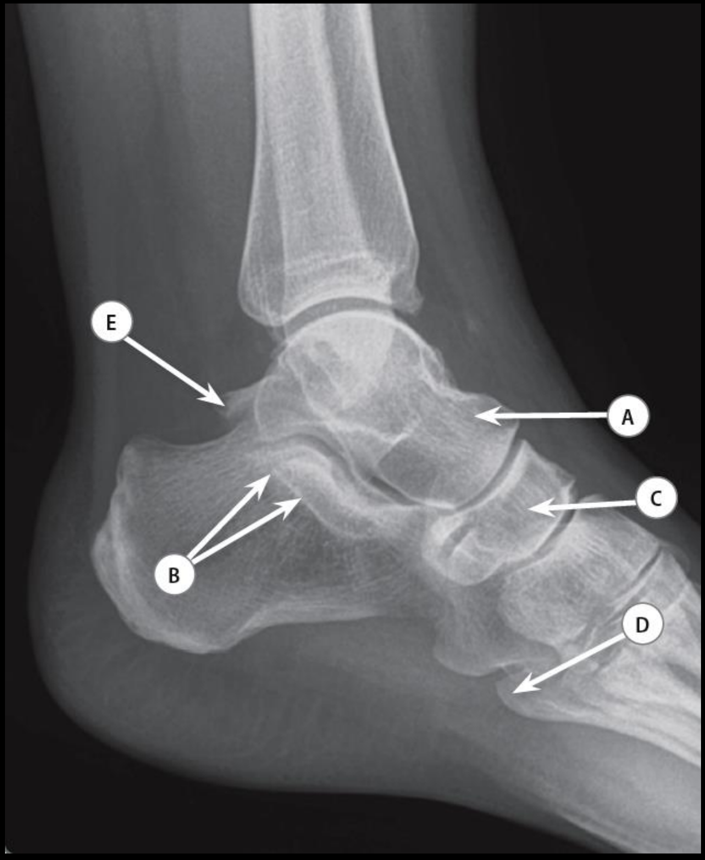
LOWER LIMB



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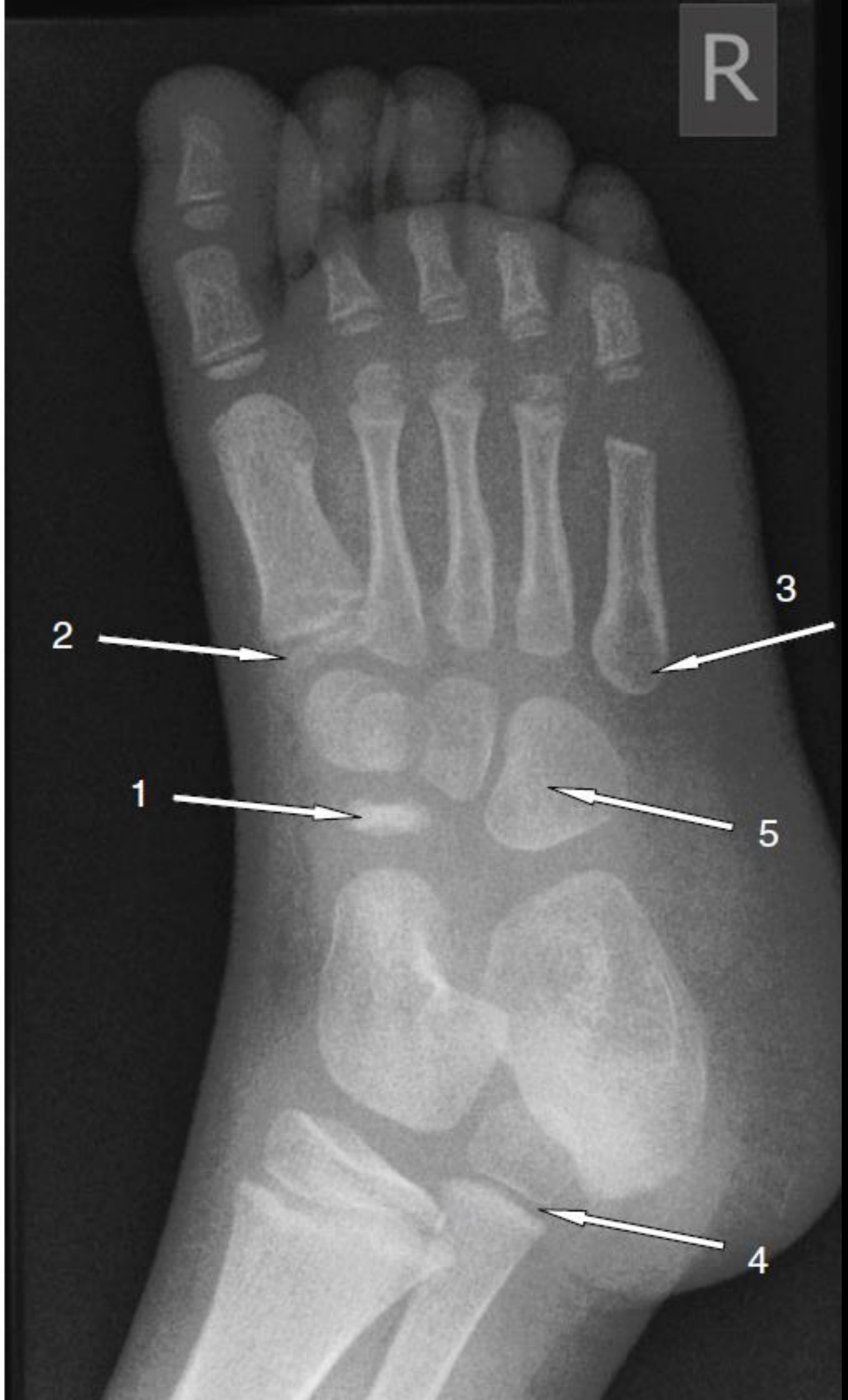
Foot Radiograph

1. Right lateral cuneiform
2. Sesamoid bones in right flexor hallucis brevis muscle
3. Tuberosity of base of right 5th metatarsal
4. Right navicular
5. Proximal phalanx of right second toe

Some of the most common accessory ossicles in the foot are os trigonum, posterior to talus; os vesalianum, base of 5th metatarsal; os peroneum, between cuboid and base of 5th metatarsal within tendon of peroneus brevis muscle; and os tibiale externum, medial to tuberosity of navicular within tendon of tibialis posterior.


R
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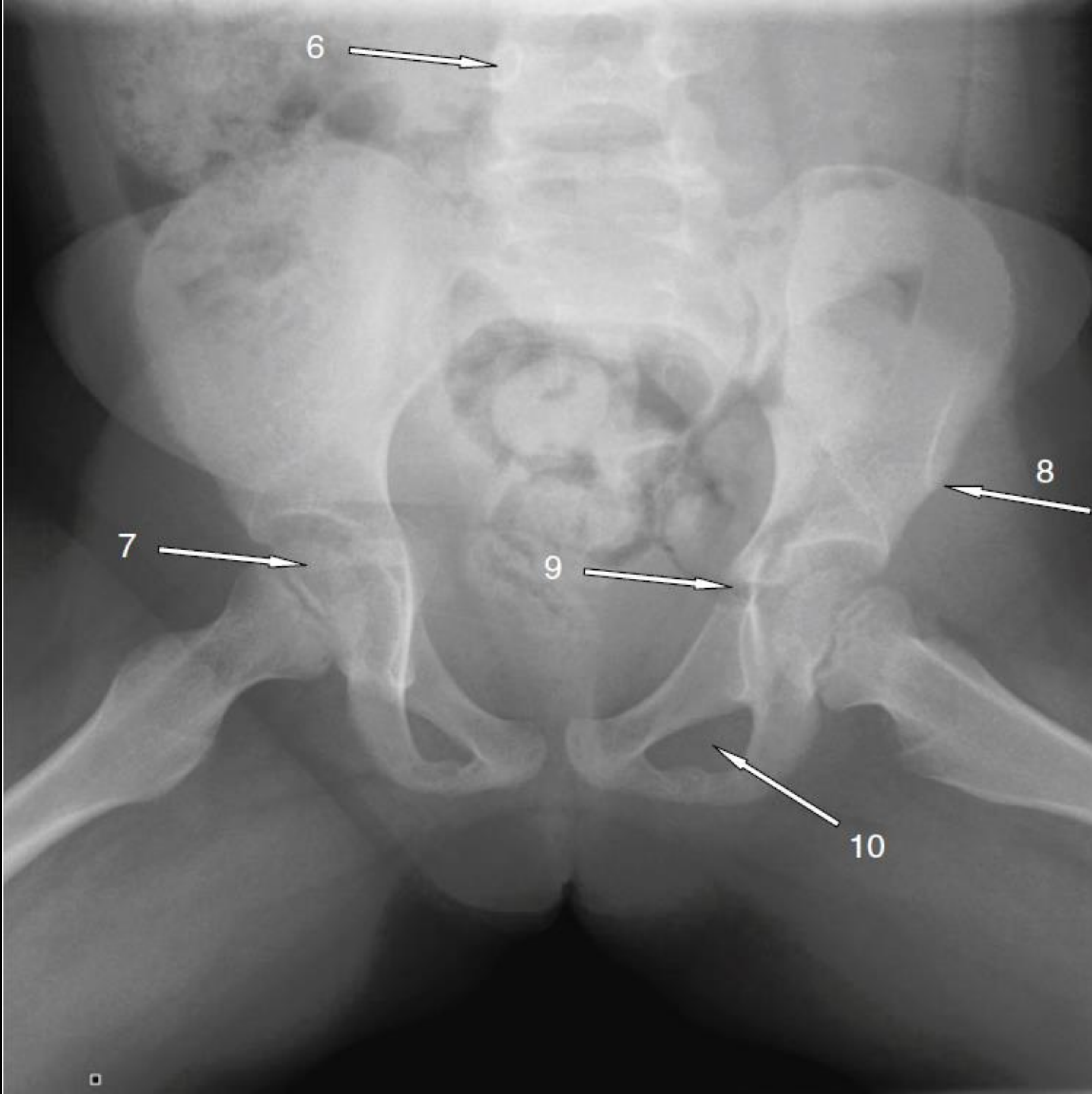
Foot Radiograph

1. Right navicular
2. Secondary ossification centre of right first metatarsal
3. Right peroneus brevis
4. Distal right fibular physis
5. Right cuboid

The navicular may appear irregular or fragmented as a normal variant during ossification. A residual cleft at the base of the first metatarsal following fusion of the secondary ossification centre is often mistaken for a fracture.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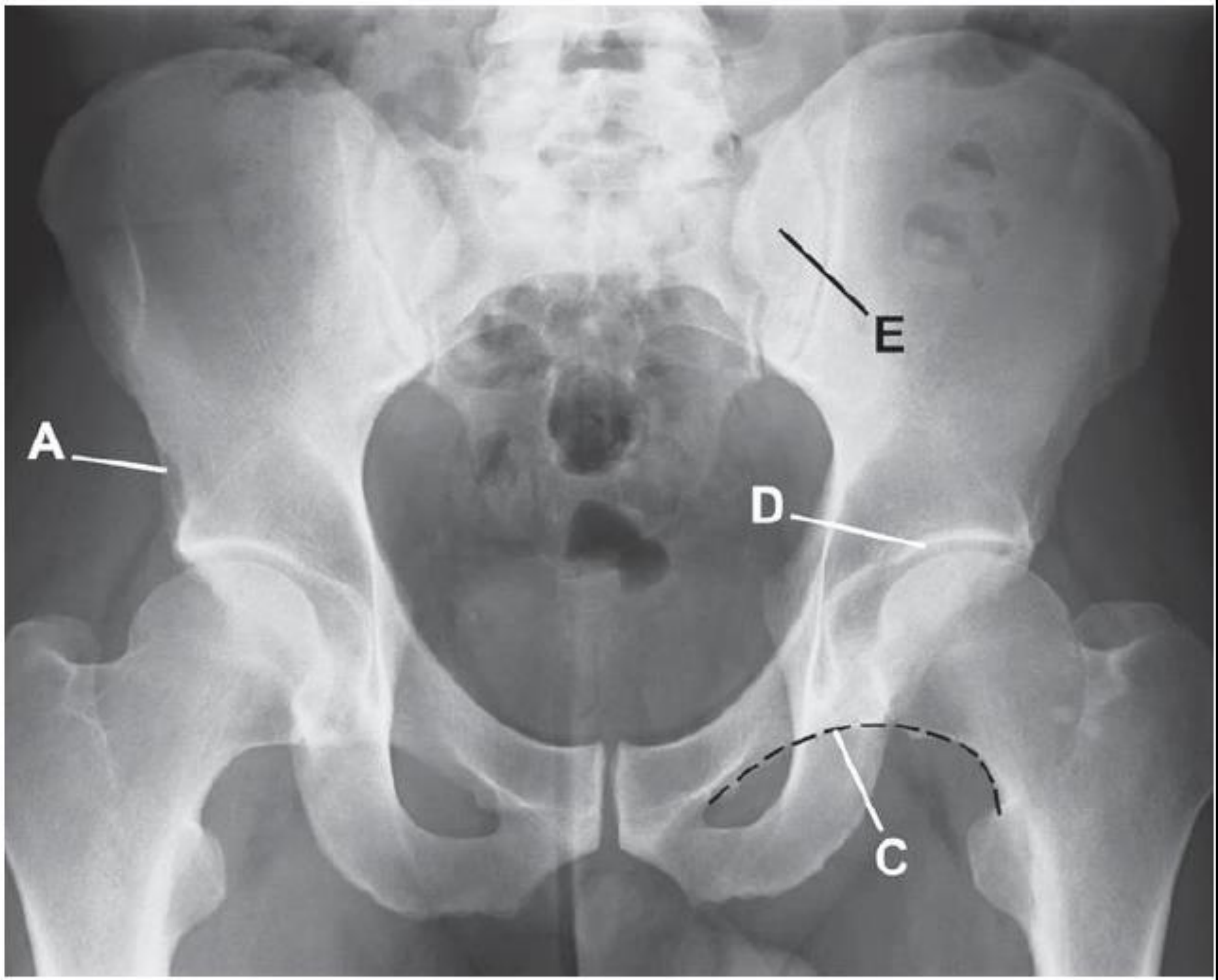
Pelvic Radiograph

6. Right pedicle of L4 vertebra
7. Right capital femoral epiphysis
8. Left rectus femoris – straight head
9. Left triradiate cartilage
10. Left obturator foramen

The frog lateral view is the best for assessment of slipped capital femoral epiphysis. Subtle signs of a slip include reduced height of the epiphysis and a widened growth plate.

Q1

a Name the muscle that attaches to the structure labelled A
b Name the ligament that attaches to the structure labelled A
c Name the line labelled C
d Name the structure labelled D
e Name the structure labelled E



Q1 Answers

a Straight head of rectus femoris muscle
b Iliofemoral ligament (of Bigelow)
c Shenton's line
d Acetabular roof
e Sacral ala

Radiograph of pelvis, AP view

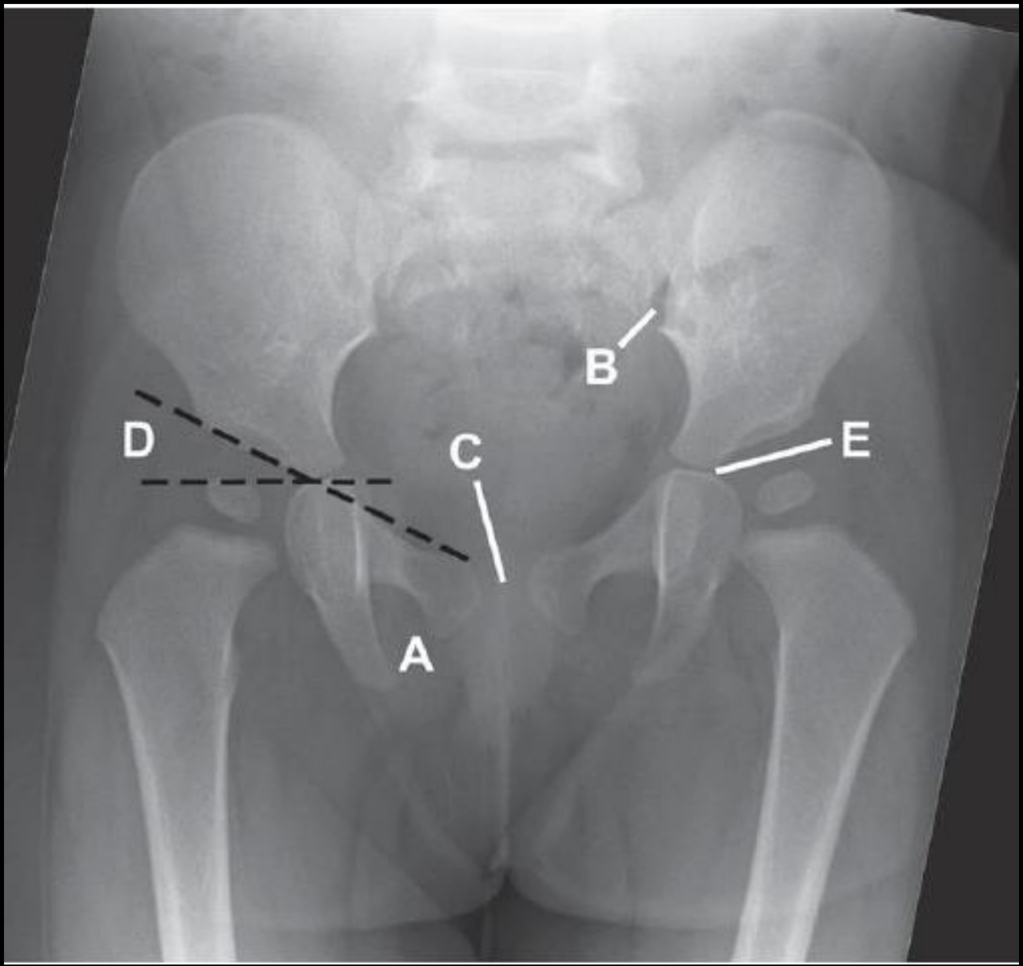
A number of lower limb muscles originate from the bony pelvis. Of the anterior femoral muscles, sartorius and tensor fascia lata originate from the anterior superior iliac spine (ASIS) while the straight head of rectus femoris arises from the anterior inferior iliac spine (AIIS). The adductor muscles including gracillis and pectineus arise from the pubic bone. The largest of these, adductor magnus, also takes origin from the ischiopubic ramus and the ischial tuberosity. The three hamstrings also arise from the ischial tuberosity. The ASIS and AIIS both have accessory ossification centres which appear at puberty and fuse at around 25 years.

The hip joint is stabilized by three ligaments and the joint capsule. The capsule encloses the femoral head and neck and is strongest in the anterior and superior portions. The iliofemoral ligament (of Bigelow) attaches the ASIS to the intertrochanteric line. Posterior support is provided by the ischiofemoral ligament and inferior support by the pubofemoral ligament.

Shenton's line should course a smooth, unbroken curve along the underside of the femoral neck, acetabulum and superior pubic ramus on an AP pelvic radiograph. This was originally described specifically in relation to tuberculosis of the hip, however a variety of hip conditions can cause interruption or angulation of this line. When assessing the posterior (ilioischial) and anterior (iliopubic) columns of the acetabulum with a radiograph, oblique projections (Judet views) are commonly used.

The sacral ala is the wing-like portion positioned lateral to the sacral body which is the product of fused costal elements and transverse processes of the sacral vertebrae.

Shenton EWH. Disease in bone and its detection by the X-Rays. 1911; *Macmillan*:42–43.



B
D
C
E
A

Q2 Answers

a Ischiopubic synchondrosis
b Sacroiliac joint
c Symphysis pubis
d Acetabular angle
e Triradiate cartilage of the acetabulum

Pelvic radiograph in a 12 month-old infant, AP view

The inonimate bones of the pelvis are made up of the ilium, ischium and pubis. In infants and children these bones are each separated by a radiolucent physis. The three bones converge at the triradiate cartilage of the acetabulum.

Assessment of the acetabulum and femoral head on paediatric radiographs can be complemented using two principal measurements. Both of these utilize a line drawn connecting the tri-radiate cartilages on both sides (known as the 'Y–Y' or Hilgenreiner line).

The acetabular angle is measured between the Y–Y line and a line along the ossified acetabular concavity and pubic ramus. This angle is approximately 28 degrees at birth and decreases gradually with age, reflecting normal bony maturation of the acetabulum. Developmental dysplasia of the hip (DDH) often results in an increased acetabular angle.

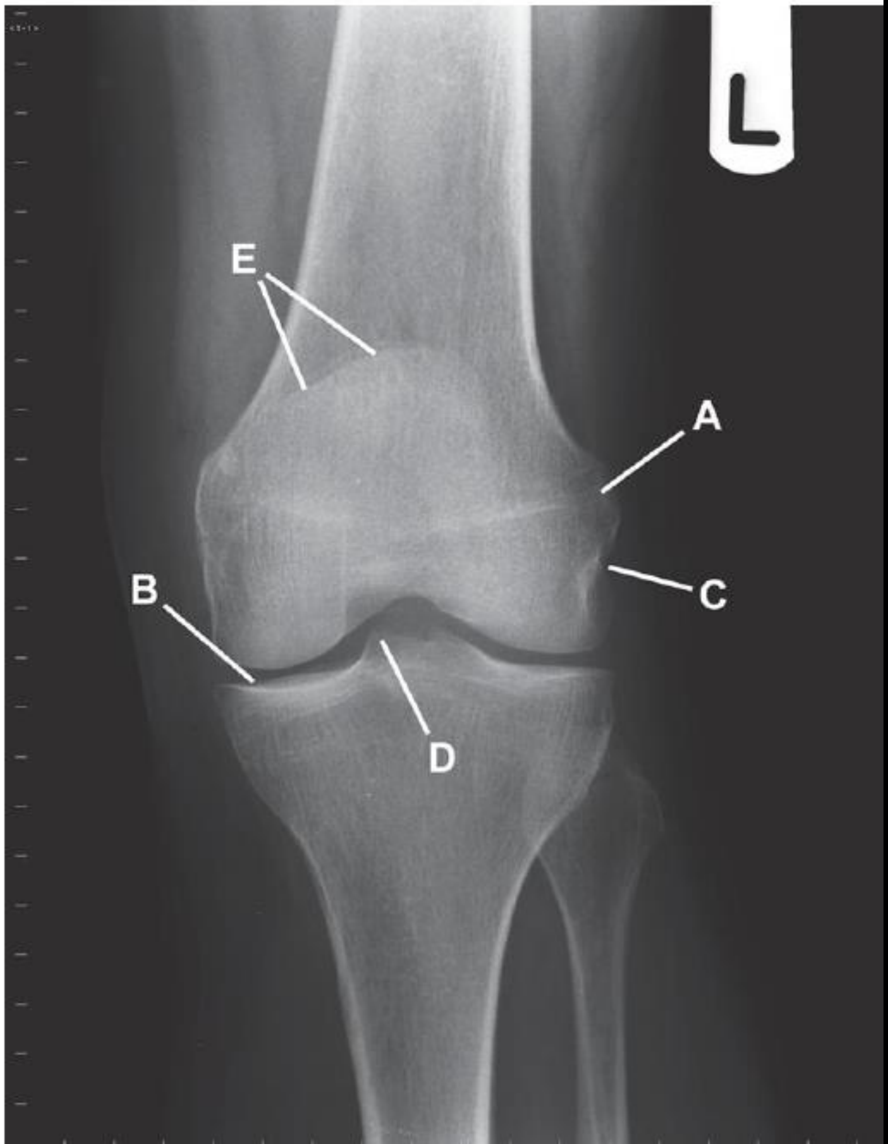
Positioning of the femoral head can be assessed by adding a line which is drawn perpendicular to the Hilgenreiner line at the outer acetabular margin (known as the Perkins line). These will serve to divide the hip into quadrants. The normal location of the ossified femoral head is in the infero-medial quadrant.

The sacro-iliac joints are synovial joints but despite this have very little movement. They are extensively reinforced by means of the anterior, posterior and interosseous sacroiliac ligaments. The pubic symphisis is a secondary cartilaginous joint which is normally immobile.

Norton KI, Polin SAM. Developmental Dysplasia of the Hip. *Radiology* 2009; eMedicine: www.emedicine.medscape.com

Q8

a Name the structure labelled A
b Name the structure labelled B
c Name the structure that runs through the groove labelled C
d Name the structure labelled D
e Name the structure labelled E



Q8 Answers

a Lateral femoral epicondyle
b Medial tibial plateau
c Popliteus tendon
d Medial tibial spine or tubercle of intercondylar eminence
e Patella

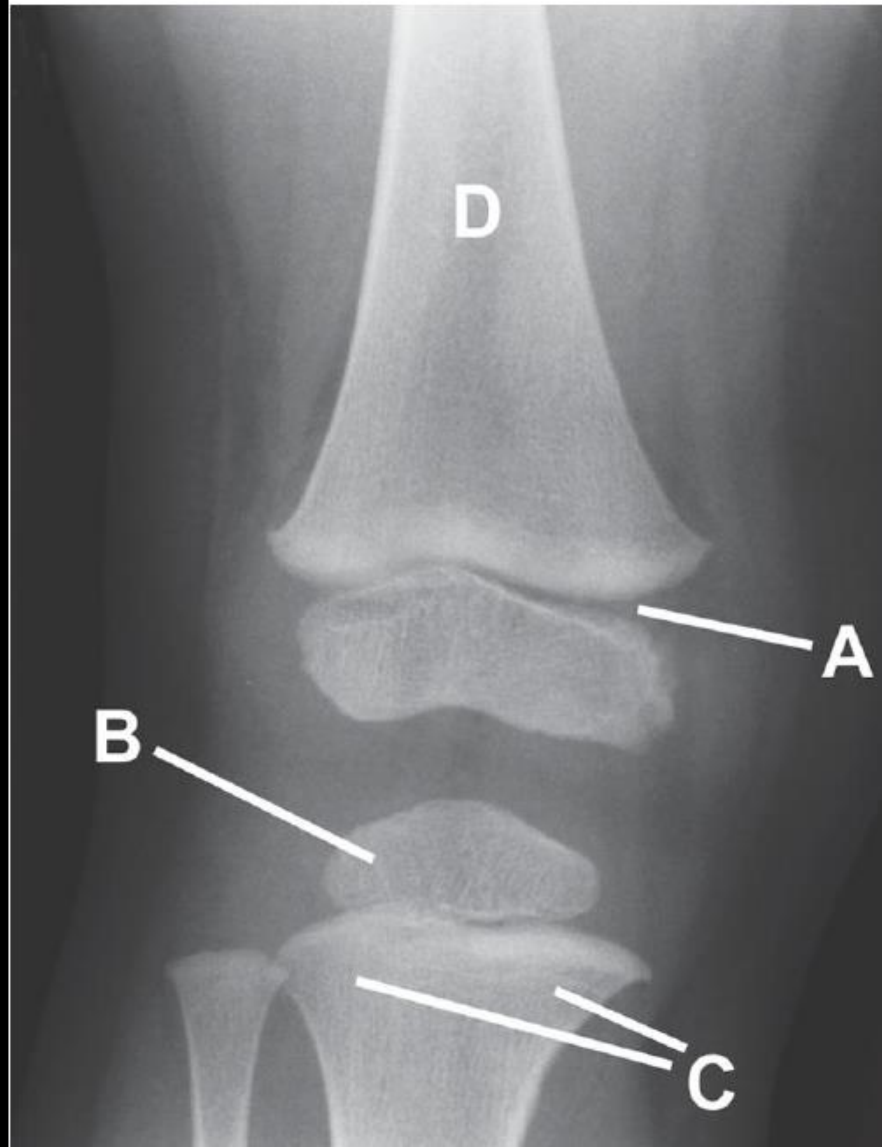
AP radiograph of knee

The tibiofemoral space should normally measure 3–8mm. The tibial plateaus match the shape of the respective femoral condyles with the medial side being smaller and more rounded. The tibial spines, or tubercles of the intercondylar eminence, are the distal attachment of both anterior and posterior cruciate ligaments (ACL and PCL, respectively).

Popliteus is the only muscle that enters the knee joint.

Q9

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Define the age at which ossification of the patella normally begins



Q9 Answers

a Distal femoral epiphyseal (growth) plate
b Proximal tibial epiphysis
c Proximal tibial metaphysis
d Femoral diaphysis
e 3–6 years

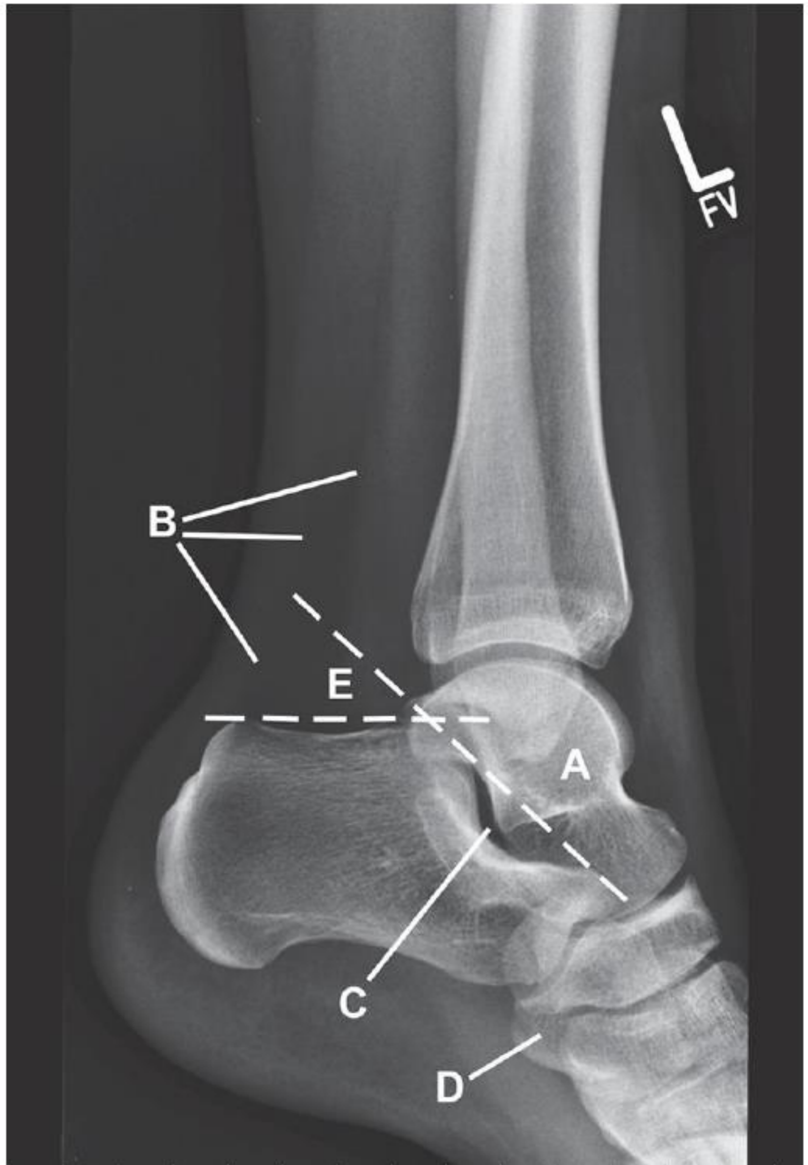
AP knee radiograph in a 2 year-old child

Long bone formation and growth occur as a result of cartilaginous ossification. All long bones have a cartilaginous growth plate or epiphyseal plate. The ossified bone on either side of this is known as the epiphysis (distal) and metaphysis (proximal). The shaft of a long bone is the diaphysis and the junction between it and the metaphysis is termed the diametaphysis. An apophysis is an ossified area which is located on one side of the bone. Apophyses do not normally contribute to increasing the length of a bone and are usually situated at the site of a tendinous insertion, for example at the 5th metatarsal base.

Ossification of the patella begins sometime between the ages of three and six and is usually completed by the onset of puberty. Ossification originates in several different locations that normally coalesce to form a single bone. Occasionally one centre (typically the upper lateral quadrant) will not fuse with the others which results in a bipartate patella.

Q15

- **a** Name the structure labelled A
- **b** Name the structure labelled B
- **c** Name the joint space labelled C
- **d** Name the structure labelled D
- **e** Define the normal angle at the position labelled E



Q15 Answers

a Talus
b Achilles tendon
c Posterior subtalar joint (talocalcaneal joint)
d Cuboid
e 30 degrees

Radiograph of ankle, lateral view

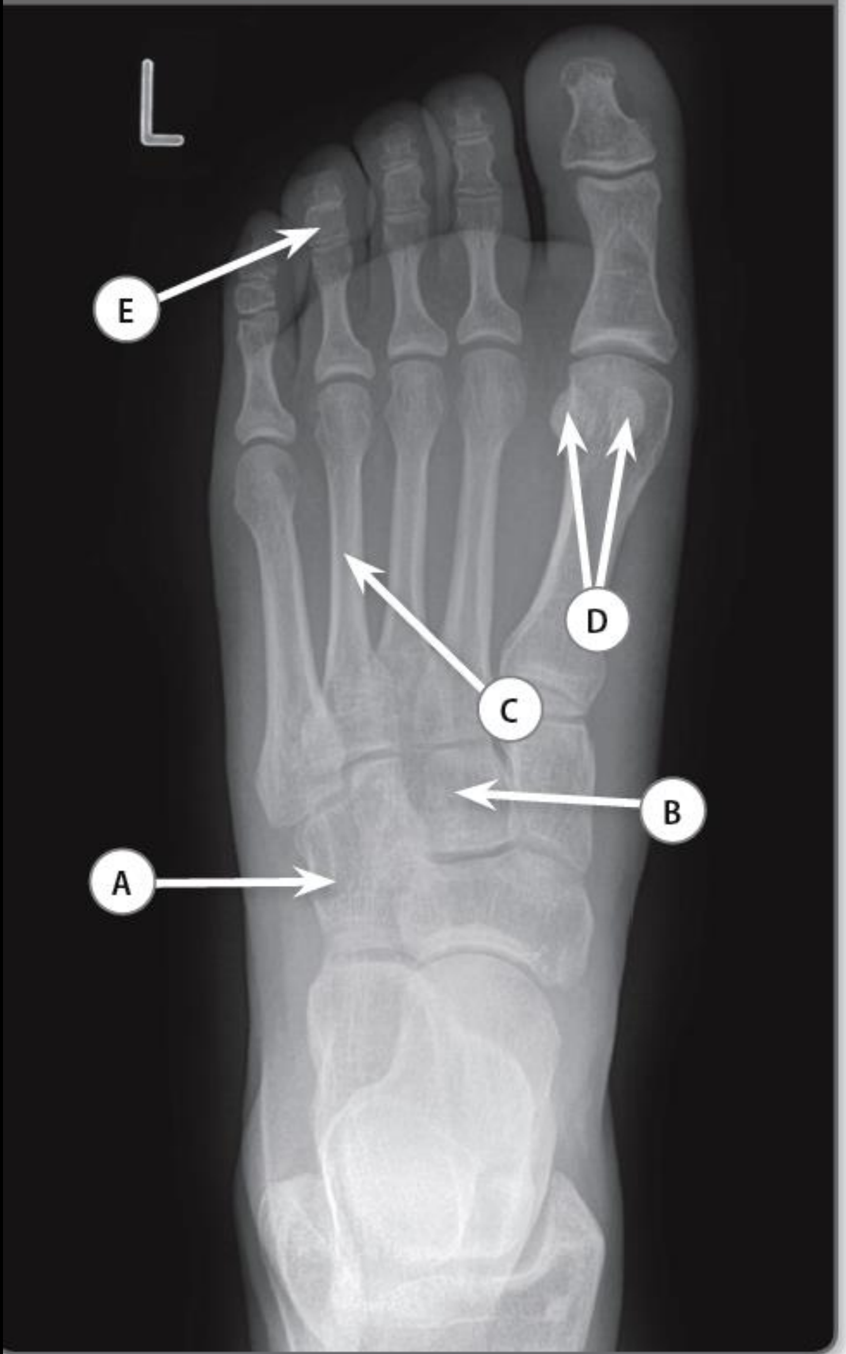
The talus consists of a head, neck and body and is a bone with no muscular attachments. As the name suggests, the neck is the slightly narrowed part of the talus which joins the body (posterior) and head (anterior). In adults it is angled such that it points roughly along the line of the first metatarsal.

The subtalar joint is functionally a single joint between the talus and calcaneum however it is made up of two components. The talocalcaneal (posterior) joint is between the posterior facet on the underside of the talus and the adjacent facet that is located on the upper calcaneum. The talocalcaneonavicular joint adjoins the talar head, the antero-superior surface of the calcaneum and the posterior surface of the navicular together with the spring ligament.

Bohler's angle is a means of assessing the calcaneal profile height. The lines converge on the anterior end of the superior articular facet, with one line beginning at the posterior end of the same articular facet and the other beginning at the postero-superior calcaneal margin: 30 degrees is normal. Calcaneal fractures are usually due to excessive axial loading (often resulting from a fall or a road traffic accident) which can cause impaction and flattening of the posterior facet and a reduction in Bohler's angle. In the context of trauma, an angle <23 degrees is highly suggestive of a calcaneal fracture.

Isaacs J, Baba M, Szomer ZS. FA5: The Diagnostic Accuracy of Böhler's Angle in Fractures of the Calcaneus. *J Bone Joint Surg [Br] Proceedings* 2010; 92: 178.

Case 4.1



Case 4.1

A Left cuboid

B Left intermediate cuneiform

C Left 4th metatarsal (shaft)

D Sesamoid bones in left flexor hallucis brevis

E Middle phalanx of the left 4th toe

Dorsiplantar plain radiograph of the left foot.

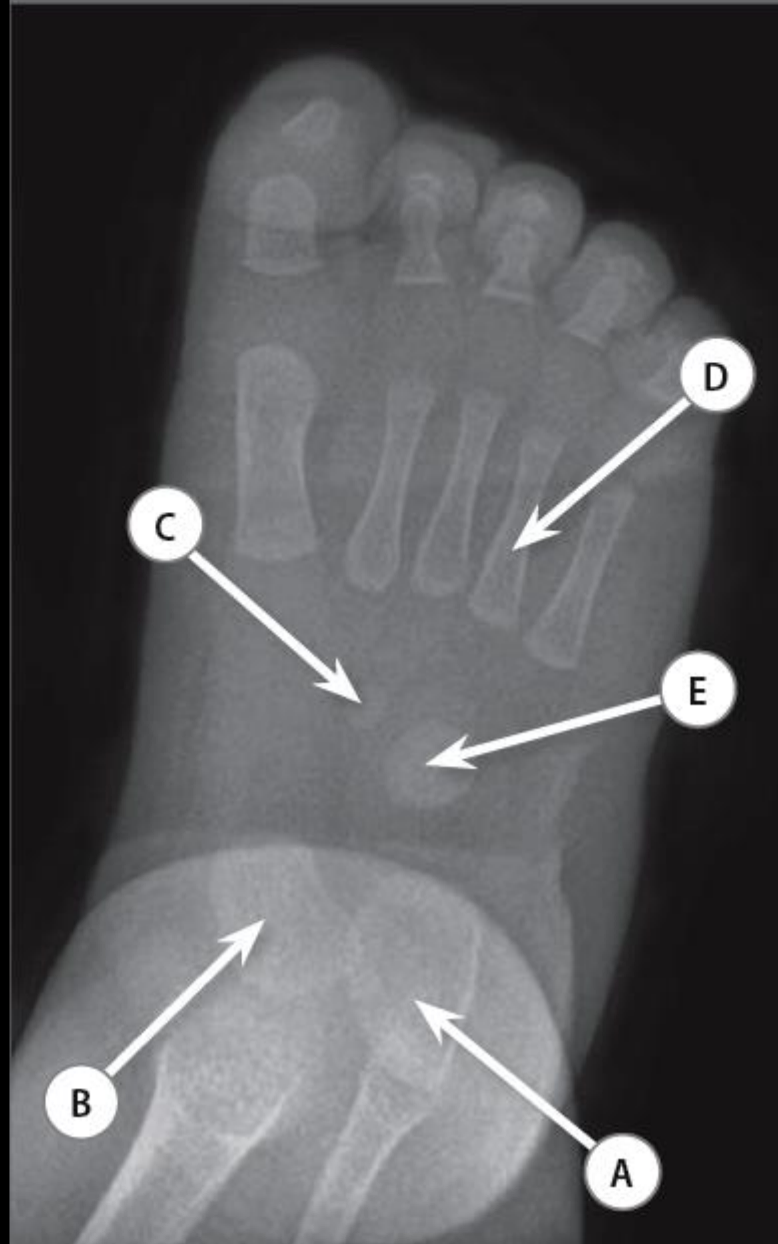
The cuboid lies at the lateral side of the tarsus distal to the calcaneus and proximal to the 4th and 5th metatarsals. The lateral surface has a groove which contains the tendon of the peroneus longus.

The three cuneiform bones are wedge shaped. The lateral and intermediate cuneiforms are wider distally and narrower proximally while the medial cuneiform is the opposite. The medial cuneiform articulates with the 1st metatarsal. The intermediate cuneiform articulates with the 2nd and the lateral cuneiform articulates with the 3rd metatarsal.

The five metatarsal bones have a base proximally, a head distally and a shaft in between. The head of the 1st metatarsal has two grooves on the under surface which contain sesamoid bones. These bones lie in the tendon of the flexor hallucis brevis. Giving 'sesamoid bone' as the answer to D, may result in lost marks.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 214.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 284–287.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 375–376.

Case 4.2



Case 4.2

A Right calcaneus

B Right talus

C Right lateral cuneiform

D Shaft of the right 4th metatarsal

E Right cuboid

Anteroposterior radiograph of the foot (child).

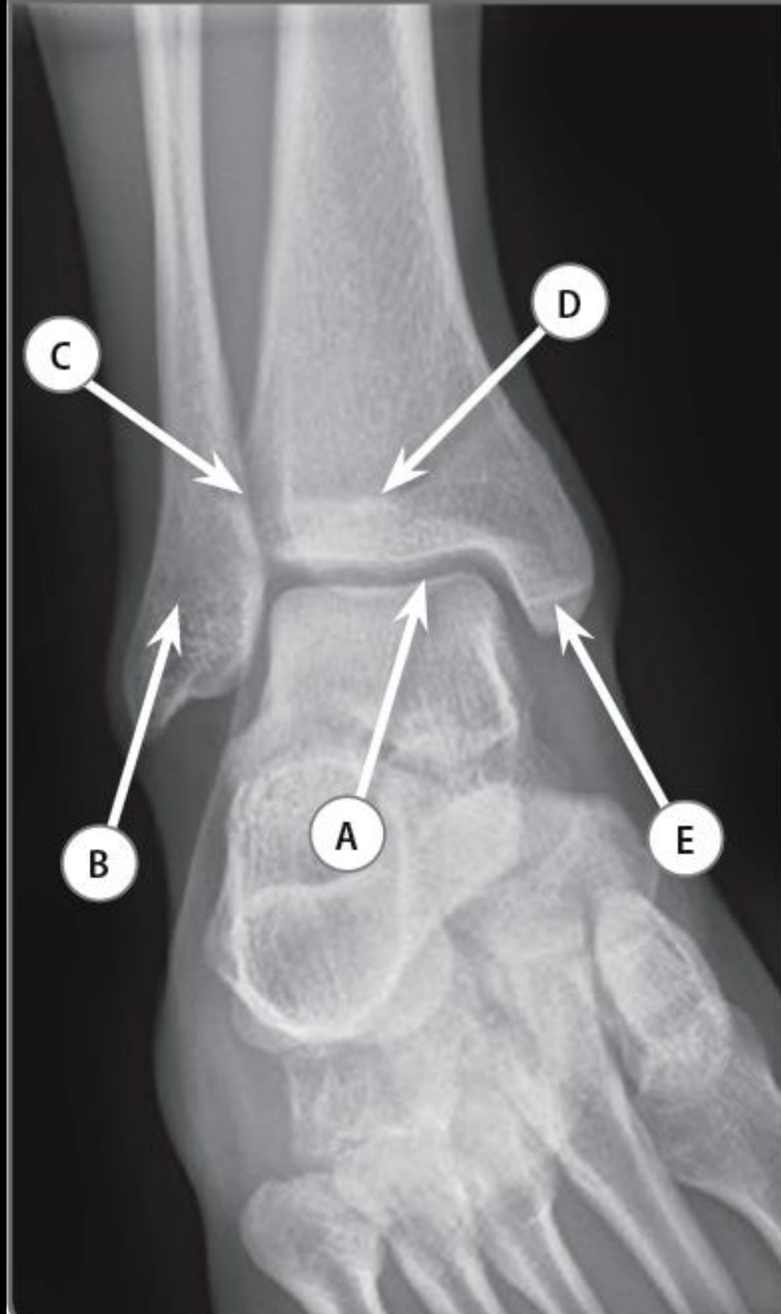
Identifying the tarsal bones on the radiograph of a child is challenging as they ossify at different times. Consequently, the normal relationships between the tarsal bones are not always visible to help identify them.

The calcaneus, the talus and cuboid begin to ossify during fetal life. So in the radiograph of the foot of the normal child, these three bones will always be present (note that the cuboid ossification may be delayed until three weeks).

Of the cuneiforms, the lateral appears first (4–20 months) followed by the medial cuneiform (2 years of age). The intermediate cuneiform ossifies last (3 years of age).

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 215.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 372–376.

Case 4.3



Case 4.3

A Dome of the right talus (trochlear surface of talus)

B Right lateral malleolus (distal fibula)

C Right distal tibiofibular joint

D Distal epiphyseal scar of the right tibia

E Right medial malleolus

Anteroposterior radiograph of the ankle.

The articular surfaces of the ankle joint are:

- the lower tibia
- the inner surface of the medial malleolus of the tibia
- the medial surface of the lateral malleolus of the fibula
- the trochlear surface of the talus.

On radiographs of long bones in adults, a radiodense band can be seen at the junction of the epiphysis and the metaphysis. This is called the epiphyseal scar.

The inferior tibiofibular joint (syndesmosis) is formed by the convex medial surface of the distal fibula and the concave lateral surface of the distal tibia. It is reinforced by the interosseous ligament and the anterior and posterior tibiofibular ligaments.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 212.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 300–304.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 378.

