Anatomy of the Lower Extremity: Hip Joint

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Every year, a significant number of endoprostheses are implanted in the hip joint region which demonstrates the extreme vulnerability of the capsular ligament complex. Therefore, physicians must know the anatomy, functional anatomy, and pathophysiology of the hip joint. Orthopedists and surgeons often hear patients complaining about pain in the hip joint. Without sufficient knowledge, it is impossible to help these patients competently.

Anatomy of the Hip Joint

The hip joint is a cotyloid joint or ball-and-socket joint. It consists of the acetabulum (hip socket) and the femoral head (ball) of the femur. It has 3 degrees of movement: flexion/extension, abduction/adduction, and internal/external rotation.

Acetabulum

The acetabulum consists of 3 parts: the ilium, the pubis, and the ischium. They meet in the Y-shaped growth plate. This growth plate is completely closed between the ages of 14 and 16 years and forms the proximal articular surface of the hip joint. The articular surface is concave and does not completely surround the femoral head.
Acetabular labrum

The acetabular labrum is a triangular-shaped structure consisting of dense connective tissue and fibrocartilage. It forms a ring around the acetabulum and is fixed at the acetabular limbus, the osseous ridge that surrounds the acetabulum proximally. It serves as an enlargement of the articular socket surface.

Acetabular incision

The acetabular incision is an indentation at the socket edge and is devoid of labrum. It is located at the suture area between the pubis and ischium, and is covered by the transverse acetabular ligament.

Femur

Femoral parts are distinguished based on the parts that are directly part of the joint and those that are close to it:

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<th>Femoral parts directly part of the joint</th>
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<td>• Trochanteric fossa</td>
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<td>• Linea aspera</td>
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Femoral Head

The spherical, convex head of the femur is the articulating surface of the femur and forms the distal part of the hip joint.
The fovea of the femoral head is a depression on the femoral head in the 4th or dorsocaudal quadrant and serves as the insertion area of the ligament of the femoral head. The strong cartilage layer of the femoral head lies cranial to the fovea and has a thickness of up to 4 mm.

Femoral neck

The femoral neck connects the femoral head with the femoral shaft and transitions into the intertrochanteric line (ventral) and the intertrochanteric crest (dorsal).

Greater trochanter

The greater trochanter is an apophysis and lies lateral to the trochanteric fossa. It serves as the insertion point of the gluteus medius and minimus muscles, the piriformis muscle, the internal obturator muscle, and the gemellus muscles.

Lesser trochanter

The ‘little brother of the greater trochanter’ is located medial to the intertrochanteric line and among other functions, serves as the insertion point for the iliopsoas muscle.

Intertrochanteric line

The intertrochanteric line lies ventrally between the greater and lesser trochanters and serves as the insertion of the iliofemoral ligament and as the origin of the vastus medialis muscle.
Intertrochanteric crest

The intertrochanteric crest is an osseous ridge that connects the greater and lesser trochanters. Among other functions, it serves as the insertion of the hip joint capsule.

Trochanteric fossa

The trochanteric fossa is a depression which is located dorsomedial to the greater trochanter. It serves as the insertion of the external and internal obturator muscles and the superior and inferior gemellus muscles.

Linea aspera

As with the intertrochanteric crest, the linea aspera is also an osseous ridge located on the dorsal surface of the femoral shaft. It is the insertion point of the gluteus maximus muscle, the adductor longus muscle, the adductor brevis muscle, the adductor magnus muscle, and the pectineus muscle. It is also the origin of the vastus medialis and lateralis muscles, and the short head of the biceps femoris muscle.

Gluteal tuberosity

The gluteal tuberosity lies cranial to the linea aspera and serves as the insertion point of the gluteus maximus muscle.

Pectineal line

It lies ventral to the linea aspera towards the greater trochanter and is the insertion point of the pectineus muscle.

Here you can read more about the muscles of the hip and thigh.

Functional Anatomy: Angles of the Femur

CCD angle
The femoral neck angle is the angle between the femoral neck and shaft of the femur. It is normally between 120 and 135 degrees. When it is over 135 degrees, it is called coxa valga. When it is under 120 degrees, it is called coxa vara.

**Angle of anteversion**

The femoral head is anterior to the plane of the femur, creating an angle between the frontal plane and the femoral neck. This angle is called the angle of anteversion. Normal anteversion is between 5 and 15 degrees. When it is over 15 degrees, the femur is said to be anteverted. When it is below 5 degrees, the femur is retroverted. Patients with increased anteversion may walk with an intoeing (pigeon-toed) gait.

**Articular Capsule of the Hip Joint**

The articular capsule of the hip joint is one of the strongest capsules in the body. It consists of 2 layers: the fibrous membrane and the synovial membrane.

**Fibrous membrane**

The fibrous membrane is firm and thick with fibril bundles that run in the longitudinal and diagonal direction. They insert at the edge of the acetabulum, the transverse ligament of the acetabulum, and the intertrochanteric line of the ventral femur. The dorsal insertion point is the femoral neck medial to the intertrochanteric crest. The membrane is studded with mechanoreceptors, which lead proprioceptive afferents to the central nervous system.

