CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Dislocation after hip replacement

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 [8].
- The hemipelvis comprises three bones: the ilium, ischium, and pubis, which unite at the triradiate cartilage within the concave acetabulum [8].
- 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 [8].
- The acetabulum is incomplete inferiorly, forming a notch through which vital blood vessels and nerves pass to supply the joint [8].
- 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 [8].
- The neck-shaft angle of the femur averages 125° [8].
- Normal version, defined as the head-neck angle in the frontal plane, averages 15 to 20° [8].
- The acetabulum is normally anteverted 15 degrees and obliquely oriented in the coronal plane 45 degrees caudally [14].
- The posterosuperior articular surface of the acetabulum is thickened to accommodate weight bearing [14].
- The inferior surface of the acetabulum contains the acetabular (cotyloid) notch, which is bound by the transverse acetabular ligament [14].
- The femoral neck is normally anteverted approximately 14 degrees in relation to the femoral condyles, with a range of 1–40 degrees [14].
- The femoral neck-shaft angle averages 127 degrees, beginning at 141 degrees in the fetus [14].
- The weakest area in the femoral neck is located in the Ward triangle [18].
- 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 [18].
- Fractures of the proximal femur follow the path of least resistance [18].

CQ HAND + UPPER LIMB
Dr Kieran Hirpara — Specialist Orthopaedic Surgeon
Suite 2, Level 1, Mater Private Hospital Rockhampton, 31 Ward Street, The Range, QLD 4700
Phone 07 4863 6556 · office@cqupperlimb.com.au · cqupperlimb.com.au

LIGAMENTS AND CAPSULE

- The hip is surrounded by a dense fibrous capsule extending from the periphery of the acetabulum to the intertrochanteric line of the femoral neck [8].
- The capsule enhances joint stability by preventing translation of the femoral head in the acetabulum [8].
- The iliofemoral ligament is Y-shaped and is the thickest and strongest of the three main ligaments supporting the hip [8].
- The medial portion of the iliofemoral ligament connects the anterior inferior iliac spine to the anterior intertrochanteric line, while the lateral portion originates slightly superior to the medial arm and attaches to the anterior greater trochanter [8].
- The iliofemoral ligament functions to limit external rotation, while in isolation, the lateral arm limits extension of the joint [8].
- The ischiofemoral ligament extends from the ischial margin of the acetabulum to the greater trochanter of the femur, providing support posteriorly and restricting internal rotation motion [8].
- The pubofemoral ligament extends from the obturator crest of the pubic bone to the femoral neck and acts to limit abduction of the joint [8].
- Deep fibers from all three ligaments merge to form the zona orbicularis, which circumvents the femoral neck [8].
- The hip capsule attaches anteriorly and posteriorly along the periphery of the acetabulum outside the labrum, and inferiorly to the acetabular labrum [9].
- The capsule is attached to the femur anteriorly along the intertrochanteric crest, but on the posterior side, it attaches only partially, leaving the basicervical region of the femoral neck and the intertrochanteric region of the femur extracapsular [9].
- The iliofemoral ligament becomes taut in full extension, preventing anterior dislocation and hyperextension of the hip [9].
- The twisted orientation of the hip ligaments provides a screw mechanism for the hip in full extension [9].
- The ligamentum teres originates in the cotyloid fossa and attaches on the fovea of the femoral head [9].
- The sacrospinous ligament creates the upper border of the lesser sciatic foramen and the lower border of the greater sciatic foramen [9].
- The sacrotuberous ligament creates the inferior border of the lesser sciatic foramen [9].

LABRUM

- 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 [8].
- 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 [8].
- 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 [8].
- The labrum is highly innervated, with the presence of both mechanoreceptors and nociceptors [8].

- The labrum is absent in the area of the inferior acetabular notch, where the transverse acetabular ligament serves as the continuation of the labrum [8].
- The fibrocartilaginous labrum deepens the acetabulum, enhancing stability [5].
- Labral functions include load transmission, maintenance of vacuum seal, regulation of synovial fluid hydrodynamics, and joint lubrication [5].

