BONE

BIOMECHANICS OF THE PELVIS AND LOWER LIMBS

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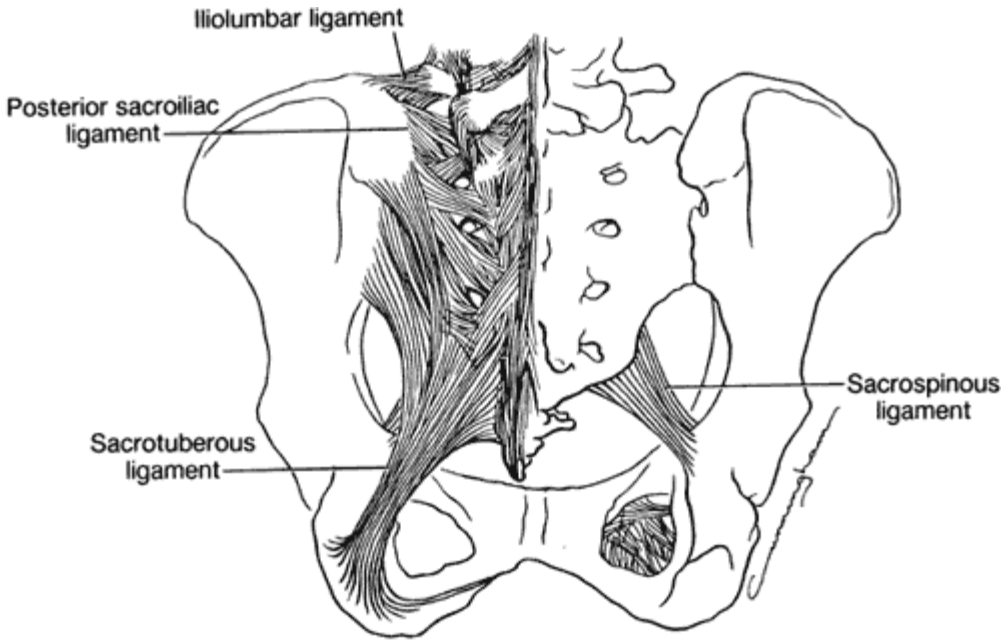
Pelvis



Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

The major posterior stabilizing structures of the pelvic ring that are the posterior tension band of the pelvis include the iliolumbar ligament, the posterior sacroiliac ligaments, the sacrospinous ligaments, and the sacrotuberous ligaments.

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Fig. 273-1 Accessed 05/05/2010

Pelvis

- Consists of the two innominate bones (ilium, ischium, and pubis); the sacrum; and the coccyx.
- The two innominate bones and sacrum form a ring structure, which is the basis of pelvic stability.
- This stability is dependent on the strong posterior sacroiliac, sacro-tuberous, and sacro-spinous ligaments.
- The iliopectineal, or arcuate line, divides the pelvis into the upper, or false, pelvis, which is part of the abdomen, and the lower, true pelvis.
- This line constitutes the major portion of the femoro-sacral arch.

Pelvis

- The femoro-sacral arch with the subsidiary tie arch (bodies of pubic bones and superior rami), supports the body in the erect position.
- In the sitting position, the weight-bearing forces are transmitted by the ischio-sacral arch augmented by its tie arch, the pubic bones, inferior pubic rami, and ischial rami.

Pelvis

- Incorporated in the pelvic structure are five joints that allow some movement in the bony ring.
- The lumbosacral, sacro-iliac, and sacro-coccygeal joints, and the symphysis pubis allow little movement.
- The acetabulum is a ball-and-socket joint that is divided into three portions:
- The iliac portion, or superior dome, is the chief weight-bearing surface
- The thin inner wall consists of the pubis
- The posterior acetabulum is derived from the thick ischium.

Pelvis

- The anterior superior iliac spine and pubic tubercle lie in the same vertical plane.
- The tie arches fracture first, especially at the symphysis pubis, pubic rami, and just lateral to the sacroiliac joints.
- Any single break in the ring will yield a stable injury without significant risk of displacement.
- An injury with two breaks in the ring is unstable with the risk of displacement.

Muscles of the pelvis

- The obturator internis lies on the pelvic surface of the ilium and ischium (and runs to the sacro-tuberous ligament below and the posterior border of the body of the ischium) and passes through the lesser sciatic foramen to insert on the greater trochanter of the femur.
- The pifiromis lies on the pelvic surface of S2 to S4, attaches to the superior margin of the greater sciatic notch and sacro-tuberous ligament, and passes through the greater sciatic foramen to insert on the greater trochanter of the femur.

Muscles of the pelvis

- The coccygeus runs from the ischial spine and overlies the sacro-spinal ligament. It inserts on the inferior end of the sacrum.
- With the levator ani it forms the pelvic diaphragm that separates the pelvis from the perineum.
- The pubococcygeus arises from the pubis. It is the major part of the levator ani and supports the pelvic organs. (The iliococcygeus also forms part of the levator ani.)

Sacral plexus

- The sacral plexus supplies the lower limbs. Ventral rami of L4-S3 roots.
- The anterior division supplies the tibial nerve (L4-S3), and the nerves to the obturator internus (L4) and quadratus femoris (L5) muscles.
- The posterior division supplies the common fibular (S1-S2), superior (L4-S1) and inferior gluteal nerves (L5-S2).
- The nerves lie medial to piriformis in the pelivs. The superior gluteal nerve passes superior to the piriformis as it leaves the pelvis. The other nerves pass inferior to the piriformis.

Pelvis

- The anterior division of the internal iliac artery provides the umbilical (and superior vesical), obturator, inferior vesical, middle rectal, internal pudendal and superficial gluteal arteries.
- In the female, the uterine and vaginal arteries also arise from the internal iliac.
- The posterior division provides the superior gluteal, lateral sacral, and iliolumbar arteries.

Pelvis

- The oburator artery and vein pass over the Psoas fascia and exit through the obturator foramen.
- The pudendal artery and nerve exit the greater foramen, re-enter the lesser foramen, and proceed to the urogenital diaphragm.
- The inferior rectal nerve, perineal nerve, and dorsal nerve of the penis branch from the pudendal nerve. The pudendal nerve innervates all muscles of the perineum.
- The urogenital diaphragm is pierced by the urethra.
- The urogenital diaphragm is composed of a superior layer of fascia, the deep transverse perineus and sphincter urethrae muscles, and the perineal membrane. It contains Cowper’s glands.

Pelvis

- Lateral compression fractures account for approximately half the injuries.
- Type I The lateral force is applied posteriorly.
- This causes a crush effect on the sacroiliac joint.
- Type II The force is applied anteriorly.
- The anterior pubic ramus fractures.
- Rotation of the pelvis around the anterior sacral margin may occur, causing rupture of the posterior sacroiliac ligaments.
- A crush fracture of the sacrum may also be seen.

Pelvis

- Alternatively, a fracture of the iliac wing may occur, which dissipates the rotational forces and thus leaves the posterior ligaments intact.
- Type III The force is applied laterally, causing internal rotation of the anterior hemipelvis.
- Continuing through to the contralateral hemipelvis, the force causes it to rotate externally.
- The result is a pattern of lateral compression on the ipsilateral side, with apparent anteroposterior compression on the contralateral side.

Pelvis

- This results in rupture of the posterior sacroiliac ligaments on the ipsilateral side, and the sacrospinous-sacrotuberous complex and anterior ligaments on the contralateral side.
- Pubic ramus fractures are to be expected.
- Alternatively, there may be an iliac wing fracture sparing the posterior sacroiliac joint on the ipsilateral side.

Pelvis

- Mortality rates are 13% following such injury.
- Approximately 4L of blood may be lost in a pelvic fracture.
- In an antero-posterior compression fracture, The force is delivered in an antero-posterior direction, opening the pelvis.
- This gives rise to mild splaying of the symphysis, due to rupture of the anterior sacroiliac ligaments.

Pelvis

- In an injury due to vertical shear, the injury force vector is delivered in a vertical plane.
- Fractures of the pubic rami are usually seen anteriorly, while fractures of the sacrum, sacroiliac joint, or iliac wing are usually seen posteriorly.
- The fractures are vertical and are associated with vertical displacement of fragments.
- Ligamentous injury to the posterior and anterior sacroiliac ligaments may be seen, as well to sacrospinous-sacrotuberous, and (possibly) symphysis ligaments may be seen.

Pelvis

- Mortality rates approach 25 percent for severe antero-posterior compression fractures and vertical shear injuries.
- Avulsion fractures
- The fracture force is either transmitted laterally through the hip or through the femur (e.g., knee striking dashboard).
- Acetabular fractures are seen commonly with other injuries including femur, hip fractures and dislocations, and knee injuries.

Pelvis

- Vaginal laceration is the most common injury seen with anterior pelvic fractures in women.
- Gynecologic injuries are uncommon.
- In males, urethral tear is common (in the superficial space).
- Urine collects in the penis and scrotum, and passes up the abdominal wall. It does not spread to thigh or anal triangle.