**Synovial membrane**

Synovial membrane inserts at the outer edge of the base of the acetabular labrum, at the cartilage-bone border, and at the intertrochanteric crest. Since the pointy edge of the labrum does not articulate with the membrane, the recessus perillimicus is formed between the capsule and the labrum.
The membranes serve as an axis for vessels and supply the femoral neck with blood on their way to the hip head. Also, the synovial membrane forms a tube around the ligament of the femoral head that keeps the joint away from the acetabular incision and the acetabular fossa.

Ligaments and Bursae of the Hip Joint

The ligaments of the hip joint guide and limit the movements and ensure the complete stabilization of the hip joint. In anatomy, there is a distinction between intra-articular and extra-articular ligaments:

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<tr>
<th>Intra-articular ligaments</th>
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<td>• Ligament of the femoral head</td>
<td>• Iliofemoral ligament</td>
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<td>• Pubofemoral ligament</td>
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<td>tabulum</td>
<td>• Ischiofemoral ligament</td>
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<td>• Zona orbicularis</td>
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Ligament of the femoral head

The ligament of the femoral head lies within the joint and is covered by a synovial membrane. The bundle of fibers runs from the anterior and posterior horn of the lunate surface and the superior edge of the transverse ligament of the acetabulum to the fossa. It is subject to tension when the flexion, adduction, and external rotation movements are combined. This ligament is often referred to as teres femoris ligament in other medical textbooks and journals.

Transverse ligament of the acetabulum

This ligament supports the head of the femur inferiorly and connects the ends of the labrum (outer layer) and the 2 horns of the lunate surface (inner layer).

Iliofemoral ligament

This ligament is V-shaped and is divided into a lateral part and a medial part. The common insertion point is the intertrochanteric line, and the tip of the V is fused with the rectus femoris muscle. The lateral part, also called Bertini’s ligament is the strongest ligament in the human body since it can resist tensile stress of up to 350 kg. The medial part (lower tract) is very thin compared to the lateral one. The fibers spiral with each other. They relax in case of external rotation.

Pubofemoral ligament

This ligament runs from the iliopsoas groove and the obturator crest to the intertrochanteric line where it connects to the iliobpiral ligament. Additional connections are established with the articular capsule and the zona orbicularis.

Ischiofemoral ligament

The ischiofemoral ligament originates from the dorsocaudal edge of the socket and the cranial edge of the ischial tuberosity, and helically runs in cranial-lateral direction. It inserts at the inner surface of the greater trochanter and the zona orbicularis. The ligament fuses with the lateral part of the iliobpiral ligament.
Zona orbicularis

The zona orbicularis ligament is a loop which contains fibers of all extra-articular ligaments. It is connected to the articular capsule.

Iliopectineal bursa

The iliopectineal bursa protects the thin articular capsule and is located between the iliofemoral and the pubofemoral ligaments. It is located under the tendon of the powerful iliopsoas muscle.

Innervation of the Hip Joint

Altogether, 5 nerves supply the hip joint and its structures. They are the femoral nerve, the obturator nerve, the ischiadic nerve, the superior gluteal nerve, and the quadratus femoris nerve.

Femoral nerve

This nerve gives off a branch to the anterior articular area. This branch runs distally of the lateral circumflex femoral artery.

Obturator nerve

The obturator nerve sends fibers to both the hip and the knee joints. The fibers originate from the segments L3-L4 and run to the caudal hip joint.

Ischial nerve

The ramus acetabularis coxae of the ischiadic nerve branches off shortly before the infrapiriform foramen and supplies the dorsal hip joint.

Superior gluteal nerve

This nerve supplies the superior lateral part of the hip joint.
Quadratus femoris nerve

The branches of the quadratus femoris nerve innervate the dorsocaudal hip joint.

Clinical Hip Joint

Arthritis

Arthrosis: 1) osteophyte 2) subchondral sclerosis 3) subchondral cyst 4) joint space

Arthritis of the hip joint is caused by the progressive abrasion of the cartilage. Patients suffer from immobilization and pain in the joint. The condition can be treated surgically with total hip arthroplasty (joint replacement).

Pectineal bursitis

Pectineal bursitis is an inflammation of the bursa that may develop from continuous overuse or infections. Patients with pectineal bursitis are likely to experience pain when contracting the iliopsoas muscle.

Instability and dislocation

Image: “Congenital dislocation of the hip joint” by James Heilman, MD - Own work, License: CC BY-SA 3.0

Dislocation of the hip joint mostly occurs in cases of severe trauma. At extreme external rotation, the femoral head can be pressed ventrally and levered out of the socket. Inappropriate patient movement after total hip replacement surgeries can result in postoperative dislocation.

Fracture of the femoral neck and necrosis

If the femoral neck breaks due to falling trauma or osteoporosis, the blood supply to the femoral head can be stopped if the fracture line runs within the capsule. If such a lesion is not (surgically) treated as soon as possible, post-traumatic necrosis can occur due to the lack of blood supply to the bone.

Necrosis can also occur due to old age if the ligament of the femoral head is not sufficiently supplied with blood and degenerates.
Hip dysplasia

Hip dysplasia is an innate or acquired malformation of the hip socket. If the diagnosis is delayed, it results in irreversible damages in the articulating osseous structures, which leads to pain and limp. Extreme dysplasia makes the hip joint chronically unstable and vulnerable to dislocation. Treatment of dysplasia depends on the degree of the disease.

References


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