Case 4.4

Case 4.4

A Head of talus

B Sustentaculum tali of the calcaneus

C Navicular

D Base of 5th metatarsal

E Os trigonum

Lateral radiograph of the ankle.

The talus is composed of a body, a head and a neck. The body lies between the tibia and the calcaneum. The head is the anterior, rounded portion of the bone and the neck is the constriction between the body and head.

The posterior surface of the body of talus, narrows to a pointed tubercle called the posterior process. Sometimes the process is represented as a separate bone. This is a normal anatomical variant called os trigonum. This normal variant is present in this image. Note that in the exam, you may be asked to name the anatomical variant present on an image but not necessarily labelled.

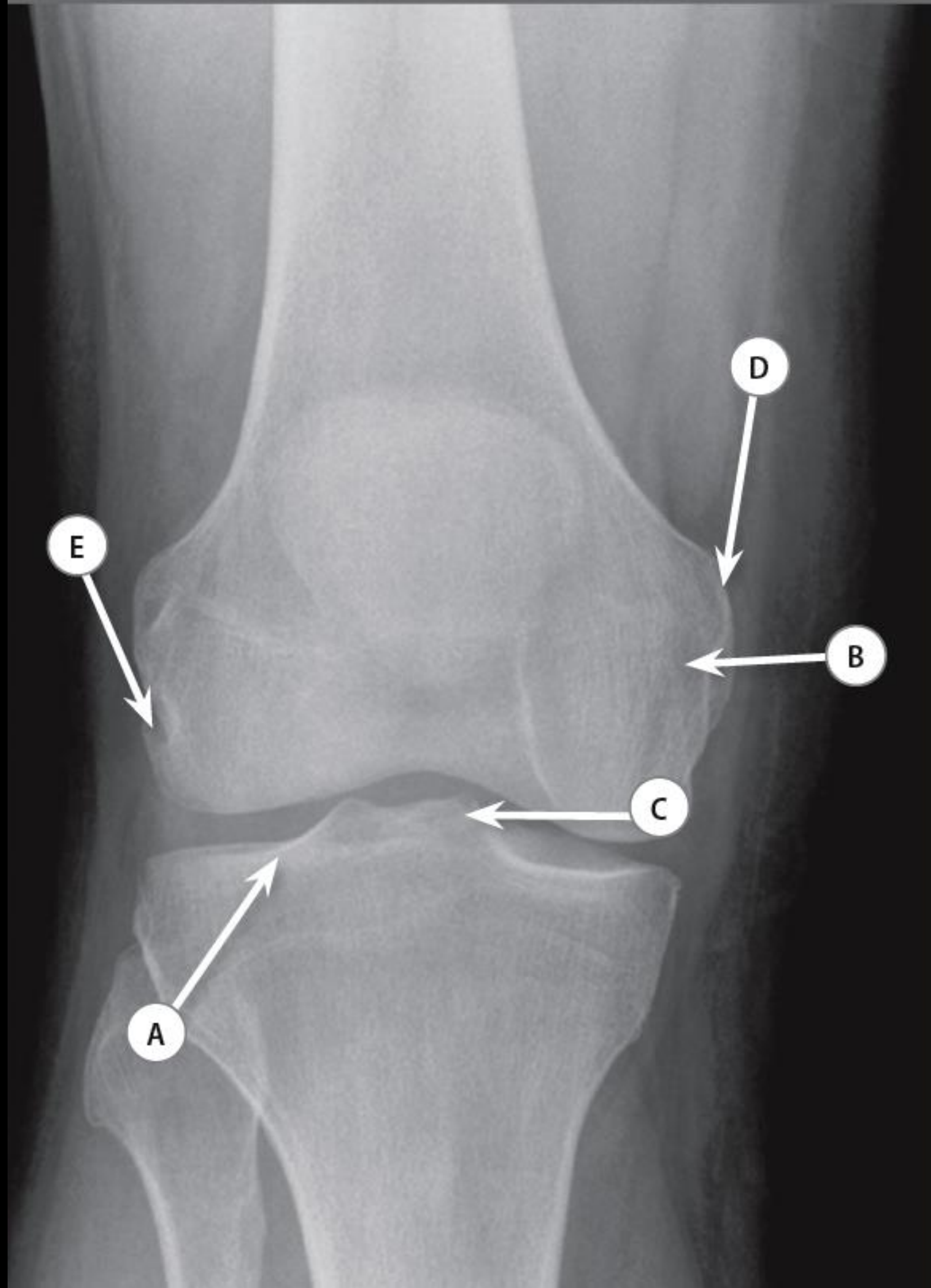
The inferior surface of the talus has two articular surfaces. They are separated by a deep groove, the sulcus tali. Both these facets articulate with portions of the calcaneum. Part of the anterior facet articulates with the sustentaculum tali which projects from the medial side of the calcaneum.

The navicular lies between the talus and the cuneiform bones. It is described as boat shaped. The posterior surface of the navicular articulates with the head of talus.

The base of the 5th metatarsal can be seen on a lateral ankle radiograph. Its lateral surface has a prominent tubercle which projects backwards and laterally.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 212.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 300–304.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 378.

Case 4.7



Case 4.7

A Lateral tibial plateau of the right knee

B Medial femoral epicondyle of the right femur

C Medial tibial spine of the right tibia

D Adductor tubercle of the right femur

E Popliteal groove of the right femur

Plain frontal radiograph of the knee.

The articular surfaces of the knee joint that are visible on the anteroposterior radiograph consist of the condyles of the femur and the flat upper surfaces of the tibial condyles (tibial plateau).

Between the articular facets of the proximal tibia lies the intercondylar eminence which is surmounted on either side by the tibial spines (medial and lateral). Anterior and posterior to the intercondylar eminence, are the attachments of the anterior and posterior cruciate ligaments and the menisci.

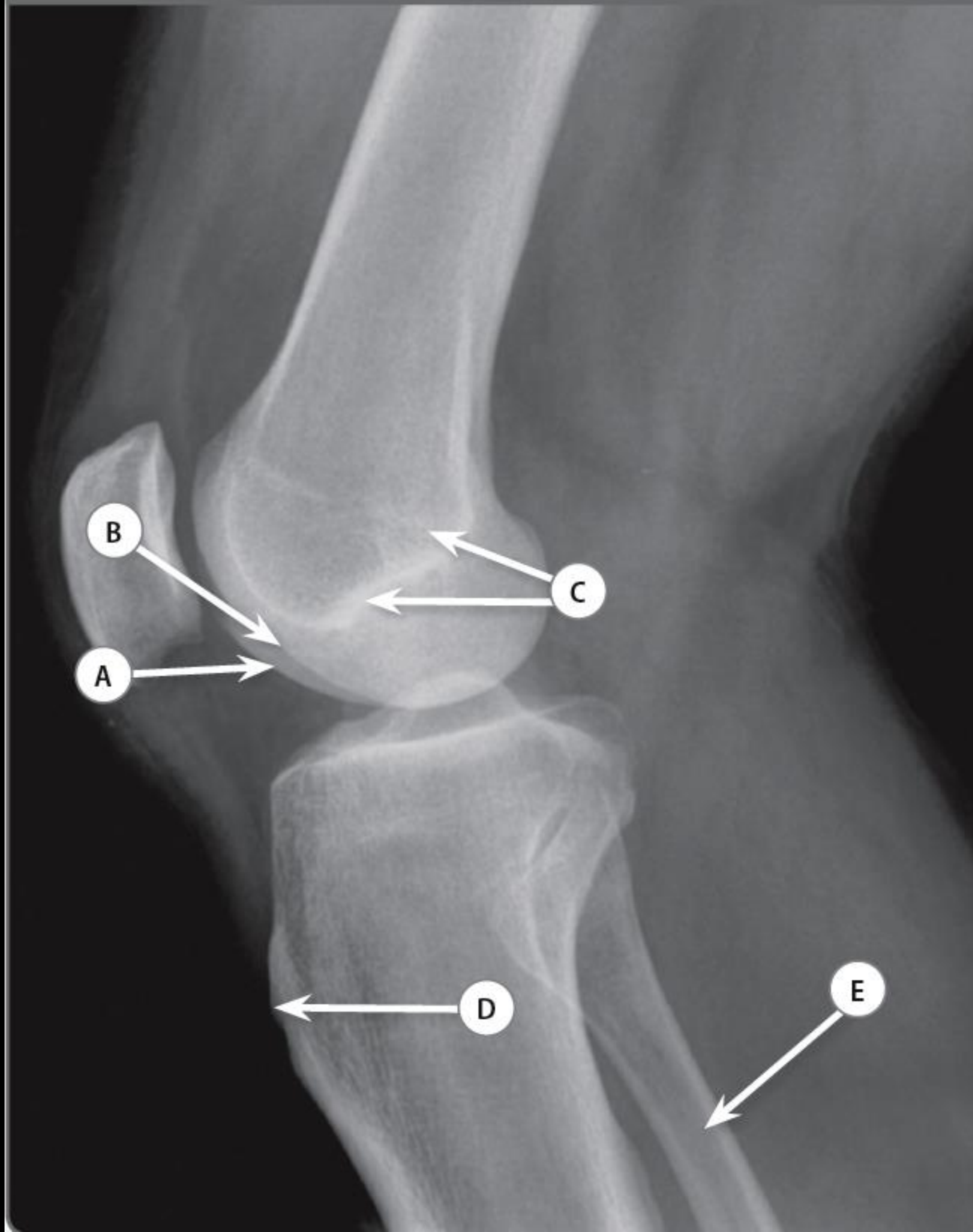
The linea aspera is a ridge of bone in the posterior surface of the femur. Distally, the linea aspera is prolonged by two ridges. The medial ridge ends in the adductor tubercle. The tendon of the adductor magnus inserts there.

The popliteal groove is a landmark in the lateral condyle of the femur between the epicondyle and the articular margin. Its anterior end gives origin to popliteus. When the knee is fully flexed, popliteus helps to 'lock' the knee by lodging into the posterior end of this grove.

In radiographs of the limbs, when laterality is indicated by a marker on the radiograph, it is better to indicate which limb it is after the structure. For example: 'Adductor tubercle of the left femur' rather than 'Left adductor tubercle'.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 210.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 295.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 366.

Case 4.8



Case 4.8

A Medial condyle of the right femur

B Lateral condyle of the right femur

C Intercondylar fossa of the right femur

D Right tibial tuberosity

E Diaphysis of the right fibula

Lateral radiograph of the knee.

In a lateral radiograph of the knee, the femoral condyles are superimposed. If asked to differentiate between the medial and the lateral femoral condyles, use the size of the condyles and the lateral femoral notch to help do this.

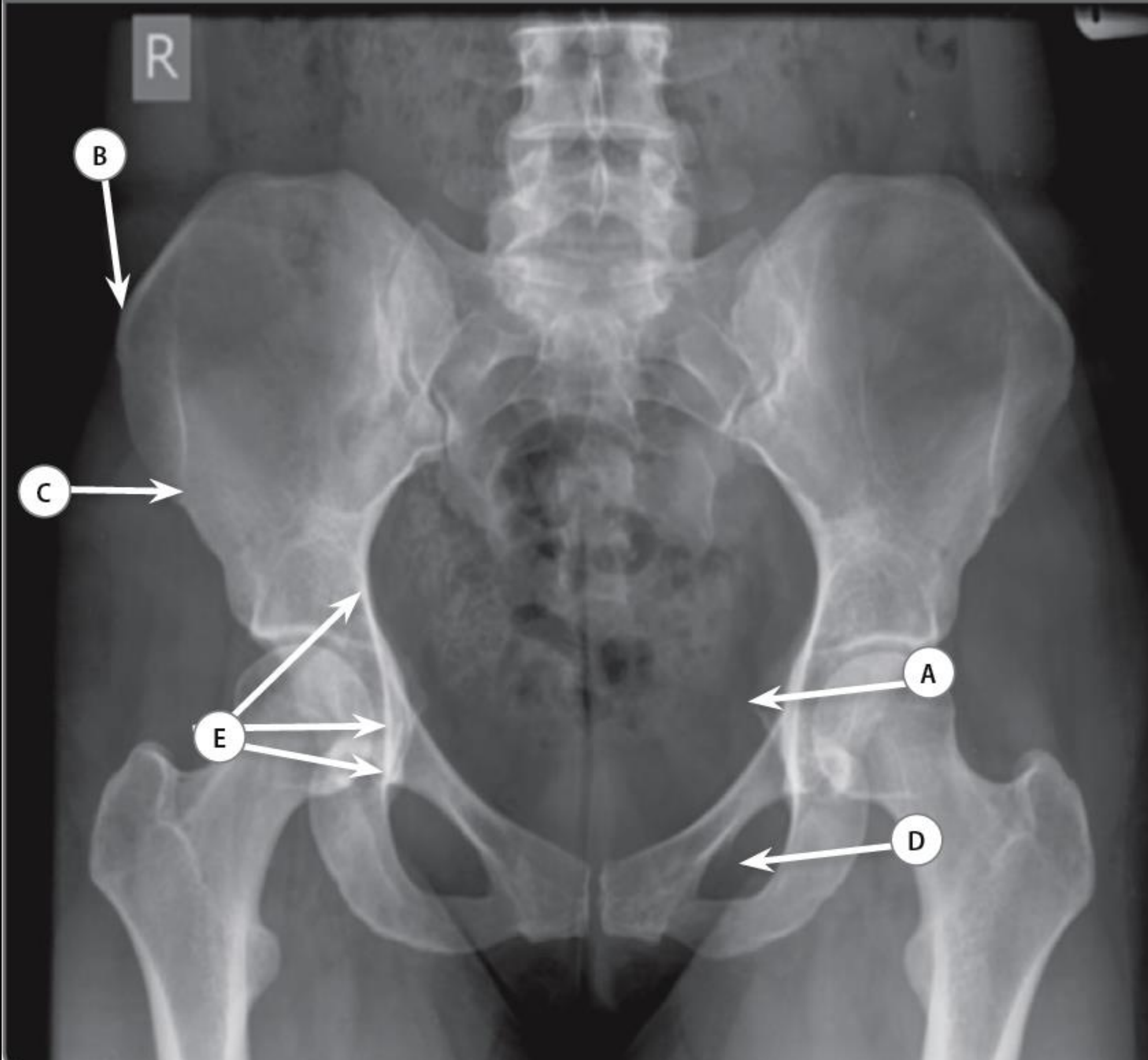
The medial condyle is larger and projects more inferiorly.

The lateral femoral notch (also known as lateral condylopatellar sulcus) forms a shallow groove in the middle of the lateral femoral condyle.

Make sure the specific parts of the long bones are named rather than just naming the bone e.g. diaphysis of fibula instead of fibula.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 210.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 295.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 366.

Case 4.13



Case 4.13

A Left ischial spine

B Right anterior superior iliac spine

C Right anterior inferior iliac spine

D Left obturator foramen

E Right Iliopectineal line

Plain radiograph of the pelvis.

Candidates consider plain film radiographs the easier part of this exam as they are more familiar with them. However, it is very easy to lose precious marks by not paying attention to details on these radiographs. Also it is important to consider which muscles attach to prominent structures as this may be asked in the exam.

The ischial spine forms the lower margin of the greater sciatic notch and it separates it from the lesser sciatic notch.

There are a number of features at the borders of the ilium. The anterior superior ischial spine (ASIS) and the anterior inferior ischial spine (AIIS) can be easily identified on a plain radiograph. The ASIS provides attachment for the inguinal ligament, sartorius and tensor fasciae latae. The AIIS provides attachment for the straight head of rectus femoris.

The obturator foramen is occluded by the obturator membrane. Its upper border is the superior pubic ramus. The superior border of the superior pubic ramus is sharp and forms the pectineal line. This structure together with the arcuate line of the ilium forms the iliopectineal line which can be seen as a dense structure on the plain radiograph.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 173.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 221.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 352.

Question 2: Axial MRI of the right lower leg

Answer: Medial head of the right gastrocnemius muscle

- The gastrocnemius muscle has two heads: the medial head arises from the medial condyle of the femur and the lateral head originates from the lateral condyle of the femur.
- The soleus and gastrocnemius muscle tendons join together to form the Achilles tendon, which inserts onto the calcaneus. The soleus and gastrocnemius muscles are known as the triceps surae.
- A sesamoid bone known as the fabella is commonly found in the lateral head of the gastrocnemius muscle.

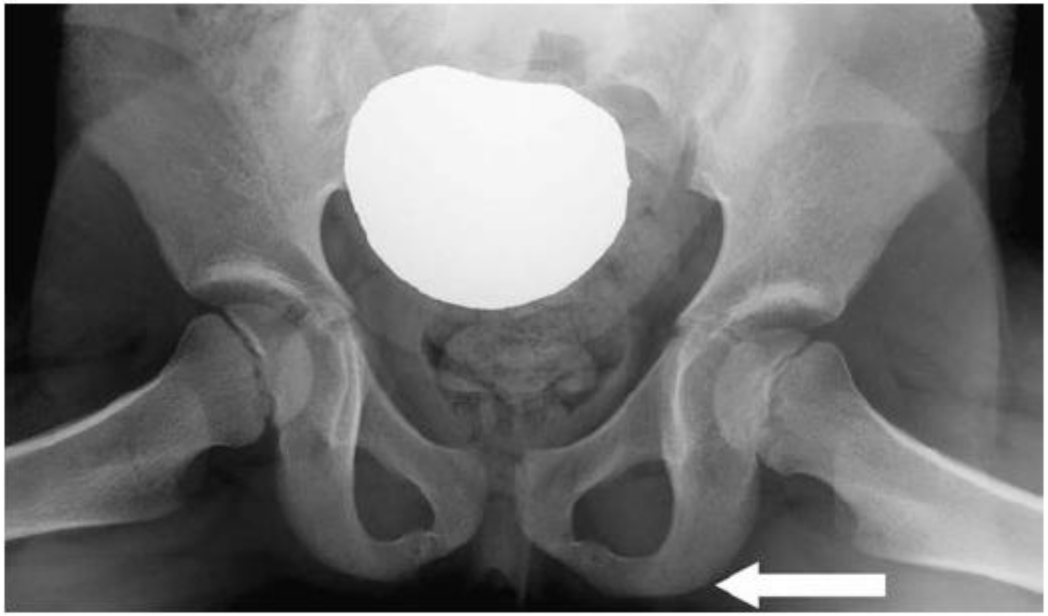
- **Question 4:**

■ Question 4: Lateral radiograph of the left ankle

Answer: Left talus

- The talus can be divided into three parts: head, neck, and body.
- It articulates with the calcaneus caudally and navicular bone anteriorly.
- The tarsal sinus is a cylindrical cavity between the talus and calcaneus on the lateral aspect of the foot. It runs medially and opens posterior to the sustentaculum tali of the calcaneus.

- **Question 7:**



Question 7: Frogleg lateral hip radiograph

Answer: Left ischial tuberosity

- On this radiograph, the ischial tuberosity is seen lateral to the inferior pubic ramus; however, in reality, it is much more posterior.
- The ischial tuberosity is the common attachment for the hamstrings (semimembranosus, semitendinosus, and biceps femoris).
- Note the appropriate use of a gonad shield.

Question 13:

Question 13: Lateral radiograph of the knee

Answer: Hoffa's fat pad

- The Hoffa's fat pad is the fat pad posterior to the patellar tendon and anterior to the knee joint.
- Fat is low density so it appears dark on plain radiography. On both T1- and T2-weighted MRI sequences, fat will appear high intensity (bright).
- A fluid level in the Hoffa's fat pad or within the suprapatellar recess of the joint is called a lipohaemarthrosis and is a direct sign of an intra-articular fracture.

Question 17:

Question 17: AP radiograph of the pelvis

Answer: Right gluteus medius muscle

- The gluteus medius muscle attaches to the lateral aspect of the greater trochanter.
- The obturator externus and the superior and inferior gemellus muscles attach to the medial aspect of the greater trochanter.

- Question 25:

Question 25: Lateral radiograph of the ankle

Answer: Sustentaculum tali

- The calcaneus is a complex bone. It articulates anteriorly with the cuboid and cranially with the talus.
- The sustentaculum tali, also known as the talar shelf, is a horizontal eminence on the medial aspect of the calcaneus that serves as the site of ligamentous attachment.

- **Question 36:**

■ Question 36: AP radiograph of the left foot

Answer: Distal phalanx of the left great toe

- The flexor hallucis longus muscle is the most powerful muscle within the posterior compartment of the leg—the other muscles being flexor digitorum longus and tibialis posterior.
- The flexor hallucis longus muscle originates from the middle third of the fibula and travels in an oblique direction down the leg and under the sustentaculum tali of the calcaneus to run on the plantar aspect of the foot and inserts into the base of the great toe distal phalanx.

Question 4.7

Name the structures labelled **A** to **E**.

4.7 AP oblique X-ray of the left foot

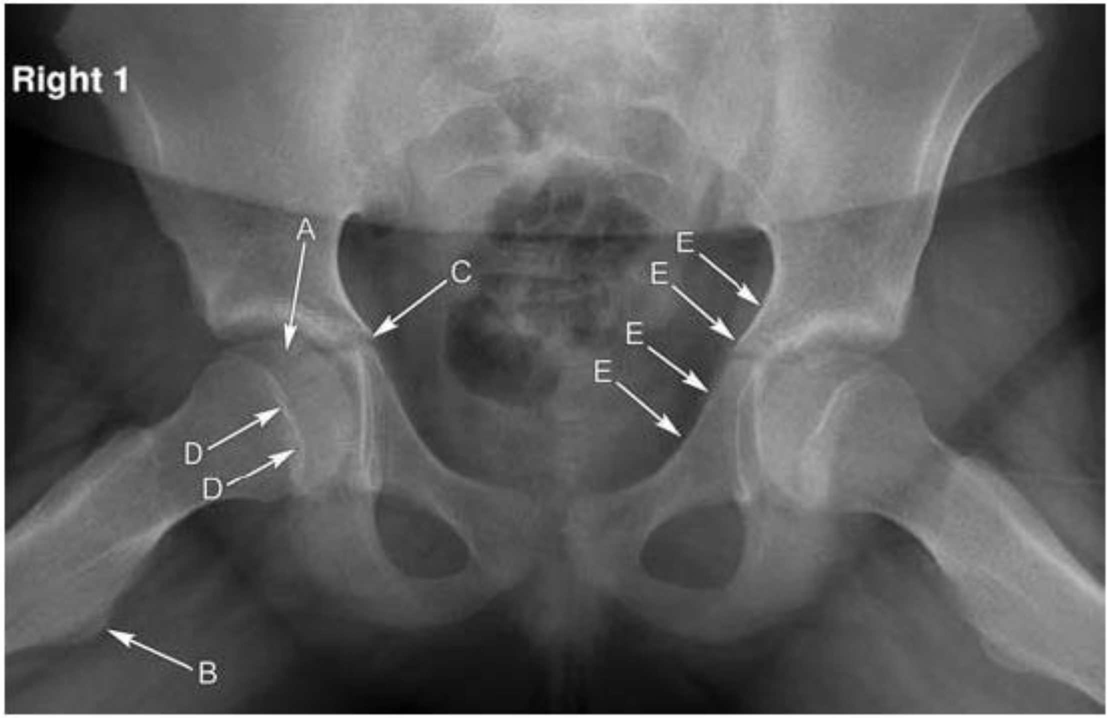
A Proximal phalynx little (fifth) left toe,
B Left sesamoid bone.
C Left lateral cuneiform.
D Left os peroneum.
E Left talonavicular joint.

There are a number of accessory ossicles of the foot, which are normal variants and should not be confused with fractures. The os peroneum is an accessory ossicle located lateral to the cuboid.

A sesamoid bone is a bone embedded in a tendon, the largest example in the body being the patella (located within the quadriceps tendon). They are also found in the hand adjacent to the head of the first metacarpal (within the tendons flexor pollicis brevis and adductor pollicis). Within the foot, two sesamoid bones are located adjacent to the head of the first metatarsal (both within the tendon of flexor hallucis brevis).

Please refer to Question 1.20 for the other accessory ossicles of the foot and their locations.

Question 4.19



Name the structures labelled **A** to **E**.

4.19 Frog-leg X-ray of the pelvis

A Right femoral capital epiphysis.
B Right lesser trochanter.
C Right triradiate cartilage or 'Y' cartilage of the acetabulum.
D Right femoral capital epiphyseal plate or physis.
E Left iliopectineal line.

The frog-leg lateral pelvis X-ray is taken with the child supine with the knees flexed and the legs abducted with the heels together. It is used for the child presenting with hip pain for detection of a slipped capital femoral epiphysis. The femoral epiphysis first slips posteriorly before moving medially. This is why the subtle posterior movement of the epiphysis is best viewed on the lateral projection. The triradiate cartilage is the common physis of the three pelvis bones (the ilium, ischium and pubis), from which acetabular growth occurs.

Question 6.7

Name the structures labelled **A** to **E**.

6.7 AP X-ray of a paediatric ankle

A Left tibial diaphysis.
B Left tibial physis (or epiphyseal plate).
C Left tibial epiphysis.
D Left fibular metaphysis.
E Left cuboid.

Long bones can be divided into three sections – the diaphysis (shaft), metaphysis (junction between diaphysis and epiphysis), and the epiphysis (expanded articular end of a long bone). In the paediatric skeleton the growth plate (physis) is seen in between the metaphysis and the epiphysis.

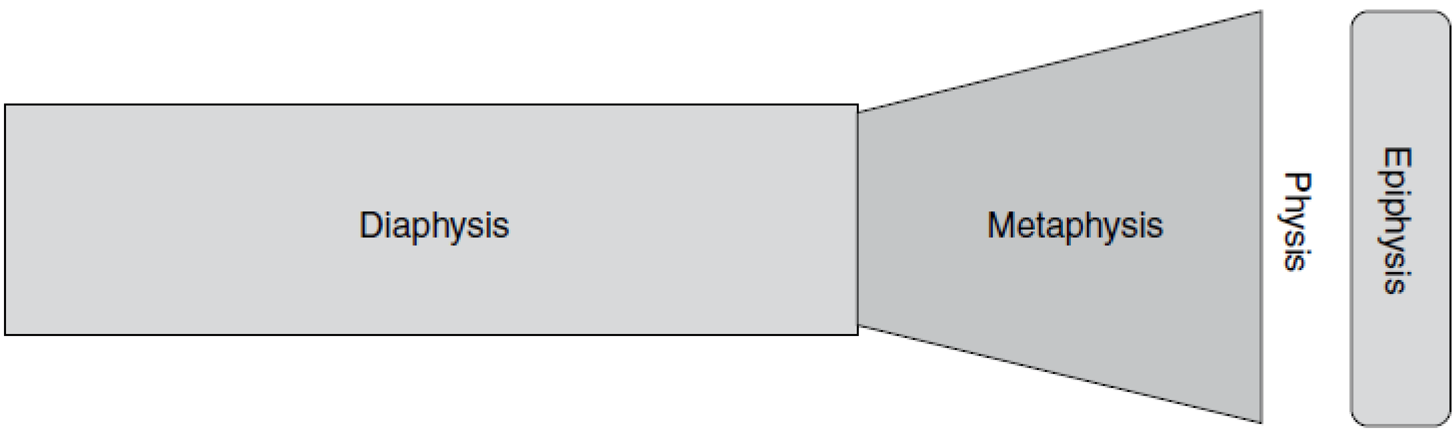
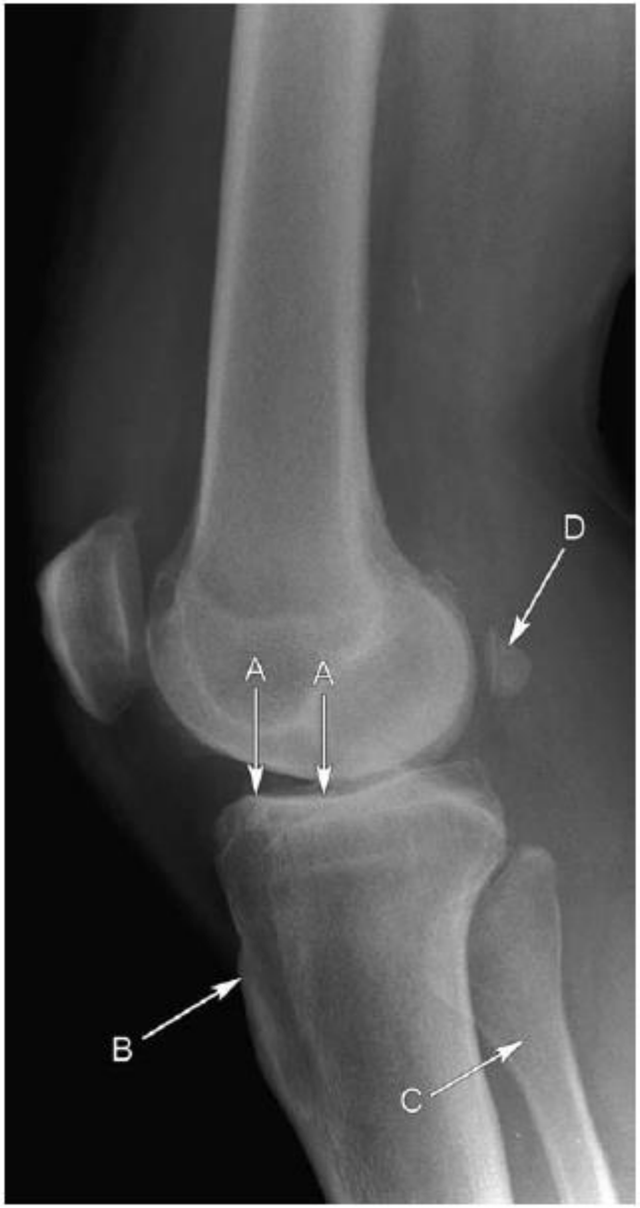


Figure 6.1 The paediatric skeleton

Question 6.17



This is lateral X-ray of the right knee.
Name the structures labelled **A** to **D**.
E What structure may be damaged by a fracture at the level of **C**?

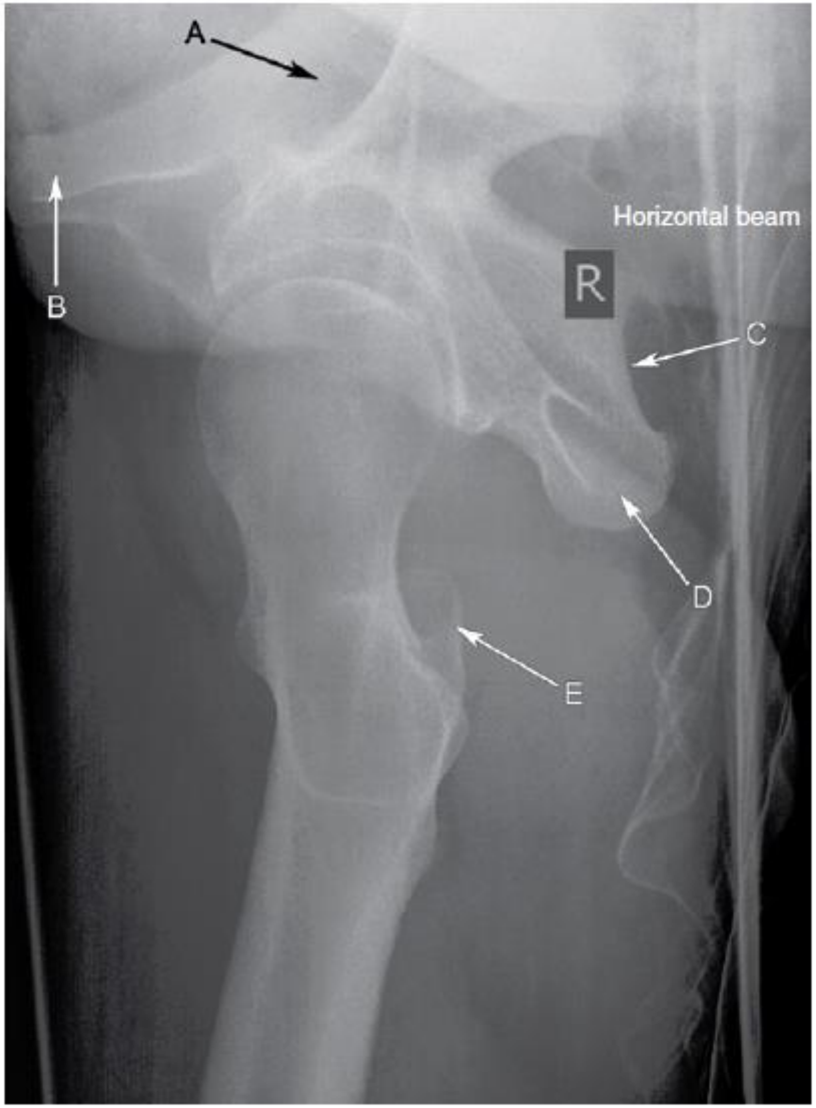
6.17 Lateral X-ray of the right knee

A Tibial plateau.
B Tibial tuberosity.
C Neck of fibula.
D Fabella.
E Common peroneal nerve.

The common peroneal nerve is a terminal division of the sciatic nerve. It passes obliquely along the lateral side of the popliteal fossa before wrapping around the head and neck of the fibula. Fractures of the fibula in this region can cause damage to the common peroneal nerve, leading to a foot drop.

The fabella is a sesamoid bone occasionally found within the tendon of the lateral head of gastrocnemius muscle. It is a normal variant present in approximately 10–30% of people and is frequently mistaken for a loose body. There can be two or three parts (fabella bipartita and tripartita). The tibial tuberosity gives rise to the patella ligament and is a common site of pathology in active adolescents (Osgood–Schlatter disease, also known as tibial tubercle apophyseal traction injury).

Question 9.6



Name the structures labelled **A** to **E**.

9.6 Lateral X-ray of the hip

A Right obturator foramen.
B Right superior pubic ramus.
C Right lesser sciatic notch.
D Right ischial tuberosity.
E Right greater trochanter.

The obturator foramen is formed by the ischium and pubis bones. The obturator canal passes through this and contains the obturator artery, nerve and vein. The lesser sciatic notch is covered by the sacrotuberous and sacrospinous ligaments to become the lesser sciatic foramen. This foramen transmits the obturator internus tendon and nerve, and the internal pudendal vessels and nerve. The ischial tuberosity gives rise to the adductor magnus, the semimembranosis, the long head of the biceps femoris, the semitendinosis and the sacrotuberous ligament.

Question 9.17

This is a lateral X-ray of the right ankle.
Name the structures labelled **A** to **E**.

9.17 Lateral X-ray of the right ankle

A Navicular.
B Talar dome.
C Subtalar joint.
D Calcaneous.
E Cuboid.

There are seven tarsal bones in each foot: the talus, calcaneus, navicular, cuboid and three cuneiform bones. The talus and calcaneus form the hindfoot and the cuboid, navicular and cuneiforms form the midfoot.

The subtalar joint is the articulation between the talus and the calcaneus and allows inversion and eversion of the foot.

For further descriptions of the bony anatomy of the feet see Question 1.20.

Question 10.19

Name the structures labelled **A** to **D**.
E What normal variant is present?

10.19 AP X-ray of the left ankle

A Left talar dome.
B Left talonavicular joint.
C Left navicular.
D Left medial cuneiform.
E Left os subfibulare.

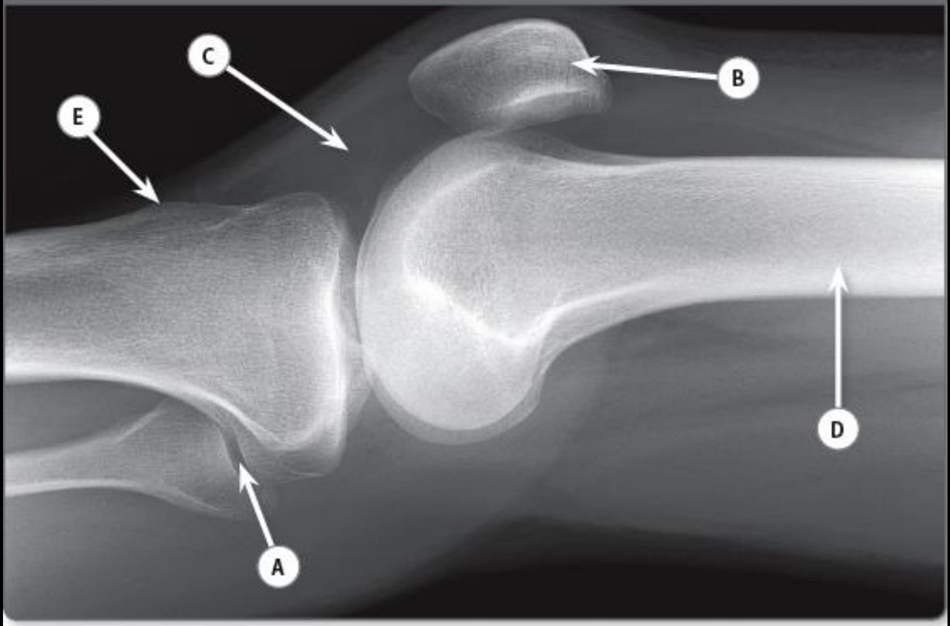
An os subfibulare is an accessory ossicle located just inferior the tip of the fibial epiphysis.

Other accessory ossicles around the ankle include:

Os tibiale externum	Also called an accessory navicular or os naviculare secundarium Ossicle located adjacent to the medial side of the navicular and within the tendon of the tibialis posterior
Os trigonum	Located posterior to the talus
Os supratalare	Located anterior superior to the talus
Os talotibiale	Located anterior to the tibia

For more information on the accessory ossicles of the foot see Question 1.20.

Case 1.1



Case 1.1

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure that inserts into the structure labelled E.	

Case 1.1

A Proximal tibiofibular joint

B Patella

C Infrapatellar (Hoffa's) fat pad

D Distal femoral diaphysis

E Patellar tendon

The patella lies in the anterior trochlear groove of the femur and is stabilised by the quadriceps tendon superiorly and the patellar tendon inferiorly. The patellar tendon courses superficial to Hoffa's fat pad and inserts onto the tibial tuberosity.

Case 1.13

Case 1.13

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 1.13

A Right sesamoid bone (in flexor hallucis brevis tendon)

B Left fourth metatarsophalangeal joint

C Right navicular bone

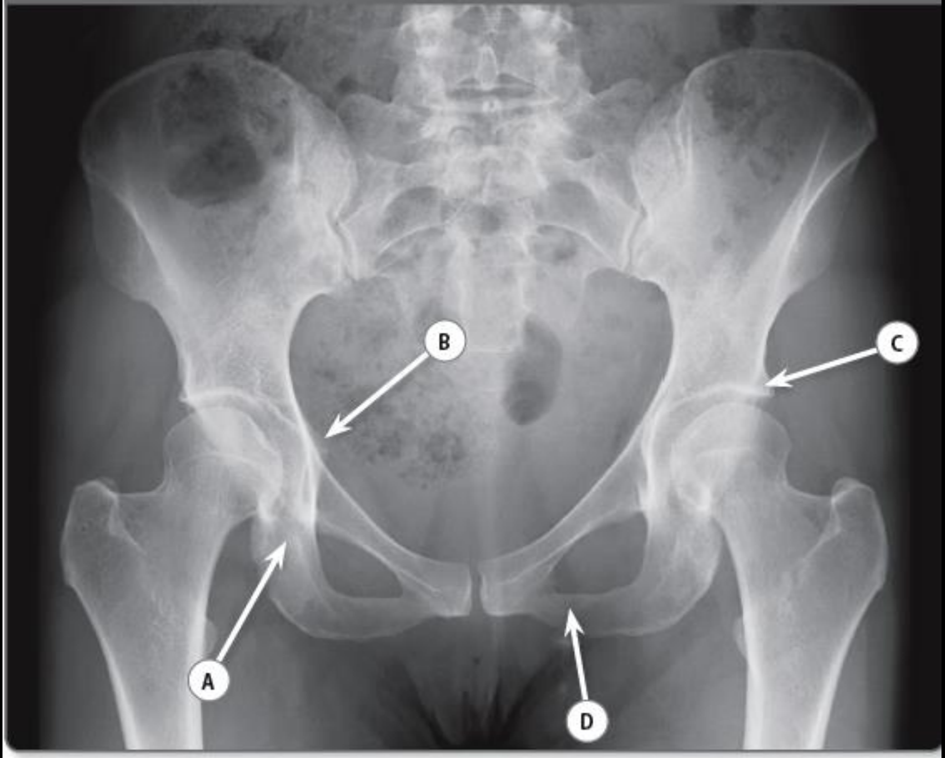
D Tuft of the distal phalanx of the left great toe

E Left intermediate cuneiform bone

Remember to name the side of the labelled structure when this information is provided on the image in question. The anatomy exam is testing your understanding of radiological anatomy but is also seeing if you can translate this into a report that is understandable by clinicians.

The osseous anatomy of the mid- and forefoot is fundamental knowledge and if you are struggling with this question please refer back to an anatomy text/atlas.

Case 2.9



Case 2.9

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	What muscle originates from the structure labelled C?	
D	Name the structure labelled D.	
E	Where is the insertion point of the right iliopsoas muscle?	

Case 2.9

A Right ischial ramus

B Right ischial spine

C Left rectus femoris

D Left inferior pubic ramus

E Right lesser trochanter

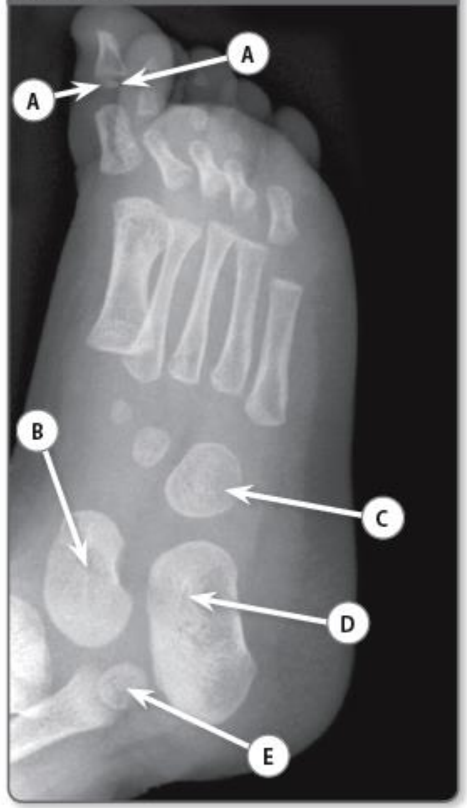
Knowledge of the muscular and tendinous attachments in the bony pelvis is important given their clinical relevance (not least in the context of avulsion fractures, particularly in adolescent patients) and this is frequently assessed in examinations.

Iliopsoas is formed from psoas major and iliacus, which merge to pass under the iliac ligament to insert onto the lesser trochanter. Iliopsoas is the most powerful hip flexor and can avulse the lesser trochanter.

Rectus femoris originates from the anterior inferior iliac spine whereas sartorius arises from the anterior superior iliac spine (as does tensor fascia lata).

The hamstring origin is the ischial tuberosity and is the most common avulsion site in the pelvis.

Case 2.19



Case 2.19

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 2.19

A Epiphysis of distal phalanx of great toe

B Talus

C Cuboid

D Calcaneum

E Distal fibular epiphysis

This is an oblique radiograph of the foot of an 18-month-old child. As would be expected for a patient of this age, the calcaneum, talus and cuboid are the most well-developed talar bones (having commenced ossification during fetal life). The ossification centre of the lateral cuneiform (the first of the cuneiforms to ossify) is better developed than the intermediate cuneiform. The medial cuneiform normally begins to ossify nearer 3 years of age, hence is not visualised on this radiograph.

Case 3.18

Case 3.18

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Which anatomical variant is present on this image?	

Case 3.18

A Left lateral cuneiform

B Left calcaneal tuberosity

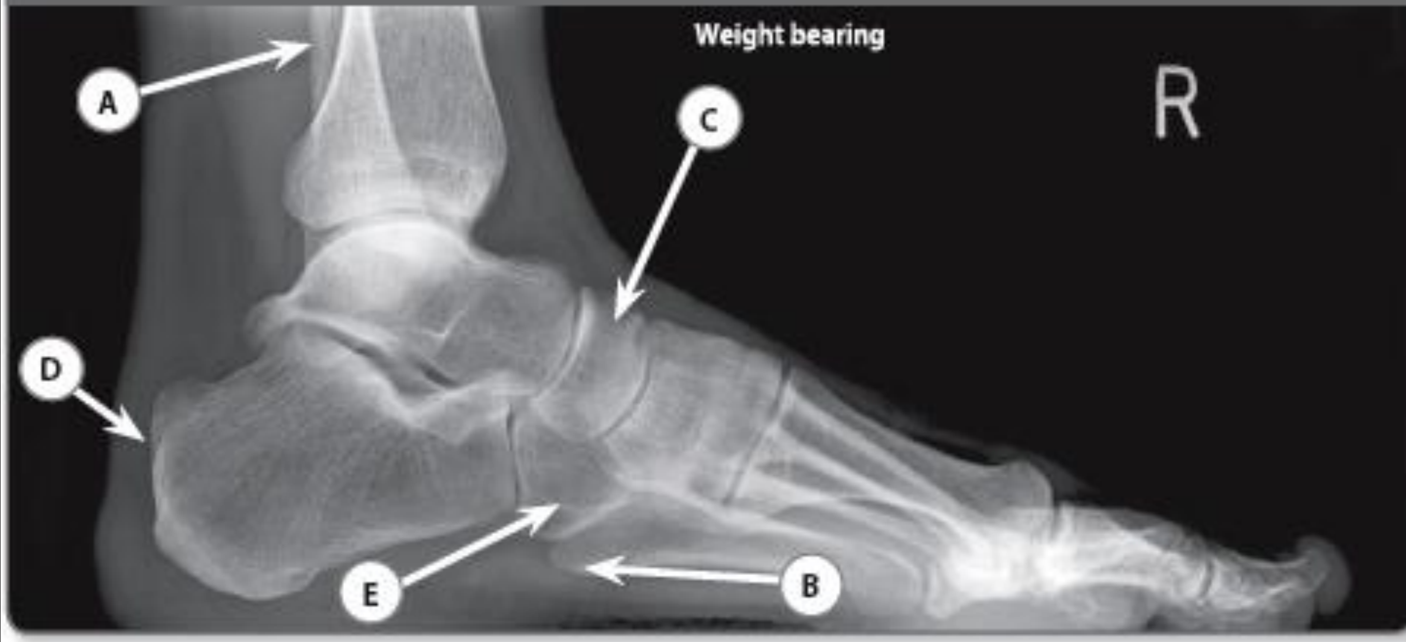
C Left cuboid

D Head of left talus

E Bipartite hallucal sesamoid bone

The hallucal sesamoid bones are present in the majority of the adult population. The most common variant is a bipartite hallucal sesamoid, as shown in this example. It is important to recognise this entity as a variant of normal and for it not to be mistaken as a sesamoid fracture. Bipartite sesamoids will demonstrate smooth, well-corticated margins, whereas fractures will have sharp irregular margins, often with overlying soft tissue swelling.