MUSCULAR ANATOMY

- The average range of motion of a normal hip is approximately 120° of flexion, 30° of extension, 45° of abduction, 20° to 30° of adduction, 35° of internal rotation, and 45° of external rotation [16].
- Normal gait function requires hip flexion of 30°, hyperextension of 10°, abduction and adduction of 5°, and internal and external rotation of 5° [16].
- The primary hip flexor muscles are the iliopsoas, rectus femoris, and sartorius muscles [16].
- The gluteus maximus and hamstring muscles are the most important hip joint extensors [16].
- The abductors of the hip are predominantly the gluteus medius and minimus muscles [16].
- The gluteus medius and minimus muscles function together to maintain and abduct the femur during the stance phase of gait [16].
- The external rotators of the hip include the obturator internus and externus, superior and inferior gemelli, quadratus femoris, and piriformis muscles [16].
- The piriformis forms the reference structure for the posterior part of the hip, with structures identified by whether they originate above or below it [16].
- The superior gluteal nerve and artery exit the pelvis above the piriformis muscle, whereas 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 all exit the pelvis below the piriformis [16].
- In 10% of cases, the common peroneal component of the sciatic nerve can pass through the division in the piriformis [16].
- The most consistent internal rotators of the hip joint are the gluteus medius and tensor fascia latae muscles [16].

NEUROVASCULAR ANATOMY

- The medial femoral circumflex artery is the main blood supply to the femoral head, terminating in the posterior aspect of the extracapsular arterial ring [18].
- The lateral femoral circumflex artery gives rise to the anterior aspect of the arterial ring [18].
- The superior and inferior gluteal arteries also contribute branches to the extracapsular arterial ring [18].
- The ascending cervical arteries originate from the extracapsular arterial ring and are divided into four distinct groups: lateral, medial, posterior, and anterior [18].
- The lateral group of ascending branches is the main blood supply to the femoral head [18].

- The lateral epiphyseal artery penetrates the femoral head and is believed to be the dominant blood supply to the femoral head from this system [18].
- Fractures that disrupt the ascending blood flow to the lateral epiphyseal vessel have an increased risk of osteonecrosis [18].
- 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 [18].
- 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 [21].
- From the age of 4 years to adulthood, the posterosuperior and posteroinferior retinacular arteries (from the medial circumflex artery) are the major blood supply [21].
- In adulthood, the major blood supply to the femoral head is from the medial femoral circumflex and lateral epiphyseal arteries [21].
- The common femoral artery arises from the external iliac artery as it passes underneath the inguinal ligament [21].
- The common femoral artery passes anterior and medial to the hip capsule [21].
- The common femoral vessels are the most commonly reported extrapelvic vascular structures that are injured during total hip arthroplasty [21].
- The most common mechanism for injury to the common femoral vessels is errant retractor placement anterior to the acetabulum [21].
- 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 [21].
- Superior gluteal artery injury can occur with the placement of screws in the region of the sciatic notch [21].
- 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 [21].
- The inferior gluteal vessels can be injured by screws in the posterior column that are at least 5 mm past the bony margin [21].

PATHOPHYSIOLOGY OF INSTABILITY AND IMPINGEMENT

- Femoroacetabular impingement (FAI) is recognized as a common cause of hip dysfunction and secondary osteoarthritis [3].
- In FAI, distinct structural abnormalities produce repetitive impingement between the acetabulum and the femoral head-neck junction [3].
- Three types of FAI are recognized: cam, pincer, and combined cam/pincer [3].
- Cam impingement involves femoral-based abnormalities such as an aspherical femoral head and reduced head-neck offset, resulting in repetitive abutment of the acetabular rim and femoral head-neck junction [3].