Male pelvis

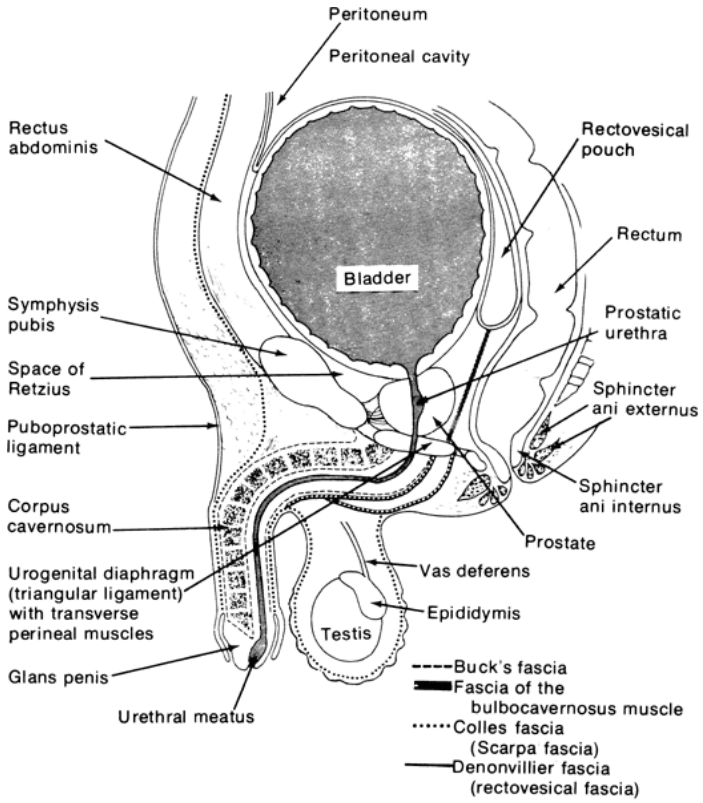

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Fig. 273-2 Accessed 05/05/2010

Gait cycle

Phase	Mechanics	Active muscle groups
Initial contact (heel strike)	**Lower forefoot to ground** **Deceleration (reverse forward swing)** **Preserve longitudinal arch of foot**	**Ankle dorsiflexors (eccentric contraction)** **Hip extensors** **Flexor digitorum brevis and tibialis anterior**
Loading response	**Accept weight** **Decelerate mass (dorsiflexion)** **Stabilize pelvis** **Preserve longitudinal arch of foot**	**Knee extensors** **Ankle plantar flexors** **Hip abductors** **Flexor digitorum brevis, long flexors of digits, and tibialis posterior**

Gait cycle

Midstance	**Stabilize knee** **Preserve momentum (conserve dorsiflexion)** **Stabilize pelvis** **Preserve longitudinal arch of foot**	**Knee extensors** **Ankle plantar flexors and gastrocnemius (eccentric contraction)** **Hip abductors** **Flexor digitorum brevis, long flexors of digits, and tibialis posterior**
Terminal stance (heel off)	**Accelerate mass** **Stabilize pelvis** **Preserve arches of foot and fix forefoot**	**Ankle plantar flexors (concentric contraction)** **Hip abductors** **Adductor hallucis, long flexors of digits, tibialis posterior**

Gait cycle

Preswing (toe off)	**Accelerate mass** **Preserve arches of foot and fix forefoot**	**Long flexors of digits** **Adductor hallucis, long flexors of digits, tibialis posterior**
Initial swing	**Decelerate thigh (prepare for swing)**	**Hip flexors (eccentric contraction)**
Midswing	**Accelerate thigh, vary cadence** **Clear foot**	**Hip flexors (concentric contraction)** **Ankle dorsiflexors**
	Clear foot	**Ankle dorsiflexors**
Terminal swing	**Decelerate thigh** **Decelerate leg** **Position foot** **Extend knee to place foot (control stride) and prepare for contact**	**Hip extensors (eccentric contraction)** **Knee flexors (eccentric contraction)** **Ankle dorsiflexors** **Knee extensors**

Hip flexors

- In the standing position, the psoas major, acting inferiorly, and with the iliacus, flexes the thigh.
- The iliacus stabilizes the hip joint. Attach at lesser trochanter.
- In the sitting position, the psoas major, acting inferiorly, and with the iliacus, flexes the trunk.
- The iliacus stabilizes the hip joint.
- The psoas major, acting superiorly, flexes the vertebral column laterally.
- The psoas major stabilizes the trunk.
- The quadratus laborum extends and laterally flexes the vertebral column; it fixes the 12^{th} rib in inspiration.

Psoas Abscess

- It may present as back pain or groin pain mimicking septic hip.
- Sub acute onset.
- Usually seen in patients having infective spondylitis, infections of sacroiliac joint, renal infections and those who have diabetes mellitus.
- Tuberculosis is the classic underlying illness.
- Usually presents with flexion of the hip and lumbar lordosis.
- Distal extension of psoas may generate mass in inguinal region.

Psoas Abscess

- The iliopectineal bursa that separates the tendon from hip joint communicates with the capsule of hip in 15% of population and may serve as a means of infection spread.

Abductors and rotators of the thigh

- The gluteus maximus extends the thigh (particularly from a flexed position) and assists in lateral rotation.
- It steadies the thigh and (with the hamstrings) aids in arising from a sitting position.
- Attaches to the greater trochanter.
- Innervated by the inferior gluteal nerve.

Abductors and rotators of the thigh

- The gluteus medius and minimus with the tensor of fascia lata adduct and medially rotate the thigh.
- All are innervated by the superior gluteal nerve.
- Their major function is to keep the pelvis level when ipsilateral limb is weight bearing as well as when advancing unsupported (opposite) side during its swing phase.

Extensors of the thigh
Flexors of the leg

- The semitendinosus and semimembranosus muscles extend the thigh. ("hamstrings")
- They flex the leg and rotate it medially when the knee is flexed.
- When the thigh and leg are flexed, these muscles extend the trunk.
- Arise from ischial tuberosity and insert on the tibia.
- The biceps femoris flexes the leg and rotates it laterally when the knee is flexed.
- When starting to walk, it extends the thigh. It arises from the ischial tuberosity but inserts on the fibula. It is innervated by the common fibular part of the sciatic nerve.

Flexors of the thigh
Extensors of the leg

- The rectus femoris steadies the hip joint and helps the iliopsoas flex the thigh. Via the common tendon with the vasti (lateralis, medialis, intermedius), the four muscles extend the leg at the knee joint. Quadriceps femoris.
- The vastus lateralis is the first muscle to atrophy with knee joint disease.
- The sartorius arises from the anterior superior iliac spine.
- It flexes both the hip and the knee; rotates the thigh and leg laterally.

Abductors and rotators of the thigh

- The pyriformis, obturator internus, and superior and inferior gemelli (through the common tendon with the obturator internus) laterally rotate the extended thigh and abduct the flexed thigh.
- They also steady the femoral head in the acetabulum.
- Attach at the greater trochanter.
- The quadratus femoris laterally rotates the thigh. It steadies the femoral head in the acetabulum as well.
- Attaches at the greater trochanter.
- The obturator externus also rotates the thigh. Attaches at the greater trochanter.

Adductors of the thigh

- he adductor longus adducts the hip, while the adductor brevis adducts the hip and flexes (minor) the thigh.
- The adductor magnus adducts the hip.
- The adductor portion flexes the thigh while the hamstring portion extends the thigh.
- The tibial part of the sciatic nerve and the obturator nerve innervate the muscle.
- The gracilis adducts the hip, flexes the leg and aids in medial rotation. It inserts on the tibia.
- The obturator externis laterally rotates the thigh. It steadies the head of the femur in the acetabulum.

Compartments

- The quadriceps femoris and the sartorius muscles occupy the anterior compartment of the thigh.
- They are innervated by the femoral nerve (L2-L4).
- The medial compartment contains the adductors longis, brevis, magnus, the gracilis, and the obturator externus.
- They are innervated by the obturator nerve.
- All arise from the pubis and, apart from the gracilis, insert on the femur.
- The hamstrings arise from the ischial tuberosity and are innervated by the tibial part of the sciatic nerve. They occupy the posterior compartment.

Ligaments of the hip

- Iliofemoral ligament extends from anterior inferior iliac spine to inter-troachanteric spine (“Y-ligament of Bigelow”).
- Limits hyperextension.
- Pubofemoral ligament runs from the pubic region of the acetabulum and medial pubic ramus (medial) to the femoral neck near the lesser trochanter.
- Limits hyperextension and abduction.

Ligaments of the hip

- Ischiofemoral ligament extends from the ischial region of the acetabulum (posterior) to the femoral neck near the greater trochanter (lateral).
- Limits hyperextension.
- Ligamentum teres (round ligament) runs from the acetabulum to fovea capitis in femoral head.
- Limits adduction.

Hip fracture

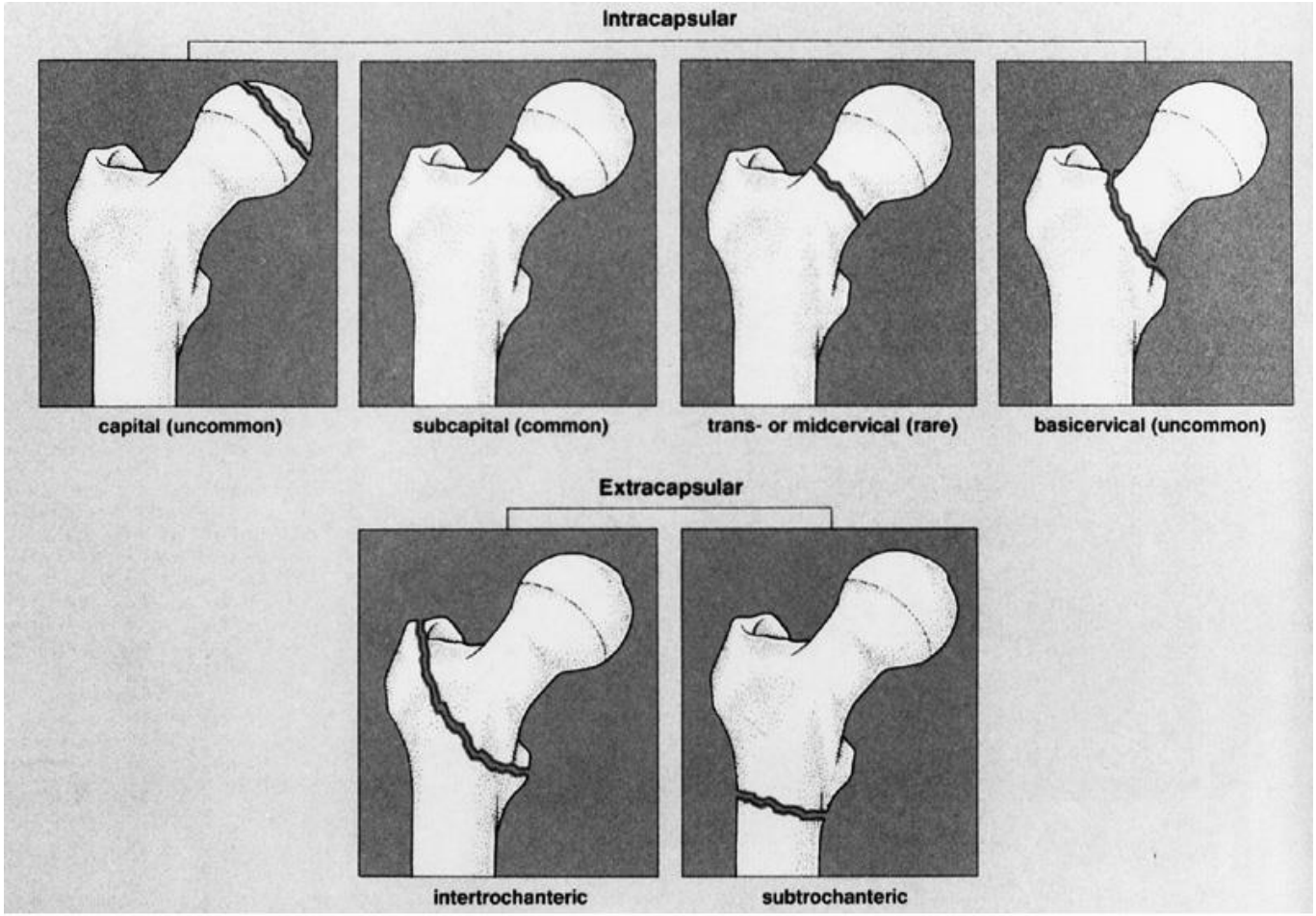

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Fig. 273-18 Accessed 05/05/2010