Case 6.6



Case 6.6

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the tendon that inserts into the structure labelled D.	
E	Name the structure labelled E.	

Case 6.6

A Right distal fibula

B Base of right fifth metatarsal

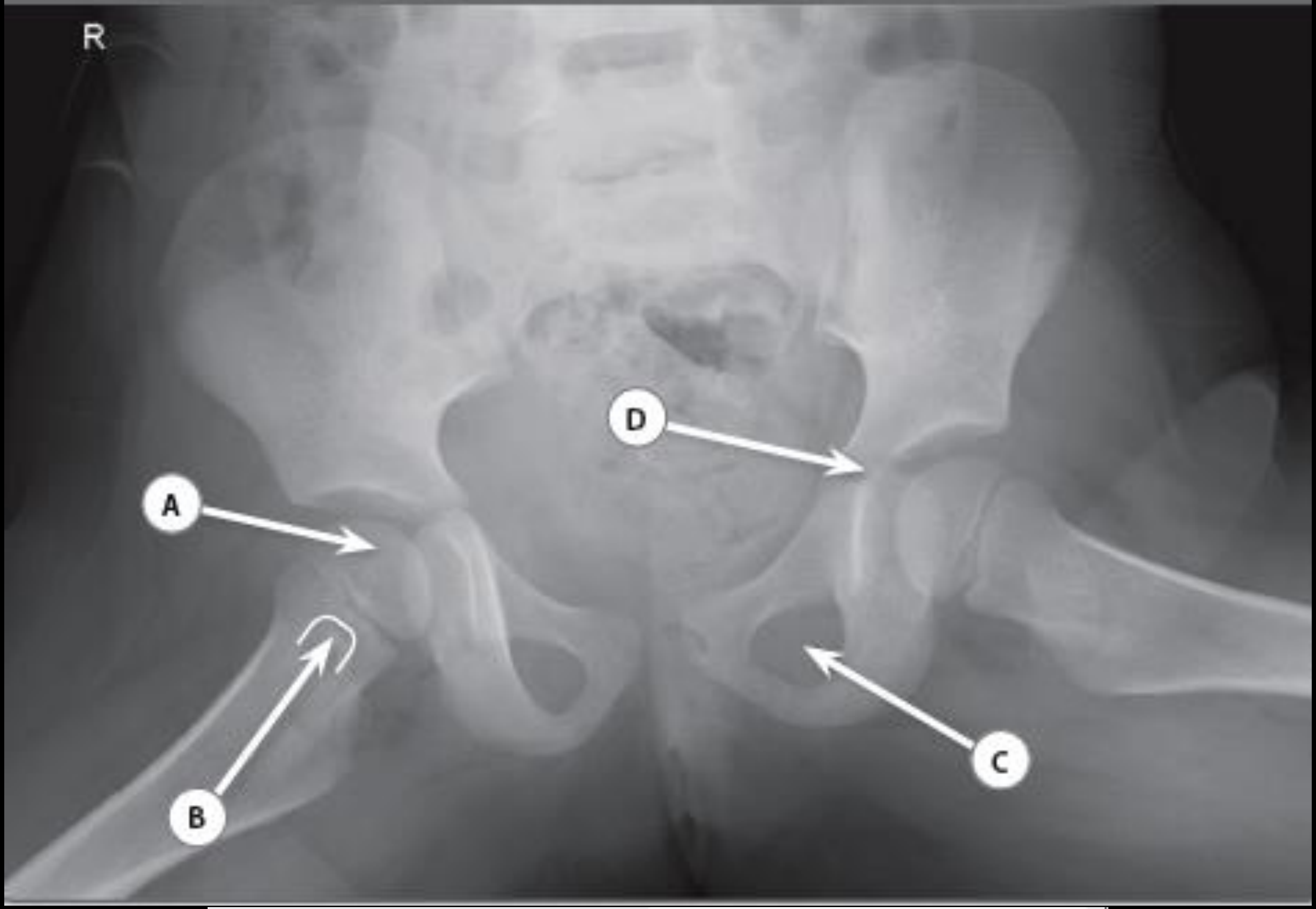
C Right navicular

D Right Achilles tendon

E Right cuboid

This question is rather simple provided the fundamental anatomy of the hind- and midfoot articulations is understood. The laterally positioned calcaneus articulates with the laterally placed cuboid, which in turn articulates with fourth and fifth metatarsals at the tarsometatarsal joint. The medially located talus articulates with the navicular, which in turn articulates with the medial, intermediate and lateral cuneiforms.

Case 7.18



E	What is the name given to this radiographic view?	

Case 7.18

A Right capital femoral epiphysis

B Right greater trochanter

C Left obturator foramen

D Triradiate cartilage of the left acetabulum

E 'Frog leg'

This is a 'frog leg' pelvic radiograph which is performed with the patient's knees flexed and the thighs maximally abducted. The primary purpose of this view is to assess for the presence of slipped capital femoral epiphyses, which are usually rendered more conspicuous than on a standard AP view with posteromedial displacement of the femoral head. On the frog leg lateral view, the greater trochanter is visualised en face, projected through the proximal femur. The Y-shaped triradiate cartilage is the point at which the ilium, ischium and pubis meet; this usually fuses by 20 years of age.

Case 8.16

Case 8.16

A Right distal fibula

B Right talus

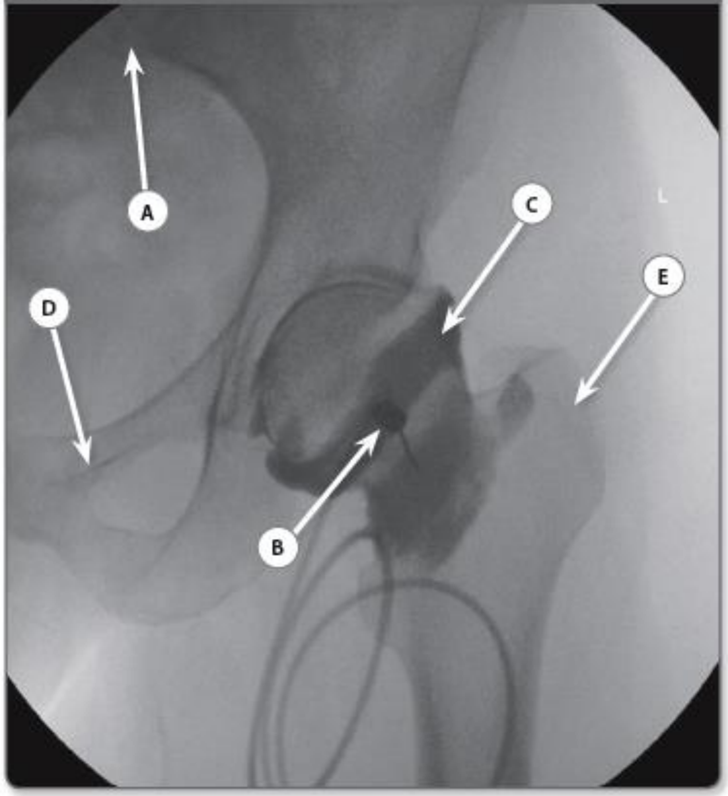
C Right navicular

D Right cuboid

E Base of the fifth right metatarsal

The calcaneum, talus and cuboid begin to ossify in utero. The cuneiform ossification centres develop at one to three years of age (progressing in the order lateral, intermediate and finally medial cuneiform). Ossification of the navicular commences in the third year of life, sometimes with several ossification centres apparent. Accordingly, of all the ossification centres visible on this radiograph of a 3-year-old child, the navicular ossification centre is the least well developed. Metatarsal and phalangeal shaft ossification centres also start to develop in utero, although ossification centres of the phalangeal epiphyses are usually not seen until after the age of 2, and the ossification centres of the metatarsal bases are typically evident after the age of 3 years.

Case 10.12



Case 10.12

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	What is the radio-opaque non-anatomical structure labelled B?	
C	In what space (labelled C) is contrast pooling?	
D	Name the structure labelled D.	
E	Name one muscle that inserts into the structure labelled E.	

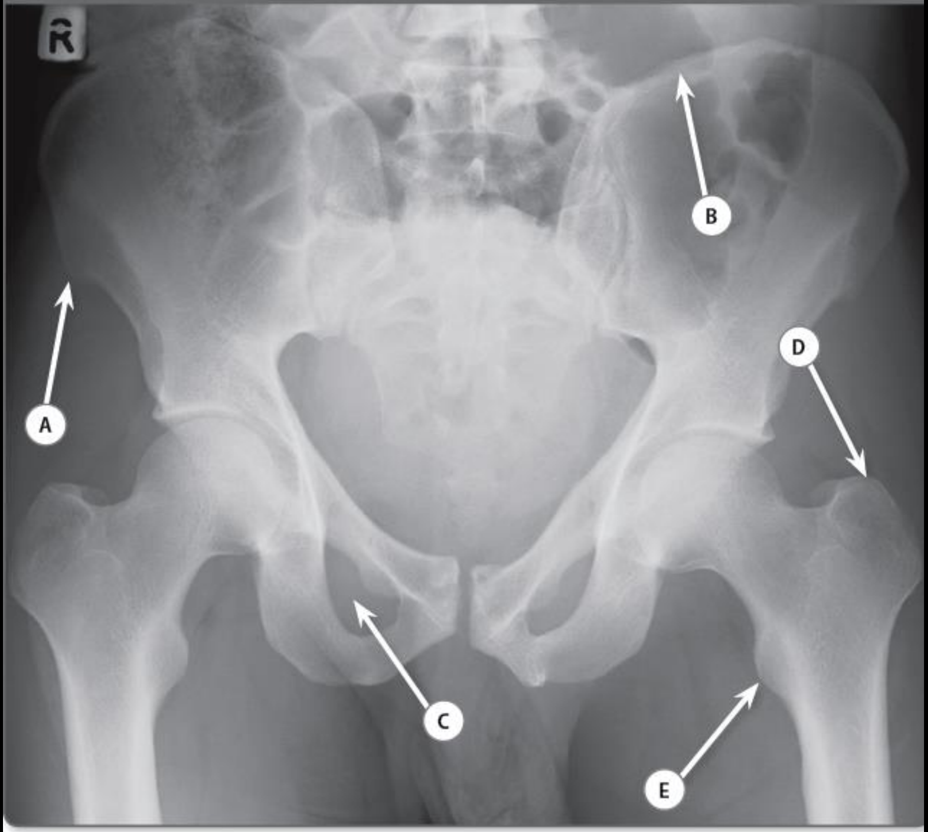
Case 10.12

- **A** Left sacroiliac joint
- **B** Hub of needle
- **C** Joint capsule of the left hip
- **D** Left superior pubic ramus
- **E** Left gluteus minimus, gluteus medius, piriformis, obturator internus or gemellus (superior or inferior) muscles

Fluoroscopic hip arthrography has been replaced by MR arthrography in modern day imaging. However, contrast joint injection is still performed under fluoroscopic guidance and the patient is subsequently imaged using MRI.

When injecting contrast into the joint, it is vital to appreciate the location of the contrast being administered. A puncture overlying the medial femoral head may result in filling of the extra-articular iliopsoas bursa. A successful intra-articular injection will show free flow of contrast around the entirety of the femoral head.

Case 12.9



Case 12.9

	QUESTION	WRITE YOUR ANSWER HERE
A	What muscle originates from A?	
B	Name the osseous structure labelled B.	
C	What nerve passes through C?	
D	Name one muscle that inserts into the structure labelled D.	
E	What muscle inserts into the structure labelled E?	

Case 12.9

A Right rectus femoris muscle

B Left iliac crest

C Right obturator nerve

D Left gluteus medius or minimus muscle

E Left iliopsoas muscle

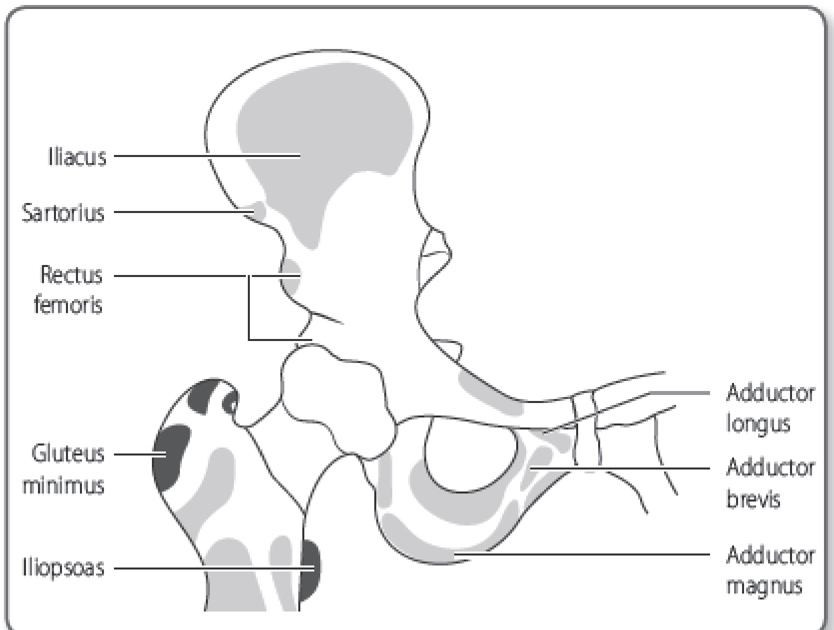
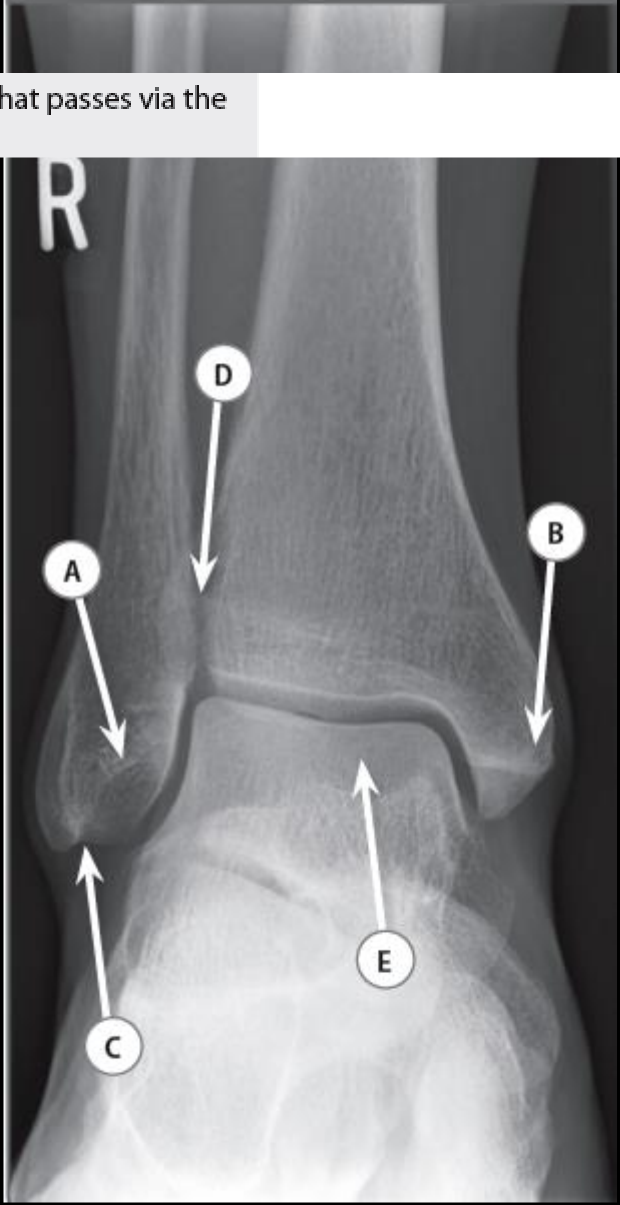


Figure 12.1 Selected muscle origins and insertions of the pelvis.

Case 12.15

C	Name a tendon that passes via the space labelled C.	



Case 12.15

A Right lateral malleolus

B Right medial malleolus

C Right peroneal brevis/longus tendons

D Right distal tibiofibular syndesmosis

E Dome of the right talus

Structural stability of the ankle is provided by numerous bone and ligamentous articulations, most notably involving the distal tibia and fibula. The distal tibiofibular syndesmosis acts as a fulcrum of stability of the ankle joint which, if disrupted, renders any ankle injury unstable.

The medial malleolus is a pyramidal process of the distal tibia. The lateral malleolus is the terminal fibula. The malleoli provide horizontal stability of the joint due to their strong ligamentous attachments.

The medial flexors of the ankle, which run under the medial malleolus, include: Tom, Dick and Harry – Tibialis posterior, flexor Digitorum longus, and flexor Hallucis longus.

The lateral flexors of the ankle, the tendons of which run under the lateral malleolus, include peroneus brevis and peroneus longus.

Case 13.7

se 13.7

UESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the tendon which attaches to the structure labelled D.	
E	Name the structure labelled E.	

Case 13.7

A Middle phalanx of fourth toe

B Lateral malleolus/distal fibula

C Interphalangeal joint of great toe

D Peroneus brevis tendon

E Cuboid

The fundamentals will allow you to score full marks for this question:

1. The great toe only has two phalanges, hence interphalangeal joint
2. The base of the fifth metatarsal is the insertion site for the peroneal brevis tendon, one of the two lateral ankle flexors
3. The cuboidal bone articulates with the bases of the fourth and fifth metatarsals
4. The medial, intermediate and lateral cuneiforms articulate with the first, second and third metatarsal bases respectively.

Case 14.13

Case 14.13

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	What structure attaches to D?	
E	What accessory ossicle is present?	

Case 14.13

A Dome of right talus

B Right navicular bone

C Head of right talus

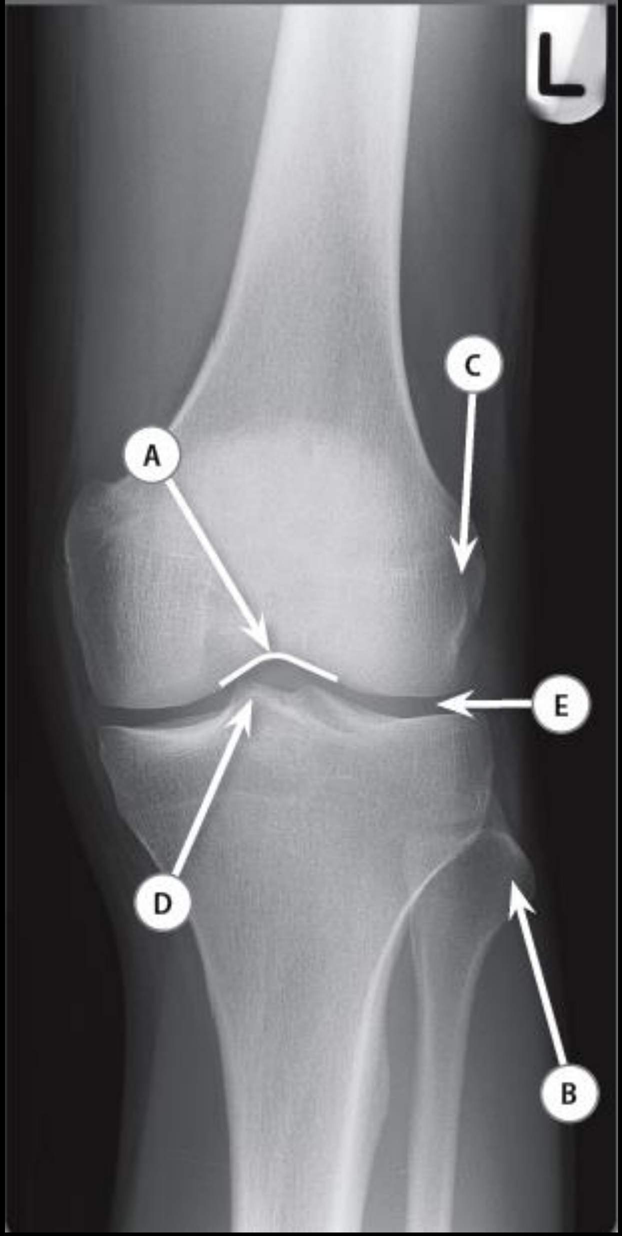
D Right plantar fascia

E Os trigonum

Accessory ossicles of the foot are seen in approximately one in five people. There are at least 15 known accessory ossicles, the most commonly seen being:

- os tibiale externum (accessory navicular)
- os fibulare (peroneum)
- os trigonum
- os supranaviculare

Case 15.6



Case 15.6

A Intercondylar notch of the left femur

B Head of left fibula

C Lateral condyle of left femur

D Medial prominence of tibial spine (intercondyloid eminence)

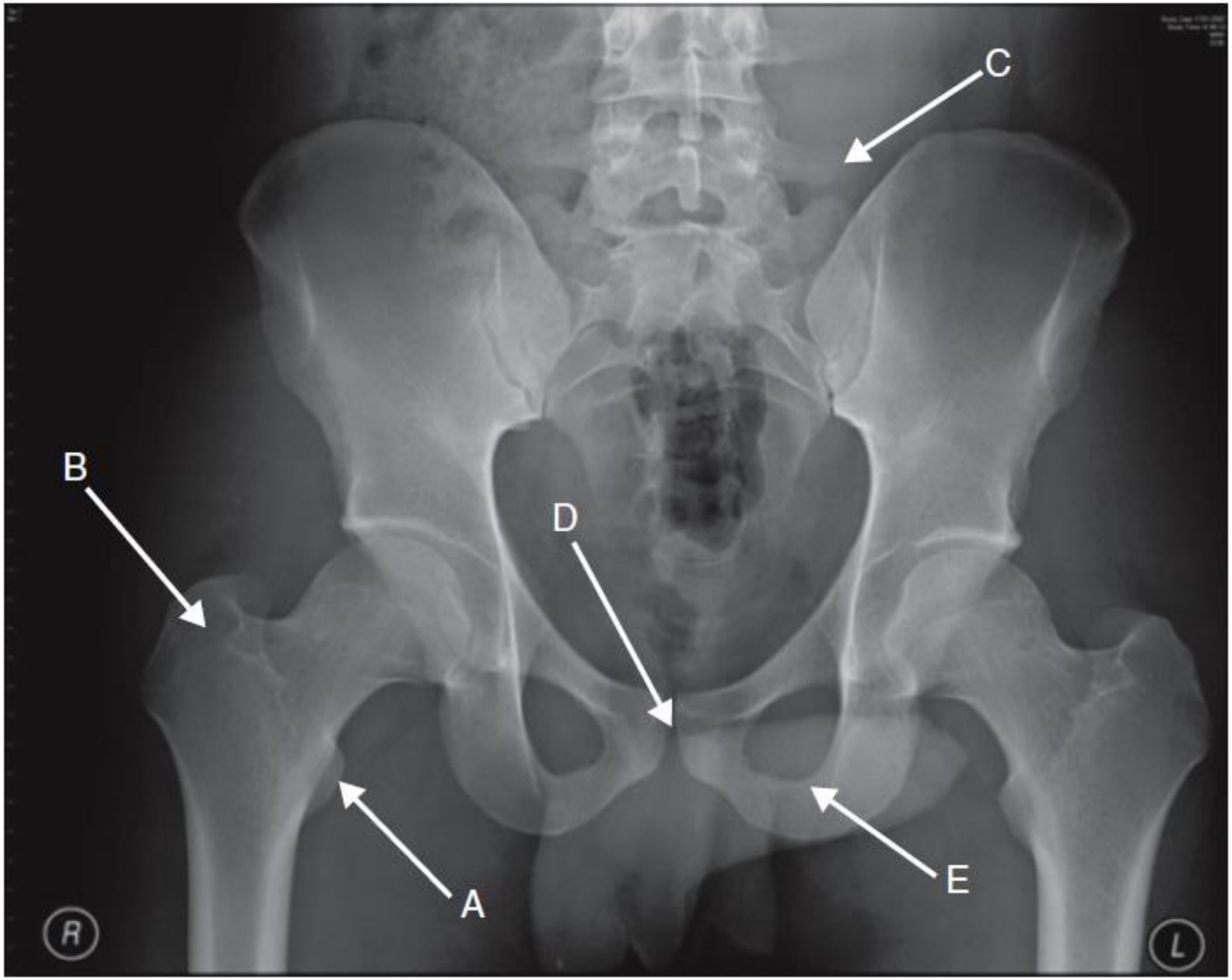
E Left lateral meniscus

Four bones are evident on the frontal knee radiograph:

1. distal femur
2. proximal tibia – medial
3. proximal fibula – lateral
4. patella – superimposed onto the distal femur. Depending on the beam angle, you may see the inferior patellar pole projected over the intercondylar notch of the distal femur

Remember the fibu**LA** lies **LA**teral to the tibia.

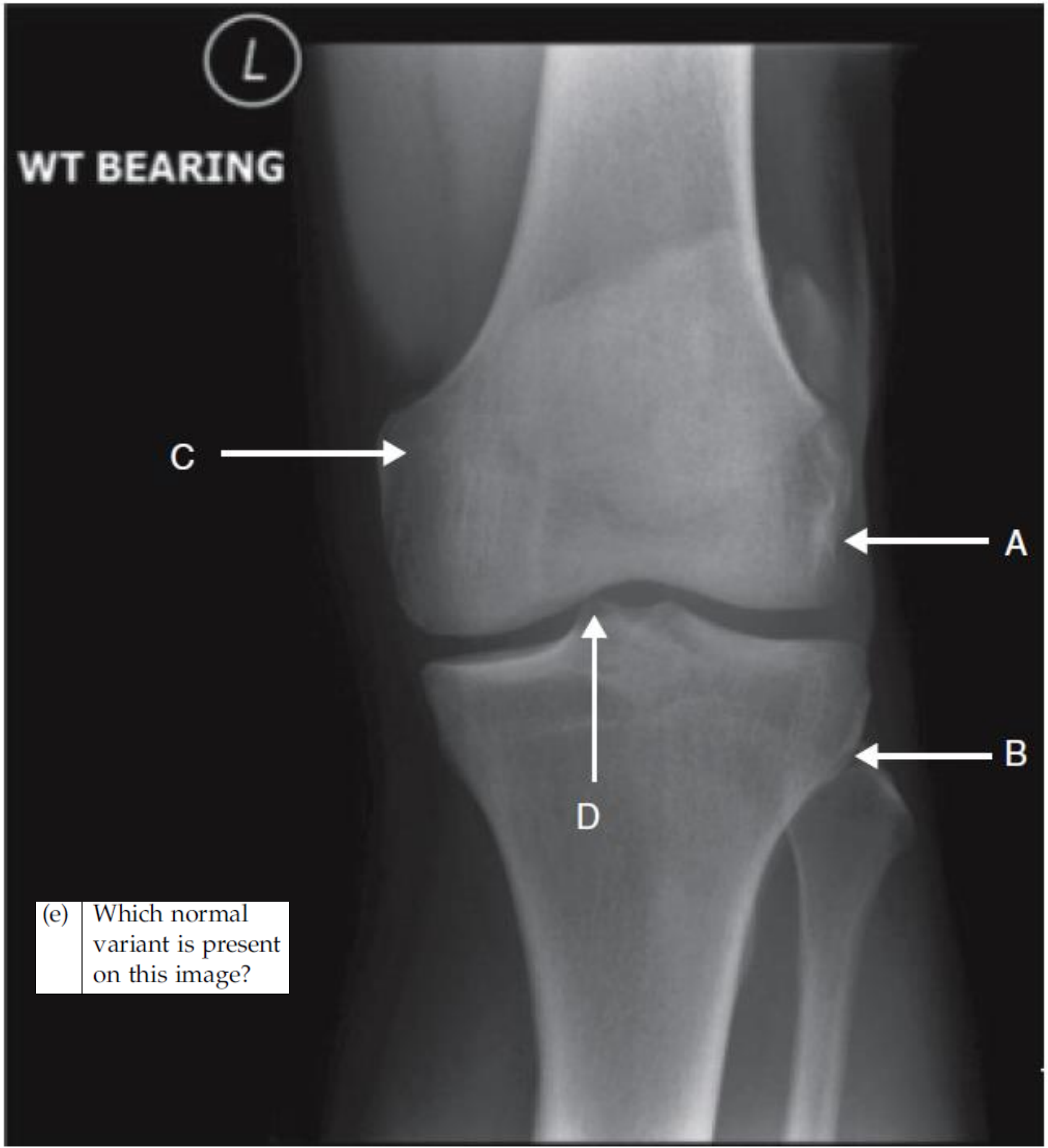
Case 3.1



3.1 AP radiograph of the pelvis

(a) Lesser trochanter of the right femur. The iliopsoas tendon attaches here. This is a powerful flexor of the hip.
(b) Greater trochanter of the right femur. Gluteus medius and gluteus minimis attach here. These tendons act to perform hip abduction and lateral rotation. They can produce avulsion fractures of the greater trochanter in trauma.
(c) Left L5 transverse process. The ilio-lumbar ligament attaches here. Traction of this ligament in pelvic trauma can cause an avulsion fracture of the transverse process. It also acts as an anatomical landmark on MRI for identifying the L5 vertebral body.
(d) Pubic symphysis. It is a secondary cartilaginous joint.
(e) Left inferior pubic ramus. Adductor magnus and adductor brevis attach here acting to adduct the hip.

Case 5.1



(e)	Which normal variant is present on this image?

5.1 AP radiograph left knee

(a) Popliteus tendon. This point represents the popliteal groove or sulcus within which the popliteus tendon inserts. The popliteus tendon is an important structure that contributes to stability of the postero-lateral corner of the knee.

(b) Styloid process of the fibular head. Biceps femoris, a powerful hamstring muscle, attaches here along with the fibular collateral ligament and the arcuate ligament complex. The fibular styloid process can be avulsed during high energy trauma to the postero-lateral corner of the knee producing an 'arcuate sign' on radiographs.

(c) Medial collateral ligament (MCL). The MCL is an important medial stabilizer of the knee, resisting valgus stress. A bony avulsion of the proximal MCL attachment may produce a non-united fragment called a Pellegrini–Stieda lesion, visible on AP radiographs.

(d) Medial tibial spine. The medial tibial spine bears the attachment of the medial meniscal roots along with the footprint of the antero-medial bundle of the anterior cruciate ligament.

(e) Bipartite patella. A bipartite patella is an unfused secondary ossification centre on the supero-lateral corner of the patella. These must not be mistaken for acute fractures, but may become symptomatic if the synchondrosis between the two bone fragments is disrupted following direct trauma.

Case 8.9

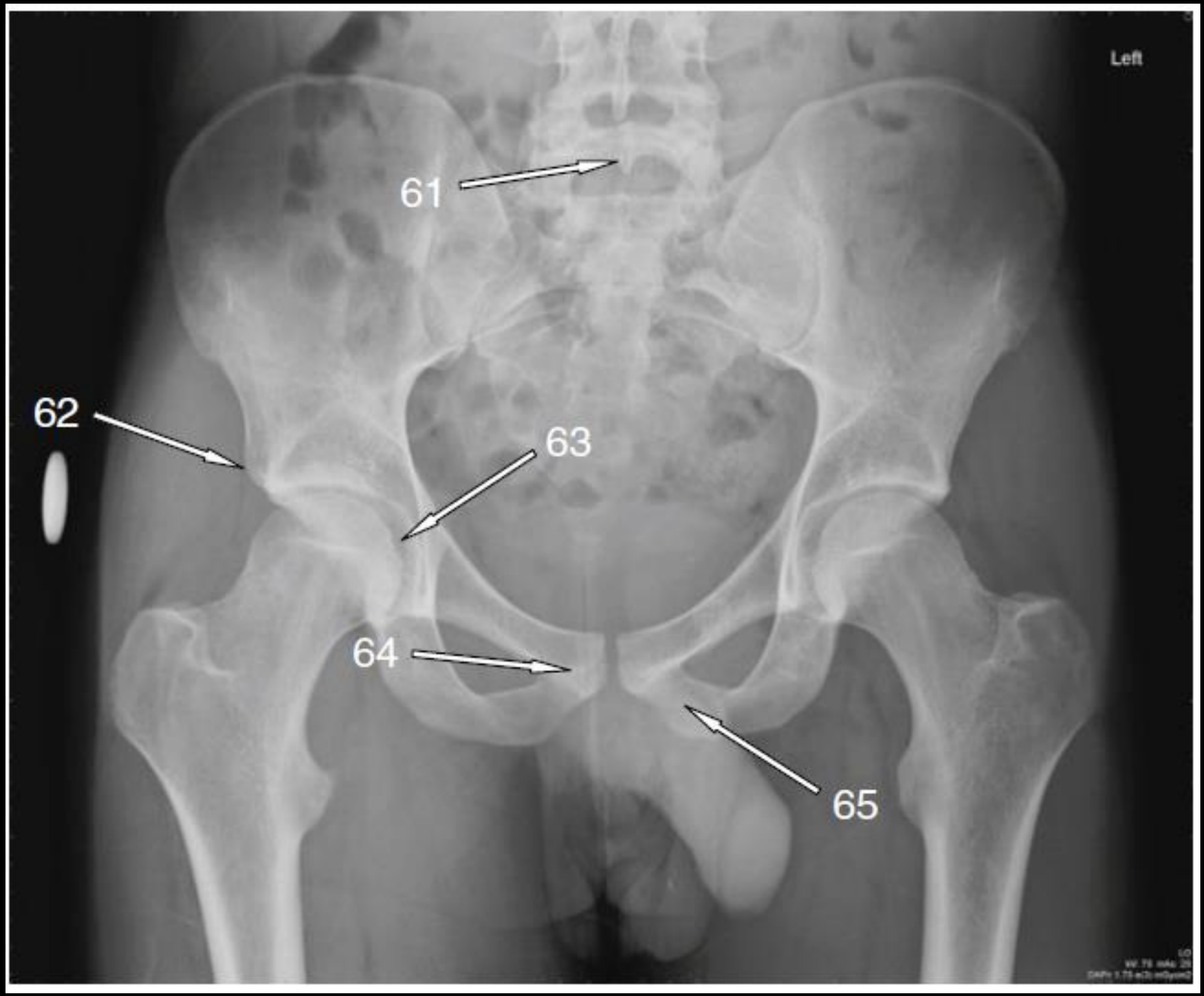
(e)	Which normal variant is present on this image?

8.9 AP and oblique radiograph of the right foot

(a) First metatarso-phalangeal joint. A common place to look for primary osteoarthritis which results clinically in hallux rigidus. If rheumatoid arthritis affects this joint then the result is hallux valgus. Gout also has a predilection for this joint although is now rarely seen on imaging due to the efficacy of medical management.
(b) Base of the second metatarsal. This is held in place by a mortice made by the medial, middle and lateral cuneiform bones and is informally referred to as the Lisfranc joint. It is important to verify alignment on trauma films to rule out a midfoot (Lisfranc) dislocation:

- On the AP view the medial margin of the base of the second metatarsal should align with the medial margin of the middle cuneiform.
- On the oblique view the medial margin of the base of the third metatarsal should align with the medial margin of the lateral cunieform.

(c) Tuberosity of the fifth metatarsal. A common place of avulsion fractures due to inversion injuries. If the fracture line lies within the proximal diaphysis (distal to the joint line of the fourth tarsometatarsal joint), then this fracture is known as a Jones' fracture, which notoriously results in delayed or non-union. It is not an avulsion fracture. The Jones' fracture is named after Sir Robert Jones (1857–1933), Professor of Orthopaedic Surgery at Liverpool University.
(d) Calcaneum.
(e) Os tibiale externum. This can lie entirely separately within the tendon of tibialis posterior (type 1) or have a cartilaginous (type II) or osseous (type III) connection with the medial aspect of the navicular bone.


Left
61
62
63
64
65

Pelvic Radiograph

61. Spinous process L5 vertebra
62. Right anterior inferior iliac spine
63. Right fovea capitis of femur
64. Right body of pubic bone
65. Left inferior ramus of pubic bone


L
96
97
100
99
98

Foot Radiograph

96. Left middle phalanx 2nd toe
97. Left 2nd metatarsophalangeal joint
98. Left talus (head of talus)
99. Left navicular bone
100. Left styloid process 5th metatarsal

35.	How old is this patient?

Ankle Radiograph

31. Talus (neck of talus)
32. Distal tibial physeal line
33. Unfused calcaneus secondary ossification centre
34. Navicular bone
35. Between 5 years old and puberty

The calcaneus has two ossification centres. The posterior centre ossifies at age 5 and fuses at puberty.


L
86
87
88
89
90

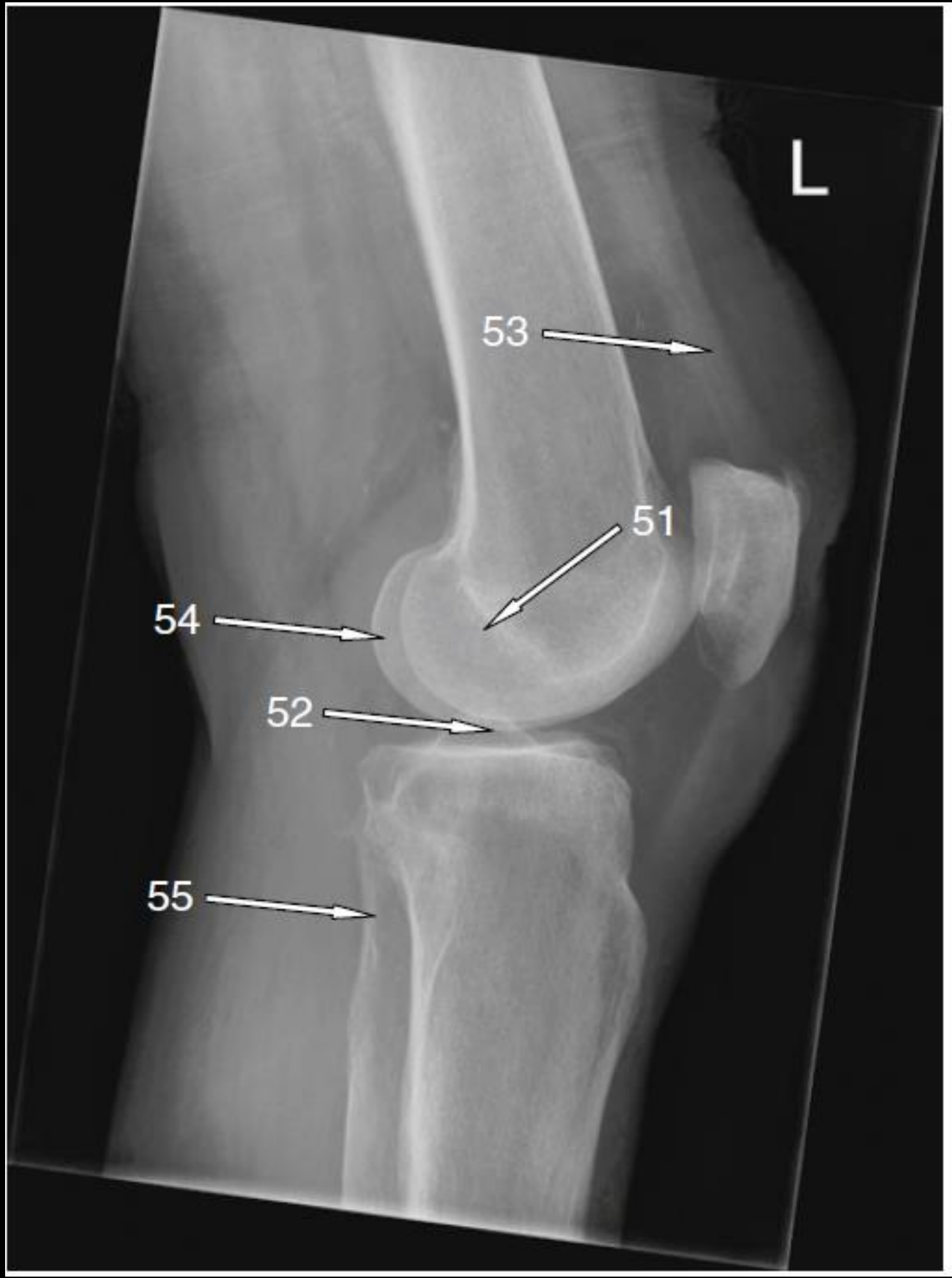
Foot Radiograph

86. Left 1st metatarsophalangeal joint
87. Left sesamoid bone in flexor hallucis brevis tendon
88. Medial malleolus of left tibia
89. Left cuboid
90. Left calcaneus


L
81
84
82
83
85

Ankle Radiograph

81. Left diaphysis tibia
82. Left lateral malleolus (of fibula)
83. Left talus
84. Left tibio-talar joint
85. Unfused epiphysis left medial malleolus (of tibia)


L
53
51
54
52
55

Knee Radiograph

51. Intercondylar fossa (Left)
52. Tubercles of intercondylar eminence/tibial spine (Left)
53. Left quadriceps tendon
54. Left femoral condyle
55. Neck of fibula (Left)

Case 6.17

Case 6.17

A Right proximal tibial epiphysis

B Right cuboid

C Right distal femoral epiphysis

D Right distal tibial metaphysis

E Right tibial diaphysis

Anteroposterior radiograph of the right tibia/fibula (child).

For further discussion see Chapter 4, Cases 4.2–4.8.

Case 5.15

Case 5.15

A Right calcaneocuboid joint

B Right navicular

C Right middle cuneiform

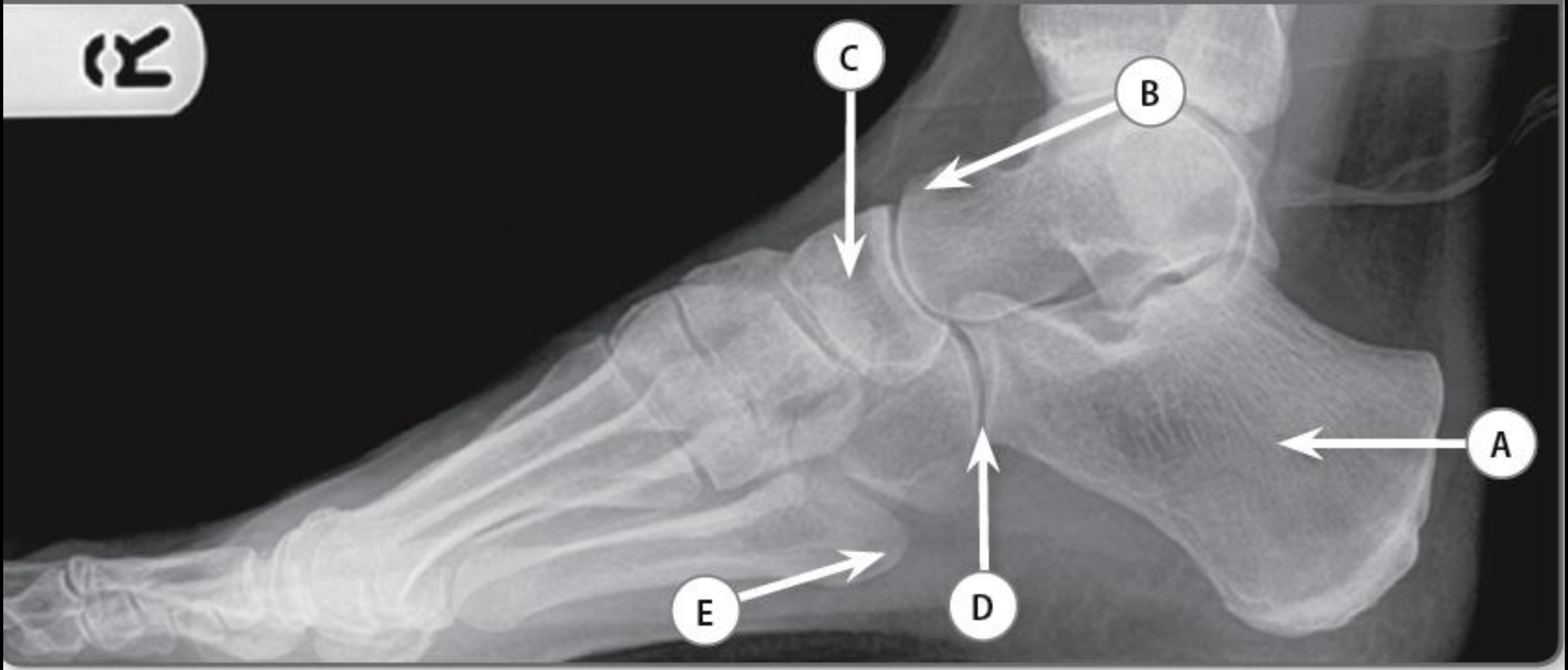
D Right 4th metatarsal

E Right cuboid

Dorsoplantar and dorsoplantar oblique radiographs of the right foot.

For further discussion see Chapter 4, Cases 4.1 and 4.2.

Case 5.16



Case 5.16

A Right calcaneum

B Head of the right talus

C Right navicular

D Right calcaneocuboid joint

E Base of the right 5th metatarsal

Lateral weight bearing radiograph of the right foot.

