Subjective patient-reported outcomes support hip arthroscopy as the treatment of choice for properly selected patients with FAI who have previously failed nonsurgical treatment [46].
- Arthroscopic treatment for intra-articular hip pathology has demonstrated improved patient-reported outcomes with a lower rate of complications, revision surgery, and patient morbidity compared with traditional methods [3].
- Significant variability exists in return-to-play protocols among institutions due to a lack of standardization [3].
- Most rehabilitation protocols after hip arthroscopy are not evidence-based and rely on expert opinion [3].

COMPLICATIONS AND RISKS

- Iatrogenic chondrolabral injury can occur while gaining access to the central compartment and was the most reported complication in one systematic review [6].
- Neurapraxia is a common but transient complication following hip arthroscopy, with an incidence approaching 50% in one series [6].
- The lateral femoral cutaneous nerve (LFCN) is the most commonly involved nerve in neurapraxia after hip arthroscopy [6].
- Permanent nerve injury after hip arthroscopy is less than 5% [6].
- Pudendal neurapraxia can occur even with short traction times, especially in stiff, prearthritic hips [6].
- Traction injuries related to the post include skin and soft-tissue necrosis [6].
- Inadequate resection in FAI surgery, more commonly on the femoral side, is the most common reason for revision hip preservation surgery [6].
- Excessive resection has been proposed as a potential reason for failure after hip arthroscopy [46].
- Persistent structural disease is the most common cause of repeat hip preservation surgery [4].
- Complications associated with hip arthroscopy include FAI underresection, sequelae of FAI overresection (including iatrogenic instability and femoral neck fracture), heterotopic ossification, deep vein thrombosis, pulmonary embolism, osteonecrosis, and abdominal compartment syndrome [6].
- Hip arthroscopy has a steep learning curve and requires techniques to access a deep, highly congruent joint through a thick soft-tissue envelope [6].

NON-OPERATIVE MANAGEMENT

- A trial of conservative management should be attempted prior to considering surgical management for hip dysplasia [46].
- Anti-inflammatory medications, activity modification, physical therapy, and intra-articular injections may alleviate symptoms and should be the first line of treatment [46].

- Conservative means are unable to adequately correct osseous abnormalities, making surgical correction often necessary [46].
- Prior randomized studies have demonstrated benefit with physical therapy for hip dysplasia, but high crossover rates were seen and additional investigation is needed [46].
- A FAI syndrome-specific physical therapy program has the potential for a moderate to large positive effect on hip pain, function, and hip adductor strength [3].
- Hip strength deficits are common in patients presenting with unilateral symptomatic FAI, occurring most commonly in hip abduction and flexion [3].
- Persons with FAI syndrome exhibit altered pelvifemoral coordination regardless of weight-bearing status [3].

Complications

IATROGENIC AND INTRAOPERATIVE

- Iatrogenic chondrolabral injury can occur while the surgeon is gaining access to the central compartment [6].
- Iatrogenic chondrolabral injury was the most reported complication in one systematic review [6].
- Acute iatrogenic dislocation has been reported following hip impingement arthroscopic surgery [4].
- Hip subluxation has been reported as a complication of arthroscopic debridement [4].
- Anterior dislocation of the hip has been reported after arthroscopy in a patient with capsular laxity [4].
- Femoral neck fracture has been reported after arthroscopic management of femoroacetabular impingement [4].
- Abdominal compartment syndrome has been reported after hip arthroscopy [4].

NEUROLOGICAL

- Neurapraxia is a common but transient complication following hip arthroscopy [6].
- The incidence of neurapraxia following hip arthroscopy approaches 50% in one series [6].
- The lateral femoral cutaneous nerve (LFCN) is the most commonly involved nerve in neurapraxia following hip arthroscopy [6].
- It is unclear whether LFCN neurapraxia is related to direct injury from portal placement, traction from the portals and cannulas, swelling associated with arthroscopy, or a combination of causes [6].
- LFCN neurapraxia is now considered by many hip arthroscopists to be a sequela of hip arthroscopy rather than a complication [6].
- Permanent injury to the LFCN following hip arthroscopy is less than 5% [6].
- Pudendal neurapraxia can occur following hip arthroscopy, even with short traction times [6].
- Pudendal neurapraxia is especially likely in stiff, prearthritic hips [6].

- Symptoms of nerve dysfunction after hip arthroscopy are an under-reported complication [4].
- The sciatic and pudendal nerves are most frequently injured by traction when using a perineal post [13].
- The maximum traction weight, not the duration of traction, has been associated with sciatic nerve injury [13].
- The anterior portal puts the lateral femoral cutaneous nerve at risk [13].
- The ascending branch of the lateral femoral circumflex artery and the femoral neurovascular bundle are at risk from the anterior portal [13].
- The anterolateral portal is associated with injury to the superior gluteal nerve [13].
- The posterolateral portal places the sciatic nerve at risk, particularly when the hip is externally rotated [13].

VASCULAR AND THROMBOEMBOLIC

- Venous thromboembolic disease has been reported following hip arthroscopy [4].
- Fatal pulmonary embolism has been reported in a polytraumatized patient following hip arthroscopy [4].

OTHER

- Heterotopic ossification has been reported to occur following hip arthroscopy [13].
- NSAIDs have been shown to reduce the incidence of heterotopic ossification following hip arthroscopy [13].
- Skin and soft-tissue necrosis are traction injuries related to the post that are substantial but avoidable [6].
- Inadequate resection in femoroacetabular impingement (FAI) surgery is the most common reason for revision hip preservation surgery [6].
- Inadequate resection in FAI surgery is more commonly on the femoral side [6].

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