- Pincer impingement involves acetabular-based disorders such as acetabular retroversion, global overcoverage, and acetabular protrusio, creating abnormal abutment of the acetabular rim and femoral head-neck junction [3].
- Impingement abnormalities can cause labral tears, degeneration, or ossification [3].
- Impingement abnormalities can cause acetabular cartilage delamination [3].
- Impingement abnormalities can cause secondary osteoarthritis [3].
- DDH is a gradually progressive disorder associated with distinct anatomic changes, many of which are initially reversible [13].
- In unstable hips at birth, the posterosuperior rim of the acetabulum loses its sharp margin and becomes flattened and thickened in the area over which the femoral head slides [13].
- A ridge of thickened articular cartilage called the neolimbus arises along the posterosuperior acetabular wall as the head rides in and out of the socket [13].
- In hips that remain dislocated, the fatty tissue known as the pulvinar thickens in the depths of the acetabulum and may impede reduction [13].
- The ligamentum teres elongates and thickens in dislocated hips, taking up valuable space within the acetabulum [13].
- The transverse acetabular ligament is often hypertrophic in dislocated hips and may impede reduction [13].
- The inferior capsule of the hip assumes an hourglass shape in dislocated hips, eventually presenting an opening smaller in diameter than the femoral head [13].
- The iliopsoas tendon is pulled tight across the capsular isthmus, contributing to narrowing and acting as a barrier to closed reduction [13].
- The capsule narrows through a “Chinese finger-trap” mechanism in dislocated hips [13].
- When attempting to reduce a hip against the narrowed capsule, the femoral head abuts the cartilaginous acetabular lip and tends to push this rim into the acetabulum [13].
- The blocking structure encountered in patients with DDH is not only the labrum but also a significant portion of the cartilaginous acetabulum itself [13].
- The vital cartilaginous acetabular anlage is essential for the normal growth and development of the acetabulum and should not be excised [13].
- Excessive pressure on the cartilaginous upper femur can cause a loss of vascular perfusion, resulting in the necrosis of chondrocytes [11].
- Muscle imbalance, such as excessive adductor pull or inadequate abductor muscle function, results in a valgus deformity of the upper femur [11].
- The labrum contributes significantly to the development of acetabular depth, making excision of the labrum during the treatment of DDH ill advised [11].
- The majority of acetabular shape development is determined by approximately 8 years of age [11].
- Late acetabular development during adolescence is enhanced by the growth of secondary acetabular centers such as the os acetabulum [11].

Investigations

CLINICAL EXAMINATION

- A thorough history is essential for differentiating between common causes of hip pain [1].
- Clinical examination tests and imaging findings should be used to confirm a suspected clinical diagnosis [1].
- Patients with symptomatic femoroacetabular impingement (FAI) frequently present with activity-related groin pain exacerbated by hip flexion activities [3].
- Patients with FAI exhibit restricted hip internal rotation in 90° of flexion [3].
- The impingement test (flexion, adduction, internal rotation) elicits pain in patients with FAI, but the test is not specific for FAI [3].

RADIOGRAPHY

- Conventional radiographs remain critical in the initial imaging evaluation of the hip [2].
- 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 [2].
- Acetabular morphology is assessed on AP pelvis radiographs to evaluate acetabular overcoverage and undercoverage [2].
- The femoral head-neck junction morphology is often assessed using the alpha angle [2].
- The Dunn 45° view radiograph may be more accurate for determining the alpha angle measurement than CT or MRI [2].
- The “crossover” sign on AP pelvis radiographs indicates acetabular retroversion related to lateralization of the anterior acetabular wall relative to the posterior acetabular wall [2].
- Pelvic tilt or rotation may lead to false-positive and false-negative “crossover” signs on AP pelvis radiographs [2].
- For neutral pelvic tilt on an AP pelvis radiograph, the sacrococcygeal joint should be between 3 and 5 cm above the superior border of the symphysis pubis [2].
- 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 [2].
- 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 [2].
- The lateral center-edge angle (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 [2].
- Lateral center-edge angles of 20°–40° are considered normal, while angles from 20° to 25° are considered borderline [2].

- Radiographs can serially assess hardware positioning and evaluate symptomatic hardware related to total hip arthroplasty [2].
- Plain radiographs are the first imaging studies obtained for patients presenting with hip pain [25].
- 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 [25].
- The Dunn view and frog leg view are appropriate to measure the α angle to determine the presence of impingement [25].

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 [25].
- Measurements of femoral head coverage and acetabular and femoral impingement can be performed reliably using CT images [25].
- Low-dose CT with three-dimensional reformats is particularly useful in surgical planning of complex or borderline deformities [3].
- CT is performed after reduction of hip dislocations to evaluate for associated acetabular and/or femoral head fracture and loose bodies in the joint [22].
- CT is used to evaluate the location and size of femoral head fracture fragments and rule out associated acetabular fracture [22].
- CT can be used to further investigate suspected occult fractures, define fracture morphology, and assist in preoperative planning [2].