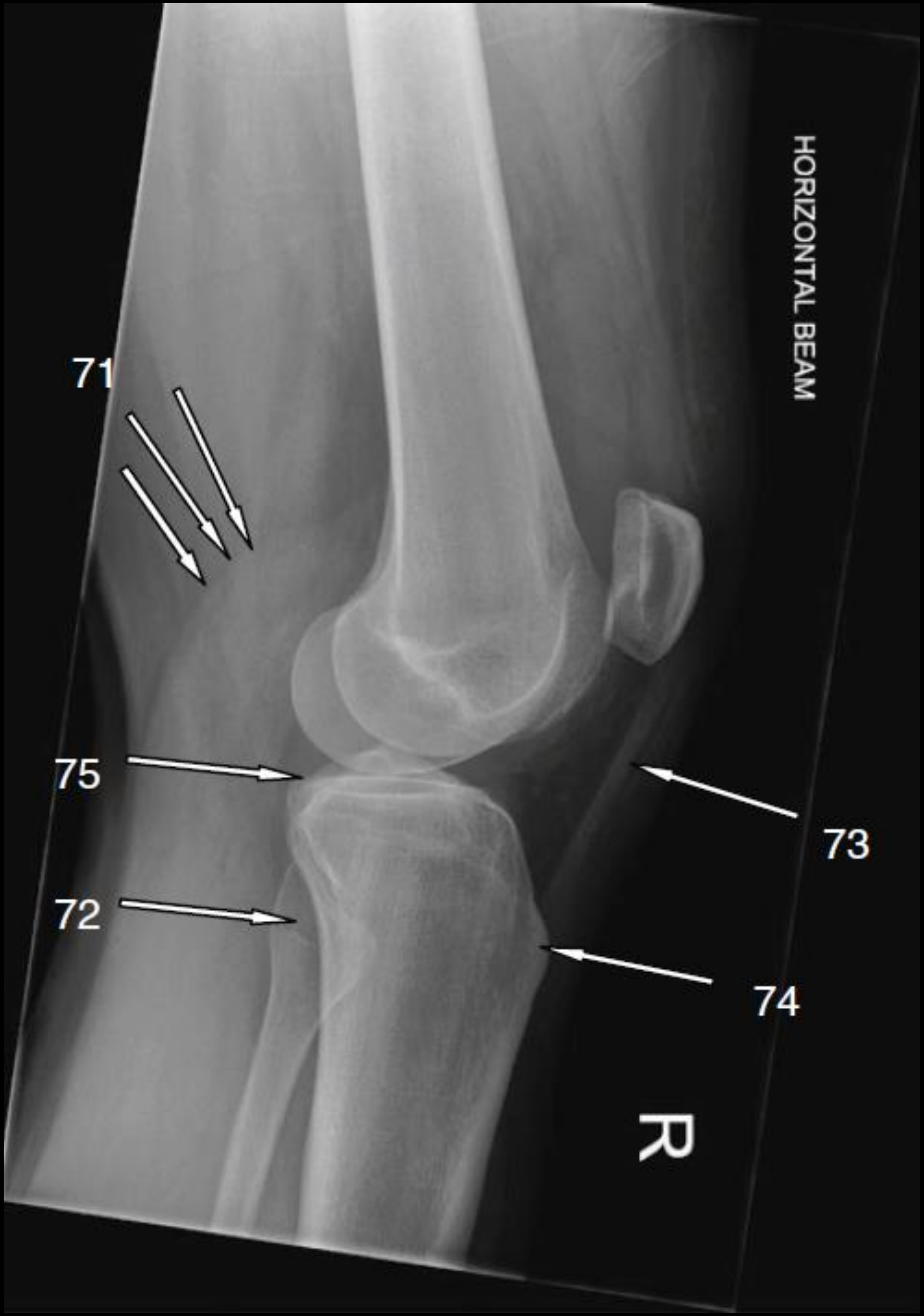
For further discussion see Chapter 4, Cases 4.1 and 4.2.


Right
27
26
29
28
30

Foot Radiograph

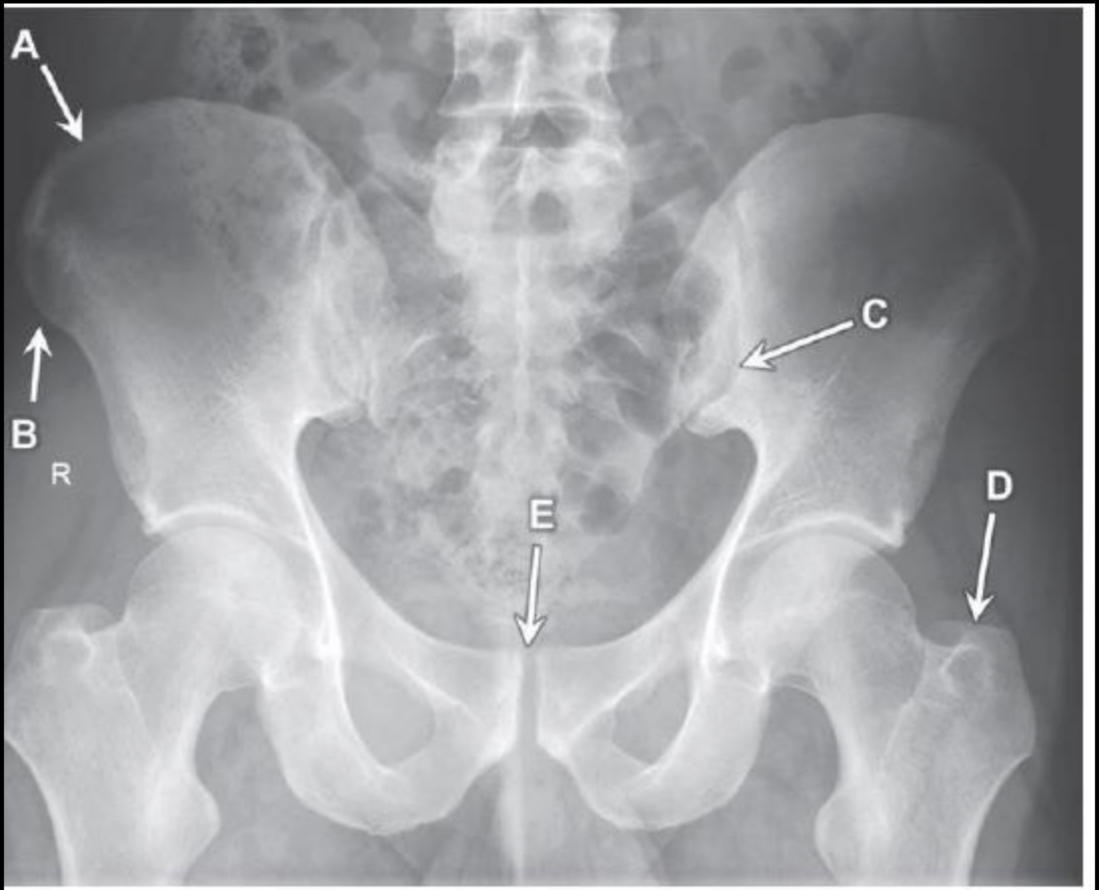
26. Right 1st metatarsophalangeal joint
27. Right head of 2nd metatarsal
28. Right cuboid
29. Right proximal phalanx of little toe
30. Right talar dome/talus

Look carefully where the arrow head is indicated, i.e. joint or the bone. On an oblique view the 3rd metatarsal should be in line with the lateral cuneiform bone.


HORIZONTAL BEAM
71
75
72
73
74
R

Knee Radiograph

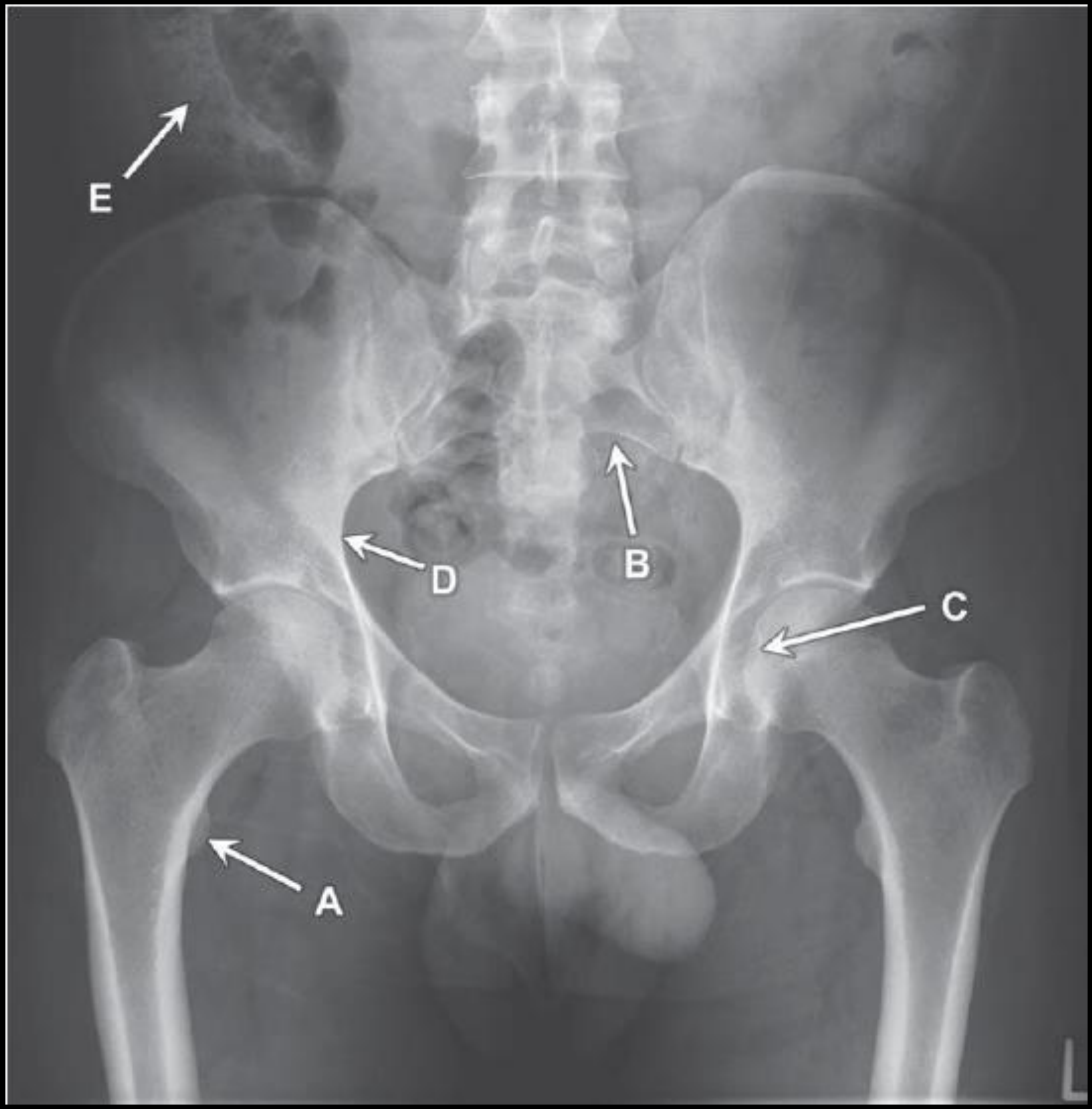
71. Right gastrocnemius muscle
72. Right head of fibula
73. Right patellar ligament
74. Right tibial tuberosity
75. Right tibial plateau


A
B
R
C
D
E

Case 5

AP radiograph. Pelvis.

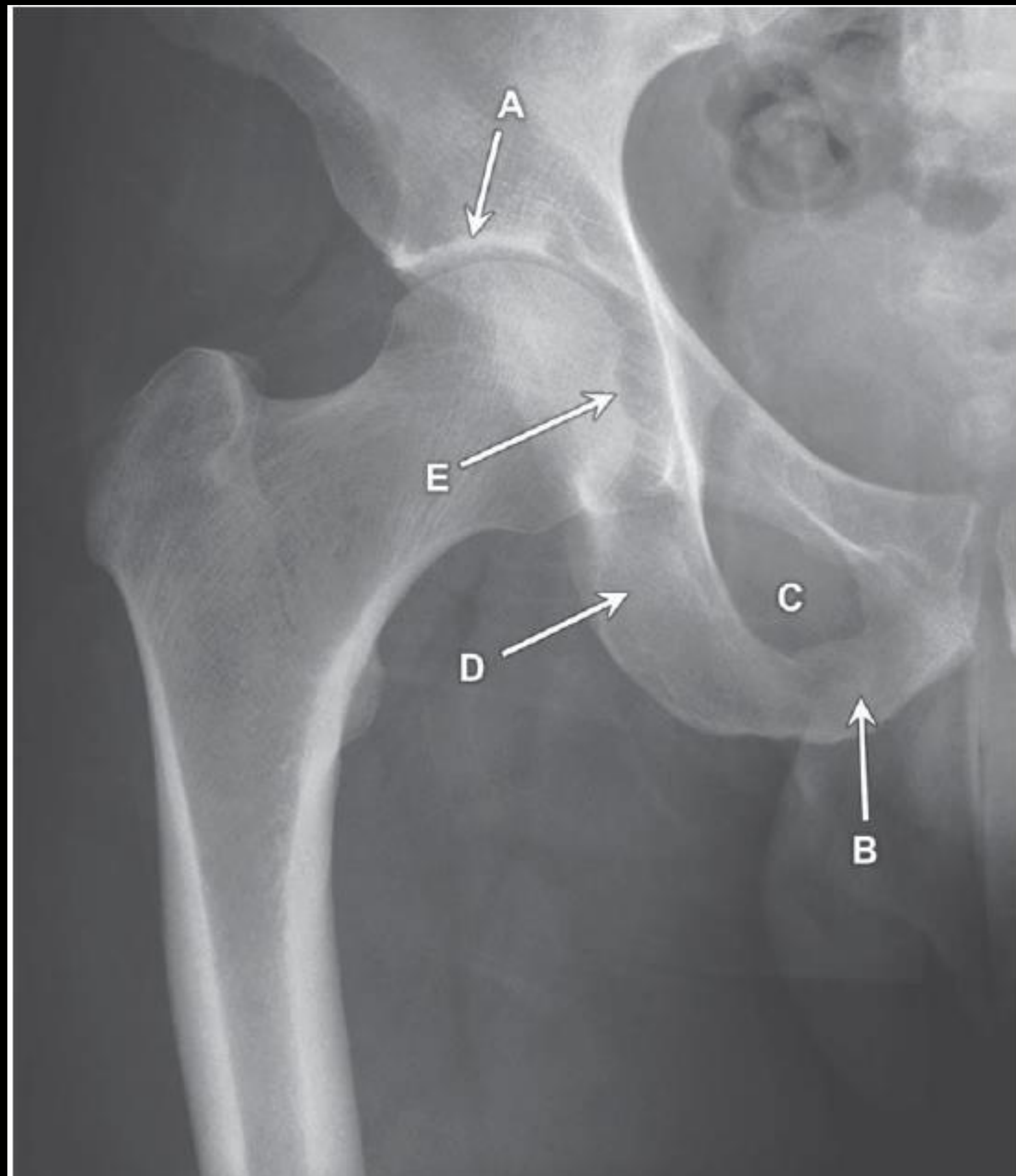
1. Right iliac crest
2. Right anterior superior iliac spine
3. Left sacroiliac joint
4. Left greater trochanter of the femur
5. Symphysis pubis


E
B
D
C
A
L

Case 1

AP radiograph. Pelvis.

1. Lesser trochanter of the right femur
2. Left sacral foramen of S3 vertebra
3. Fovea capitis of the left femur
4. Right pelvic brim
5. Caecum

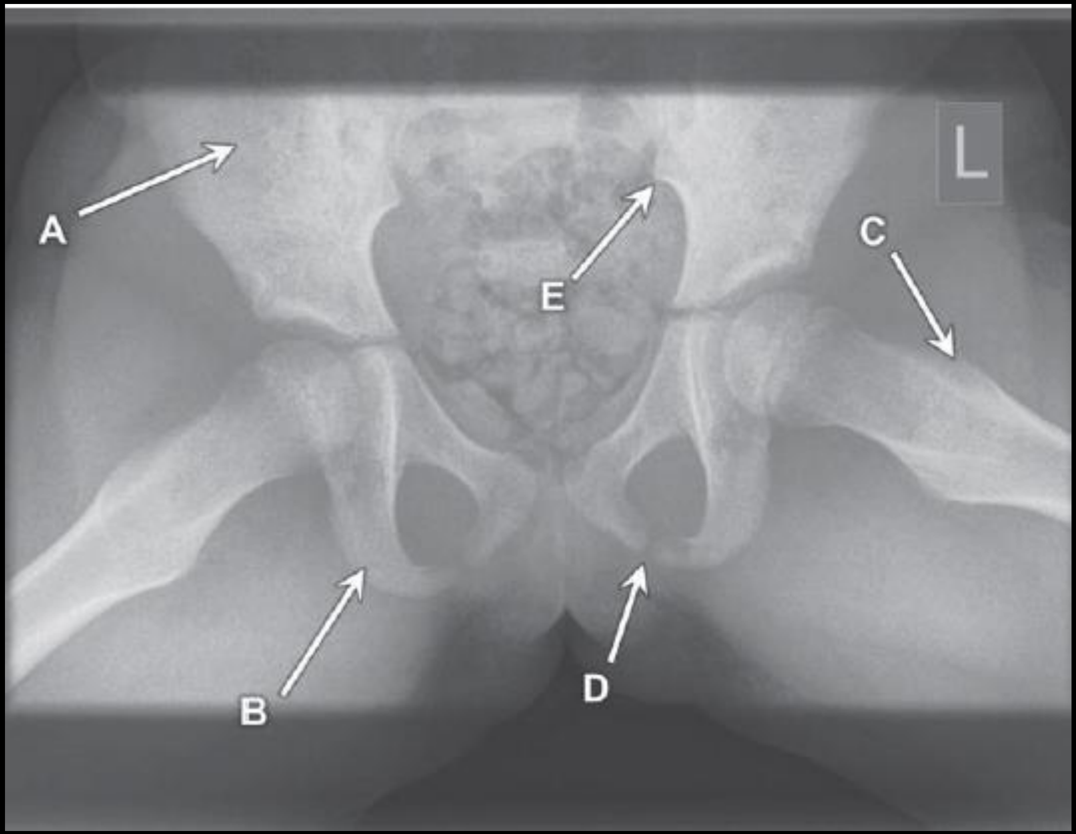

A
E
D
C
B

Case 6

Plain radiograph. Right hip.

1. Right acetabulum
2. Right inferior pubic ramus
3. Right obturator foramen
4. Right ischium
5. Right fovea capitis

One should remember that the inferior portion of the obturator ring is made up of the ischium laterally and the inferior ramus of the pubic bone medially. It is easy to mistake the whole structure for the inferior pubic ramus.



A
B
C
D
E
L

Case 1

Radiograph pelvis (child).

1. Right ilium
2. Right ischial ramus
3. Greater trochanter of left femur
4. Left ischiopubic syndesmosis
5. Left posterior inferior iliac spine

Name the normal variant

Foot Radiograph

Os tibiale externum

Sesamoid bones are relatively common on foot radiographs. Os tibiale externum is seen medial to the tuberosity of the navicular within the tendon of the tibialis posterior muscle.

Name the normal variant

Foot Radiograph

Os vesalianum fused to base of 5th metatarsal.
Within the foot, there can be multiple sesamoid bones, which you will not be expected to name. This image shows an example of where one of these, the os vesalianum, has fused to the fifth metatarsal. This may cause patient symptoms and is important to pick up.

Ankle Radiograph

Os trigonum

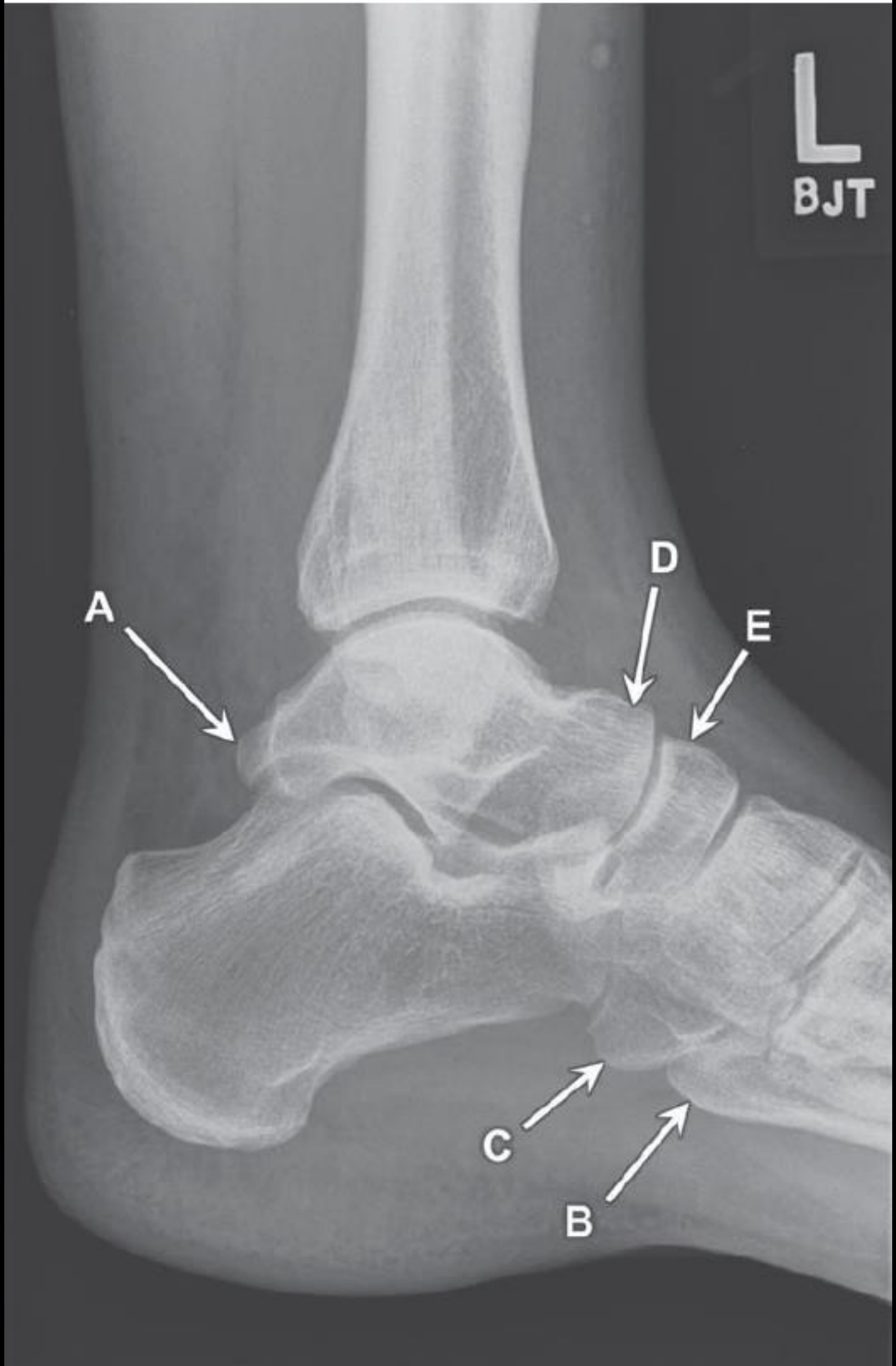
Seen in 7 % of people, it can sometimes be mistaken for a fracture. It may be a source of pain and is therefore important to recognise and report on.


B
E
C
D
A

Case 13

Plain radiograph. Oblique foot.

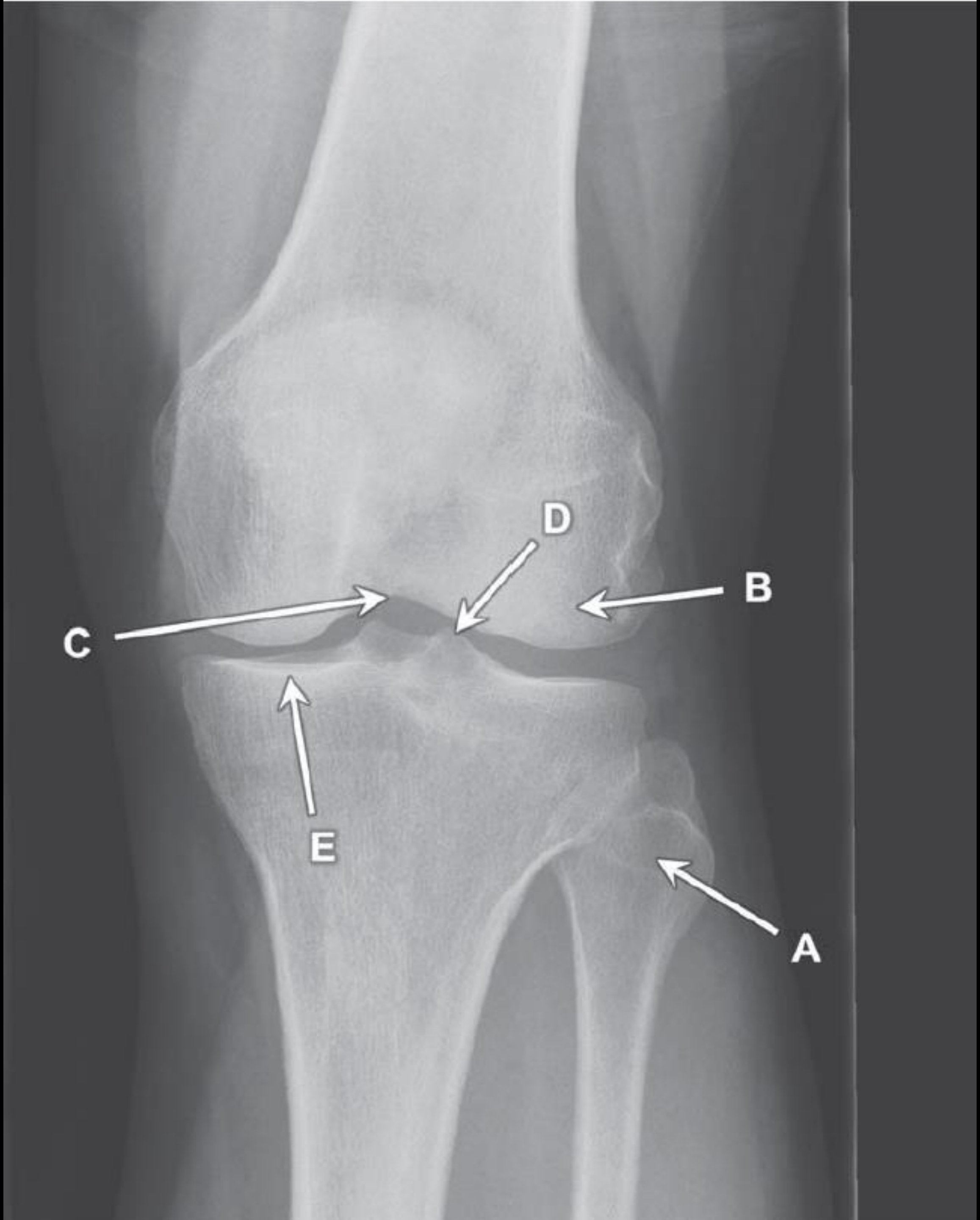
1. Fibula
2. Middle phalanx of fourth toe
3. Cuboid
4. Navicular
5. First metatarsal


L
BJT
A
D
E
C
B

Case 4

Plain radiograph. Lateral left ankle.

1. Left lateral tubercle of the talus
2. Left fifth metatarsal
3. Left cuboid
4. Left head of the talus
5. Left navicula

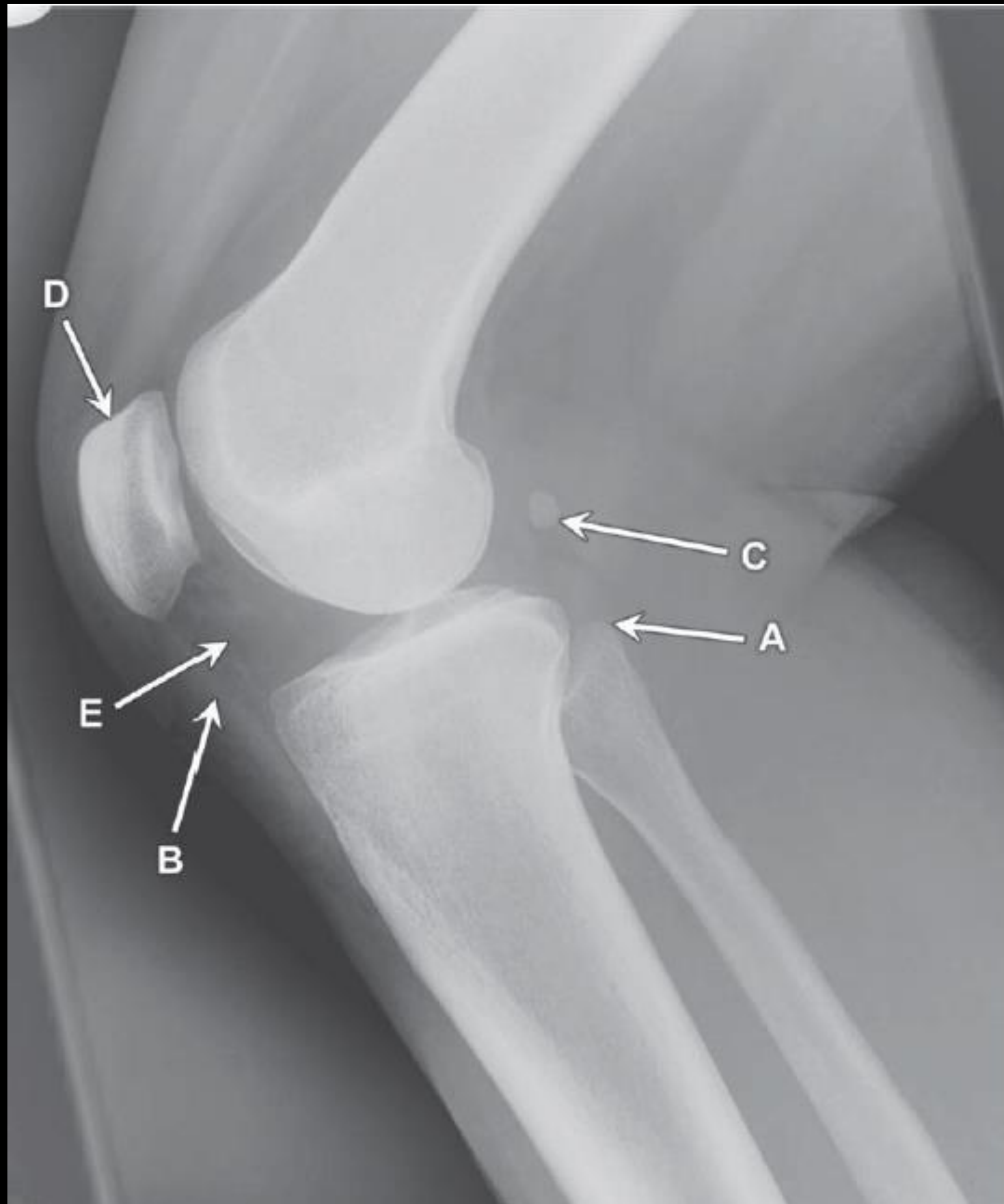


D
B
C
E
A

Case 17

Plain radiograph. AP knee.

1. Head of the fibula
2. Lateral femoral condyle
3. Intercondylar fossa
4. Lateral tibial spine
5. Medial tibial plateau


D
C
A
E
B

Case 1

Lateral radiograph, knee.

1. Styloid process of the fibula
2. Patellar tendon
3. Fabella
4. Patella
5. Hoffa's fat pad

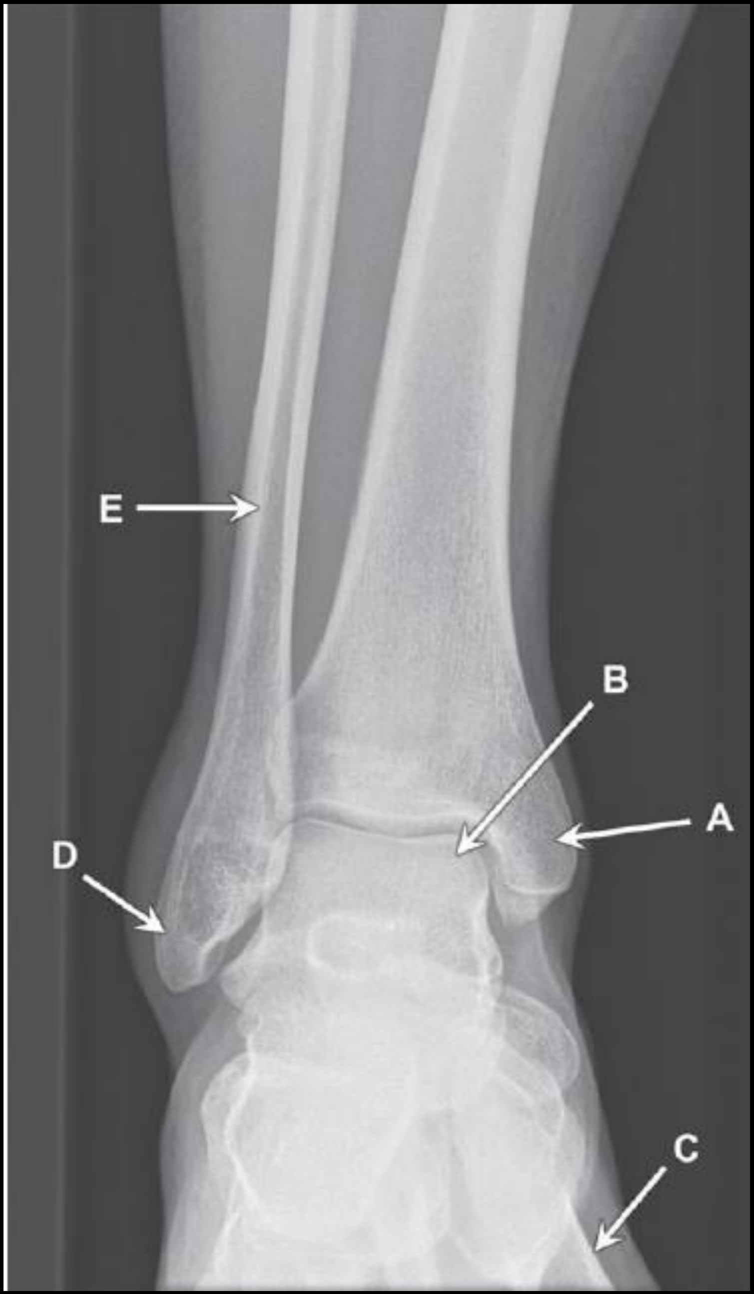
A fabella is a small accessory bone that lies within the lateral head of the gastrocnemius muscle.


LEFT
A
B
E
C
D

Case 3

Paediatric foot. DP oblique.

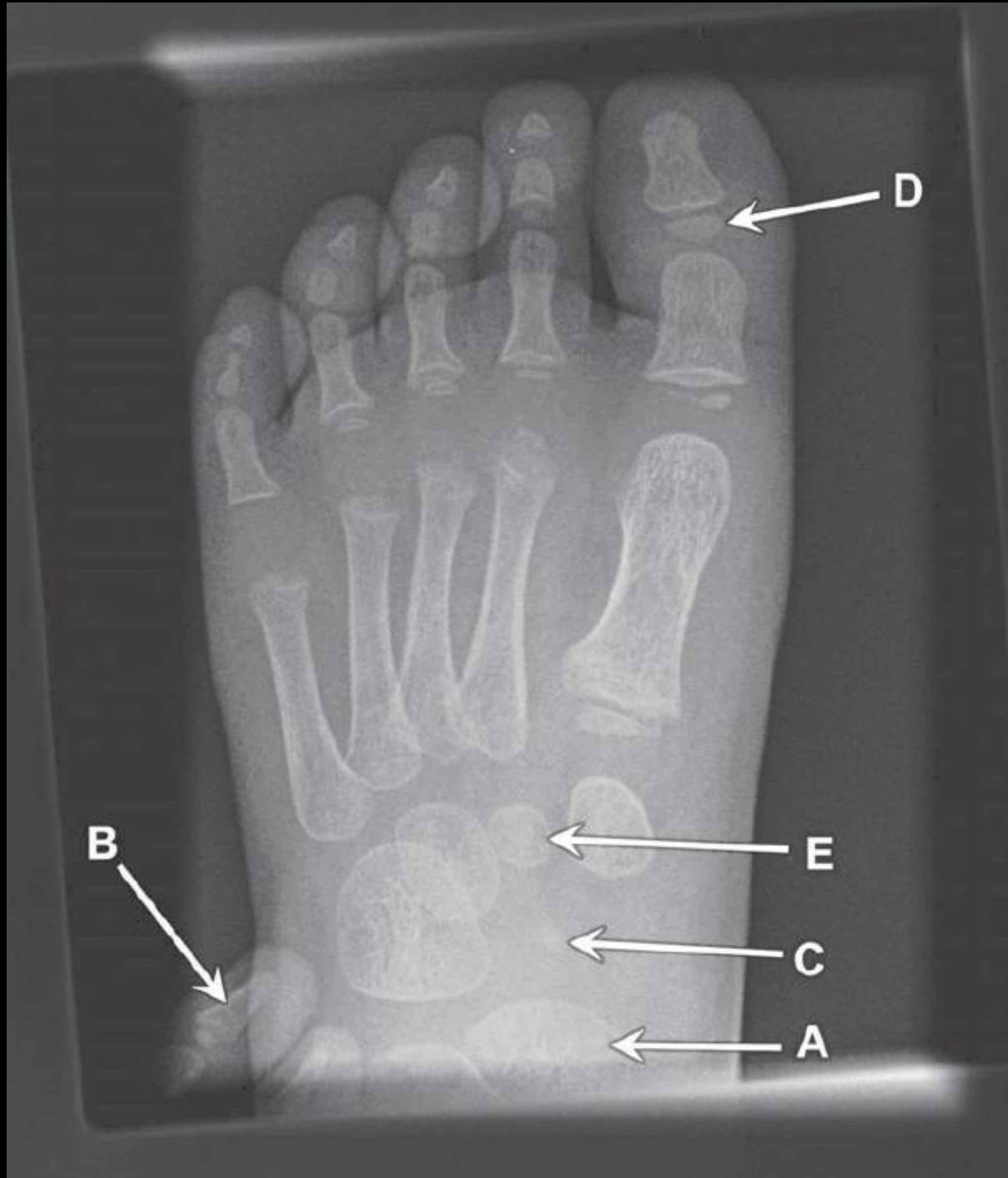
1. Left cuboid
2. Left lateral cuneiform
3. Left talus
4. Left distal fibular epiphysis
5. Left ossification centre of the navicula


E
B
A
D
C

Case 19

AP radiograph of the ankle

1. Medial malleolus (of the tibia)
2. Talus
3. First metatarsal
4. Lateral malleolus (of the fibula)
5. Fibula


D
B
E
C
A

Case 12

DP radiograph of a child's foot.

1. Calcaneum
2. Distal phalanx of a parent's finger
3. Ossification centre of the navicula
4. Proximal epiphysis of the distal phalanx of the great toe
5. Middle cuneiform

5. Name the tendon inserting on the structure labelled E.

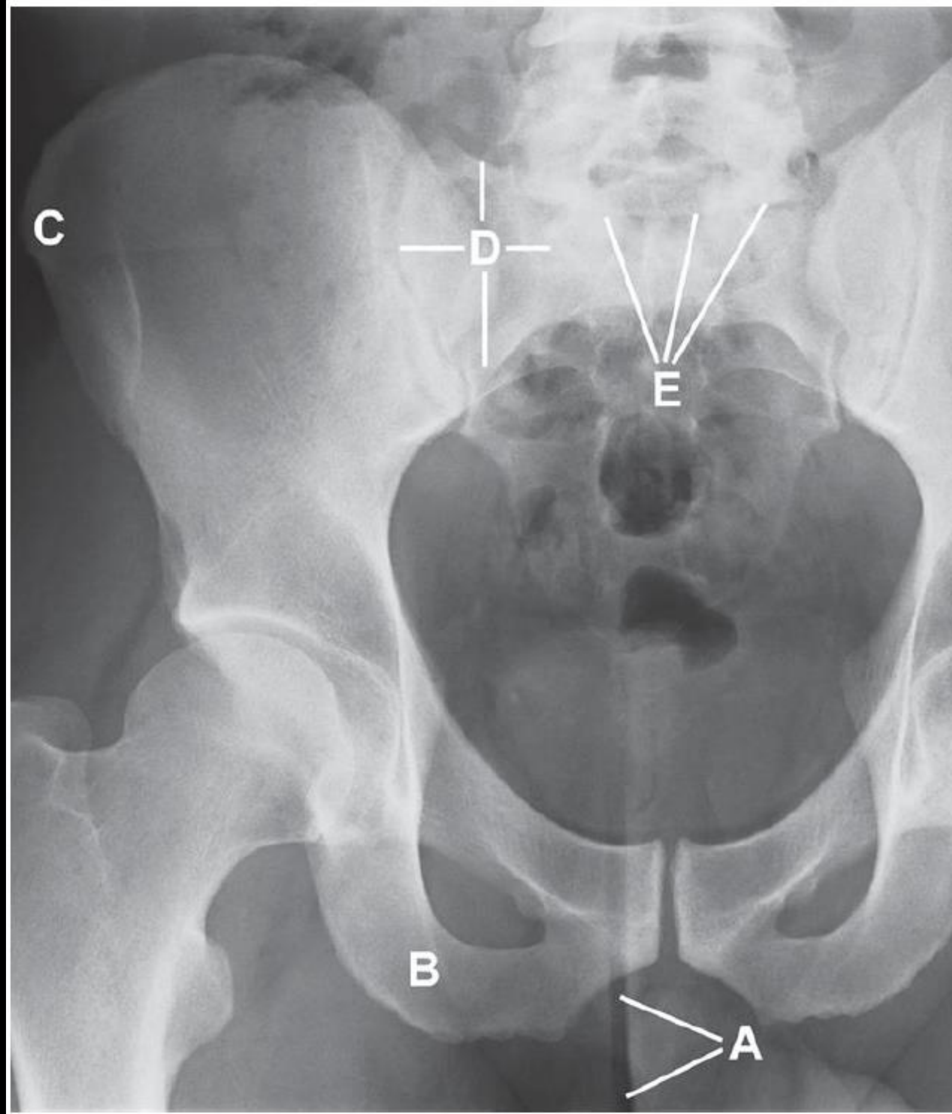
Case 16

DP radiograph of the right foot.

1. Right fibular head/ lateral malleolus
2. Right medial cuneiform
3. Right calcaneum
4. Right tibial sesamoid bone
5. Right peroneus brevis

Q6

a Name the structure labelled A
b Name the structure labelled B
c Name the two lower limb muscles that attach to C
d Name the structure labelled D
e Name the structure labelled E



Q6 Answers

a Natal cleft
b Ischiopubic ramus
c Sartorius and tensor fascia latae
d Sacral ala (or wing)
e L5/S1 joint (or interspace)

Radiograph of male pelvis, AP view

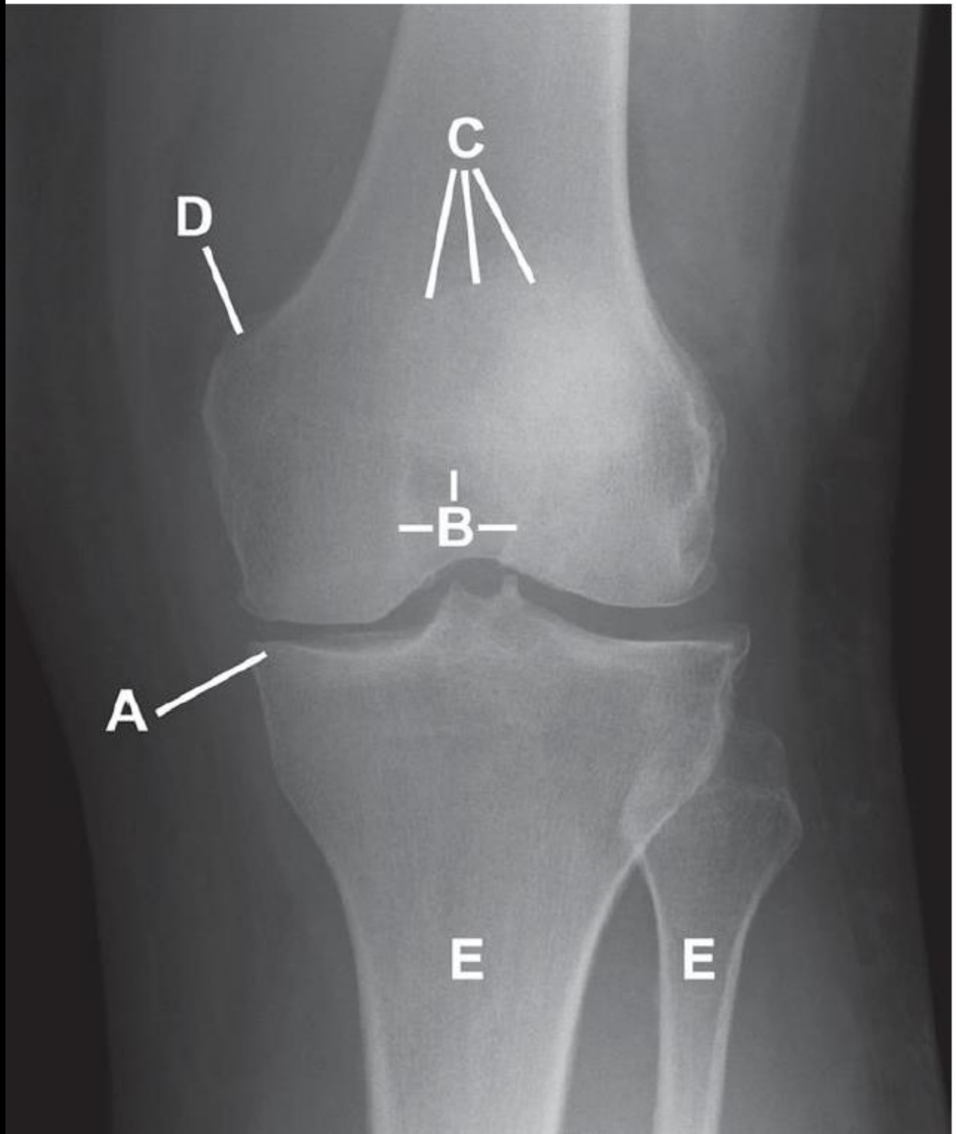
Many soft tissue shadows are seen overlying the bony structures on plain radiography. These need to be recognised to exclude them from bony lucencies; soft tissue shadows will generally extend beyond the boundaries of the bone they overlie.

The pubis joins the ilium and ischium through superior (iliopubic) and inferior (ischiopubic) rami.

The sacral alae (or wings) are the lateral expansions of the sacrum which articulate with the ilium bilaterally.