Hip fracture

Inter-trochanteric angle is 125°. If abnormally decreased, is coxa vara. If abnormally increased, is coxa valga.

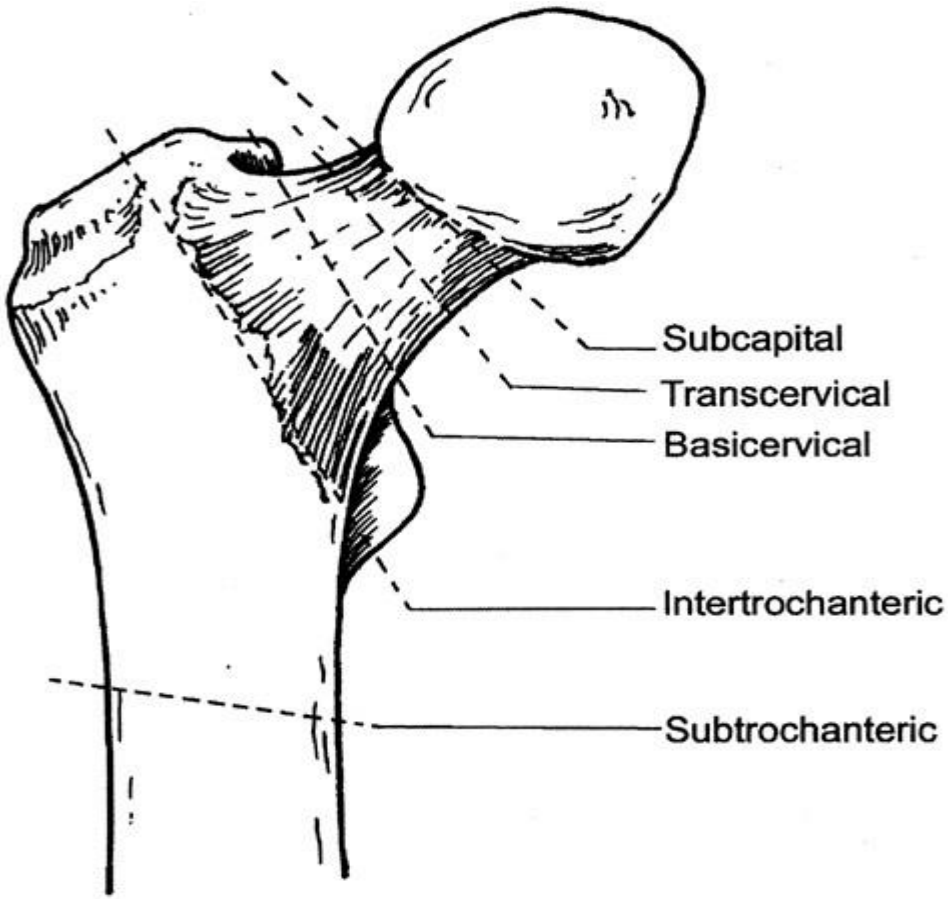

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Fig. 273-18 Accessed 05/05

Hip dislocation

- Anterior dislocations.
- 10% of hip dislocations.
- The femoral head rests anterior to the coronal plane of the acetabulum.
- If the hip is abducted, externally rotated, and flexed at the time of injury, inferior dislocation occurs.
- If the hip is abducted, externally rotated, and extended, superior dislocation occurs.
- The mechanism of injury is forced abduction that causes the femoral head to be levered out through an anterior capsular tear. The affected extremity is in abduction and external rotation.

Hip dislocation

- Posterior dislocations
- 90% of hip dislocations.
- They are caused by force applied to a flexed knee, directed posteriorly.
- Acetabular fractures may result as well.
- Leg is shortened, internally rotated, and adducted
- Hip dislocations require urgent intervention.

Pediatric hip disorders

- Congenital hip dysplasia presents at birth
- Chiefly found in female infants, first-borns, breech delivery
- Legg-Calvé-Perthes disease presents between 4-10 years of age.
- Principally found in short boys with delayed bone age.
- Limp; knee, thigh, groin pain common.
- Avascular necrosis of the femoral head
- Slipped capital femoral epiphysis presents between 9-13 years of age.
- Principally found in overweight boys.
- Limp; knee, thigh, groin pain common.

Femur fracture

- In intra-capsular fractures with displacement, the femoral neck vessels are compromised because of a tear or compression secondary to an intra-capsular hemarthrosis.
- The blood supply to the greater trochanter originates from the medial and lateral femoral circumflex arteries.
- These arteries form an extra-capsular ring that courses inside the capsule at its insertion to the proximal femur

Femur fracture

- The blood supply through the ligamentum teres from the acetabular branch of the obturator artery supplies the femoral head may not be sufficient to nourish the entire femoral head
- Consequently, avascular necrosis inevitably results (15 to 35 percent overall) unless some of the capsular vessels remain intact.
- Mortality following hip fracture ranges from 15 to 35 percent within 1 year of surgery.
- Up to 50 percent will not regain ability to ambulate.

Femur fracture

- Isolated femoral head fractures occur infrequently.
- They are usually associated with dislocations of the hip.
- Femoral head fractures occur in 10 to 16 percent of posterior hip dislocations and in 22 to 77 percent of anterior hip dislocations.
- Femoral neck fractures are commonly seen among older adults, most often because of osteoporosis, and occur more frequently in women than in men.
- Avascular necrosis has an incidence of up to 15 percent in nondisplaced fractures, and rises to near 90 percent with untreated, completely displaced fractures.

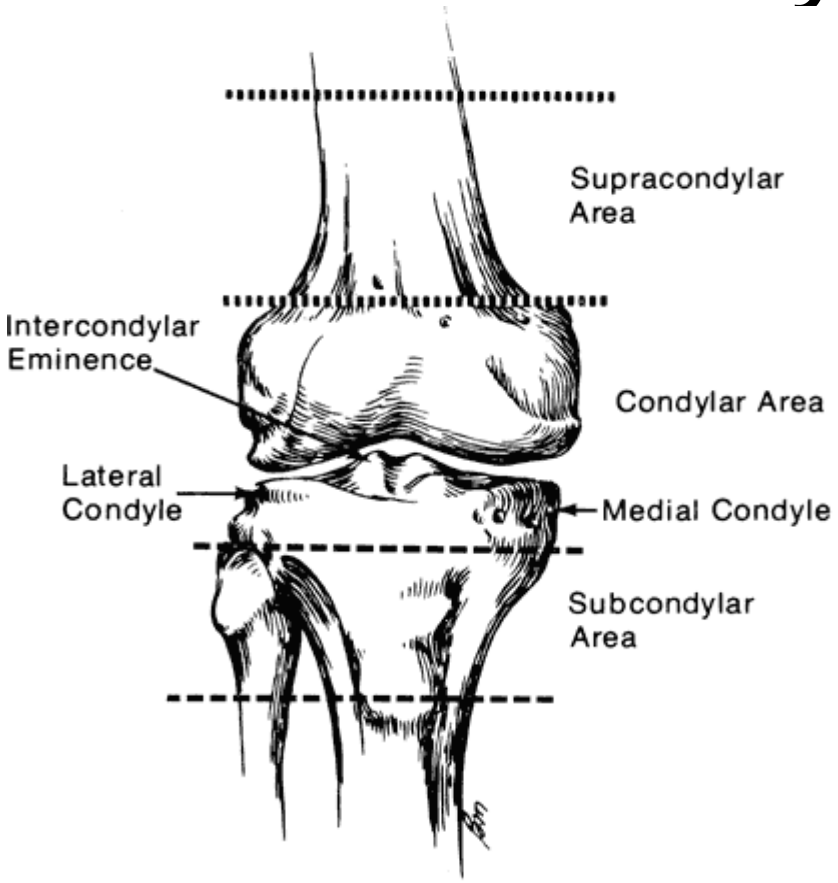
Femur fracture

- Greater trochanteric fractures are usually caused by avulsions at the insertion of the gluteus medius.
- Pain on abduction and extension.
- In adults, direct trauma.
- Lesser trochanteric fractures caused by an avulsion secondary to a forceful contraction of the iliopsoas.
- Commonly seen in children and young gymnasts and dancers.
- Pain on flexion and internal rotation.

Femur fracture

- Inter-trochanteric fractures are extracapsular.
- Usually associated with osteoporosis.
- Pain on weight bearing.
- Leg shortened, externally rotated.
- Sub-trochanteric fractures may occur as a result of a fall in an osteoporotic individual or as a result of direct trauma.
- Associated with significant blood loss.
- Mid-shaft fractures result from direct trauma.