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 [25].
- Conventional MRI is effective at identifying osteochondral injuries, musculotendinous pathologies, and inflammation [25].
- Magnetic resonance arthrography (MRA) is more appropriate than conventional MRI to determine injuries to the labrochondral structures and the ligamentum teres [25].
- MRA is used to identify the presence of loose bodies and synovial chondromatosis [25].
- 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 [25].
- 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 [25].
- 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 [25].
- MRI provides information regarding the integrity of the acetabular labrum and articular cartilage [3].
- MRI can assess the anatomy of the proximal femur as well as the version of the acetabulum and femur [3].

- The sensitivity of MRI to acetabular rim chondral lesions is limited [3].
- MRI is helpful in assessing complications of conventional and resurfacing hip arthroplasties, particularly those with metal-on-metal bearing systems [28].
- Major MRI findings that help predict histologic ALVAL scores include synovial thickening, synovitis, synovial volume, abductor disruption, and soft-tissue edema [28].
- Noncontrast MRI at 3T is generally adequate for diagnosing intra-articular pathology [28].
- If 3T imaging is unavailable, MRA can be considered at 1.5T for increased diagnostic accuracy [28].
- MRI is helpful in identifying femoral neck stress fracture in athletes and predicting patients that may require surgical intervention [28].
- MRI is more sensitive than bone scan for ruling out occult nondisplaced stress fractures if the injury is less than 24 hours old [22].

ULTRASONOGRAPHY

- Ultrasonography provides real-time dynamic assessment of the hip and is useful in diagnosing soft-tissue abnormalities about the hip joint [10].
- Ultrasonography is particularly useful in providing real-time guidance during diagnostic and therapeutic procedures [10].
- Ultrasonography can be an effective modality to identify musculotendinous disruptions, effusions associated with intra-articular pathology, or inflammatory conditions, such as bursitis [25].
- Ultrasonography is increasingly used for targeted injections into muscles, tendons, or intra-articularly around the hip [25].
- The utility of ultrasonography in evaluating the adult hip is limited [25].
- Ultrasonography cannot image inside bone because bone cortex reflects almost all sound waves [29].
- Internal joint structures are not well visualized by ultrasonography unless they are in a superficial location [29].
- Ultrasonography provides dynamic assessment of structures such as tendon and nerve subluxation [29].

References

[1] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Anatomy and Biomechanics, Evaluation, Clinical Examination, and Imaging of the Hip > Summary.

[2] Orthopaedic Knowledge Update Sports Medicine 6. Imaging of the Hip > Radiography.

[3] Aaos Comprehensive Orthopaedic Review 3. Nonarthroplasty Surgical Treatment of the Hip > I. Femoroacetabular Impingement.

[5] Miller S Review Of Orthopaedics. Genetics of musculoskeletal conditions and abnormalities are summarized in Table 1.27 > 2. Arthrology > Hip (Fig. 2.49).

[8] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Anatomy and Biomechanics, Evaluation, Clinical Examination, and Imaging of the Hip > Osseous and Ligamentous Anatomy.

[9] Aaos Comprehensive Orthopaedic Review 3. Surgical Anatomy of the Hip > IV. Hip Capsule and Ligaments.

[10] Orthopaedic Knowledge Update Sports Medicine 6. Imaging of the Hip > Introduction.

[11] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Associated Conditions > Pathophysiology.

[13] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Hip Development With Developmental Dysplasia of the Hip.

[14] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > LOWER EXTREMITY.

[16] Aaos Comprehensive Orthopaedic Review 3. Surgical Anatomy of the Hip > V. Hip Joint Muscles.

[18] Aaos Comprehensive Orthopaedic Review 3. Fractures of the Hip > I. General Considerations.

[21] Aaos Comprehensive Orthopaedic Review 3. Surgical Anatomy of the Hip > VI. Neurovascular Structures Surrounding the Hip.

[22] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > YOUNG ADULT PROXIMAL FEMUR INJURIES.

[25] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Anatomy and Biomechanics, Evaluation, Clinical Examination, and Imaging of the Hip > Imaging.

[28] Orthopaedic Knowledge Update Sports Medicine 6. Imaging of the Hip > Summary.

[29] Aaos Comprehensive Orthopaedic Review 3. Musculoskeletal Imaging* > IV. Ultrasonography.

CQ HAND + UPPER LIMB
Dr Kieran Hirpara — Specialist Orthopaedic Surgeon
Suite 2, Level 1, Mater Private Hospital Rockhampton, 31 Ward Street, The Range, QLD 4700
Phone 07 4863 6556 · office@cqupperlimb.com.au · cqupperlimb.com.au