Q7

a Name the structure labelled A
b Name the space labelled B
c Name the part of the structure labelled C
d Name the structure labelled D
e Name the muscle that arises from both of the areas labelled E



Q7 Answers

a Medial tibial condyle
b Intercondylar fossa
c Base of the patella
d Adductor tubercle
e Soleus

Radiograph of knee, AP view

Parts of the patella are named in accordance with their shape, rather than the positions in which they are found in vivo. The base forms the flatter superior aspect and the apex lies inferiorly.

Soleus muscle is one of the three superficial calf muscles, and the only muscle to arise from both the proximal fibula and tibia. It takes origin from the upper fibula, including the head, as well as from the soleal line which is a thick oblique ridge on the posterior aspect of the upper tibia. The origins are connected by a fibrous band that passes over the popliteal vessels in the posterior calf. Soleus contains a large number of small perforating veins to the great saphenous vein. It plays an important role in maintaining venous flow by forcing blood from deep veins within the calf through these perforators to superficial veins every time the muscle belly contracts and therefore acts as a 'venous pump' in the lower limb.

Meissner MH, Moneta G, Burnand K *et al*. The hemodynamics and diagnosis of venous disease. *Journal of Vascular Surgery* 2007; 46: S4–S24.


L
A
C
B
D
E

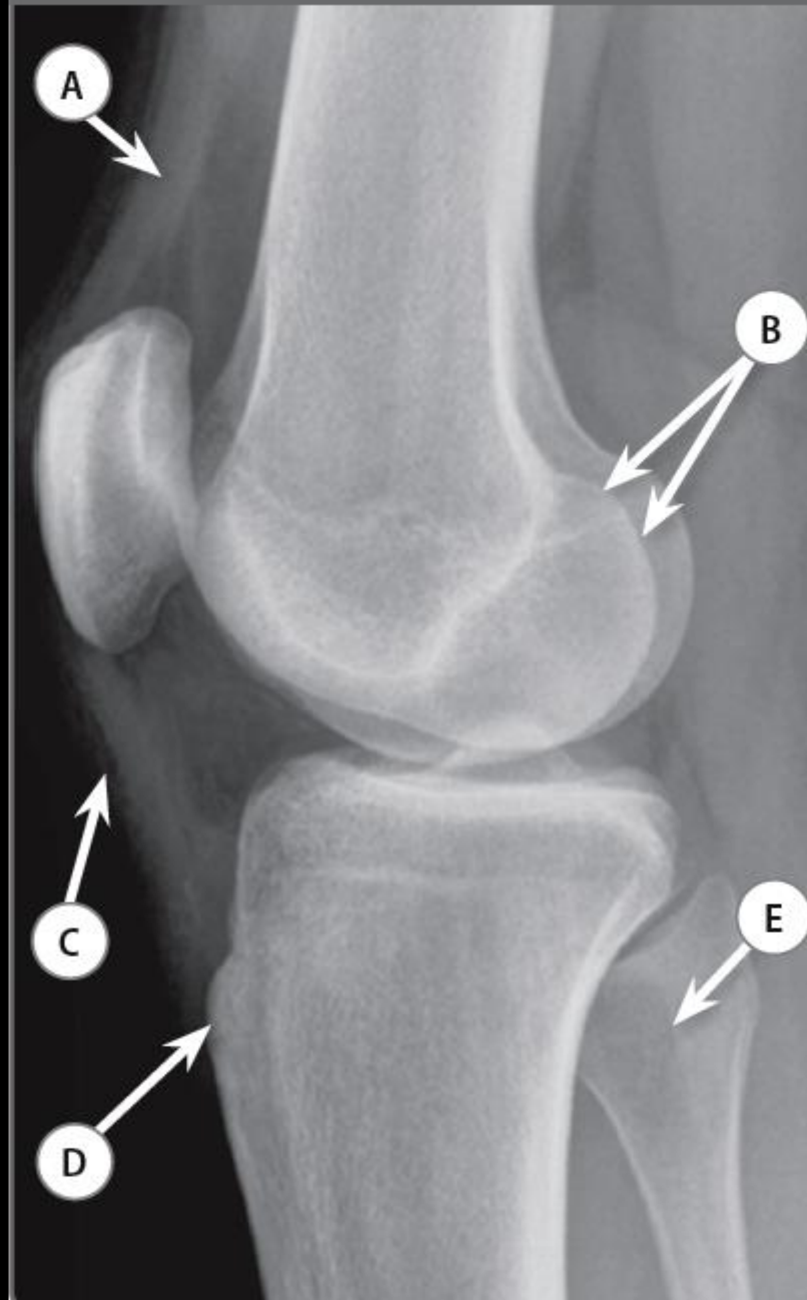
Q10 Answers

a Intermediate (middle) cuneiform
b Calcaneus
c Cuboid
d Epiphysis of 1st metatarsal
e Medial malleolus of the tibia

Radiographs of the foot in a 7 year-old child, AP and oblique views

The bones of the foot consist of the tarsus, metatarsus and phalanges. Tarsal bones of the foot are arranged in two rows. The proximal row consists of the calcaneus and talus. The distal row includes the medial, intermediate and lateral cuneiform bones medially and the cuboid laterally. On the medial side the navicular is positioned between the talus proximally and the cuneiforms distally.

Case 5.13



Case 5.13

A Quadriceps tendon

B Lateral femoral condyle

C Patella tendon

D Tibial tuberosity

E Head of fibula

Lateral radiograph of the knee.

For further discussion see Chapter 4, Case 4.7 and 4.8.

Question 1.20

Name the structures labelled **A** to **E**.

1.20 Oblique X-ray of the left foot

A Diaphysis of the left fifth metatarsal.
B Left os vesalianum.
C Left cuboid.
D Diaphysis of the proximal phalanx of the left second toe.
E Left navicular.

The cuboid is one of the seven tarsal bones of the foot. It articulates proximally with the calcaneum to from the calcaneocuboid joint and distally with the fourth and fifth metatarsals. The navicular is located on the medial side of the foot and articulates proximally with the talus, laterally with the cuboid and distally with the three cuneiform bones.

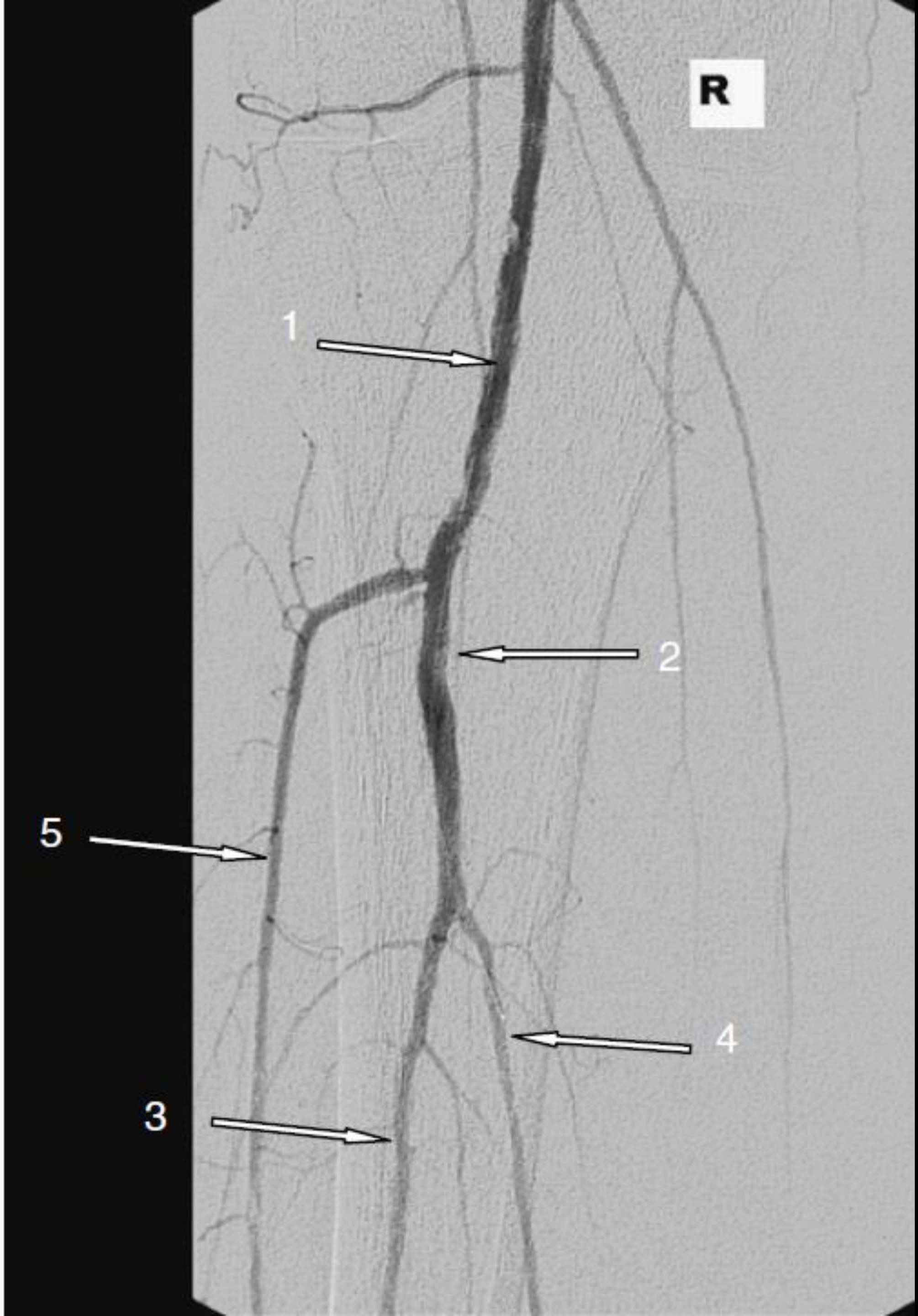
Accessory bones are normal variants and will arise in the exam. The os vesalianum is an accessory bone located proximal to the base of the fifth metatarsal, and is found within the peroneus brevis tendon. It should be remembered as a normal variant, as it is commonly confused with a fracture of the base of the fifth metatarsal.

Other common accessory variants found in the foot are:

Os peroneum	Located laterally to the cuboid Associated with the peroneus longus tendon
Os tibiale externum or os naviculare	An accessory navicular Located adjacent to the medial side of the navicular and within the tendon of tibialis posterior
Os supranaviculare	Located superior to the navicular
Os trigonum	Located posterior to the talus

For further information on the accessory ossicles of the foot, see Question 10.19.

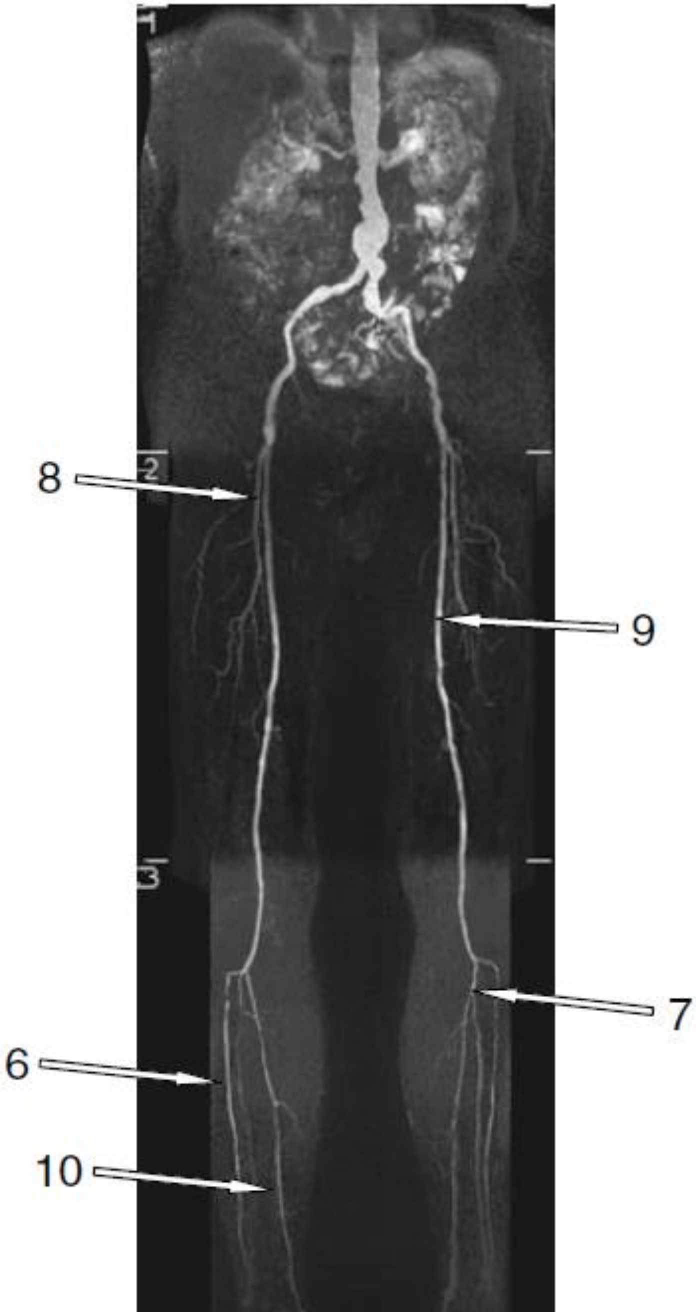
ANGIO


R
1
2
5
4
3

DSA

1. Right popliteal artery
2. Right tibioperoneal trunk
3. Right peroneal artery
4. Right posterior tibial artery
5. Right anterior tibial artery

The superficial femoral artery continues as the popliteal artery, which in turn divides into major branches of the leg below the knee joint. Usually the anterior tibial artery comes off the lateral aspect of popliteal artery. It is common practice to palpate the posterior tibial arterial pulse posterior to the medial malleolus, which should help in remembering the medial most branch as posterior tibial artery.

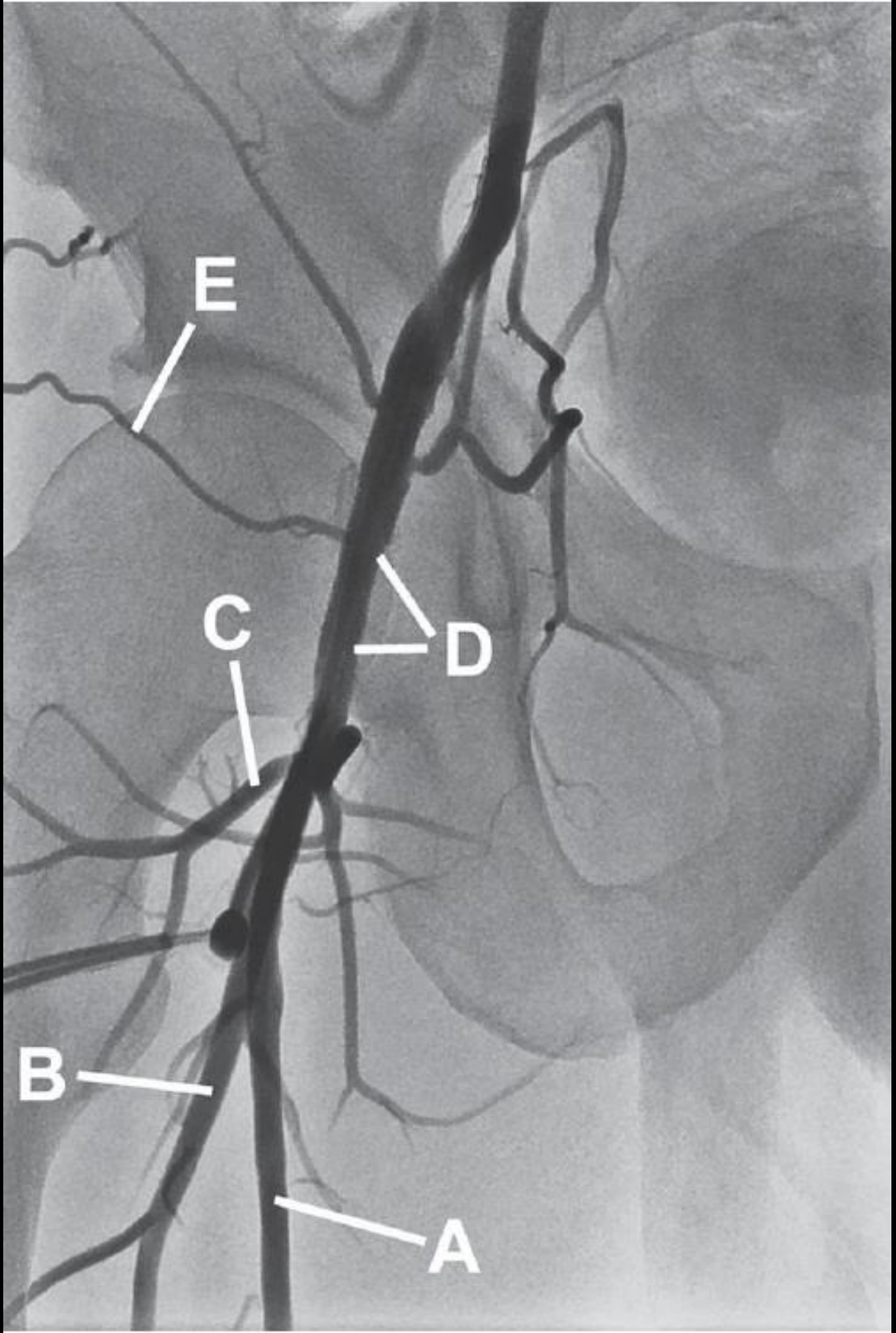


1
2
3
8
9
7
6
10

MRA

6. Right anterior tibial artery (AT)
7. Left tibioperoneal trunk (TPT)
8. Right profunda femoris artery (PFA)
9. Left superficial femoral artery (SFA)
10. Right posterior tibial artery (PTA)

The SFA has no significant branches in the thigh and has a vertical course in the thigh. Below the knee the popliteal artery divides into the tiobioperoneal trunk and anterior tibial artery over the proximal tibiofibular joint. The posterior tibial artery is the most medial vessel seen in the lower leg.


E
C
D
B
A

Q3 Answers

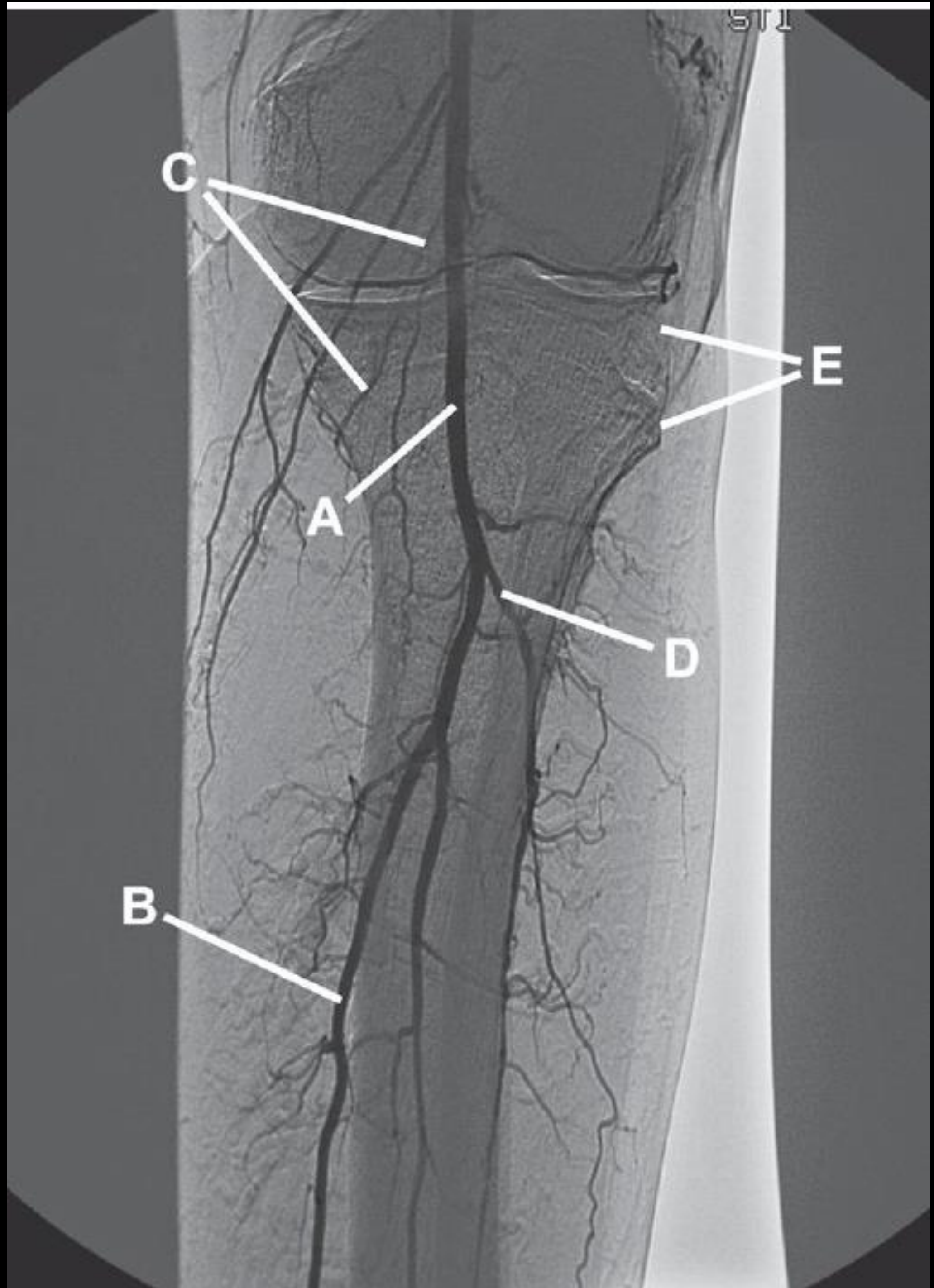
a Superficial femoral artery
b Profunda femoris artery
c Lateral circumflex femoral artery
d Common femoral artery
e Superficial circumflex iliac artery

Digital subtraction angiogram right groin

The external iliac artery becomes the common femoral artery after passing beneath the inguinal ligament, midway between the ASIS and pubic tubercle. Four arteries take their origin from the proximal common femoral artery. The superficial circumflex iliac arteries course laterally towards the femoral neck and ASIS. Running in a medial direction are the superficial epigastric artery and the superficial and deep (external) pudendal arteries.

The circumflex arteries contribute to an anastomosis with the inferior gluteal artery which encircles the proximal femur, providing most of its blood supply. Branches from this anastomosis enter the outer hip capsule to supply the femoral neck. An additional blood supply comes through the ligamentum teres, though this is minimal in the fully developed hip making the femoral head susceptible to avascular necrosis following intracapsular proximal femoral fractures. The descending branch of the lateral femoral circumflex artery also forms an anastomosis with the geniculate arteries around the knee and this can provide a path of collateralization to the leg in cases of superficial femoral artery occlusion.

The common femoral artery divides into the superficial femoral artery and profunda femoris artery, the latter of which principally supplies the thigh.



ST1
C
E
A
D
B

Q10 Answers

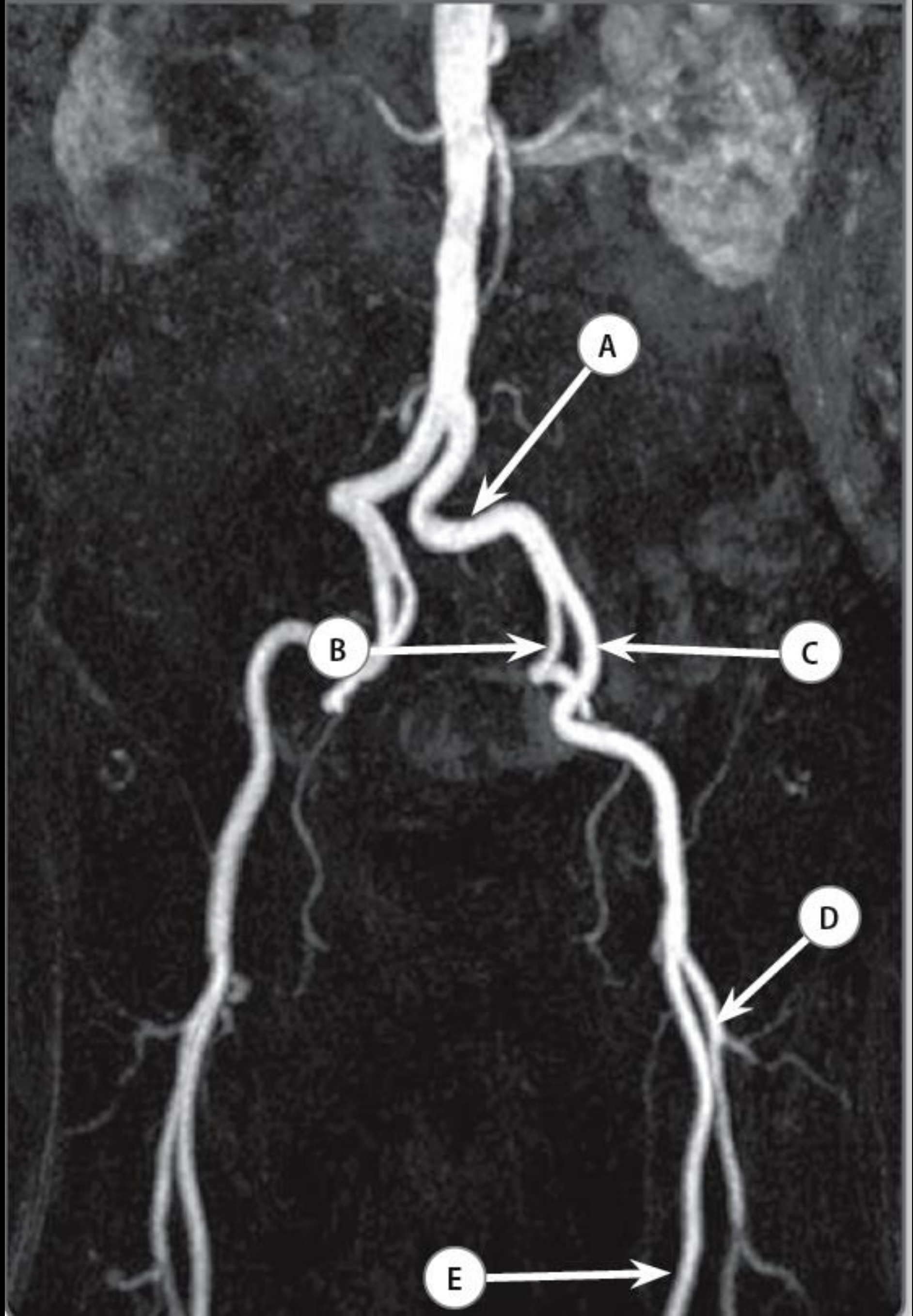
a Popliteal artery
b Posterior tibial artery
c Medial genicular artery
d Anterior tibial artery
e Fibular head

Digital subtraction angiogram of leg, AP view

The popliteal artery is a continuation of the superficial femoral artery. It gives off seven branches within the popliteal fossa which supply the knee joint and adjacent muscles: superior/inferior muscular branches; medial superior/inferior geniculatar branches; lateral superior/inferior geniculatar branches and the middle genicular branch.

The popliteal artery divides into the anterior tibial artery and posterior tibial artery below the knee. Just distal to this division, the peroneal artery branches from the posterior tibial artery (as seen on this image). As these three branches diverge within a short distance, this area is often referred to as the popliteal trifurcation.

Case 4.16



Case 4.16

A Left common iliac artery

B Left internal iliac artery

C Left external iliac artery

D Left profunda femoris

E Left superficial femoral artery

MR Angiography of the pelvis and proximal lower limbs.

The aorta divides into the two common iliac arteries at the level of the fourth lumbar vertebral body. The common iliac artery divides into the external and internal iliac arteries. The blood supply to the lower limb derives from the external iliac artery and its branches.

The external iliac artery becomes the common femoral artery when it crosses the inguinal ligament, midway between the anterior superior iliac spine and the pubic symphysis.

The profunda femoris arises 3.5 cm distal to the inguinal ligament and has six branches: the medial and lateral circumflex artery and four penetrating arteries. After the profunda is given off, the femoral artery is referred to as the superficial femoral artery.

Figure 4.2 summarises the arterial supply to the lower limb.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 187.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 306–312.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 386.

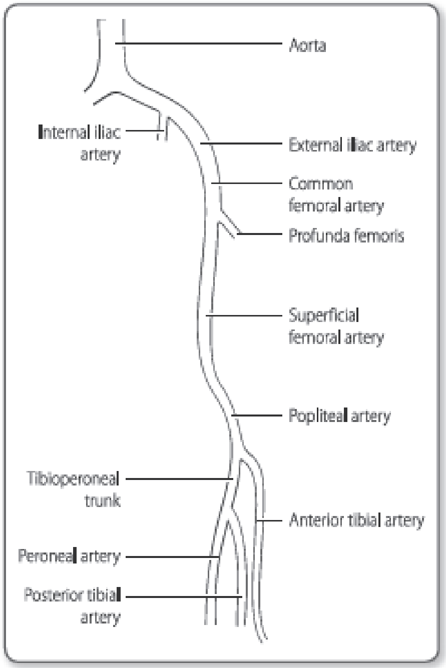
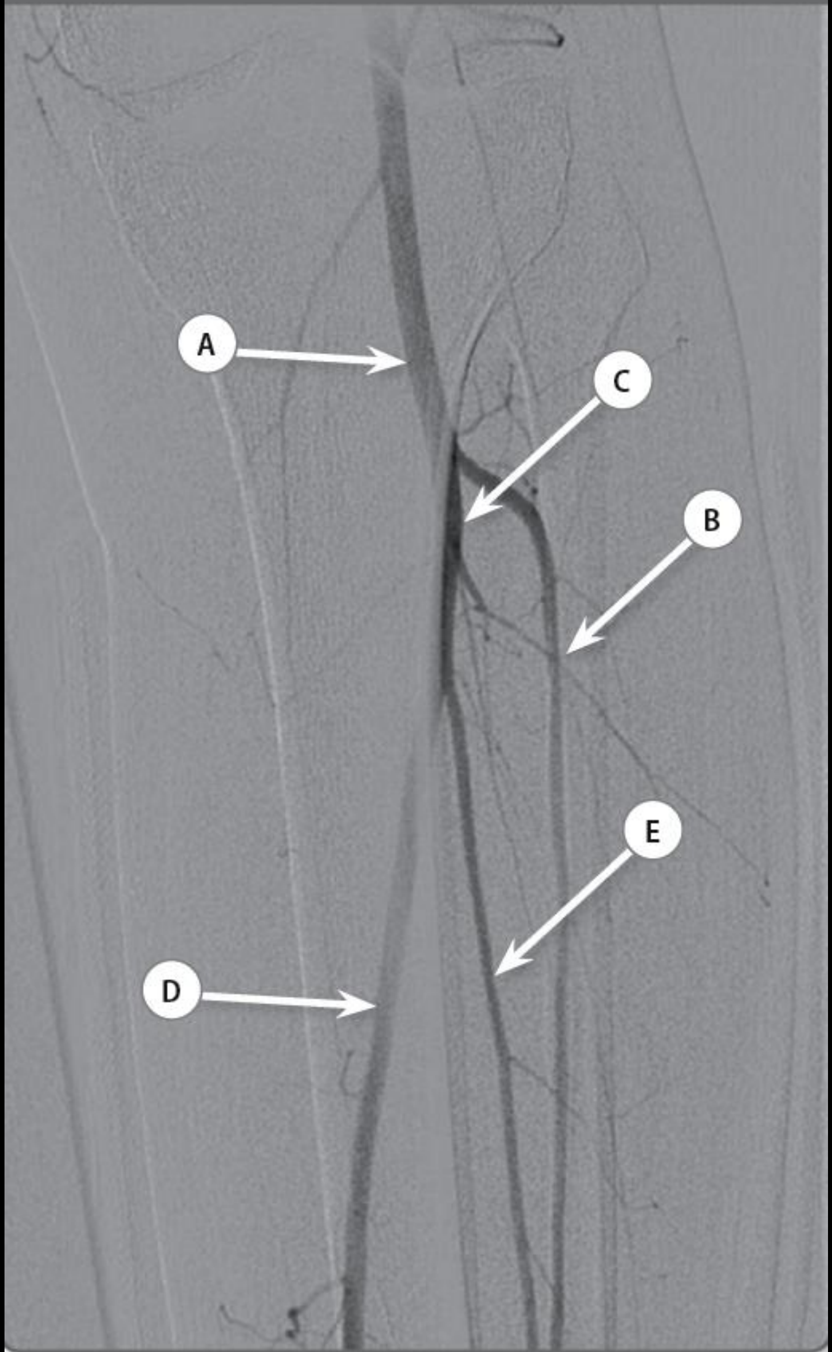


Figure 4.2 Arterial supply to the lower limb.

Case 4.17



Case 4.17

A Popliteal artery

B Anterior tibial artery

C Tibioperoneal trunk

D Posterior tibial artery

E Peroneal artery

Catheter angiogram of the left lower limb.

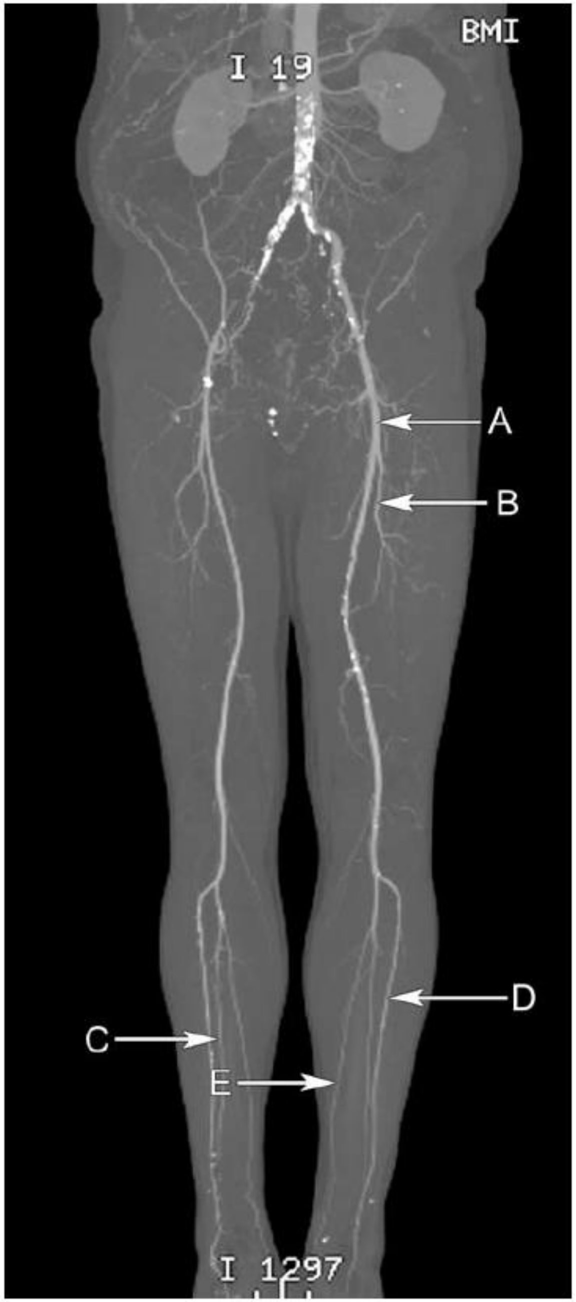
The superficial femoral artery becomes the popliteal artery after passing through the adductor hiatus of the adductor magnus tendon. Five genicular branches are given off in the popliteal fossa.

The popliteal artery ends by dividing into the anterior tibial artery and the tibioperoneal trunk .The anterior tibial artery pierces the interosseous membrane and runs into the anterior compartment of the leg.

The tibioperoneal trunk divides into the peroneal artery (which runs close to the fibula) and the posterior tibial artery (which runs in the posterior compartment).

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 217.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 310.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 387.

Question 5.18



Name the structures labelled A to E.

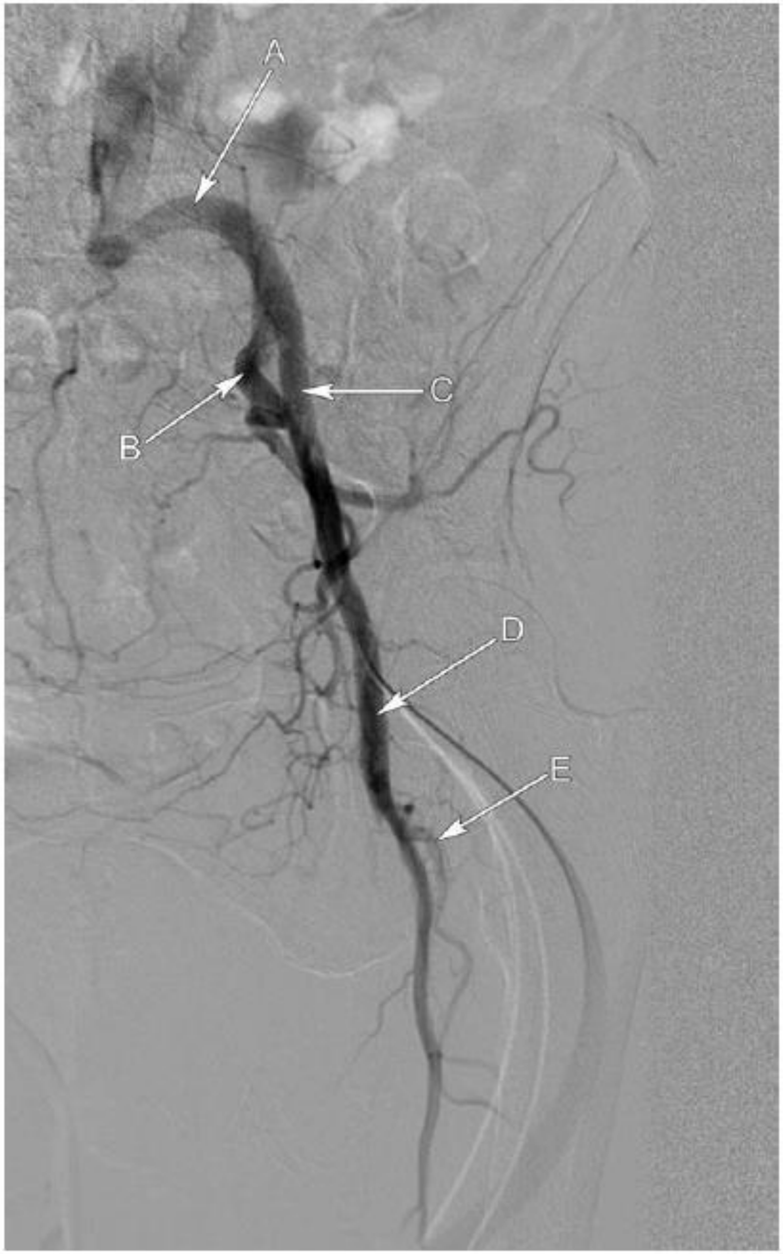
5.18 Coronal CT angiogram of the lower limbs

A Left common femoral artery.
B Left profunda femoris artery.
C Right peroneal artery.
D Left anterior tibial artery.
E Left posterior tibial artery.

The anatomical landmark for the common femoral artery is the femoral head. The femoral artery divides into the superficial femoral artery and profunda femoris around 4 cm inferior to the inguinal ligament. The superficial femoral artery follows a relatively vertical course as compared with the femur, which is more oblique. It gives off no major branches in the thigh, a fact that can help distinguish it from the profunda femoris artery, which has six major branches (medial and lateral circumflex femoral arteries, along with four perforating arteries).

The three major arteries of the lower limb are the anterior tibial artery, the posterior tibial artery and the peroneal artery. The popliteal artery divides into the anterior and posterior tibial arteries at the level of the proximal tibiofibular joint. The posterior tibial artery then gives rise to the peroneal artery branch.

Question 6.16



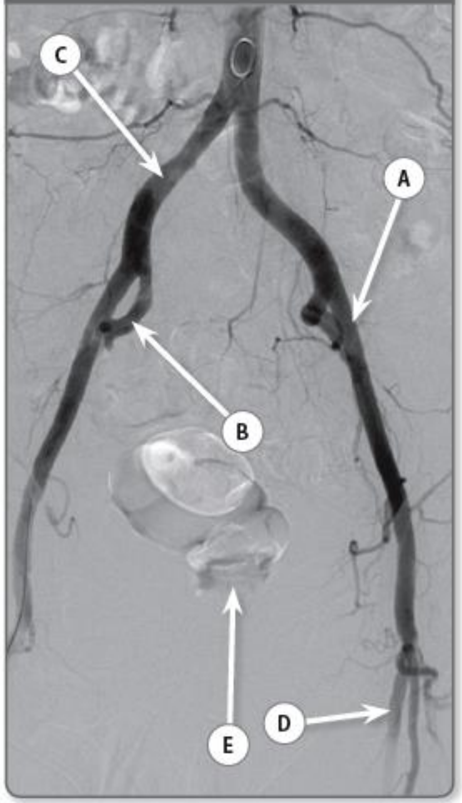
Name the structures labelled **A** to **E**.

6.16 Digital subtraction angiogram of the left leg

A Left common iliac artery.
B Left internal iliac artery.
C Left external iliac artery.
D Left common femoral artery.
E Left profunda femoris.

The aorta bifurcates into the left and right common iliac arteries at the level of L4. The common iliac artery runs along the medial side of the psoas muscles and bifurcates into internal and external branches at the level of L5/S1 (in front of the sacroiliac joint). The internal branch is the primary arterial supply of the pelvic organs and gluteal muscles. The external iliac artery continues along the medial border of the psoas and passes under the inguinal ligament. At the mid-inguinal point its name changes to the common femoral artery.

Case 2.20



Case 2.20

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 2.20

A Left external iliac artery

B Right internal iliac artery

C Right common iliac artery

D Left superficial femoral artery

E Rectum (gas filled)

Here is a very simplistic representation of the pelvic arterial tree:

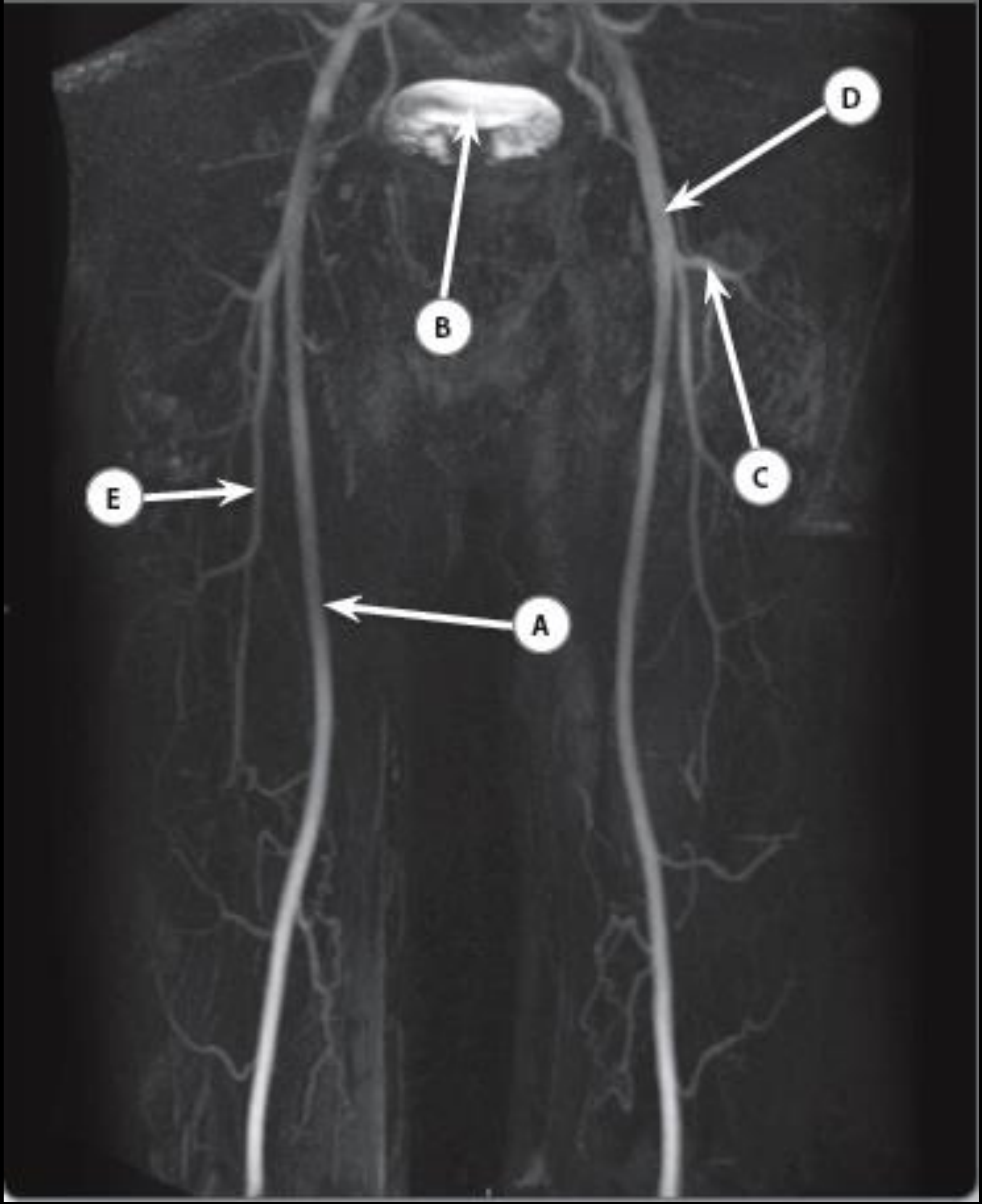
Aorta → common iliac artery

Common iliac artery → bifurcates into internal and external iliac arteries

External iliac artery → common femoral artery (extension of the external iliac artery beyond the inguinal ligament)

Common femoral artery → bifurcates into profunda femoris and superficial femoral arteries

Case 10.18



Case 10.18

- **A** Right superficial femoral artery (SFA)
- **B** Urinary bladder
- **C** Left lateral circumflex femoral artery
- **D** Left common femoral artery (CFA)
- **E** Right profunda femoris artery (PFA)

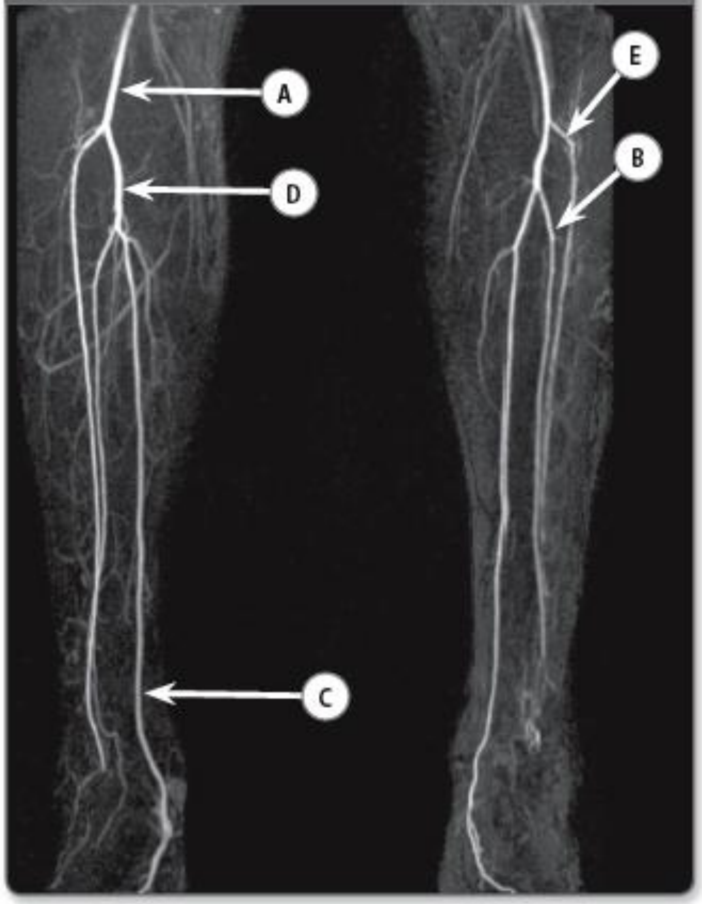
The CFA is a direct continuation of the external iliac artery from the level of the inguinal ligament. On average, the CFA is around 4 cm in length before branching into the SFA and PFA (deep femoral artery).