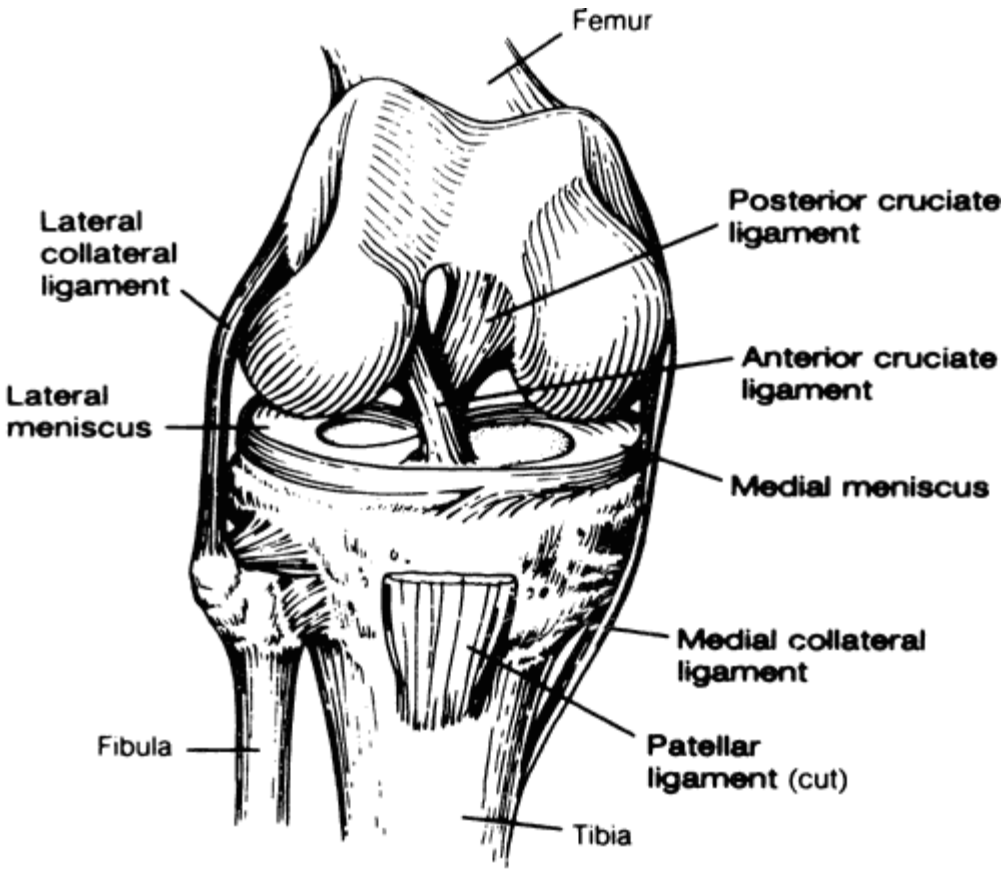
Knee anatomy



Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

(Modified with permission from Hohl M, Larson RL: Fractures and dislocations of the knee, in Rockwood CA Jr, Green DP (eds): *Fractures.* Vol. 2. Philadelphia, JB Lippincott, 1975, pp 1132, 1147.) Fig. 274-2Accessed 05/05

Knee anatomy



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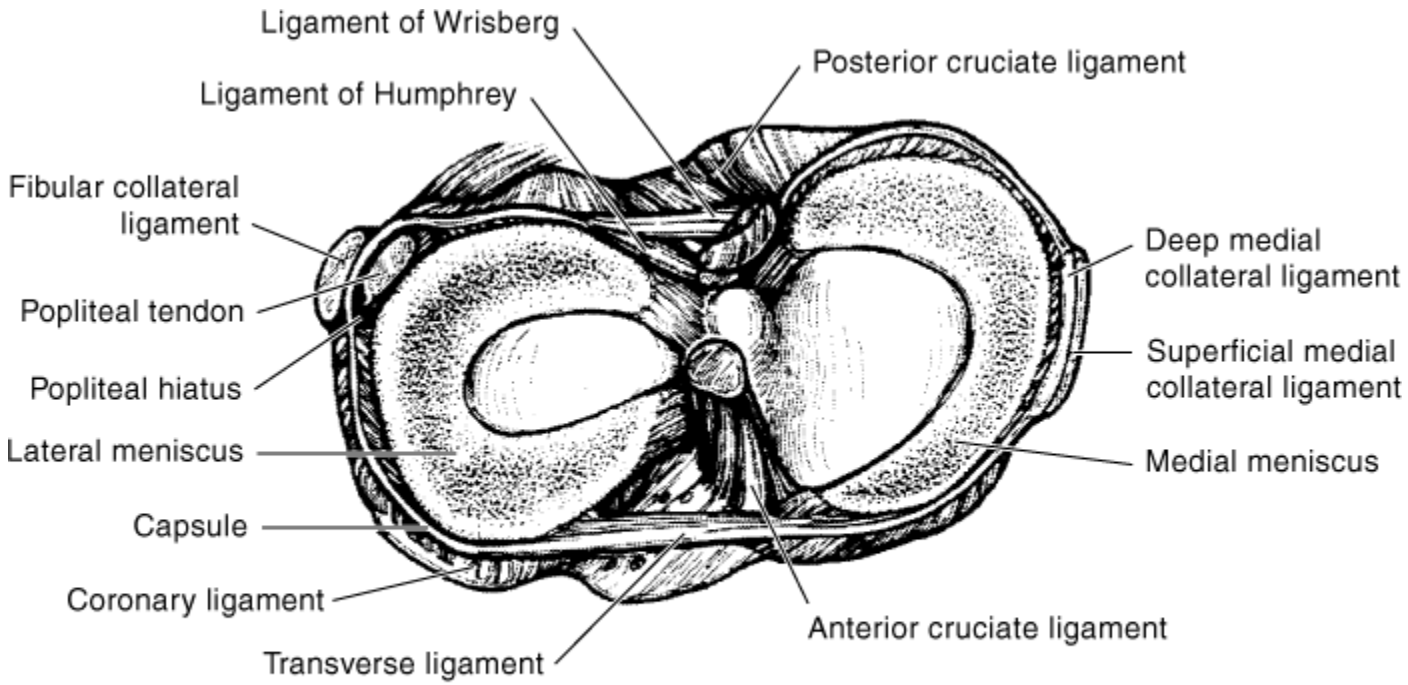
Menisci and ligaments of knee



(Reproduced, with permission, from Scott WN: *Ligament and Extensor Mechanism Injuries of the Knee: Diagnosis and Treatment.* Mosby-Year Book, 1991.)

Fig 4-31

Accessed 09/21/2010

The lateral meniscus is not attached in the region of the popliteus tendon.

Medial capsulo-ligamentous complex

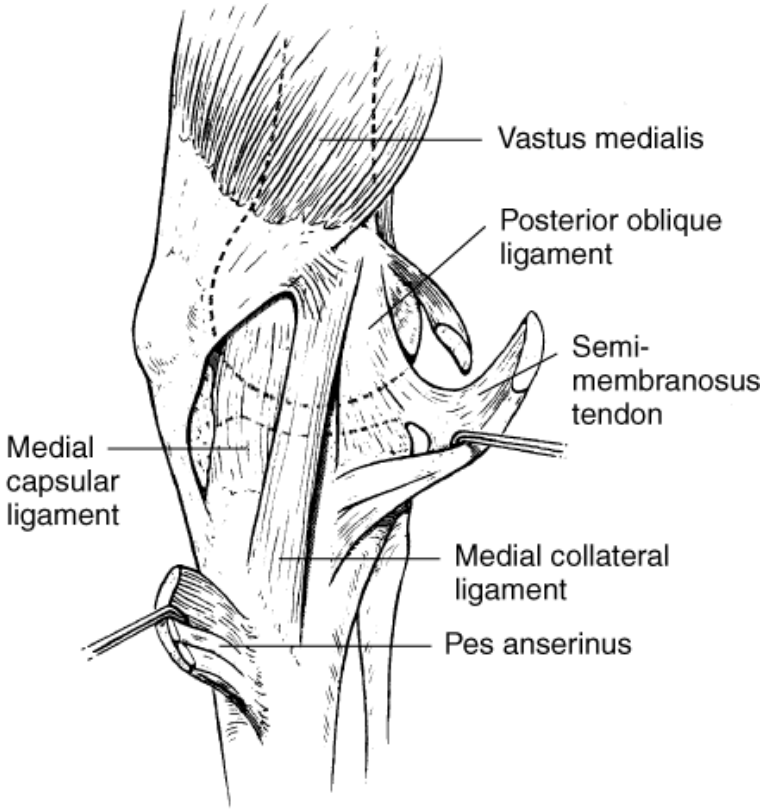


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Fig. 4-4 Accessed 09/21/2010

Lateral supporting structures of the knee

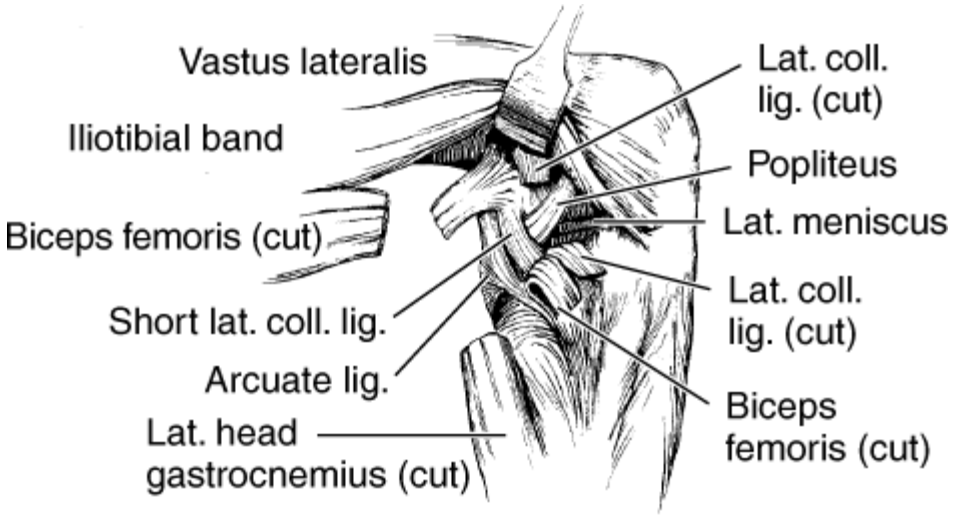

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Fig. 4-45 Accessed 09/21/2010

Rotators of the knee

- Semitendinosus and semimembranosus rotate knee medially when knee flexed
- Popliteus, when non-weight bearing knee is extended.
- If weight bearing knee is is extended, popliteus rotates knee laterally. Collateral ligaments limit movement.
- The biceps femoris rotates the knee laterally when the knee is flexed.
- The tensor of the fascia lata assists in maintaining position.