Facts:

- PFA arises laterally from the CFA and then courses posterior to the SFA.
- PFA gives rise to the lateral and medial femoral circumflex arteries.

The SFA ends at the lower third of the thigh, passing through an opening in the adductor magnus muscle (medially) known as the adductor hiatus to become the popliteal artery.

Case 11.5



Case 11.5

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Where is artery 'C' usually palpable?	

Case 11.5

A Right popliteal artery

B Left peroneal artery

C Posteroinferior to the medial malleolus

D Right tibioperoneal trunk or right posterior tibial artery

E Left anterior tibial artery

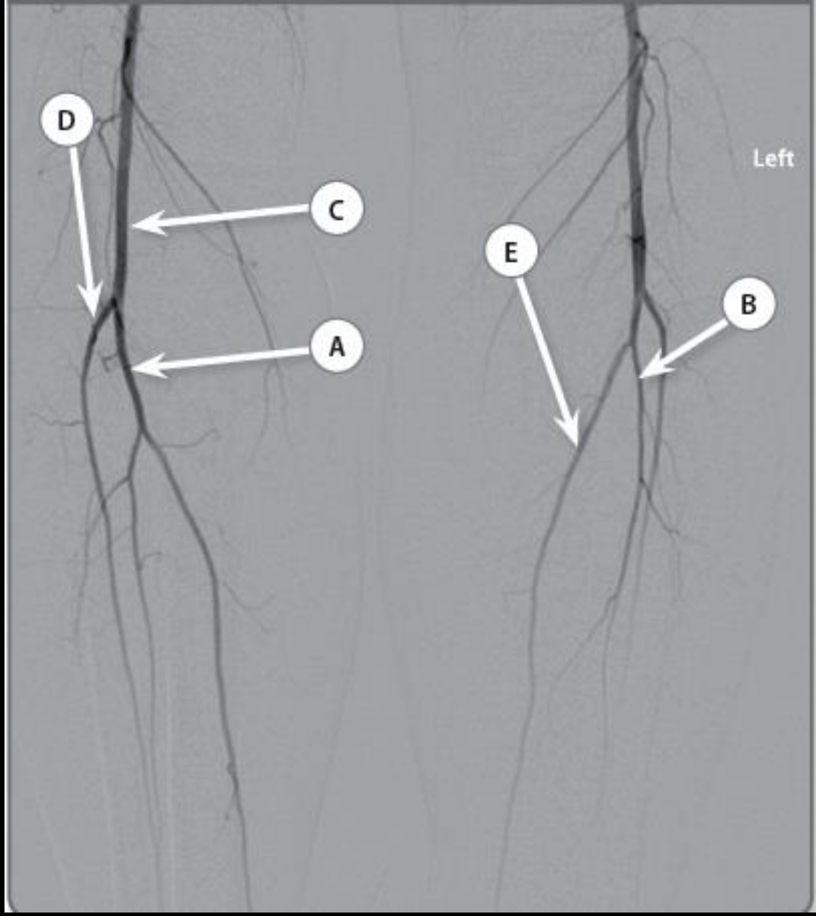
The popliteal artery bifurcates into the anterior and posterior tibial arteries. The posterior tibial artery distal to the origin of the anterior tibial and proximal to the origin of the peroneal artery is also known as the tibioperoneal trunk.

An easy way to remember the three vessel runoff of the lower limb is: **APP** (like Android or Apple apps)

- Anterior tibial artery – lateral
- Peroneal artery
- Posterior tibial artery – medial

The peroneal artery is sandwiched between the anterior tibial and posterior tibial arteries.

Case 12.4



Case 12.4

A Right tibioperoneal trunk (posterior tibial artery)

B Left peroneal artery

C Right popliteal artery

D Right anterior tibial artery

E Left posterior tibial artery

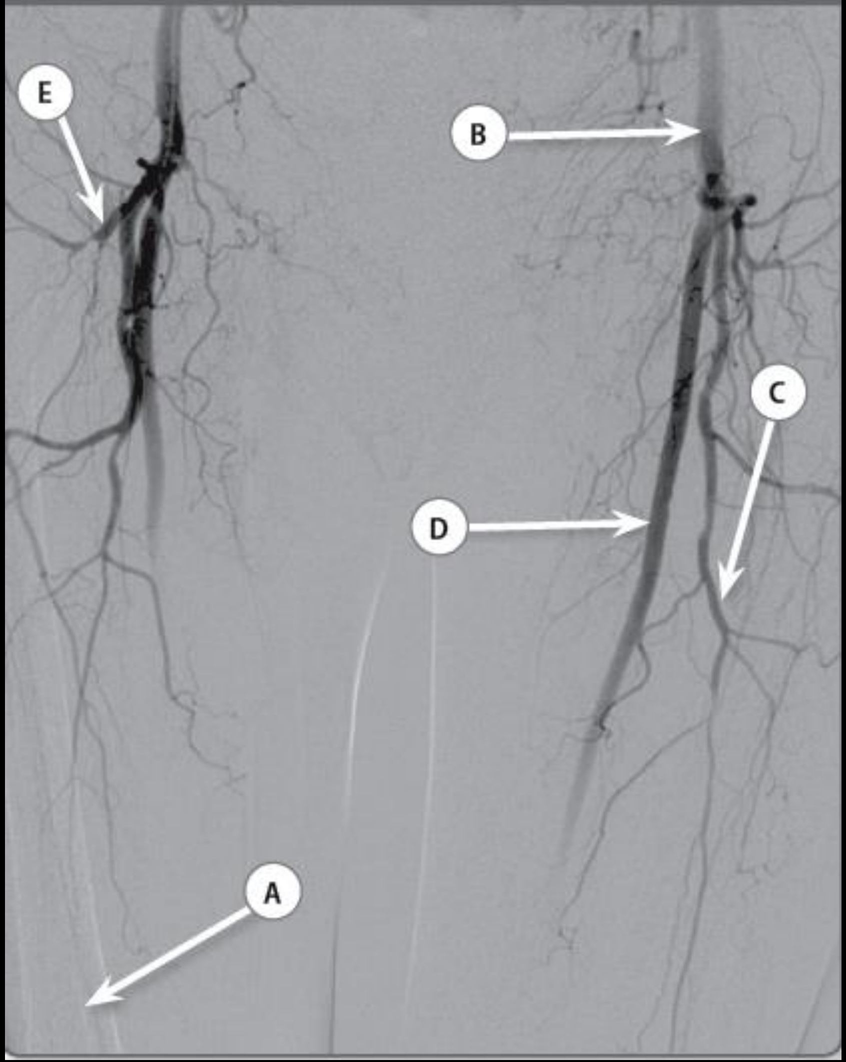
A mnemonic for the distal three vessel runoff in the lower limb is APP:

1. Anterior tibial artery – most superior branch (lateral – remember, AT is lATeral)
2. Peroneal artery – sandwiched in the middle
3. Posterior tibial artery – most medial branch.

Another useful tool to help remember which artery branches off first is the use of alphabetical order.

- A comes before P – anterior tibial artery being the first branch
- E comes before O – pEroneal artery is sandwiched between the anterior tibial and pOsterior tibial arteries.

Case 14.11



Case 14.11

A Right femur

B Left common femoral artery

C Left profunda femoris artery

D Left superficial femoral artery

E Right lateral circumflex femoral artery

The external iliac artery becomes the common femoral artery (CFA) at the level of the inguinal ligament. The CFA bifurcates into:

- profunda femoris artery
- superficial femoral artery

The profunda femoris artery has lateral and medial circumflex femoral artery branches along with multiple horizontal perforators.

Case 1.10

1.10 Angiogram left lower limb

(a) Left common femoral artery (CFA). This lies in the femoral sheath together wi
the femoral vein, which is medial to it. The femoral nerve is lateral to the sheat
(mnemonic NAVY; N=nerve, A=artery, V=vein, Y=y-front). This sheath, made u
of transversalis fascia anteriorly and fascia iliacus posteriorly, tapers and fuses wi
the vessel walls after approximately 2 cm.

The CFA is punctured at the site of maximal pulsation, usually the mid-inguinal point, halfway between the anterior superior iliac spine and pubic tubercle. While this is often described as the point of the mid-inguinal crease, it may be deceptive in old or obese patients.

(b) Left deep artery of the thigh (profunda femoris artery). This is the major arterial supply to the thigh and if the superficial artery is occluded then this vessel can supply the whole leg via collateralization to the superficial femoral artery (SFA).

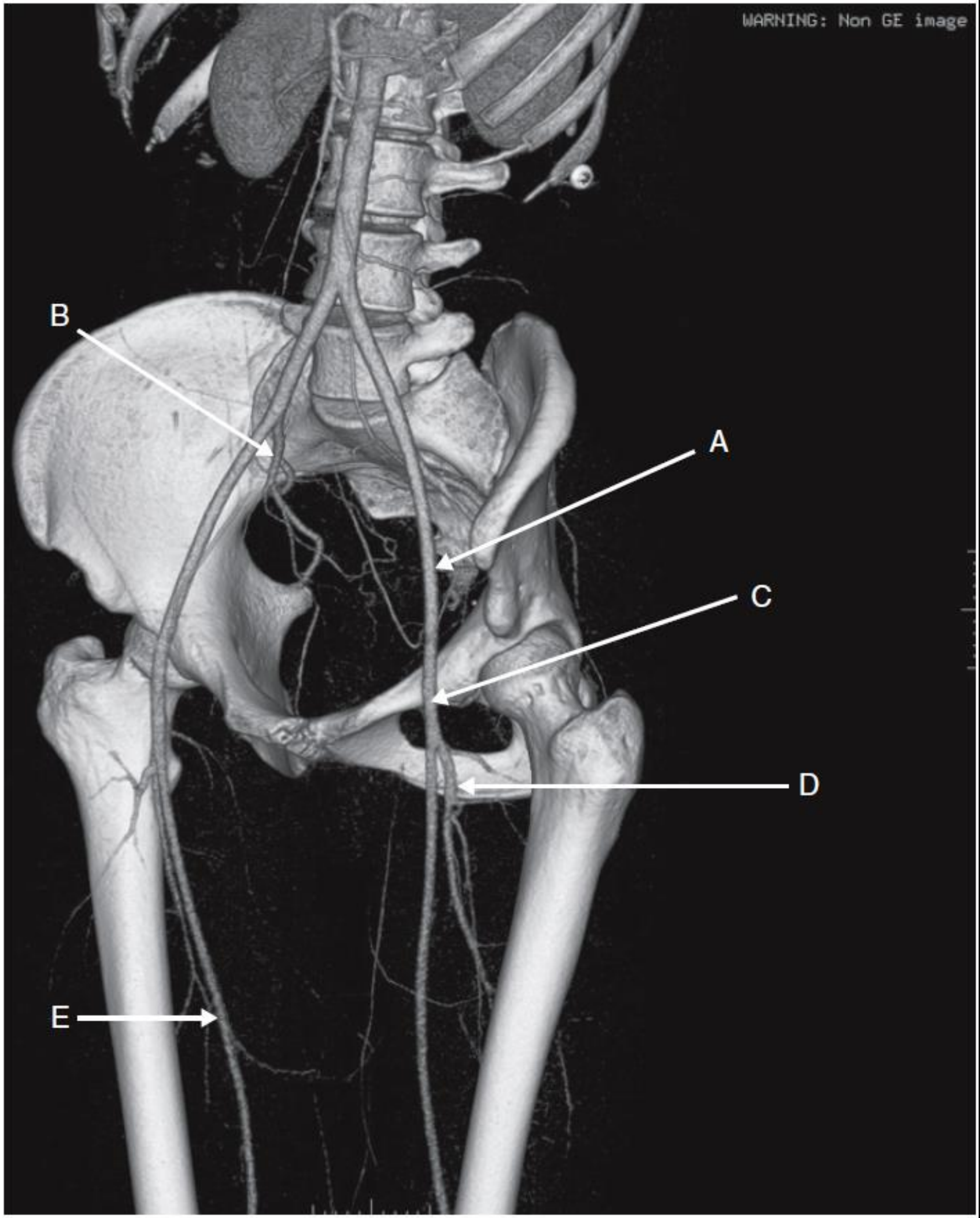
A puncture too low will often result of cannulation of this vessel, increasing the risk of pseudoaneurysm formation.

(c) Left superficial femoral artery. This vessel is the main supply to the calf and foot. In patients with peripheral vascular disease this along with the iliac vessels is a common site for stenoses or occlusion. The SFA lies medial and anterior to the profunda and therefore the arterial needle should be directed that way on puncturing the CFA.

(d) Left lateral circumflex femoral artery.

(e) Left superficial circumflex iliac artery. A retrograde puncture of the CFA needs to be below this vessel to be below the inguinal ligament. This is of importance as the femoral head lies behind this segment of the CFA and therefore haemostasis can be secured by manual compression against a bony structure.

Case 3.6

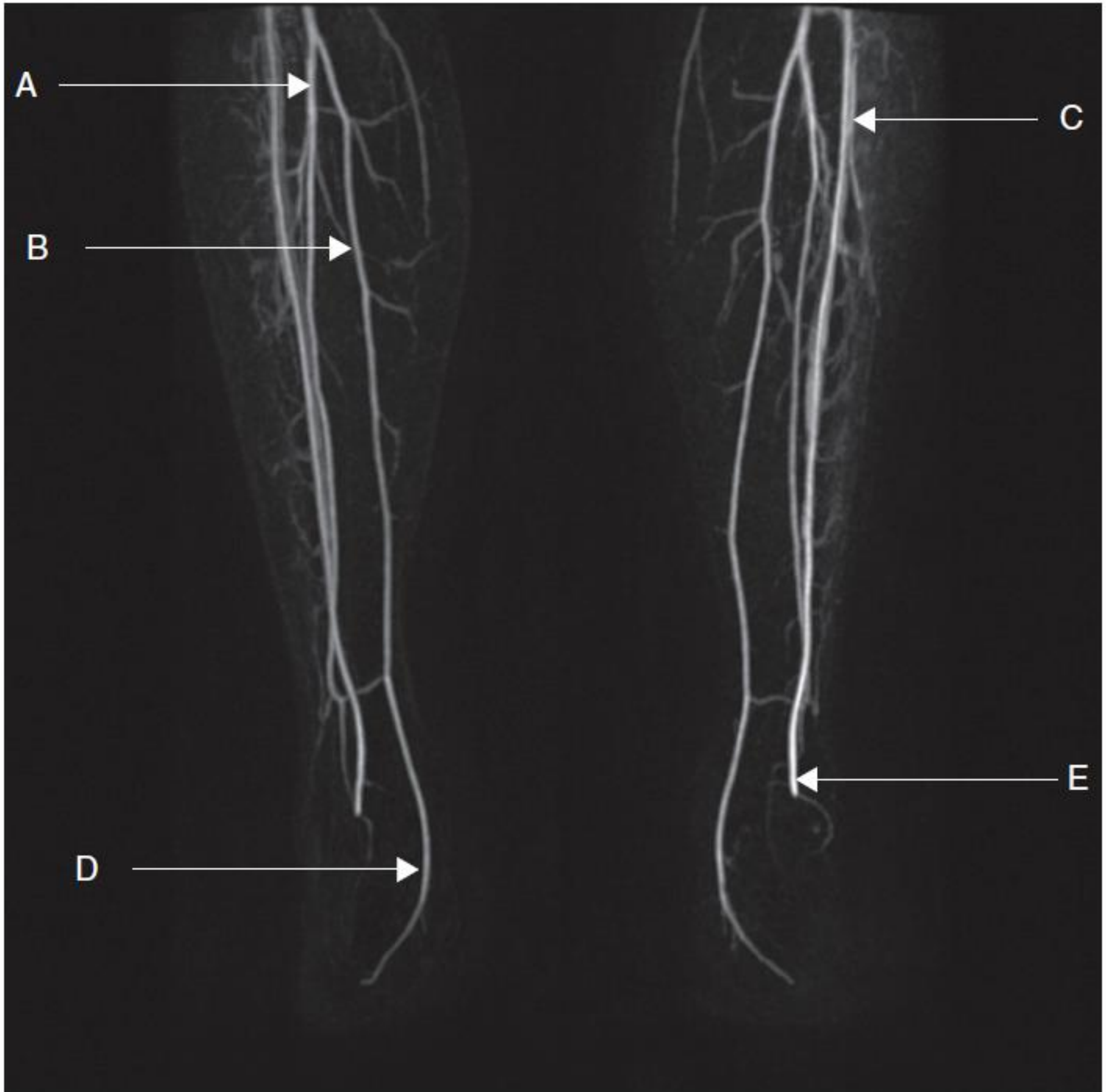


3.6 Volume rendering of the pelvis

(a) Left external iliac artery (not the common iliac artery as the internal iliac artery has already branched off).
(b) Right internal iliac artery.
(c) Left common femoral artery (CFA). For arterial puncture in angiogram the CFA needs to be targeted. With a puncture above (external iliac artery) or below (superficial femoral artery) this, manual compression to secure haemostasis cannot be performed adequately as the vessel cannot be compressed against bone. Furthermore, arterial closure devices are only licensed for use in the CFA.

(d) Left deep artery of the thigh (profunda femoris artery (PFA)). This artery supplies mainly the thigh while the superficial femoral artery (SFA) supplies the calf and foot. Of these the former is more important because if the SFA is occluded the calf can be supplied by collaterals from the PFA, whereas the opposite is not true.
(e) Right superficial femoral artery. This vessel is the continuation of the CFA after the deep artery of the thigh (profunda femoris artery) has branched off. At the inferior border of the femoral triangle it passes into the adductor canal (Hunter's or subsartorial canal). It emerges distally in an opening in the adductor magnus known as the adductor hiatus to become the popliteal artery.

Case 3.14



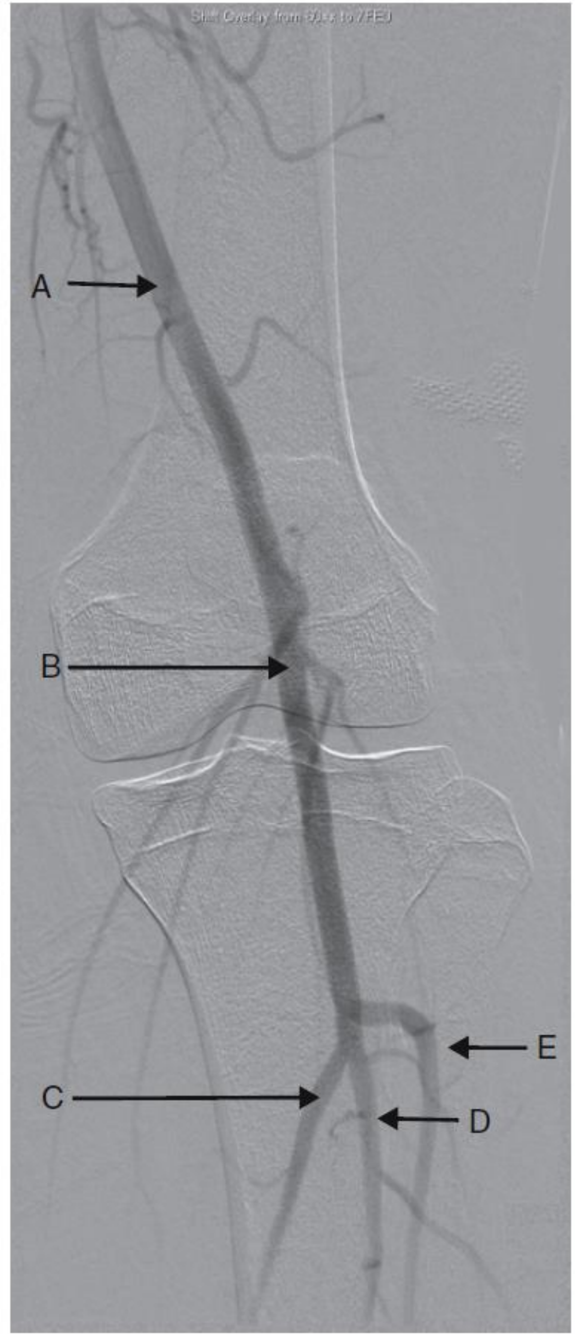
3.14 MR angiography (MRA) calf vessels

(a) Right fibular (or common peroneal) artery.
(b) Right posterior tibial artery. This artery lies deep to soleus as it runs inferiorly, becoming superficial close to the ankle joint where it it can be palpated behind the medial malleolus.
(c) Left anterior tibial artery. This is the first terminal branch of the popliteal artery. It passes forward through an opening in the intraosseus membrane and continues inferiorly. It passes anteriorly across the ankle joint beneath the extensor retinaculum to become the dorsalis pedis artery of the foot.

These three vessels (A, B and C) constitute the 'run-off' when talking about peripheral vascular disease. 'In-line flow' means at least one vessel is patent from the origin to the ankle without reliance on collateral vessels. Recent evidence suggests the longevity for below knee intervention depends upon the total number of patent vessels.

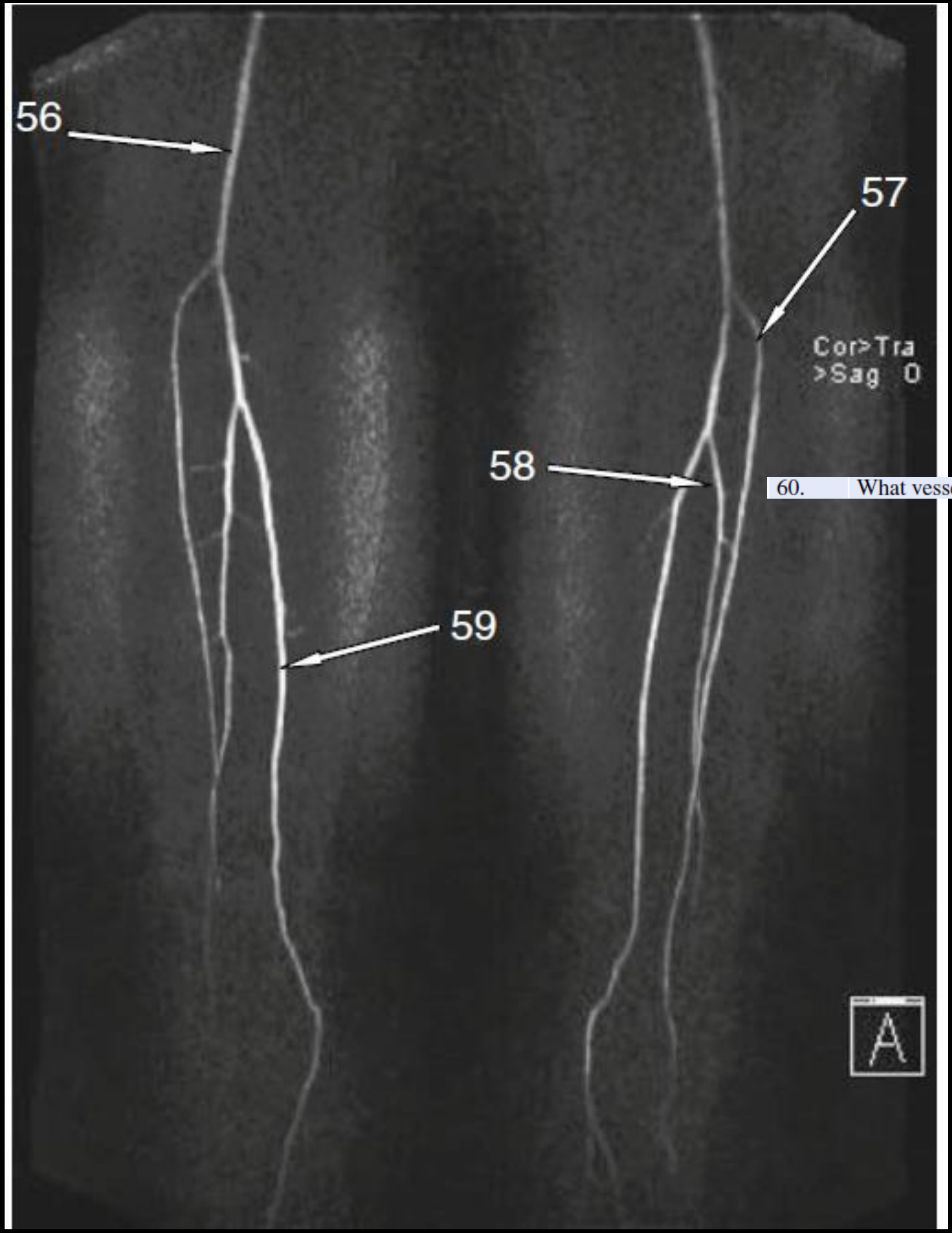
(d) Right lateral plantar artery. This together with the other branch from the dorsalis pedis, the medial plantar artery, feed into the deep plantar arch.
(e) Left dorsalis pedis artery.

Case 4.15



4.15 Angiogram left lower limb

(a) Superficial femoral artery. Distally this lies in the adductor canal lying on adductor longus, then adductor magnus, becoming the popliteal artery as it passes through the adductor hiatus in latter muscle.
(b) Popliteal artery. The popliteal artery branches into its end arteries at the lower border of popliteus in 95% of individuals. However, in particular, there is variability in the level of branching of the anterior tibial artery.
(c) Posterior tibial (PT) artery. The segment of vessel between the popliteal artery and bifurcation of the PT and peroneal artery is referred to as the tibio-peroneal trunk.
(d) Fibular (common peroneal) artery. Normally the fibular (peroneal) artery terminates in the distal calf.
(e) Anterior tibial artery. The anterior and posterior tibial arteries continue into the foot as the dorsalis pedis and lateral plantar arteries respectively.



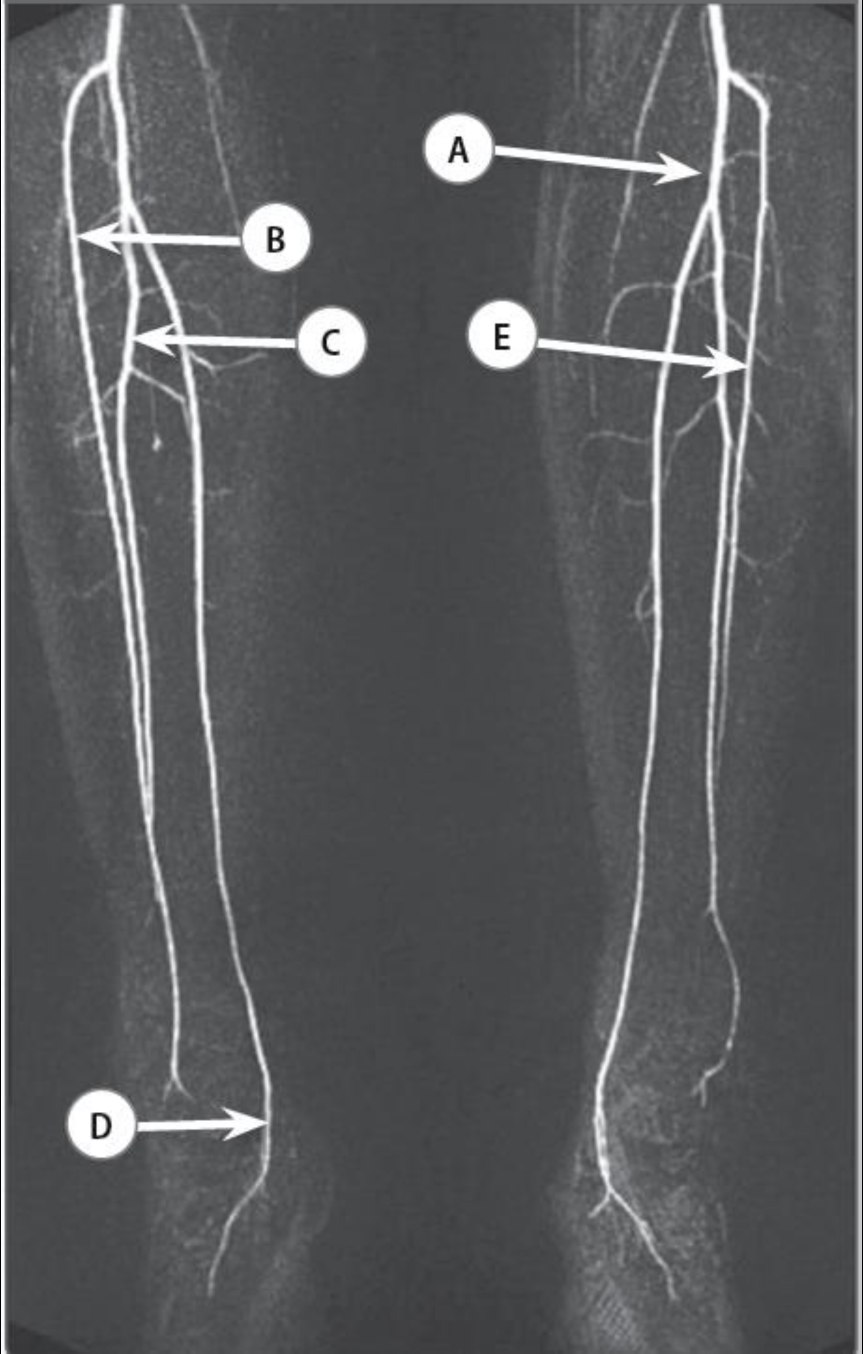
60. What vessel does vessel 57 become more distally?

MR Angiogram

56. Right superficial femoral artery
57. Left anterior tibial artery
58. Left peroneal artery
59. Right posterior tibial artery
60. Left dorsalis pedis artery

The anterior tibial artery is the first lateral branch from the popliteal artery.

Case 6.12



Case 6.12

A Left tibioperoneal trunk

B Right anterior tibial artery

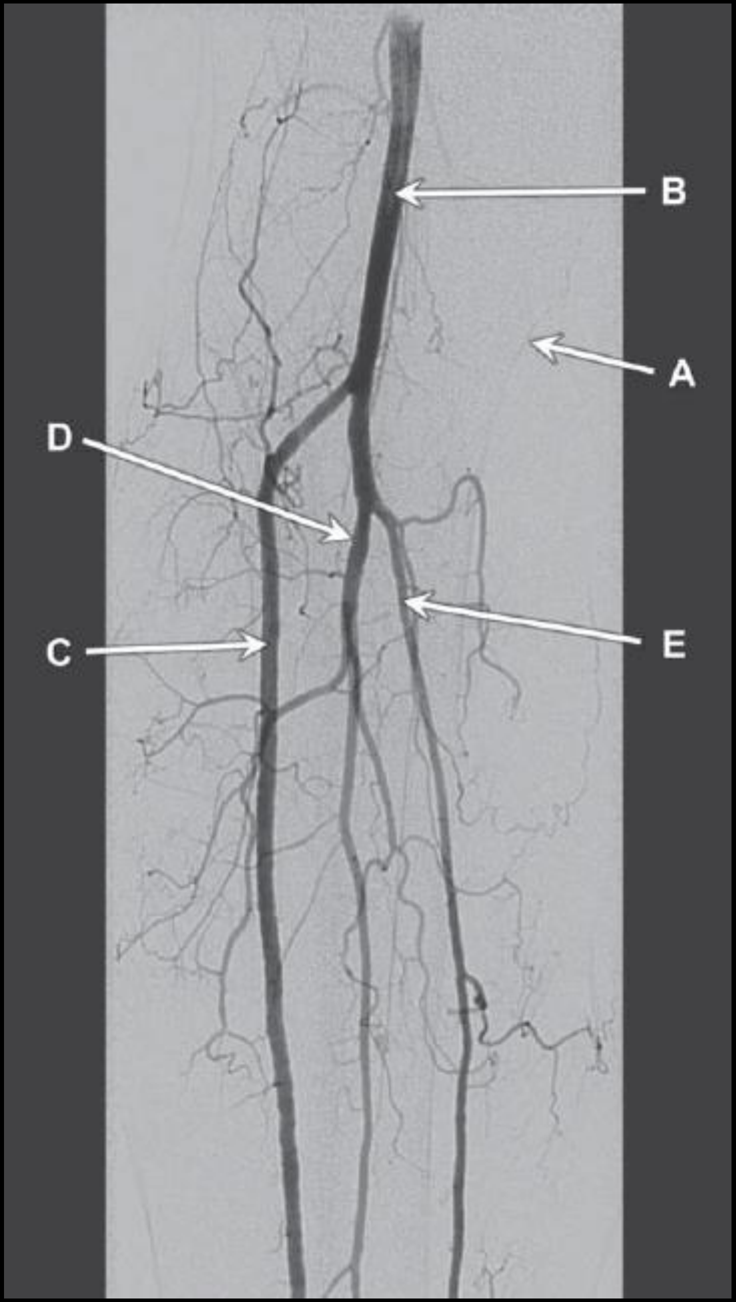
C Right peroneal artery

D Right posterior tibial artery

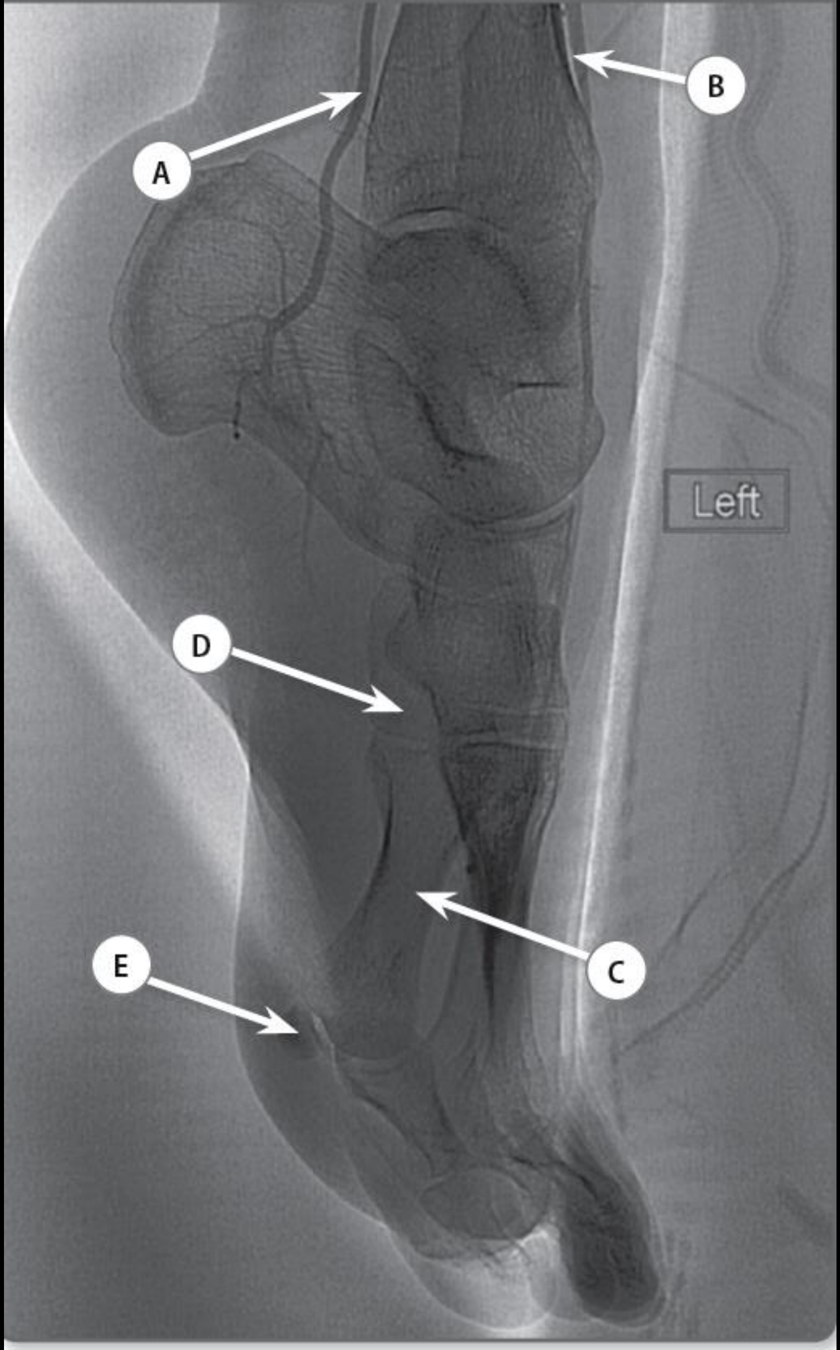
E Left anterior tibial artery

Lower limb MR angiogram.

For further discussion see Chapter 4, Cases 4.16–4.18.


B
A
D
C
E

Case 4.18



Case 4.18

A Left posterior tibial artery

B Left anterior tibial artery

C Left 1st metatarsal

D Left medial cuneiform

E Sesamoid bones in left flexor hallucis brevis

Angiogram of the foot.

The posterior tibial artery descends in the posterior compartment between tibialis posterior and soleus. It passes behind the medial malleolus, deep to the flexor retinaculum. It divides into the medial and lateral plantar arteries.

The anterior tibial artery descends in the anterior compartment of the leg on the anterior surface of the interosseous membrane. It crosses the anterior aspect of the ankle joint between the tendons of tibialis anterior and extensor hallucis longus. In the foot it is called the dorsalis pedis.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 217.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 306–312.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 386.

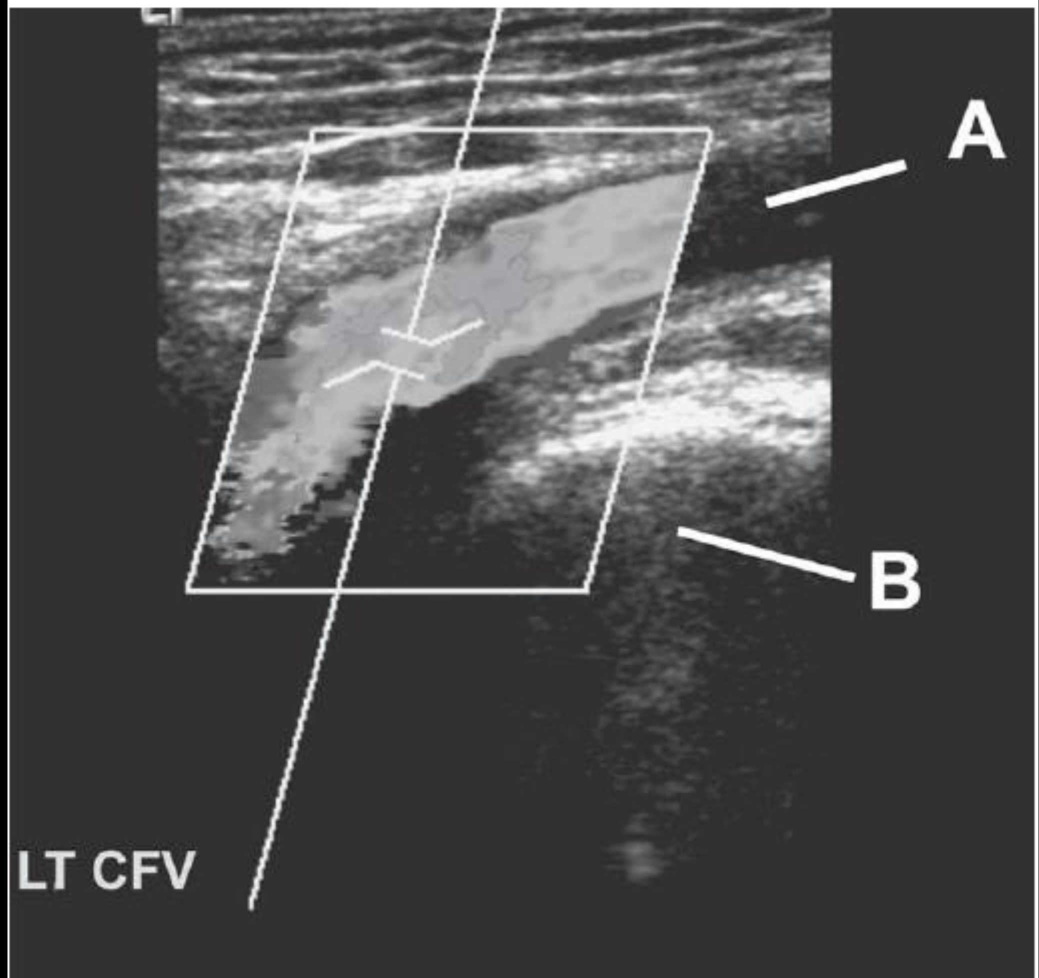
Case 1

Angiogram. Lower limb arteries.

1. Tibia
2. Popliteal artery
3. Anterior tibial artery
4. Posterior tibial artery
5. Peroneal artery

Q5

a Name the structure labelled A
b Name the structure labelled B
c Name the structure positioned lateral to structure A
d Name the space immediately medial to structure A
e Name the major superficial vein which drains into structure A



Q5 Answers

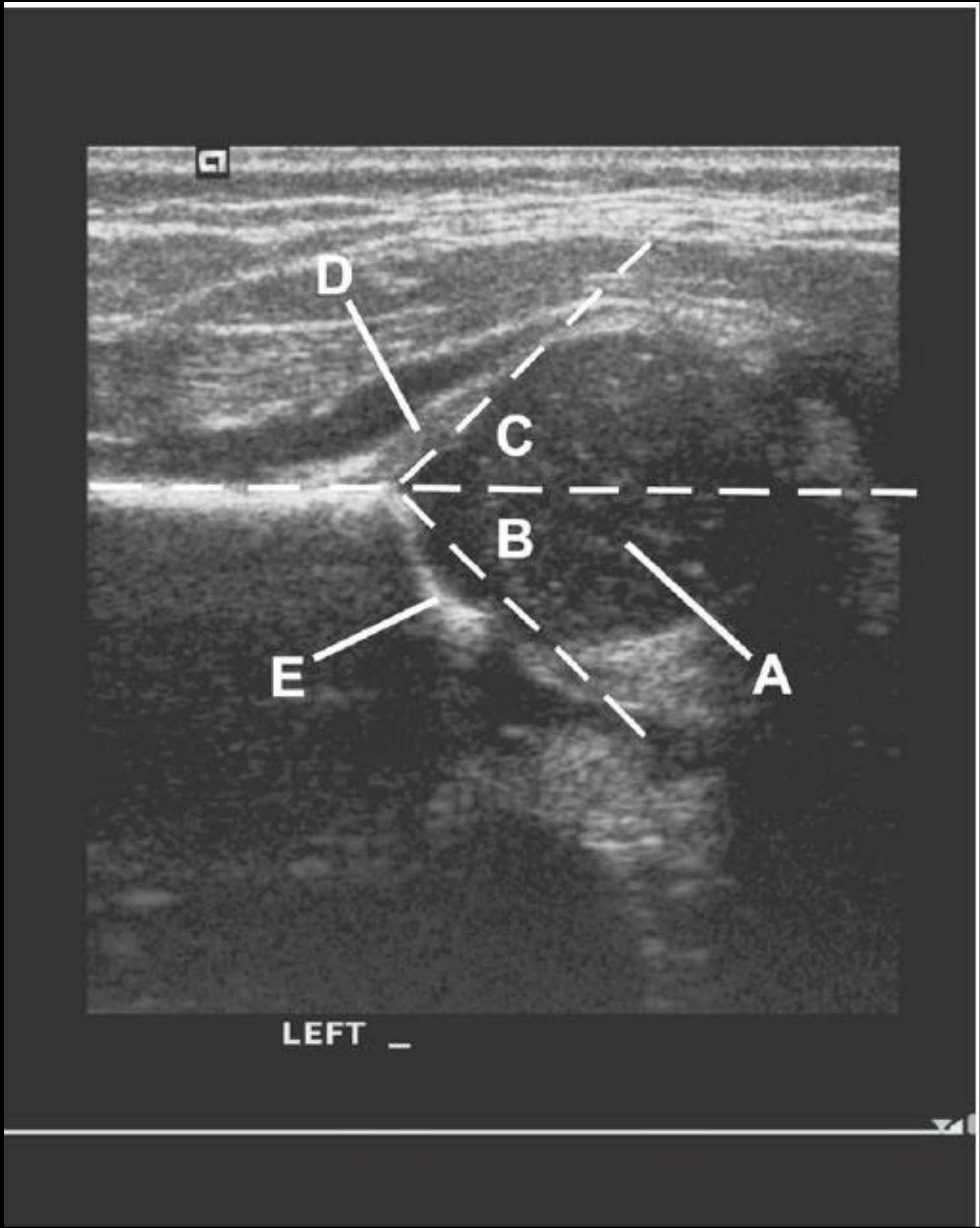
a Common femoral vein (CFV)
b Femoral head
c Femoral artery
d Femoral canal
e Long saphenous vein

Colour flow Doppler of the common femoral vein, longitudinal view

The walls of veins, like arteries, comprise of three layers; the endothelium-lined tunica intima, muscular tunica media and the connective tissue covering of tunica adventitia. Where the wall architecture of arteries and veins differ is in the thickness of these three layers and of the muscular medial layer in particular. This is relatively thin in the walls of veins which results in them being unable to oppose radial compression – a feature that can help distinguish between artery and vein on ultrasound examination. Lateral to the femoral vein lies the femoral artery. The femoral canal lies medial to the femoral vein and usually contains a lymph node (of Cloquet).

The hip joint lies deep to the common femoral vessels. As the femoral vein passes beyond the superior margin of the femoral head it adopts a deeper course before passing beneath the inguinal ligament and becoming the external iliac vein. The femoral head is used as a radiological landmark in percutaneous femoral arterial punctures to ensure that the arteriotomy is inferior to the inguinal ligament and therefore controllable with manual compression on the groin.

ULTRASOUND


D
C
B
A
E
LEFT

Q4 Answers

- **a** Femoral head
- **b** Alpha angle
- **c** Beta angle
- **d** Cartilaginous acetabular roof
- **e** Osseus acetabular concavity

Hip ultrasound in a 6 month-old child, coronal view

Normal development of the hip joint is reliant on there being adequate contact between the femoral head and acetabulum. Abnormalities of subluxation and dislocation need to be recognized in order to prevent dysplastic development. In infants there is a discrepancy in size between the large femoral head and the relatively under developed acetabulum and since the hip joint is predominantly cartilaginous, the preferred modality for assessment is ultrasound.

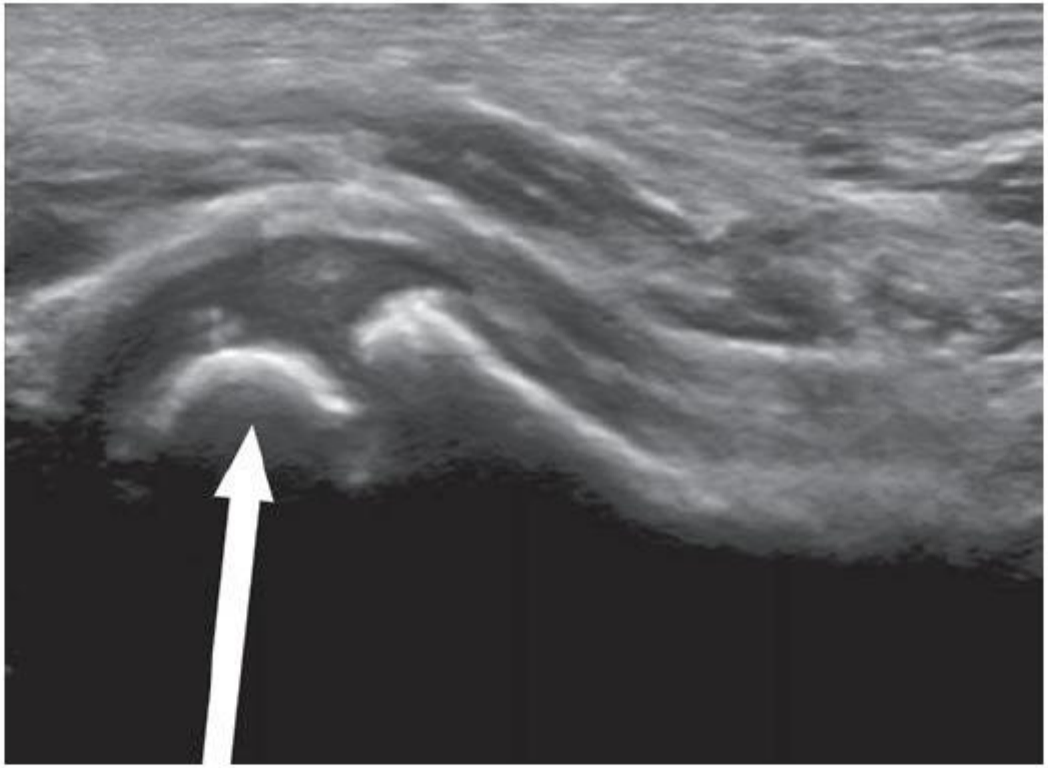
The ilium, ossified acetabulum and cartilaginous acetabulum are all seen on coronal imaging. The non-ossified femoral head has a 'speckled' echotexture. There are three lines which enable assessment of the hip joint: the 'baseline' runs parallel to the ilium; the 'acetabular roofline' runs along the plane of the bony acetabular concavity and the 'inclination' line runs from the lateral bony acetabulum along the underside of the cartilaginous roof.

The alpha angle is a measurement of acetabular depth (and therefore maturity) and lies between the baseline and acetabular roofline. The beta angle is a measurement of acetabular cartilaginous roof coverage and lies between the baseline and the inclination line. Dysplastic hips have a low alpha angle and high beta angle (i.e. immature bony acetabulum and predominantly cartilaginous coverage of the femoral head). An alpha angle >60 degrees and beta angle <55 degrees is normal.

An alternative assessment of acetabular maturity is to define the distance from the medial aspect of the femoral head to the baseline as a percentage of total femoral head diameter. This is known as the d/D ratio and a value >58% is considered normal.

Norton KI, Polin SAM. Developmental Dysplasia of the Hip. *Radiology* 2009; eMedicine: www.emedicine.medscape.com

Question 16:

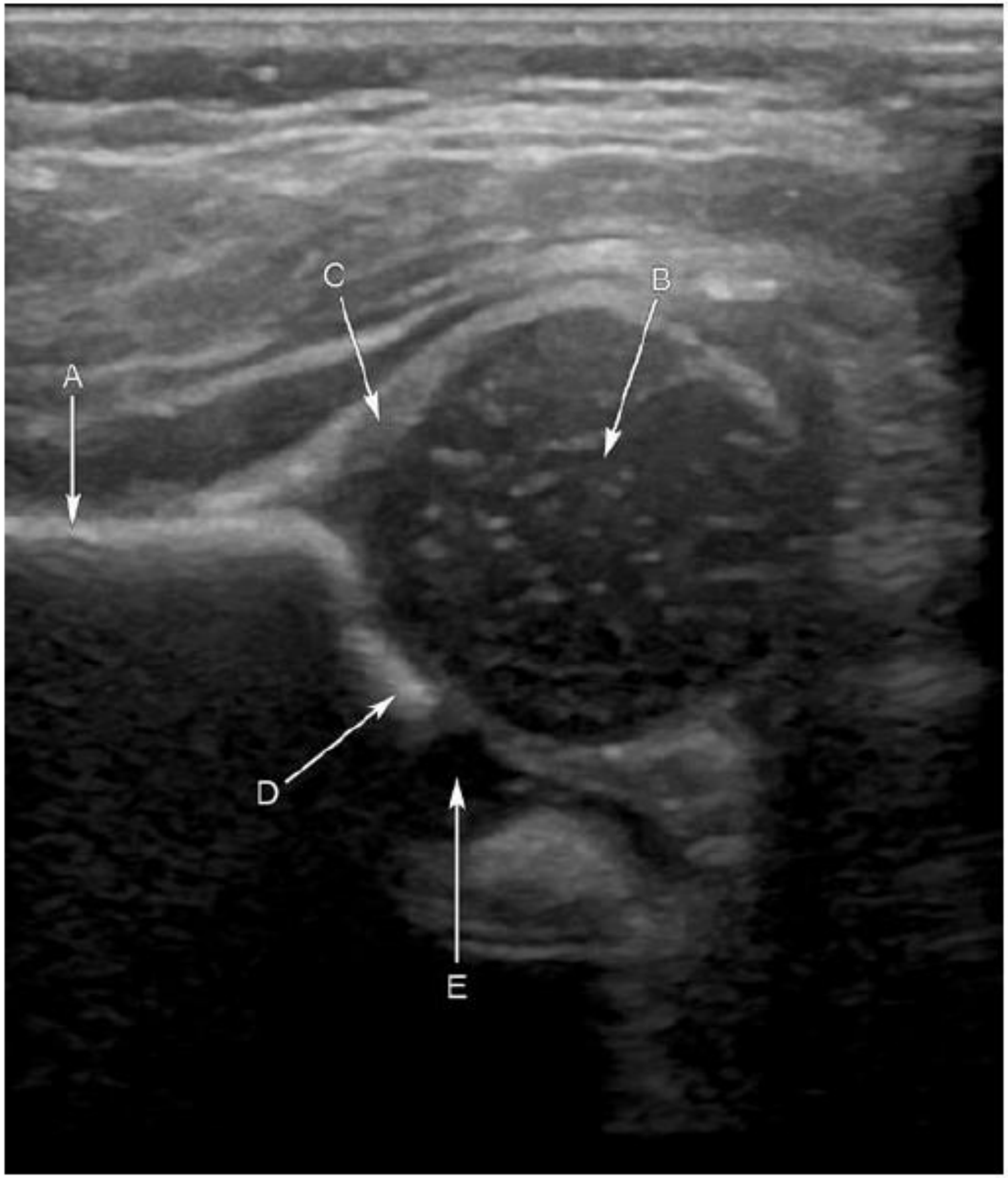


Question 16: Ultrasound of an infant's hip

Answer: Femoral head

- Paediatric ultrasound images of the hip are very common in the examination.
- Be familiar with the sagittal view. Orientate yourself with the round femoral head. Visualise the Y-shaped arrangement of the ilium/labrum/acetabular roof, which forms a caplike structure on the femoral head.
- The iliopsoas muscle can be seen as the superficial structure along the axis of imaging.

Question 3.20



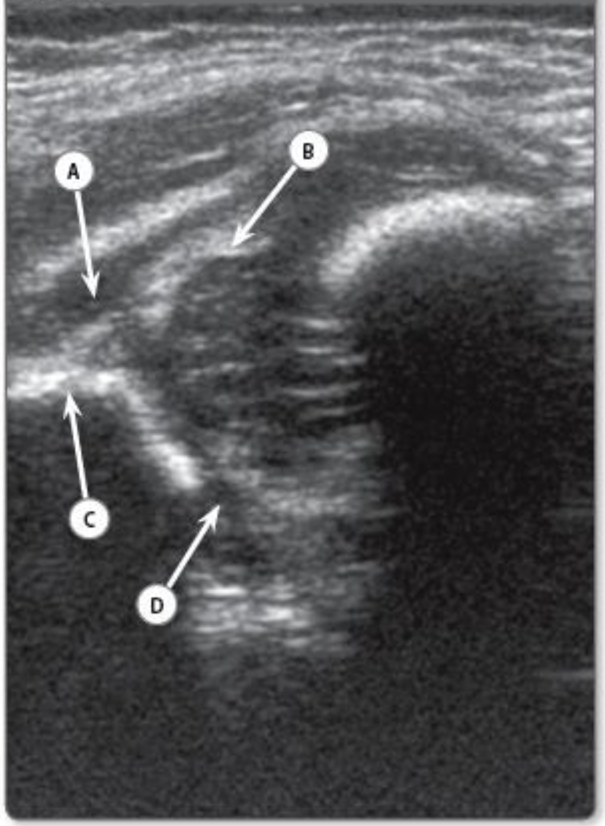
This is an ultrasound of an infant's right hip.
Name the structures labelled **A** to **E**.

3.20 Longitudinal ultrasound of the right infant hip

A Ilium.
B Femoral capital epiphysis.
C Labrum.
D Acetabulum.
E Triradiate cartilage.

Ultrasound of the paediatric hip is used for detection and follow-up of developmental dysplasia of the hip. The infant is positioned in the lateral decubitus position with the hip flexed and the probe orientated longitudinally. As the femoral head is unossified it can be easily visualized resting within the bony acetabulum. It appears as a speckled circular hypoechoic structure in the centre of the image. Sometimes an ossification centre can be visualized in the femoral head but this is not demonstrated on this image. The iliac bone is seen as the straight line running from the left of the picture and should transect the femoral head. The labrum is seen as the hypoechoic rim of tissue running between the acetabulum and the femoral head.

Case 5.19



Case 5.19

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	What is the name of the angle used to assess the acetabular depth?	

Case 5.19

A Gluteal muscles

B Acetabular labrum

C Ilium

D Gap of triradiate cartilage

E Alpha angle

This is the standard coronal ultrasound view of the infantile hip, undertaken to assess for the presence of instability or dislocation. The alpha angle is used to assess acetabular depth. It is ascertained by drawing a line parallel to the ilium and another line from the edge of the acetabulum through the gap of the triradiate cartilage (the lowest part of the bony acetabulum), and determining the angle between them. This should normally be greater than 60°. The beta angle (used to evaluate the labral prominence) is found between the line parallel to the ilium and another line drawn parallel to the edge of the labrum.

These angles and relevant anatomical landmarks are depicted in **Figure 5.2**.

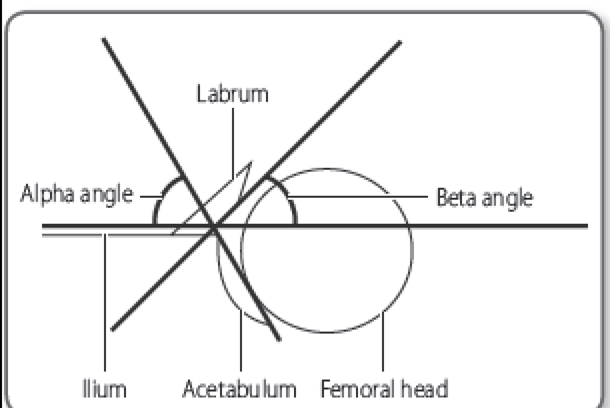
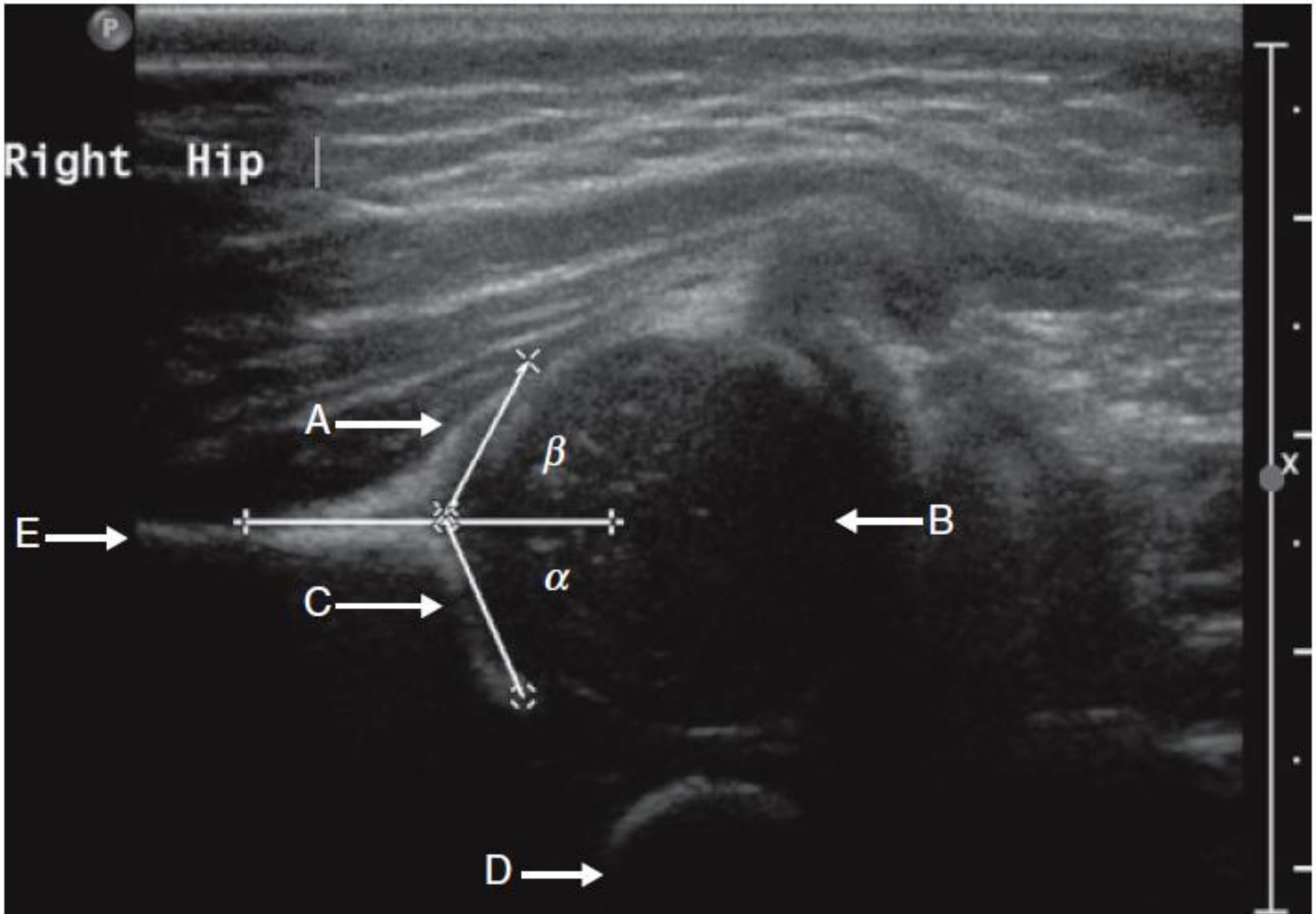


Figure 5.2 Schematic diagram of the infant hip ultrasound.

Case 5.9



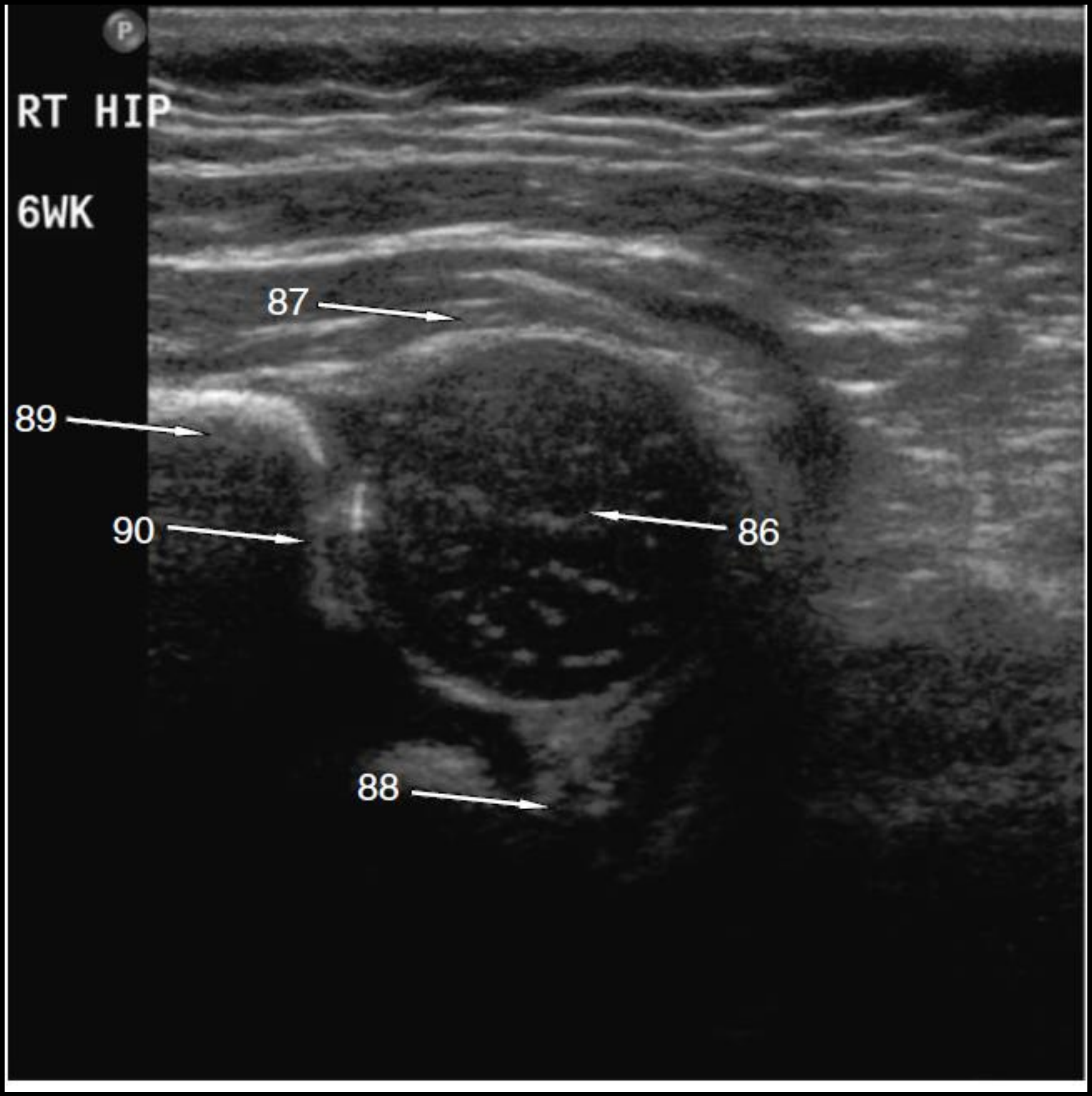
5.9 Paediatric right hip ultrasound

(a) Labrum.
(b) Femoral head.
(c) Acetabulum.
(d) Pubis.
(e) Ileum.

The beta (β) angle of the hip is the angle of the fibrocartilage to the ilium and the alpha (α) angle is the angle of depth of the bony acetabulum. The normal angles are:

$\boldsymbol{\alpha}$ >60 degrees
$\boldsymbol{\beta}$ <77 degrees.

These angles are important to define the presence and severity of congenital hip dysplasia. The Graf classification indicates the degree of congenital hip dysplasia.


RT HIP
6WK
87
89
90
86
88

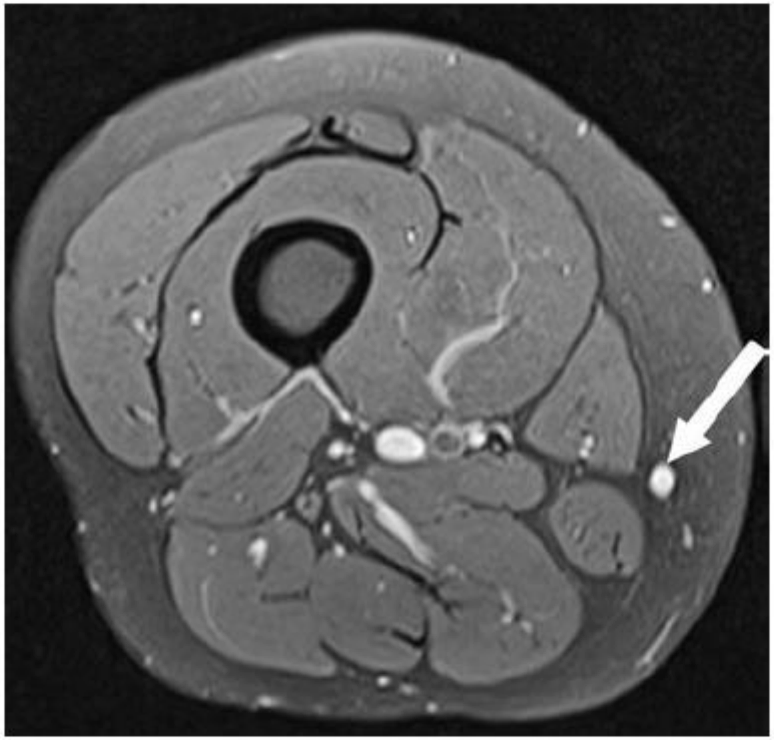
Ultrasound Hip

86. Right femoral head (unossified)
87. Right labrum
88. Right triradiate cartilage
89. Right ilium
90. Right acetabulum

This view is used to assess hip dysplasia. Alpha and beta angles as well as subjective morphological assessment of the acetabulum along with dynamic manoeuvres can be used to quantify the degree of developmental hip dysplasia.

CROSS-SECTIONAL

- **Question 43:**



Question 43: Axial MRI of the upper thigh

Answer: Great (long) saphenous vein

- The great saphenous vein is a superficial vein formed from the dorsal venous arch and dorsal vein of the great toe.
- It runs medially from anterior to the medial malleolus up the length of the leg to drain into the femoral vein in the inguinal region.
- Communicating veins connect the saphenous vein to the deep veins.
- The short saphenous vein is on the lateral aspect of the lower leg and drains into the popliteal vein.
- Because the great saphenous vein is a medial structure, you can be sure that this is the right leg and thus right great saphenous vein.

Question 3.19

This is an axial MRI of the right thigh.
Name the structures labelled **A** to **E**.

3.19 Axial T1 MRI of the right femur

A Rectus femoris muscle.
B Vastus intermedius muscle.
C Sartorius muscle.
D Gracilis muscle.
E Semitendinosus muscle.

There are four quadriceps muscles:

- Rectus femoris.
- Vastus medialis.
- Vastus intermedius.
- Vastus lateralis.

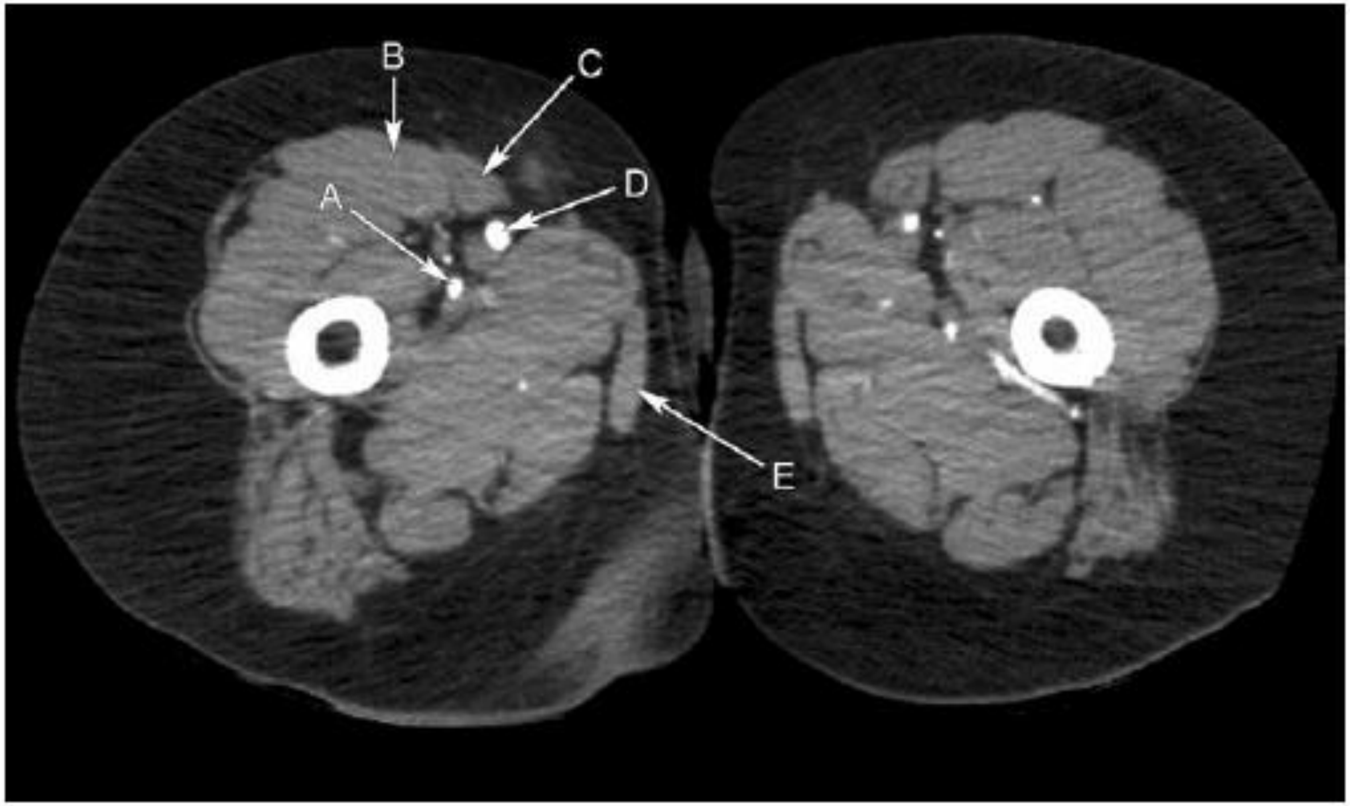
The rectus femoris can be recognized on axial section as the anterior muscle that lies directly in the midline. The sartorius is identified as the small superficial muscle overlying the superficial femoral vessels as it forms the roof of the adductor canal through which the vessels travel. The gracilis is recognized easily by its thin elongated shape and it is the most medial muscle of the thigh.

The semitendinosus is one of the hamstrings of the thigh. It originates from the ischial tuberosity and inserts into the upper medial surface of the tibia. To recognize the semitendinosus on axial section, remember that it is the smallest of the posterior muscles of the thigh, usually lies in the midline posterior to the femur and runs in between the biceps femoris (laterally) and the semimembranosus (medially).

When trying to differentiate semimembranosus from semitendinosus, remember semiTendinosus is laTeral to semimembranosus or semiMembranosus is Medial to semitendinosus.

For further images and descriptions of the thigh muscles see Questions 5.17, 6.19 and 7.20.

Question 6.19



Name the structures labelled **A** to **E**.

6.19 Axial CT angiogram of the thighs

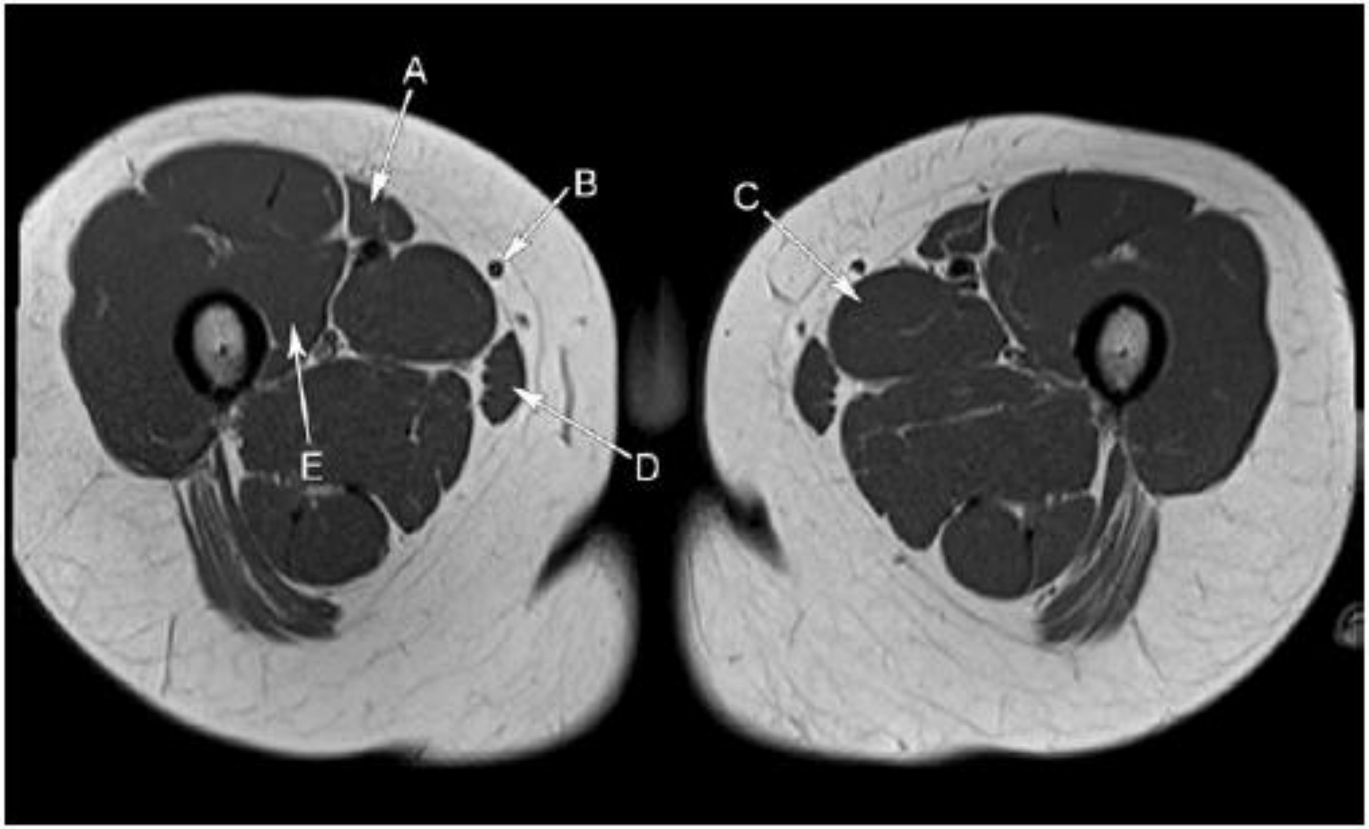
A Right profunda femoris artery.
B Right rectus femoris muscle.
C Right sartorius muscle.
D Right superficial femoral artery.
E Right gracilis muscle.

The profunda femoris is the deep branch of the femoral artery, supplying blood to the medial and posterior compartments of the thigh as well as the hip joint. The rectus femoris is one of the quadriceps muscles. Superiorly it arises from the anterior inferior iliac spine and the ilium superior to the acetabulum. Inferiorly the quadriceps muscles unite to form the quadriceps tendon that attaches to the patella.

The sartorius muscle and gracilis muscle tendons unite with the semitendinosus muscle (so-called conjoined tendons) to form the pes anserinus on the medial aspect of the knee. This inserts into the anteromedial surface of the proximal tibia.

A mnemonic for the muscles of the conjoined tendon (medial to lateral) is ‘Say Grace before Tea’ (Sartorius, Gracilis, semiTendinosus).

Question 7.20



Name the structures labelled **A** to **E**.

7.20 Axial T1 MRI of the thighs

A Right sartorius muscle.
B Right long saphenous vein.
C Left adductor longus muscle.
D Right gracilis muscle.
E Right vastus medialis muscle.

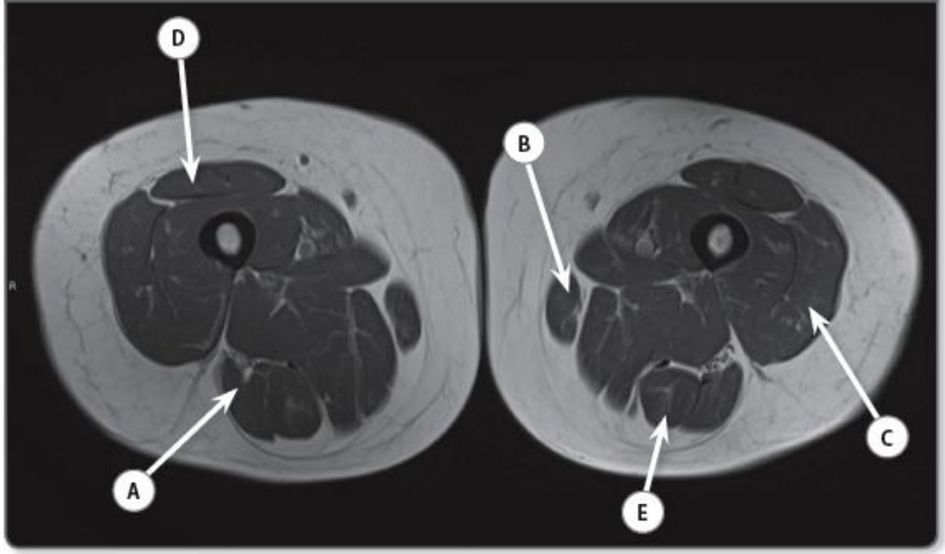
The adductor canal (also known as Hunter's canal) is a musculo-fascial tunnel in the middle third of the medial thigh that contains the femoral vessels and saphenous nerve (as well as the nerve to vastus medialis). It is approximately 15 cm long and runs from the apex of the femoral triangle to the adductor hiatus.

Boundaries of the adductor canal:

Anterolateral	Vastus medialis
Posteromedial	Adductor longus, adductor magnus
Anterior	Sartorius

For more information and images of thigh anatomy, please see Questions 3.19, 5.17 and 6.19.

Case 4.5



Case 4.5

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 4.5

A Right long head of biceps femoris muscle

B Left gracilis muscle

C Left vastus lateralis muscle

D Right rectus femoris muscle

E Left semimembranosus muscle

The anatomy of the thigh is divided into compartments which are bounded by fascial planes. A brief description of the contents of each compartment is provided below.

Anterior

- Iliotibial tract, tensor fascia lata muscle, quadriceps muscles, sartorius muscle

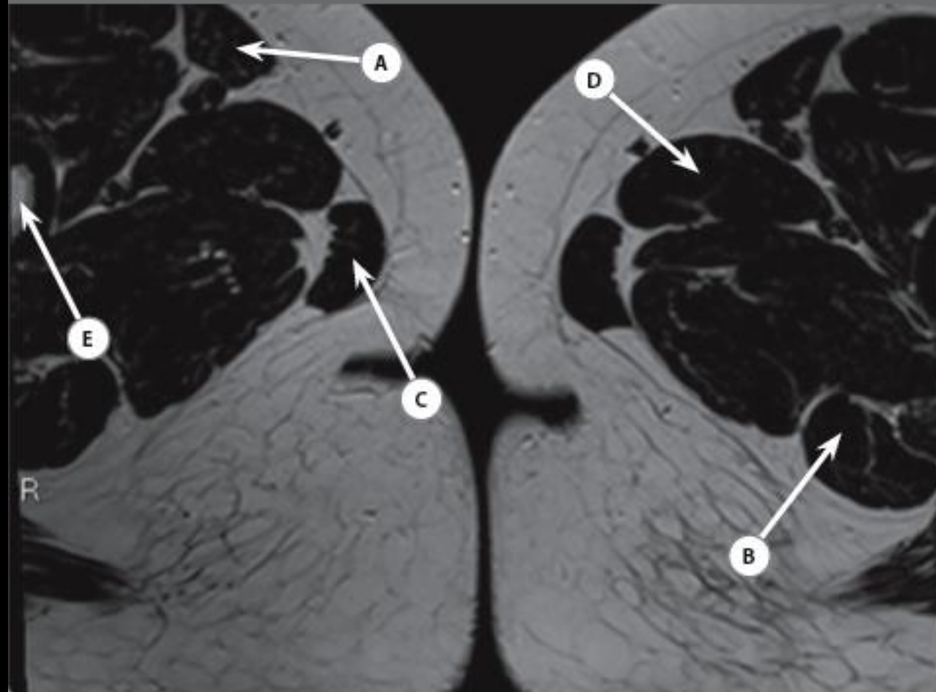
Medial

- Gracilis muscle, adductor muscles

Posterior

- Hamstring muscles, short head of biceps femoris muscle, sciatic nerve.

Case 6.12



Case 6.12

QUESTION		WRITE YOUR ANSWER HERE
A	What is the origin of the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 6.12

A Right anterior superior iliac spine

B Left semitendinosus muscle

C Right gracilis muscle

D Left adductor longus muscle

E Right femur

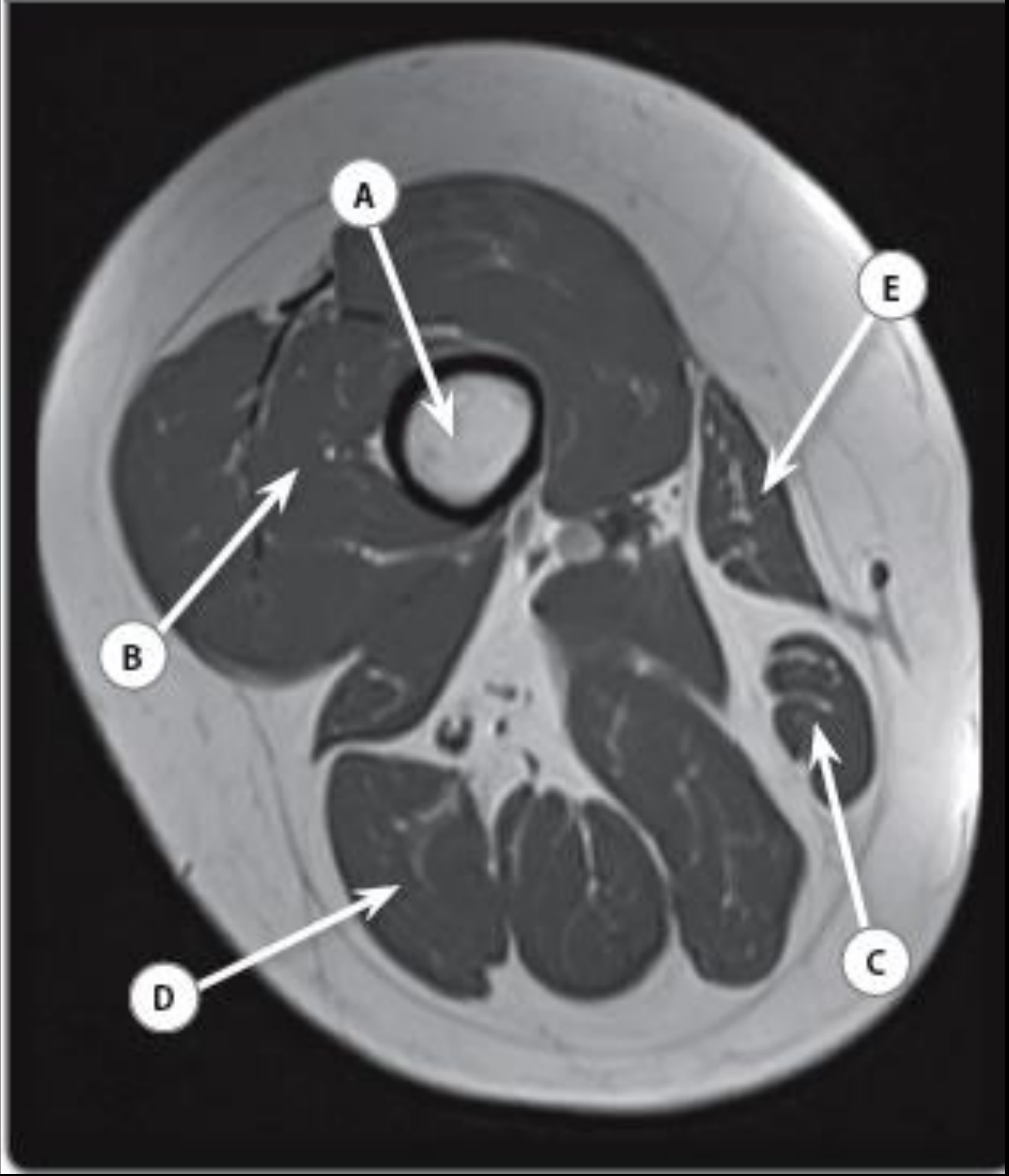
Sartorius is the longest muscle in the body that crosses two joints; the ipsilateral hip and knee joints. It originates from the anterior superior iliac spine (ASIS) and inserts into the pes anserine (proximal medial tibia).

An easy way to remember the origin of sartorius and rectus femoris is:

- ASIS – S for sartorius origin
- AIIS – rectus femoris muscle origin

To avoid confusing the proximal adductors and the quadriceps muscle groups, think of their relationships to the femur. The quadriceps muscles appear to 'hug' the femoral diaphysis, whereas the adductor group are seen in the medial thigh, away from the bone.

Case 6.20



Case 6.20

A Femur

B Vastus intermedius muscle

C Gracilis muscle

D Long head of biceps femoris muscle

E Sartorius muscle

The muscles of the thigh are divided into the anterior, medial and posterior compartments. The muscles within each compartment are as follows:

Anterior compartment

- Tensor fascia lata
- Quadriceps muscles (rectus femoris, vastus medialis, vastus intermedius and vastus lateralis)
- Sartorius

Medial compartment

- Gracilis
- Adductor muscles (adductor brevis, adductor longus and adductor magnus)

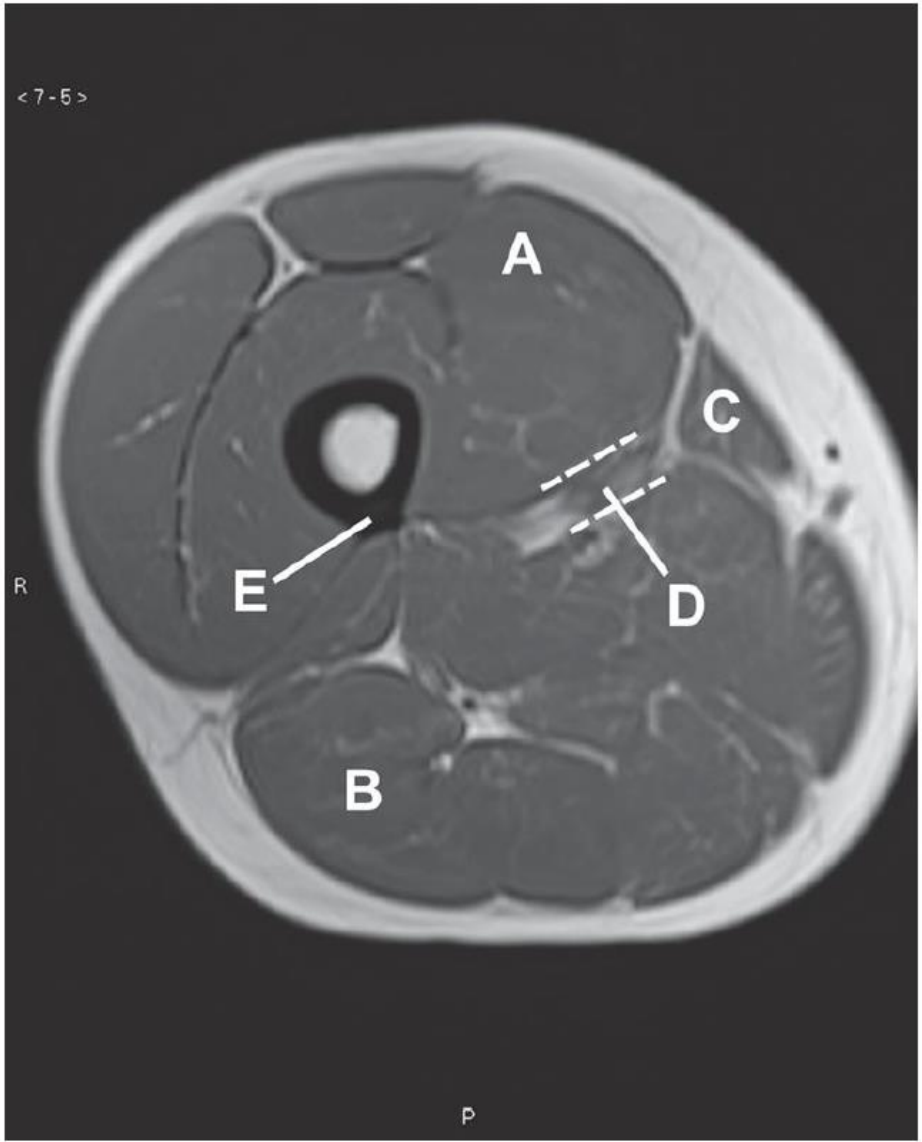
Posterior compartment

- Hamstring muscles (long head of biceps femoris, semimembranosus and semitendinosus)
- Short head of biceps femoris

Remember, the anatomical compartmental division of the thigh muscles differs from the functional groupings.