Extensors and flexors of the knee

- The quadriceps femoris extends the knee
- Efficiency decreased if hip flexed.
- Anterior cruciate ligament and anterior edge of lateral meniscus limit movement.
- The rectus femoris is the only part of the quadriceps femoris to arise from the ilium.
- The hamstrings flex the knee.
- The knee cannot be fully flexed if the hip is extended.

Extensors and flexors of the knee

- The sartorious arises from the anterior superior iliac spine.
- Flexes both hip and knee
- Rotates thigh laterally and leg medially.

Arterial supply to the kee

- The popliteal artery is the continuation of the femoral artery in the popliteal fossa.
- The origin of anterior tibial artery.
- Located medially to the popliteal vein and the sciatic (and, its extension, the) tibial nerve.
- The medial geniculate artery supplies the cruciate ligaments.

Bursae of the knee

- Suprapatellar, popliteal, and medial gastrocnemial bursae communicate within knee.
- Housemaid's Knee:
- Inflammation of prepatellar bursa. The bursa runs behind the quadriceps femoris muscle and the insertion of the tendon on the patella.
- Clergyman's Knee:
- Inflammation of subcutaneous infrapatellar bursa.
- The cruciate ligaments are extra-synovial.

Pittsburgh knee rules

- As sensitive as the Ottawa rules but more specific for injury.
- If the injury is not due to a fall or blunt trauma, x-rays of the knee are not required.
- If the patient is between 12-50 years of age, no x-rays of the knee are required if weight bearing is demonstrated.
- Knees are examined with x-rays in those less than 12 years of age or greater than 50 years of age.

Examination of the knee

- Lachman test is the best maneuver for detecting anterior cruciate ligament tears with a positive likelihood ratio (LR+) of 42, and an LR- of 0.1.
- The anterior drawer sign has only an LR+ of 3.8, and an LR- of 0.3.
- The McMurray test is inadequately sensitive to exclude a meniscal tear, yet may precipitate a full tear.
- Better for determination of a meniscal tear is the medial lateral grind, with an LR+ of 4.8, and an LR- of 0.4.

Patella injuries

- Dislocation of the patella usually occurs from a twisting injury on the extended knee and is more common in women.
- Fractures of the patella occur from a direct blow.
- Transverse fracture is the most common.
- Patella is likely to be displaced.
- Straight leg raising is impaired (extensor mechanism).

Femoral condyle injury

- Direct trauma from a fall with axial loading or a blow to the distal femur is the cause of femoral condylar fracture.
- Neurovascular injury uncommon.
- However, potential for popliteal artery damage.
- May be associated with ipsilateral hip dislocation or quadriceps injury.

Tibial spine injury

- Isolated injuries of the tibial spine are uncommon.
- Usually result in cruciate ligament insufficiency.
- Caused by a force directed against the flexed proximal tibia in an anterior or posterior direction.
- Anterior tibial spine fractures are ten times more common than posterior tibial spine fractures.
- The quadriceps mechanism inserts on the tibial tubercle.
- A sudden force to the flexed knee with the quadriceps muscle contracted may result in a complete or incomplete avulsion of the tibial tubercle.

Tibial plateau injury

- Tibial plateau injury results from a varus or valgus force combined with axial loading.
- Drives the femoral condyles into the articulating surface of the tibia.
- Fall from a height; car bumper injury as common mechanisms.
- Osteochondritis dissecans
- A disorder in which a segment of articular cartilage and subchondral bone become partially or totally separated from the underlying bone.
- Adolescents.

Osteochondritis dissecans

- Osgood-Schlatter disease.
- Dysfunction at the junction of the patellar tendon with the apophysis of the tibial tubercle.
- Sinding-Larsen-Johannson syndrome.
- Pain, tenderness, and swelling at the inferior pole of the patella at the origin of the patellar tendon.
- Jumping a frequent cause.
- Poorly localized pain characterizes patello-femoral syndrome.

Anterior cruciate ligament injury

- Most common ligamentous injury today.
- Deceleration, hyperextension, or marked internal rotation of the tibia on the femur results in an injury to the cruciate.
- There may be an associated medial meniscal tear as well.

Anterior cruciate ligament injury

- This injury is often associated with a "pop" (pathognomonic) and swelling that develops within hours.
- Approximately 75 percent of all hemarthroses are caused by disruption of the anterior cruciate ligament.
- Positive anterior drawer test (tibia pushes forward more than unaffected side).
- An avulsion fracture at the site of attachment of the lateral capsular ligament on the lateral tibial condyle (Segond fracture) as a marker.

Posterior cruciate ligament injury

- Isolated posterior cruciate injuries are not frequent.
- The posterior cruciate ligament provides initial resistance to posterior translation at all angles of flexion of the knee.
- Usually an anterior to posterior force applied to the tibia or lower leg.
- Posterior cruciate injuries are seen in association with other ligamentous injuries when a serious injury has occurred to the knee.
- Positive posterior drawer test (tibia pushes back more than unaffected side).

Other ligament injury

- Medial collateral ligament tears suggested during abduction or valgus stress test.
- Lateral collateral ligament tears suggested during adduction or varus stress test.

Meniscus injury

- Cutting, squatting, or twisting maneuvers may cause injury to the meniscus.
- The medial meniscus is approximately twice as likely as the lateral meniscus to be injured.
- Four-fifths of the tears involve the peripheral posterior aspect of the meniscus.

Knee dislocation

- Knee dislocation results from:
- Disruption of ligaments due to hyperextension
- Direct posterior force applied to the anterior tibia
- Force to the fibula or medial femur
- Force to the tibia or lateral femur
- Rotatory force resulting in anterior, posterior lateral, medial, or rotatory dislocation.
- Meniscal injury also present.
- Associated popliteal artery injury and peroneal nerve injury found principally with posterolateral dislocations.

Vessels of the leg

- The anterior tibial artery leads to the dorsalis pedis artery.
- It gives rise to the arcuate artery that give rise to the dorsal metatarsal and digital arteries.
- Perforating branches anastamose with the plantar system.
- The posterior tibial artery gives rise to the lateral plantar artery that forms the plantar arch.
- It supplies the metatarsals and digital arteries from the plantar side.
- The medial plantar artery is a deep branch of the posterior tibial artery that anastamoses with the plantar system.

Veins and lymphatics of the leg

- The superficial venous circulation passes through the great saphenous vein.
- The vein runs on the medial side of the foot and leg, and enters into the femoral vein through the saphenous hiatus.
- Vena comitantes accompany the deep branches of the arteries and form the deep venous system.
- Lymphatics drain to inguinal nodes.

Fibular fracture

- Most fibular shaft fractures occur in the setting of a tibia fracture.
- Patients are often able to walk despite the fracture.
- Proximal fibula fractures are often the result of external rotation, whereas distal fibula fractures usually result from internal rotation.
- Repetitive trauma, particularly in runners beginning their training, may result in a stress fracture of the distal fibula.

Tibial fracture

- The tibia has a major weight bearing function.
- A torsional injury occurs when the body rotates on a planted foot. This low-energy force often results in a spiral fracture.
- A bending force on the tibia often produces a transverse or short oblique fracture line.
- Crush injury may result from a direct blow.
- The scant amount of tissue between the tibia and the skin results in little protection of the shaft from direct blow.
- The lateral plateau is elevated, and more susceptible to injury than is the medial plateau.

Muscle tears

- When the soleus and gastrocnemius muscles contract, the Achilles tendon pulls up the calcaneus, plantar flexing the foot.
- Rupture often occurs in sports settings, especially in poorly conditioned players.
- Forceful plantar flexion results in rupture of the tendon.
- A popping sound is heard by the patient, who then has difficulty ambulating.

Muscle tears

- A forceful plantar flexion of the foot, often with an extended knee, results in partial tear or rupture of the medial head of the gastrocnemius near its origin on the distal femur.
- Is painful to ambulate and plantar flexion is uncomfortable.

Anterior compartment

- Bordered by the tibia medially, the interosseous ligament posteriorly, and the anterior crural septum on its lateral aspect.
- The anterior tibial artery runs through this compartment before becoming the dorsal pedal artery of the foot.
- The deep peroneal nerve that also traverses this compartment supplies motor function to the dorsal flexors of the foot and toes.
- It provides sensory innervation to the web space of the first and second toes.

Anterior compartment

- The tibialis anterior dorsiflexes the ankle and inverts the foot.
- The extensor digitorum longus extends the lateral four digits and dorsiflexes the ankle while the extensor hallucis longus extends the great toe and dorsiflexes the ankle.
- The fibularis tertius dorsiflexes the ankle and aids in the inversion of the foot.
- All are innervated by the deep fibular nerve.

Lateral compartment

- Circumscribed by the anterior peroneal septum, the fibula, and the posterior peroneal septum.
- It houses the superficial peroneal nerve, which is sensory to the lateral dorsum of the foot, and motor control for the muscles within the compartment that evert the foot.
- The peroneal nerve runs just lateral to the fibular head, where it is exposed to direct trauma.

Lateral compartment

- The tendon of the fibularis longus crosses the sole of the foot and inserts onto the first metatarsal and medial cuneiform.
- The tendon of the fibularis brevis inserts on the base of the fifth metatarsal.
- Both evert the foot and weakly plantar flex the ankle. Innervated by superficial fibular nerve.

Posterior Compartment (Superficial)

- The gastrocnemius plantar flexes the ankle when the knee is extended.
- It raises the heel during walking.
- It flexes the knee at the knee joint.
- The soleus plantar flexes the ankle independent of the position of the knee.
- It steadies the leg on the foot.
- An accessory soleus muscle is seen in 6% of humans. May lead to posterio-medial ankle pain.
- Both the gastrocnemius and the soleus insert on the calcaneus (tendo-calcaneus or Achille's tendon).
- All muscles innervated by tibial nerve.

Posterior Compartment (Superficial)

- The plantaris assists (weak) the gastrocnemius as it plantar flexes the ankle.
- The sural nerve runs through it before providing sensory innervation to the lateral heel.
- No major arteries traverse this compartment.

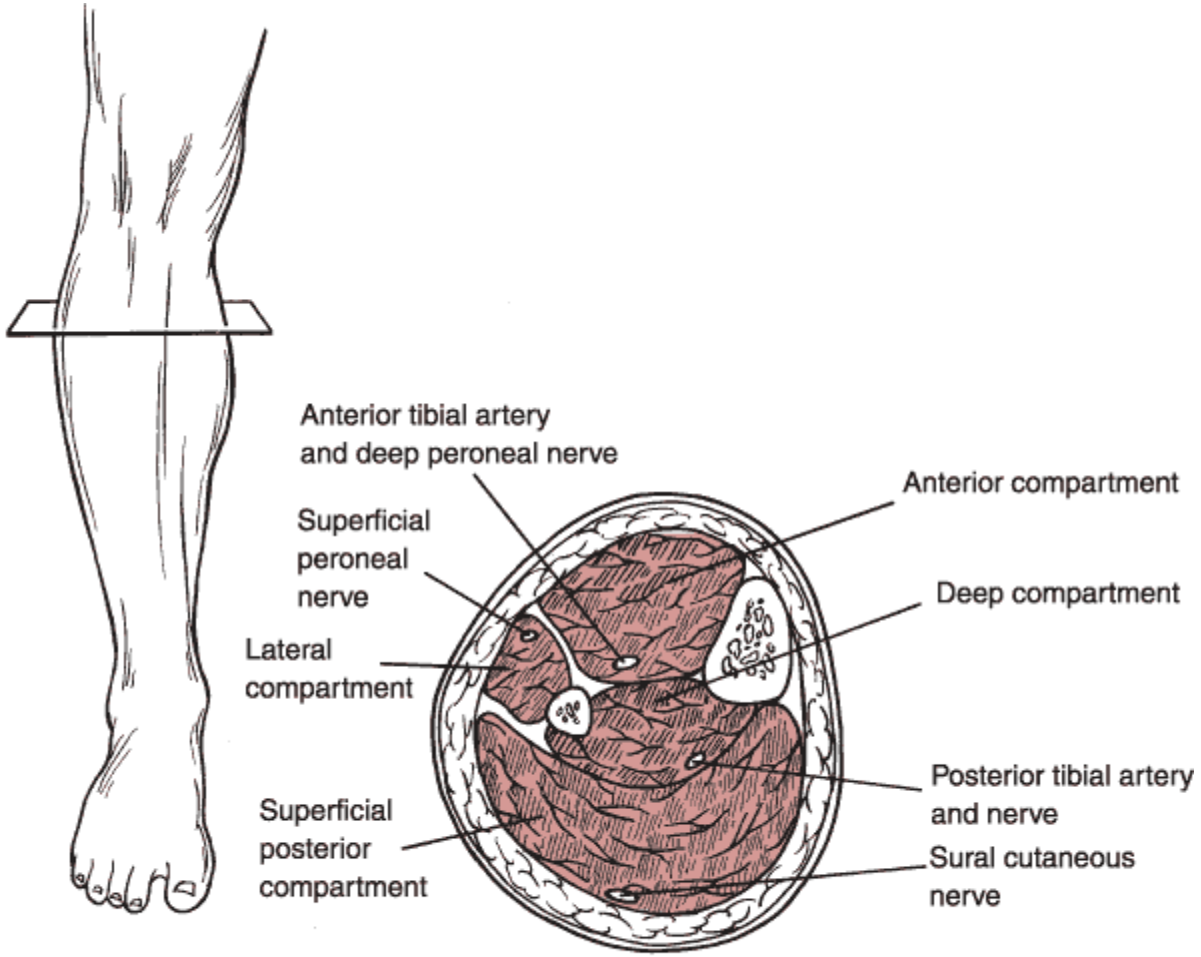
Posterior Compartment (Deep)

- The popliteus flexes the knee (weak) and unlocks it by rotating the femur 5° on a fixed tibia.
- It medially rotates the tibia of the unplanted limb.
- The flexor hallucis longus flexes the great toe at all joints and weakly plantar flexes the ankle.
- It supports the medial longitudinal arches of the foot.
- The flexor digitorum longus flexes the lateral four digits and weakly plantar flexes the ankle.
- It supports the longitudinal arches of the foot.
- The tibialis anterior plantar flexes the ankle and inverts the foot.

Posterior compartment (Deep)

- The tibial nerve provides motor control to these muscles and sensation for the sole of the foot.
- This compartment also contains the posterior tibial artery.
- Crush injury may lead to compromise of the artery.
- Pain (out of proportion to findings), Paresthesia, Pain with Passive Stretch (PPS), and Paresis
- Pain, Pallor, and Pulseless Paralysis
- Compartment syndrome is a surgical emergency

Compartment syndrome



Source: Tintinalli JE, Kelen GD, Stapczynski JS: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 6th Edition: http://www.accessemergencymedicine.com

Fig. 278-4 Accessed 05/05/2010

Ankle anatomy

- The ankle joint bears the body weight.
- The proximal part of this mortise joint is comprised of the distal fibula and the tibia.
- This part fits on top of the talus, or plafond, the distal part of the joint. The talus functions as the tenon in the joint. These three bones are bound together by three groups of ligaments.
- Bony stability is provided by the medial and lateral malleoli extending over the plafond.

Ankle anatomy

- Ligamentous stability is provided by the lateral ligament complex, the medial deltoid ligament, and the syndesmosis.
- It is weak in the anterior-posterior direction to permit dorsiflexion and plantar flexion.
- The lateral malleolus is attached to the anterior and posterior aspects of the talus and to the calcaneus, respectively, by the anterior talo-fibular, posterior talo-fibular, and the calcaneo-fibular ligaments.
- Inversion injury commonly affects the anterior talo-fibular ligament.
- The calcaneo-fibular ligament is the second most common ankle ligament injured.

Ankle anatomy

- The medial collateral or deltoid ligament is a thick triangular band of tissue that originates on the medial malleolus.
- Anterior tibio-talar, tibio-navicular, tibio-calcaneal, and posterior tibio-talar ligaments comprise the deltoid ligament.
- The superficial fibers insert on the navicular, the sustentaculum of the calcaneus, and the talus, and a deep set of fibers inserts on the medial aspect of the talus.
- The syndesmosis is a group of four distinct ligaments that attach the distal fibula to the tibia just above the plafond.

Ankle anatomy

- The talus and calcaneus articulate posteriorly and medially. This permits inversion and eversion of the ankle.
- Plane joints between the tarsi include the talo-calcaneal (inversion and eversion), calcaneo-cuboid (inversion and eversion), cuneo-navicular (little movement).
- The talo-calcaneonavicular joint (gliding and rotation) is not a plane joint as the talo-navicular articulation is a ball and socket joint.
- The spring ligament (plantar-calcaneonavicular) provides support and prevents the talar head from displacement inferiorly.

Ankle ligaments

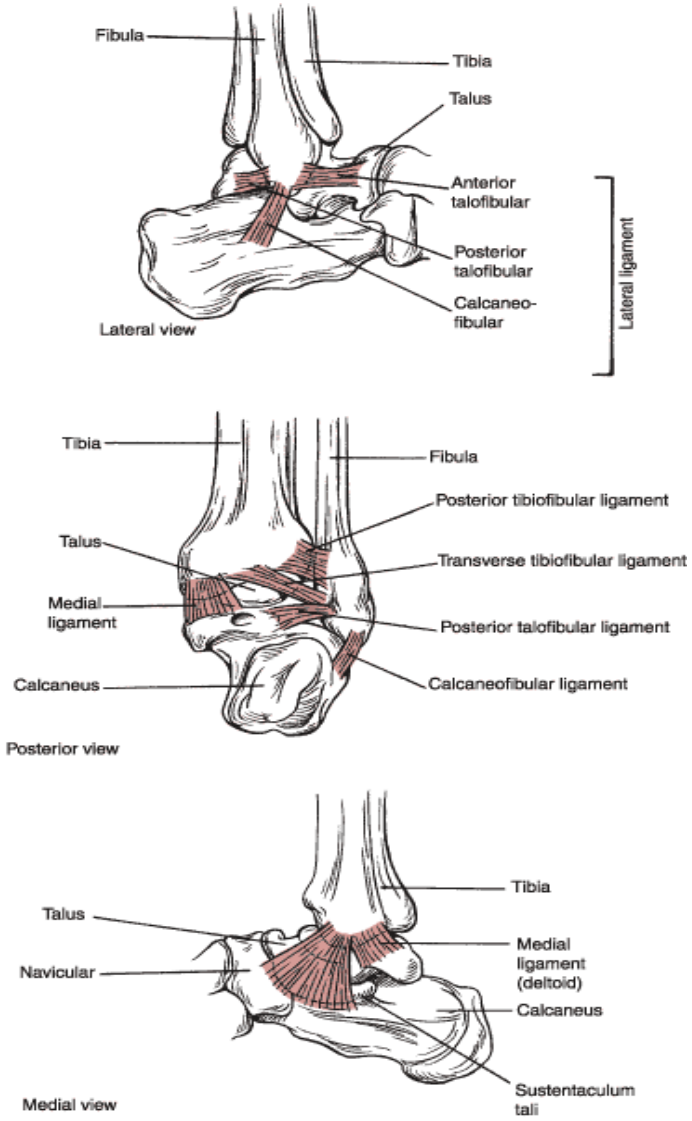


Fig. 276-1 Accessed 05/05/2010

Ankle anatomy

- The four groups of muscles that serve the ankle joint are supplied by branches of the sciatic nerve.
- Dorsiflexion is accomplished by tibialis anterior, extensor digitorum longus, and extensor hallucis longus muscles that run over the anterior aspect of the joint.
- The fibularis tertius is a weak dorsiflexor.
- The tibialis posterior, flexor digitorum longus, and flexor hallucis longus run behind the medial malleolus and contribute to inversion of the joint.

Ankle anatomy

- The peroneus and brevis muscles run laterally behind the distal fibula and contribute to eversion and plantar flexion.
- These two peroneal tendons share a common synovial sheath that is held in place by a groove on the posterior aspect of the lateral malleolus and the superior retinaculum.
- Plantar flexion is provided by the soleus and gastrocnemius muscles.

Ankle

- Fractures above the plafond may be unstable
- Injuries that cause disruption on both sides of the joint are unstable.
- Instability can result from a fracture of a malleolus and rupture of a ligament, fracture of both malleoli, or rupture of both ligaments.
- If there is an asymmetry in the gap between the talar dome and the two malleoli, the injury is presumed to be unstable.
- Lateral ankle sprains common.
- Strains are injuries to muscles or tendons and usually are not associated with a specific injury but rather are due to repetitive stress.

Ankle

- Peroneal strains and subluxations are easily confused with lateral ankle sprains.
- This occurs with hyperdorsiflexion of the foot while the peroneal tendons are taut in eversion.
- This injury most often is associated with skiing.
- The superior retinaculum holding the peroneal tendons in place is stripped off the posterolateral malleolus.
- Avulsion fractures are treated as stable ankle sprains if they are minimally displaced, smaller than 3 mm in diameter, and there is no indication of a medial ligamentous injury.

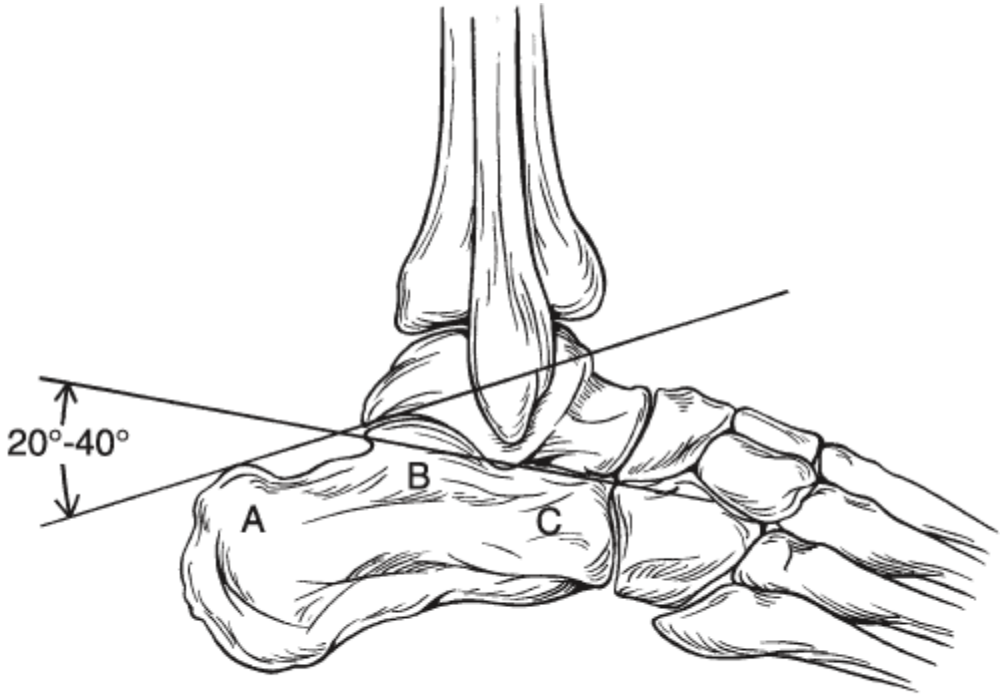
Ankle injury

- Inversion injury is the most common sprain.
- If eversion injury, associated fibular fracture.
- Pott fracture-dislocation of ankle
- Perpendicular force to lateral malleolus. Calcaneus rotates toward direction of force.
- Fractured fibula and medial malleolus; torn anterior fibular ligament
- Lateral collateral ligament lesion (anterior talo-fibular ligament torn as a result of inversion injury).

Ankle fracture

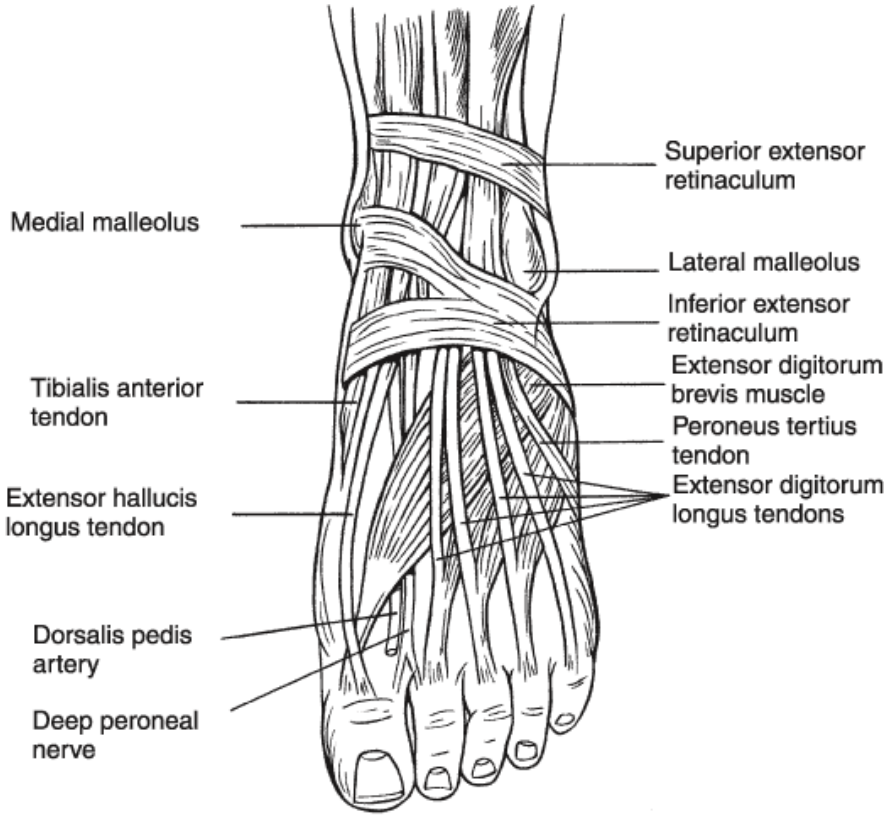
- Unimalleolar, bimalleolar, trimalleolar fractures may also be classified as to where the fibula fractures:
- Type A (fracture of the fibula below the syndesmosis) is a supination injury.
- Type B (fibular fracture at the level of the syndesmosis) is associated with an external rotation force.
- Type C (fibular fracture above the syndesmosis) is associated with an external rotation and abduction force.

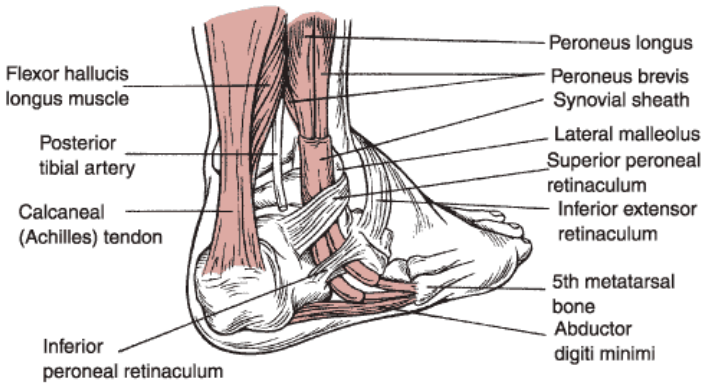
Calcaneus fracture



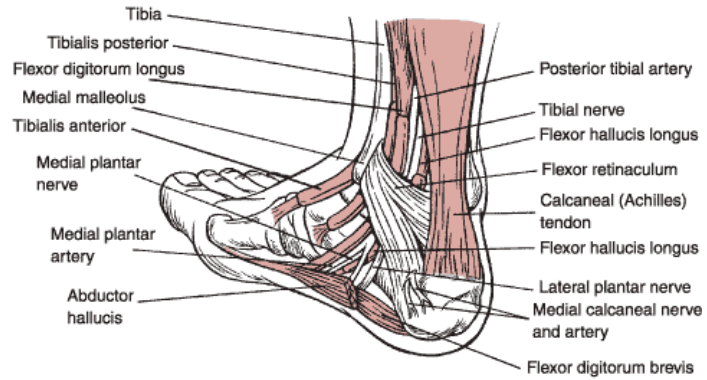
The Boehler angle is formed by two lines: one between the posterior tuberosity *(A)* and the apex of the posterior facet *(B),* and the other between the apex of the posterior facet *(B)* and the apex of the anterior process *(C).* An angle smaller than 20 degrees suggests a calcaneal compression fracture. Due to axial load to the heel.

Anatomy of ankle and foot





A Lateral



B Medial

Figs. 287-3 and 287-4 Accessed 05/05/2010

Foot

- The body weight when standing is distributed about the heel to the rear and about the five metatarsal heads to the front.
- The curved shape of the foot is held in position by three arches.
- The shape of the bones, the arrangement of the ligaments, and the tone of the muscles maintain the position of the arches.
- The long and short plantar ligaments support the lateral longitudinal arch. The calcaneo-cuboid joint forms the highest point of the arch.

Foot

- The medial longitudinal arch has the talus at its summit.
- The calcaneus is posterior.
- The navicular, three cuneiform bones, and the first three metatarsal bones lie anterior.
- It is supported by the plantar calcaneo-navicular (“spring”) ligament.
- The tibialis anterior and fibularis brevis support the arch from above; the tibialis posterior and fibularis longus support the arch from below.
- A weak ligament is associated with the clinical condition of a “flat foot.”

Foot

- The plantar aponeurosis covers the sole of the foot and is a strong band of fascia that originates on the medial side of the calcaneum and fuses with the fibrous sheaths of the phalanges, dividing the foot into three compartments by attaching to the first and fifth metatarsals.
- Supports both medial and lateral longitudinal arches.

Anatomy of the foot

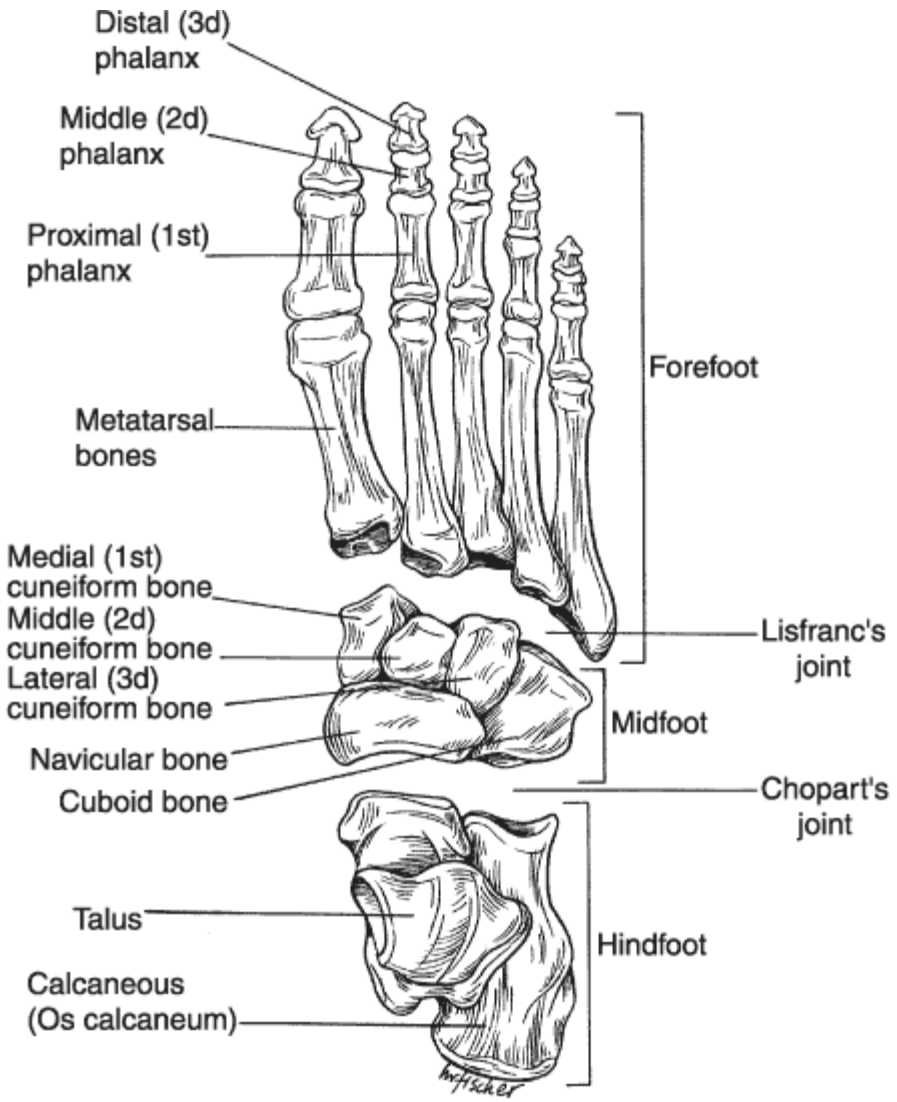


Fig. 277-1 Accessed 05/05/2010

Foot

- The blood supply of the foot comes from branches of the popliteal artery.
- The anterior tibial artery serves the dorsum of the foot (dorsalis pedis)
- Branches of the posterior tibial and the peroneal arteries serve the sole.
- The motor and sensory nerves of the foot include branches of the femoral and sciatic nerves and include branches of the saphenous, sural (sensory), and deep and superficial peroneal nerves (sensory and motor).

Foot

- Eversion and inversion occur about the subtalar and calcaneus tarsal joints.
- Adduction and abduction occur about the metatarso-phalangeal joint.
- Flexion and extension occur about the interphalangeal joint.
- The first metatarsal bears twice the weight as any other metatarsal.
- The blood supply to the foot is tenuous, and major fractures of the talus and subtalar dislocations are complicated by avascular necrosis.
- Compartment injuries are rare.

Muscles of the foot

- The abductor hallucis abducts and flexes the great toe.
- The flexor digitorum brevis flexes the lateral four toes.
- The abductor digiti minimi abducts and flexes the fifth toe.
- The quadratus plantae assists the flexor digitorum longus in flexion of the great toe.
- The lumbricals flex the proximal phalanges and extend the middle and distal phalanges of the lateral four toes.

Muscles of the foot

- The extensor digitorum brevis is located on the dorsum of the foot.
- It arises from the calcaneus and inferior extensor retinaculum.
- Innervated by the deep fibular nerve.
- It has no counterpart in the hand.
- The extensor hallicus brevis inserts into the proximal phalanx.
- Extensors for toes 2-4 join the lateral side of the extensor digitorum longus.

Joints of the foot

- Tarsometatarsal joints are plane joints.
- They permit gliding and sliding.
- While intermetatarsal joints are plane joints, they function little in foot movement.
- Metatarsaophalangeal joints are condyloid.
- They permit flexion, extension, and some abduction, adduction, and circumduction.
- Interphalangeal joints are hinge joints.
- They permit flexion and extension.

Flexor retinaculum

- Attaches at the medial malleolus and calcaneus.
- The great saphenous vein and saphenous nerve are superficial to the retinaculum and anterior to the medial malleolus.
- Deep to the retinaculum (from malleolus to calcaneus) are the tibialis posterior artery, flexor digitorum longus, the neurovascular bundle, and the flexor hallicus longus.
- The tibial nerve divides to form the medial and lateral plantar nerves. The tibialis posterior artery divides to form medial and lateral plantar arteries.
- Tibial nerve entrapment occurs in the tarsal tunnel syndrome.

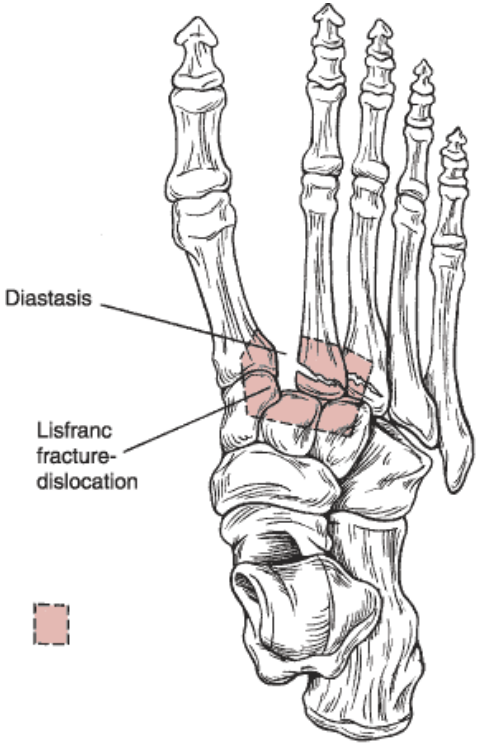
Sever’s disease

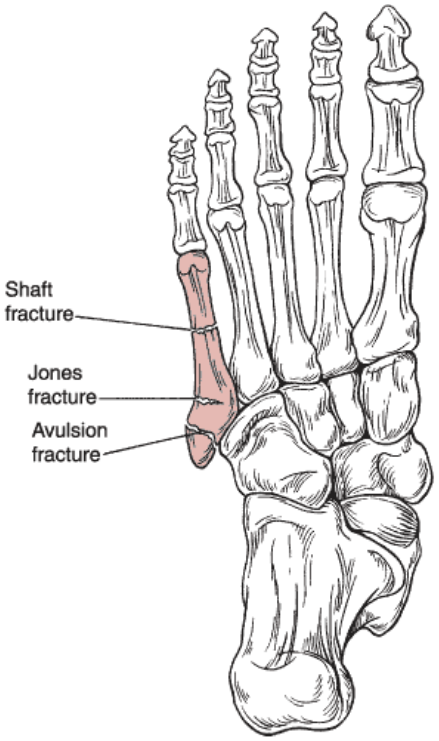
- Calcaneal Apophysitis
- Posterior heel pain in children (especially when running).
- Overuse, growth spurt as causes.
- Tight Achilles tendon.
- Tenderness of tendon insertion increased with passive dorsiflexion.

Lisfranc complex

- The six-bone tarso-metatarsal complex is known as the Lisfranc joint.
- The second metatarsal is the key to the complex.
- Plantar ecchymosis sign is a sign of injury.
- The force required and the mechanism of injury are varied and can range from a seemingly minor rotational force to a severe axial load, as seen in an automobile accident.
- The great majority of injuries to the Lisfranc joint are associated with fractures, usually of the metatarsals, the cuboid, or the cuneiforms.

Fracture of the foot





Figs. 277-3 and 277-4 Accessed 05/05/2010

Foot fracture

- A fracture of the base of the second metatarsal is pathognomonic of a disruption of the Lisfranc ligamentous complex.
- The Lisfranc injury is classified by the direction of the dislocation.
- Jones fracture involves the fifth metatarsal.
- The most common of the metatarsal fractures.
- It may be confused with lateral ligament injury. Treated conservatively.

Plantar fasciitis

- Pain on first step in morning; worse with activity.
- Point tender over medial calcaneal tuberosity.
- Gastrocnemius and achilles tendons are tight; overpronation common.
- Pain reproduced with jumping on involved toes.
- Hyperpronation.
- Overuse injury.
- Fat Pad Syndrome.
- No pain with toe jumping.
- Heel spur seen in 10-30% of normal population.
- 75% of athletes with plantar fasciitis also have a spur.