Q11

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the area outlined and labelled D
e Name the osseous ridge labelled E



Q11 Answers

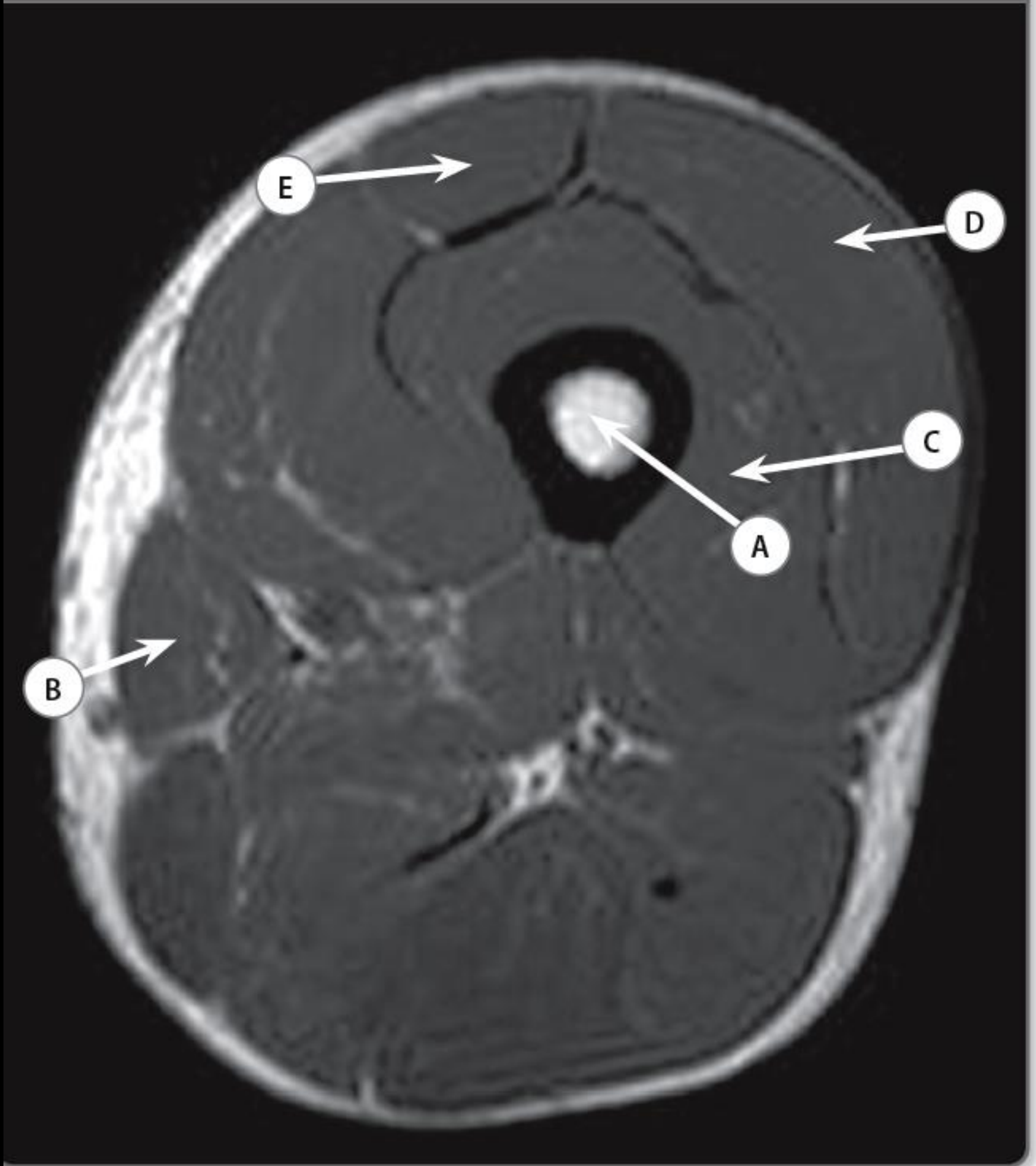
a Vastus medialis
b Biceps femoris
c Sartorius
d Adductor canal (Hunter's canal, subsartorial canal)
e Linea aspera

T1W MRI of lower thigh, axial section

The adductor canal is a continuation from the apex of the femoral triangle. It is a channel that runs down the medial and lower thigh located between vastus medialis anteriorly, the adductors posteriorly and the sartorius medially. It serves to transmit the superficial femoral artery (and descending genicular branch) and femoral vein between the thigh and the popliteal fossa. To enter the popliteal fossa, the femoral artery turns medially and passes posteriorly through an opening in the aponeurosis of adductor magnus (adductor hiatus). The femoral vein lies deep to the artery throughout the thigh, but superficial to it in the popliteal fossa. The saphenous nerve enters the canal superiorly before exiting medially between sartorius and gracilis.

The linea aspera is a roughened ridge on the posterior aspect of the femoral shaft which receives the attachments of the biceps femoris (short head) and the abductor muscles.

Case 4.12



Case 4.12

A Femur

B Sartorius

C Vastus intermedius

D Vastus lateralis

E Rectus femoris

Axial MRI of the thigh.

The anterior compartment of the thigh is bound anterolaterally by the fascia lata. Medially, it is separated from the medial compartment by the medial intermuscular septum. Laterally, it is separated from the posterior compartment by the lateral intermuscular septum.

The muscles of the anterior compartment are: the four muscles of quadriceps femoris (rectus femoris, vastus lateralis, vastus intermedius and vastus medialis), sartorius, psoas major, iliacus and pectineus.

The adductor compartment includes the adductor brevis, adductor longus, adductor magnus, gracilis and obturator externus.

The posterior compartment of the thigh is composed of the hamstrings: biceps femoris, semitendinosus and semimembranosus.

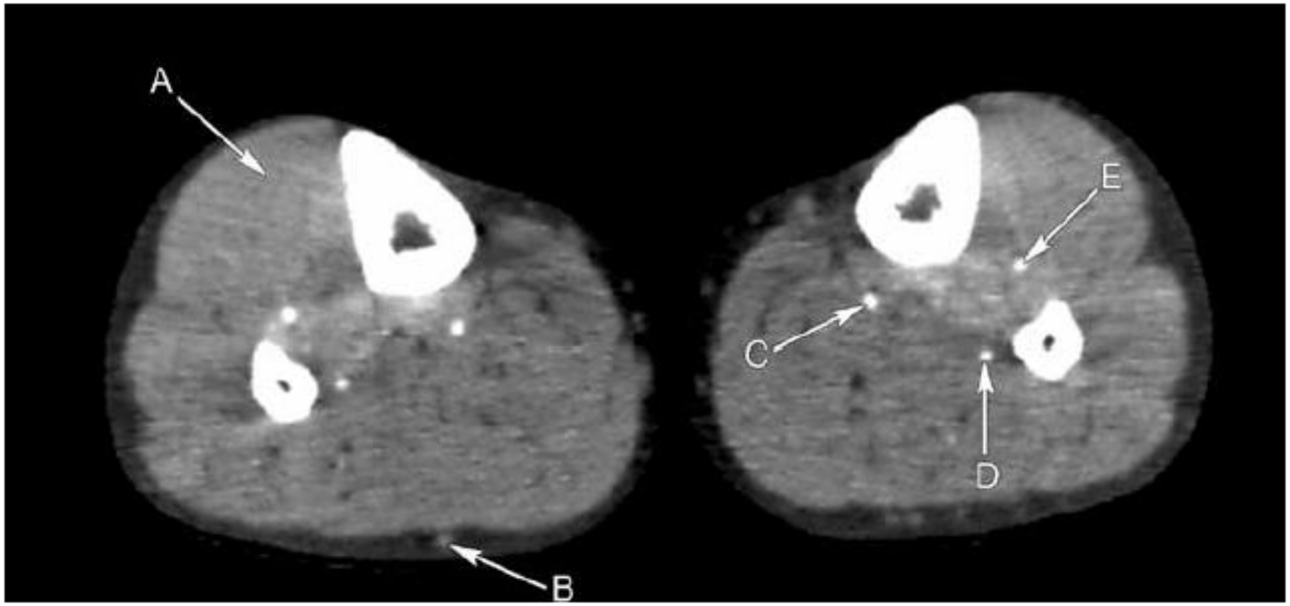
The major arteries in the thigh are the femoral, the profunda femoris, the medial and lateral circumflex femoral and the obturator artery.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 221.

Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 306.

Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 362.

Question 3.16



Name the structures labelled A to E.

3.16 Axial CTA of the lower limbs

A Right tibialis anterior muscle.
B Right short saphenous vein.
C Left posterior tibial artery.
D Left peroneal artery.
E Left anterior tibial artery.

The tibialis anterior can be easily located as it is the largest muscle of the anterior compartment of the leg, running lateral to the tibia. The short saphenous vein can be readily identified as it is the only large vessel running subcutaneously along the posterior aspect of the leg. It arises from the lateral aspect of the dorsal venous arch, passes posterior to the lateral malleolus and drains into the popliteal vein within the popliteal fossa. The popliteal artery bifurcates at the lower border of popliteus into the anterior tibial artery and the tibioperoneal trunk (which further divides into the posterior tibial artery and peroneal artery). The anterior tibial artery can be recognized on axial section as it runs in the anterior compartment of the lower limb. The posterior tibial artery can also be recognized as it passes posterior to the tibia as described in the name of the vessel. The peroneal artery runs medial to the fibula on axial section as demonstrated in the image.

Question 4.9

Name the structures labelled **A** to **E**.

4.9 Coronal T1 MRI of the lower limb

A Lateral right tibial plateau.
B Head of right fibula.
C Right tibialis posterior muscle.
D Right gastrocnemius muscle.
E Right soleus muscle.

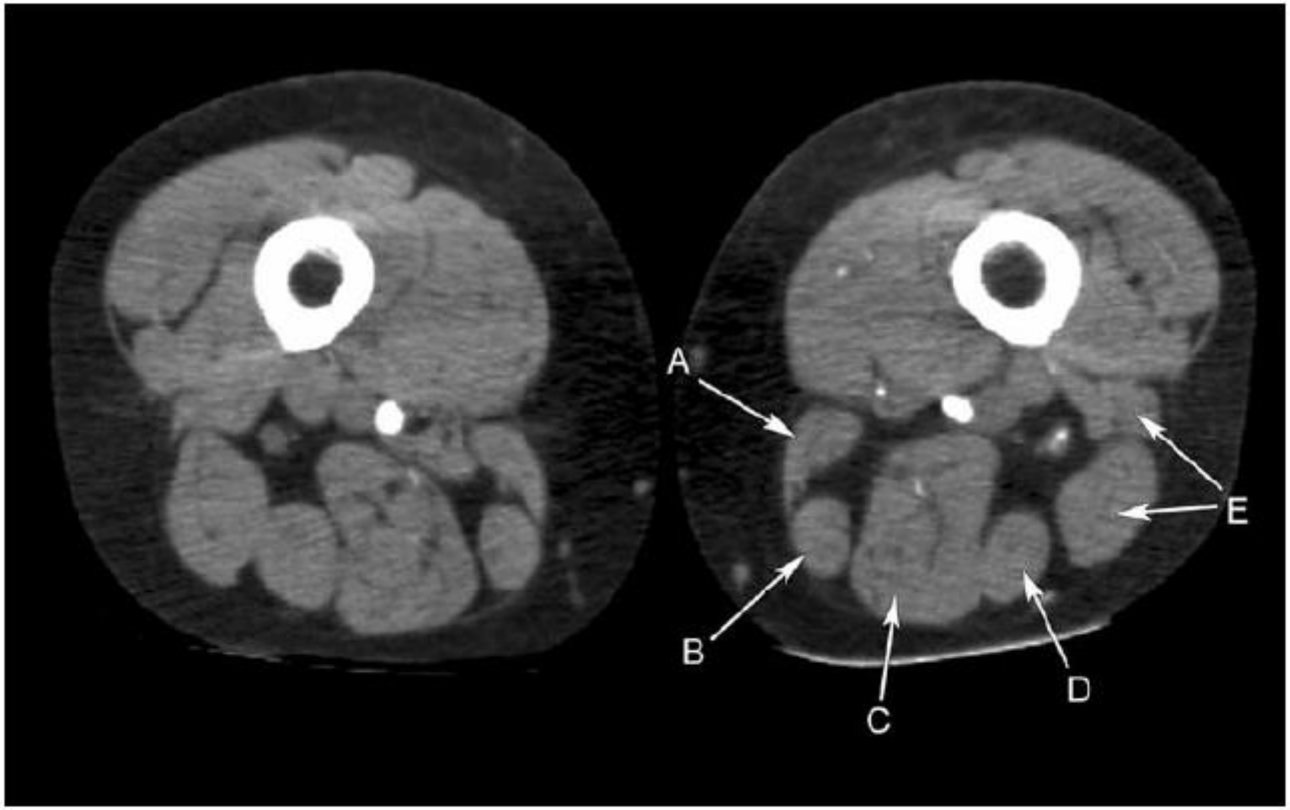
Since the fibula runs posteriorly to the tibia it can be recognized that this coronal image is demonstrating the posterior compartment of the lower limb. The lateral relation of the fibula to the tibia also helps with orientation.

The gastrocnemius is the largest and most superficial muscle of the calf. It has two heads – medial and lateral. The medial head originates from the medial femoral condyle (seen in the top left corner of the image). The lateral head arises from the lateral femoral condyle. It then forms a common tendon with the soleus (the Achilles tendon) and inserts into the posterior surface of the calcaneum.

The soleus is also found within the superficial posterior compartment of the lower limb and is located just anterior to gastrocnemius. The tibialis posterior originates from the lateral surface of the tibia and the medial surface of the fibula and runs within the deep posterior compartment of the lower limb. Distally it passes posterior to the medial malleolus (see Question 3.16) and then divides with many insertions in the foot (the major tendon inserting into the tuberosity of the navicular). It can be readily identified as it is the most central of all the muscles of the lower limb.

To see lower limb musculature in axial section please refer to Question 9.16.

Question 5.17



Name the structures labelled **A** to **E**.

5.17 Axial CT of the thigh with IV contrast

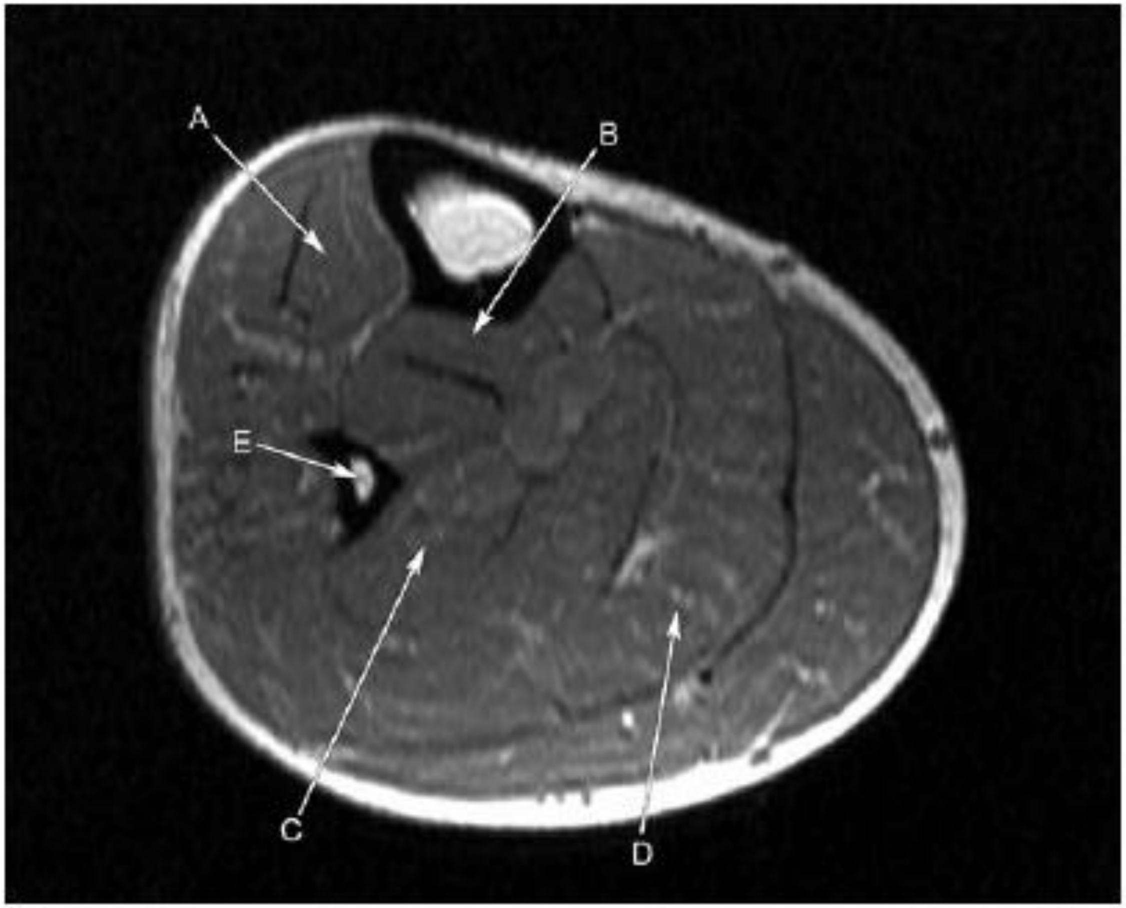
A Left sartorius muscle.
B Left gracilis muscle.
C Left semimembranosus muscle.
D Left semitendinosus muscle.
E Left biceps femoris muscle.

The thigh is divided into three facial compartments that are each supplied by a specific nerve:

Anterior compartment	Femoral nerve
Medial compartment	Obturator nerve
Posterior compartment	Sciatic nerve

The muscles in the posterior aspect of the thigh are known as the hamstrings, which consist of semitendinosus, semimembranosus and biceps femoris. These muscles span both the thigh and hip joint and are therefore both hip extensors and knee flexors. The anterior compartment contains the quadriceps muscle group and sartorius. The medial compartment contains the gracilis and the adductor muscle group.

Question 9.16



This is an axial MRI of the lower leg.
Name the structures labelled **A** to **E**.

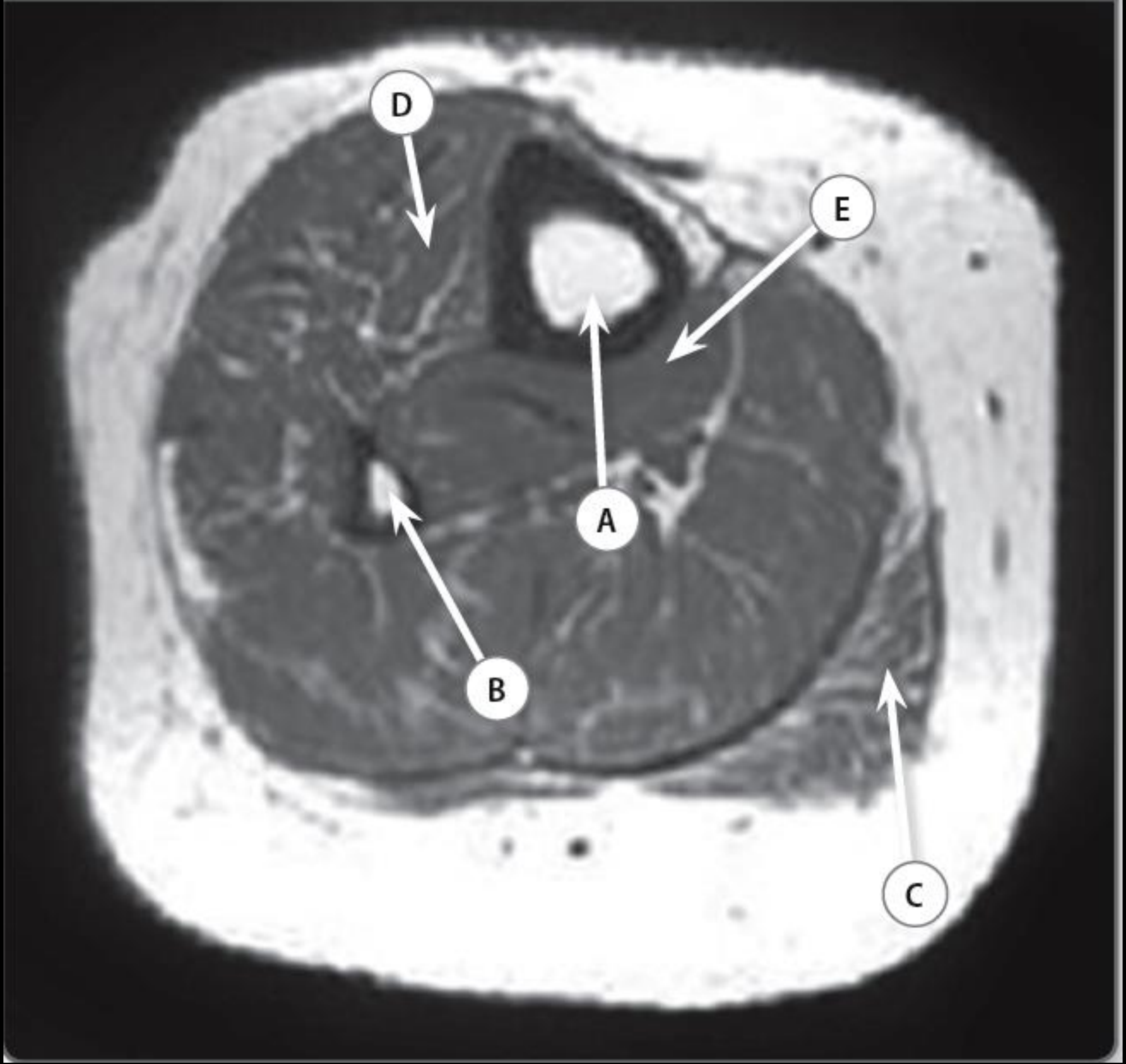
9.16 T1 MRI of the lower leg

A Right tibialis anterior muscle.
B Right tibialis posterior muscle.
C Right flexor hallucis longus muscle.
D Right soleus muscle.
E Right fibula.

The lower leg is divided into four fascial compartments with separate nerve and blood supplies:

Superficial posterior (medial sural nerve)	Gastrocnemius; soleus; plantaris
Deep posterior (tibial nerve)	Tibialis posterior; flexor hallucis longus; flexor digitorum longus; popliteus
Anterior (deep peroneal nerve)	Tibialis anterior; extensor hallucis longus; extensor digitorum longus; peroneus tertius
Lateral (superficial peroneal nerve)	Peroneus brevis; peroneus longus

Case 4.6



Case 4.6

A Tibia

B Fibula

C Medial head of gastrocnemius

D Tibialis anterior

E Flexor digitorum longus

Axial MRI of the calf.

Below the knee, the muscles of the leg are involved in the foot and ankle movement. They are divided into four compartments by the bones (tibia and fibula), the interosseous membrane and the intermuscular septi (transverse and posterior)

Tibialis anterior is the most medial muscle of the anterior compartment. It dorsiflexes and inverts the foot. It lies on the lateral side of the tibia and overlies the anterior tibial vessels and the deep peroneal nerve. The other muscles in this compartment are: extensor hallucis longus, extensor digitorum longus and peroneus tertius.

The superficial posterior compartment is made of gastrocnemius, soleus and plantaris.

Flexor digitorum longus is part of the deep posterior compartment of the leg. The other muscles in this compartment are flexor hallucis longus and tibialis posterior.

The lateral compartment is composed of peroneus longus and peroneus brevis.

Figure 4.1 illustrates the arrangement of the muscles in the leg.

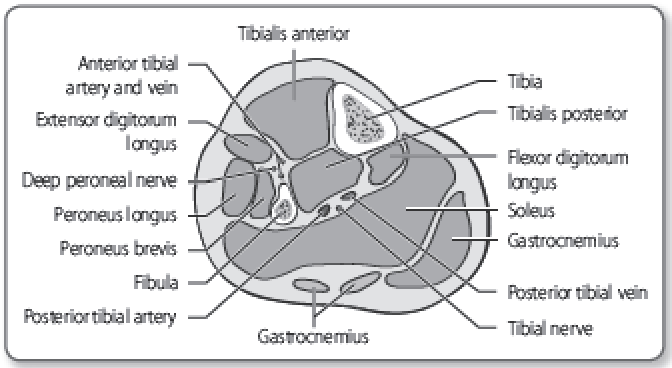
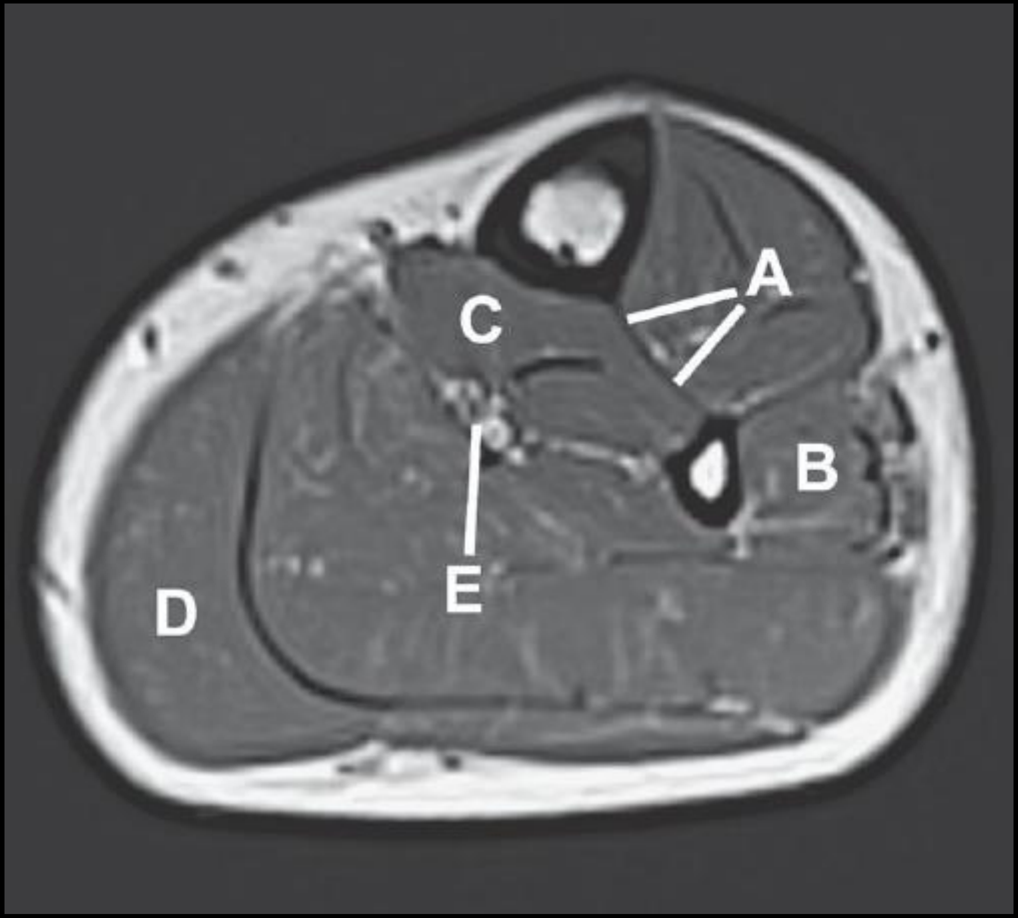


Figure 4.1 The muscles of the leg.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 229.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 307.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 370.


A
C
B
E
D

Q14 Answers

a Interosseous membrane
b Peroneus longus
c Tibialis posterior
d Medial head of gastrocnemius
e Posterior tibial neurovascular bundle

T1W MRI mid leg, axial section

Muscles of the leg are contained within three compartments: anterior (extensor); lateral (peroneal/evertor); and posterior (calf/flexor).

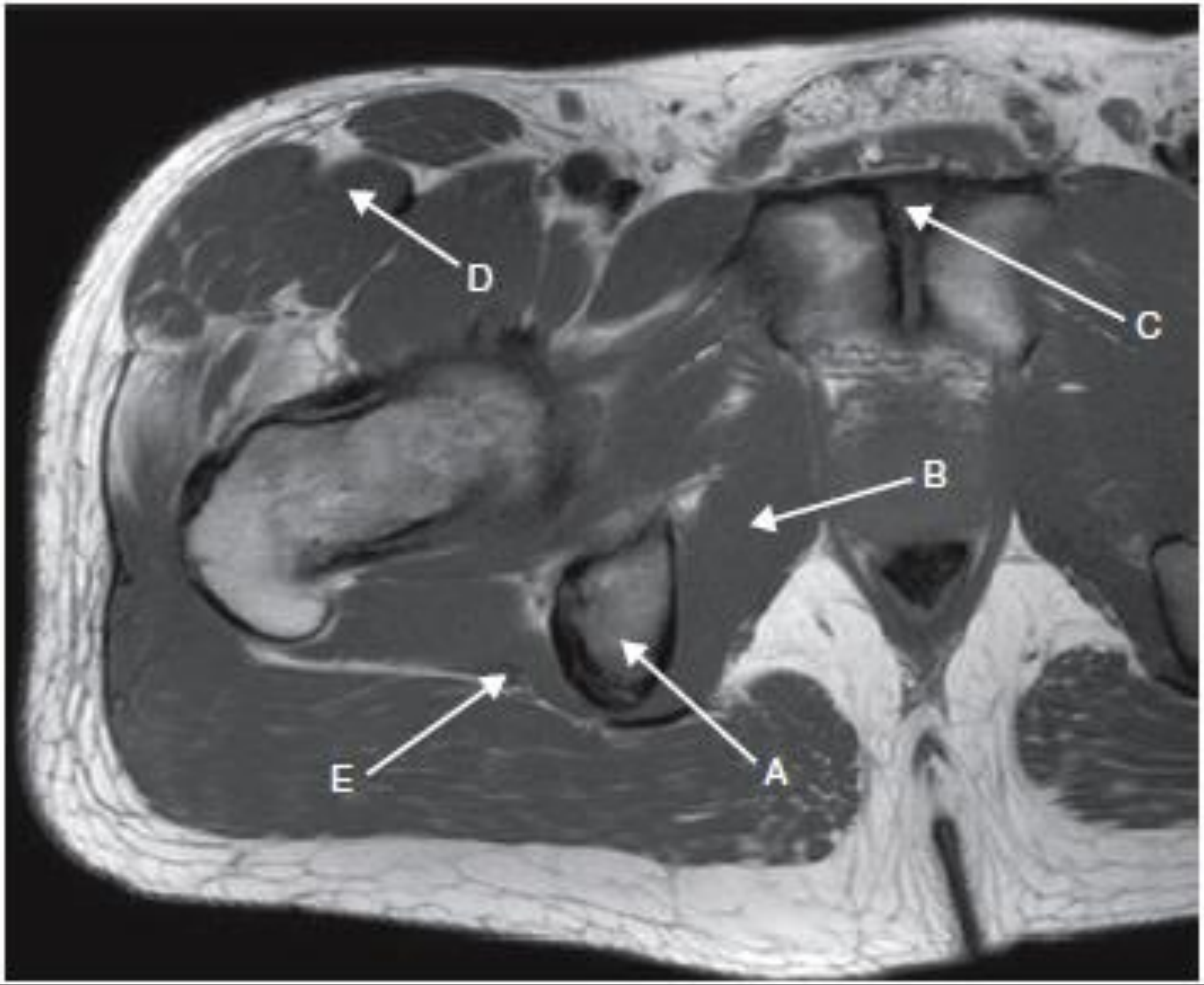
The anterior compartment contains the extensor muscles (tibialis anterior – TA, extensor hallucis longus – EHL, extensor digitorum longus – EDL and peroneus tertius) as well as the deep peroneal nerve and anterior tibial artery. It is bounded by the deep fascia and interosseous membrane and is a rigid compartment with limited scope for expansion.

The lateral compartment contains peroneus longus (PL) and peroneus brevis (PB) muscles plus the superficial peroneal nerve.

The posterior compartment is the largest and consists of superficial and deep groups which are divided by the deep transverse fascia. Soleus, the two heads of gastrocnemius and plantaris make up the superficial group whilst flexor digitorum longus (FDL), flexor hallucis longus (FHL) and tibialis posterior (TP) are the deep group. Also passing through this compartment are the posterior tibial and peroneal arteries and the tibial nerve.

HIP

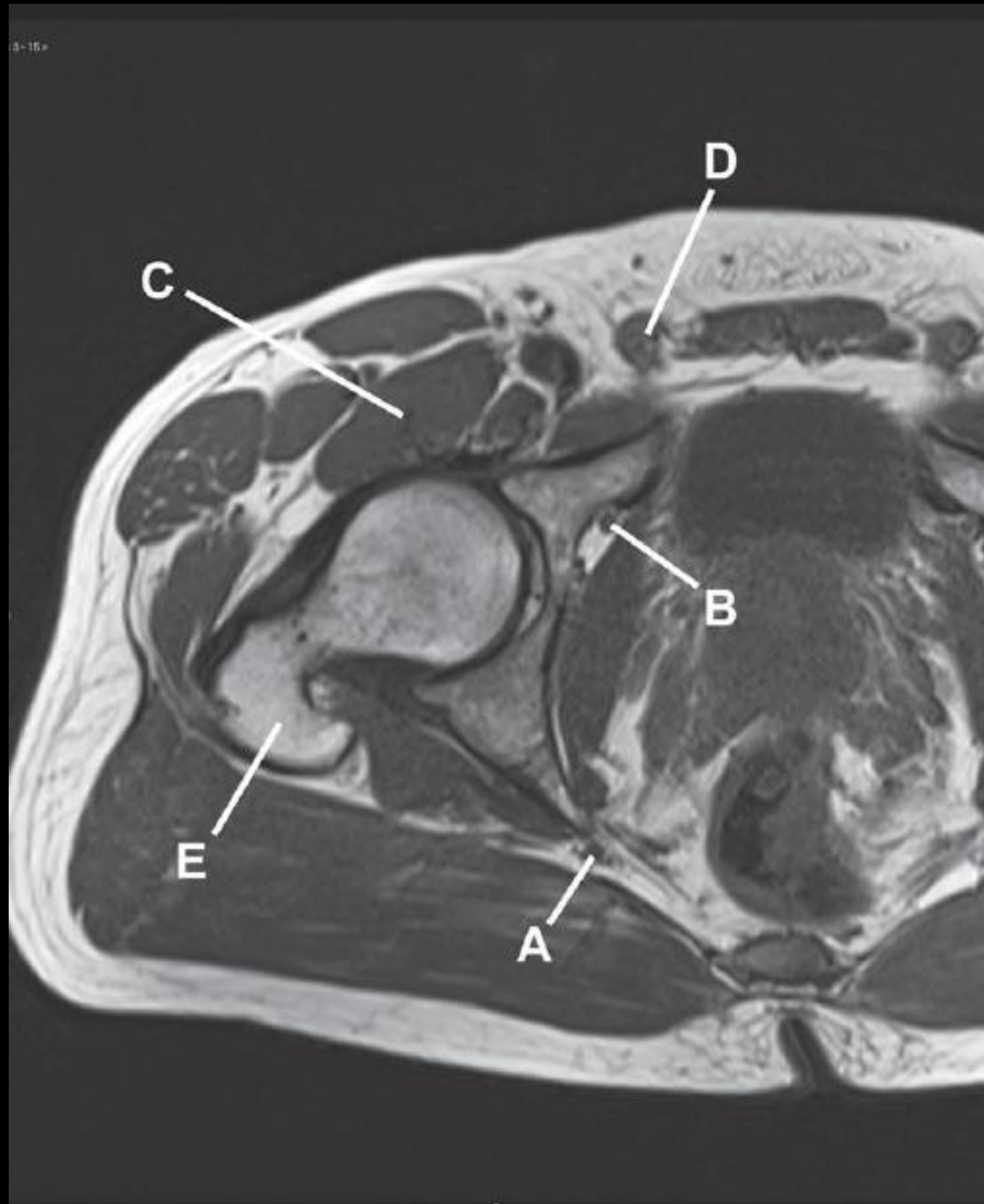
Case 5.3



5.3 Axial T1-weighted MR right hip

(a) Right ischial tuberosity. The tendons of semi-membranosus, semi-tendinosus and biceps femoris originate from the ischial tuberosity. Traumatic avulsion of the hamstring origin may be seen in sprinting and kicking sports.
(b) Right obturator internus muscle. The obturator internus arises from the internal surface of the obturator ring and inserts on the medial surface of the greater trochanter. Its action is to laterally rotate the hip and abduct the thigh when the hip is in flexion. Tumours of the rectum and ischio-rectal fossa may invade this muscle.

(c) Symphysis pubis. This is a type II fibrocartilaginous joint between the pubic bones. It resists pelvis rotation and anterior compression and thus may become disrupted during pelvic trauma following these mechanisms, resulting in symphyseal diastasis or malalignment. If missed this leads to pelvic instability and symphyseal pain.
(d) Right rectus femoris. This is an important muscle that contributes to hip flexion and knee extension. It arises from the anterior inferior iliac spine (AIIS) and in the immature skeleton the AIIS apophysis may become avulsed during kicking sports such as football. Injury of this muscle–tendon unit in adulthood usually presents with tearing at the musculo-tendinous junction.
(e) Right sciatic nerve. This is the largest nerve in the body made up of the L4, L5, S1 and S2 roots. In the region shown in the image the sciatic nerve may undergo entrapment by the piriformis muscle, which runs superficial to the nerve. This is known as 'piriformis syndrome' and may mimic other causes of sciatic neuropathy such as L5/S1 disc herniation, hence the alternative name of 'pseudosciatica'.



D
C
B
E
A

Q6 Answers

a Sciatic nerve
b Obturator nerve
c Iliopsoas muscle
d Spermatic cord
e Greater trochanter of the femur

T1W MRI hip and pelvis, axial section

The sciatic nerve (spinal nerves L4, 5, S1, 2, 3) is the largest nerve to emerge from the sacral plexus and exits the pelvis through the greater sciatic foramen to lie within the buttock. As it travels inferiorly in the posterior compartment of the thigh, branches emerge to supply the hamstring muscles. At the level of the upper popliteal fossa, it divides into the tibial and common peroneal nerves. The tibial nerve remains in the posterior compartment of the leg and supplies the flexor muscles of the calf. The common peroneal nerve swings laterally around the neck of the fibula where it divides into a superficial branch supplying the lateral compartment (evertors) and a deep branch supplying the anterior compartment (extensors) in the leg. Damage to the sciatic nerve can therefore have a devastating effect on lower limb function.

The obturator and femoral nerves are branches from the lumbar plexus (L2, 3, 4) and supply the obturator/adductor and the anterior thigh muscles respectively. Both nerves also supply sensory branches to the skin as well as the hip and knee joints. The femoral nerve exits the pelvis lateral to the artery in the femoral triangle. Medial to the femoral artery is the femoral vein, medial to which is the fat filled femoral canal. The obturator nerve exits through the obturator foramen which is located in the lateral wall of the pelvis adjacent to the common iliac bifurcation. The spermatic cord passes through the inguinal canal which is superficial and superior to the femoral canal and runs in a medial direction. All three of these channels – the femoral canal, the obturator foramen and the inguinal canal – are common sites of intestinal herniation.

Iliopsoas is the joining of the psoas major and iliacus muscles which forms at the inner aspect of the ilium. It runs anteriorly to pass beneath the inguinal ligament before inserting into the lesser trochanter of the femur.

Q7

- **a** Name the structure labelled A
- **b** Name the structure labelled B
- **c** Name the structure labelled C
- **d** Name the structure labelled D
- **e** Name the structure labelled E

Q7 Answers

a Common tendinous origin of the hamstrings
b Vastus lateralis
c Adductor magnus
d Ischio-anal fossa
e Tensor fascia lata

T1W MRI at greater trochanter level, axial section

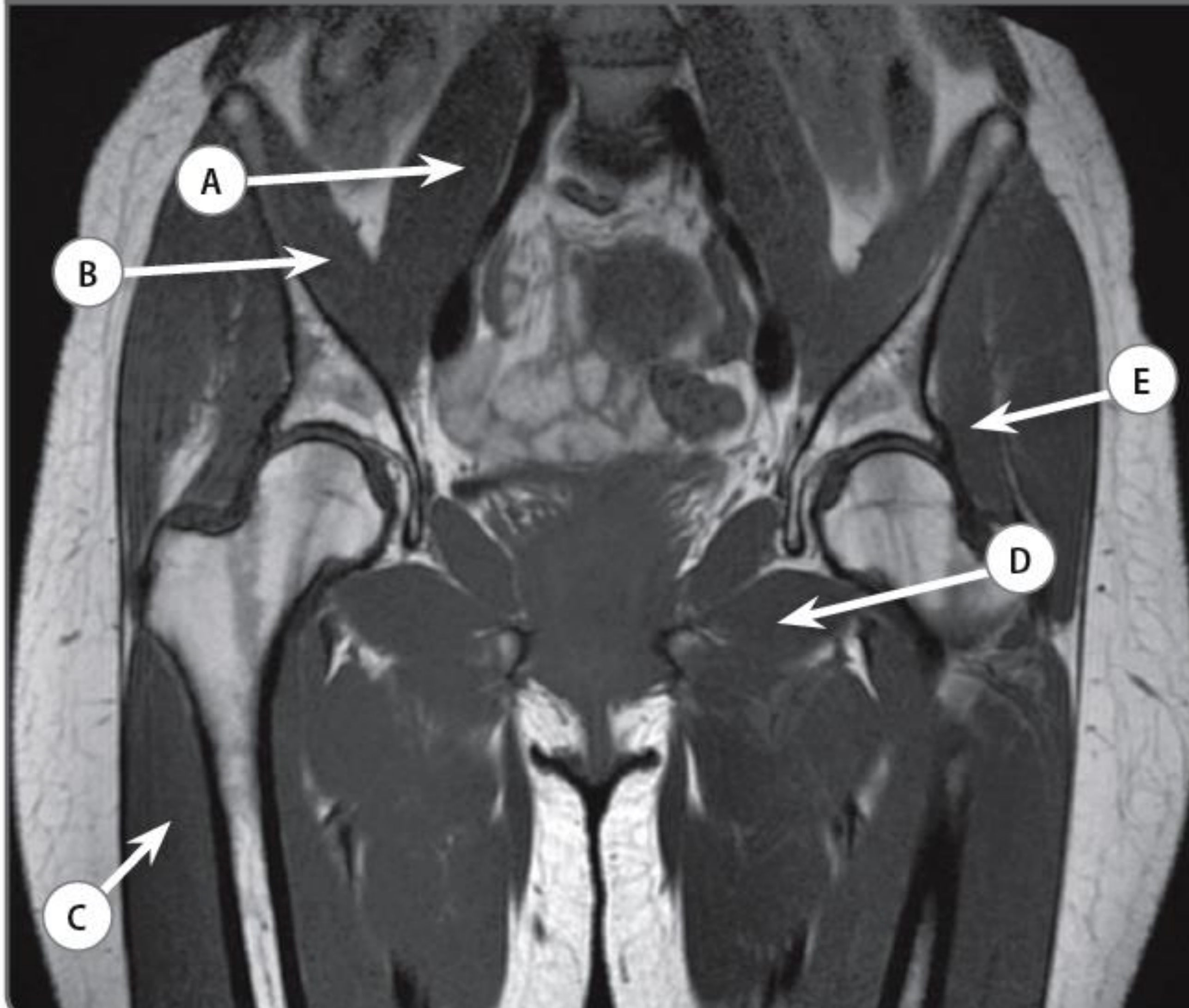
The anterior femoral muscles comprise of the iliopsoas, tensor fascia lata, sartorius and quadriceps muscles. Tensor fascia lata arises from the ASIS and inserts into the iliotibial tract which is a strong band of fascia on the lateral aspect of the thigh (fascia lata). This inserts into the fibular head. Sartorius is a narrow muscle which also originates from the ASIS and courses superficially across the thigh to insert into the medial tibial condyle. The quadriceps is made up of the three vastus muscles (lateralis, medialis and intermedius) and rectus femoris. These all share a common tendinous insertion into the tibial tuberosity via the patellar tendon and serve to extend the knee joint. Rectus femoris arises from the AIIS and the acetabulum, vastus lateralis and medialis from the greater trochanter and the linea aspera and vastus intermedius from the anterior femoral shaft. All four quadriceps muscles are supplied by the femoral nerve (L3, 4).

The hamstrings (semimembranosus, semitendinosus and biceps femoris) share a common tendinous origin from the ischial tuberosity. Biceps femoris attaches to the fibular head while semimembranosus and semitendinosus insert into the medial tibia. All are supplied by the profunda femoris artery and the sciatic nerve.

The adductor muscles are separated from the anterior thigh muscles by the medial intermuscular septum, which attaches to the fascia lata. There is no septum dividing them from the posterior compartment. They consist of gracilis and the three adductors: longus, brevis and magnus. All take origin from the pubis, with magnus having a second origin alongside the hamstrings from the ischial tuberosity. Gracilis crosses the inner aspect of the thigh superficially to insert into the superior medial tibia behind sartorius. The adductors insert into the linea aspera of the femur and in the case of adductor magnus, also into the adductor tubercle. These muscles are supplied by the obturator nerve and by the profunda femoris and obturator arteries.

The ischio-anal (also known as ischio-rectal) fossae lie below and lateral to the levator ani muscles and are enclosed by the sacrotuberous ligaments and gluteus maximus posteriorly, obturator internus fascia laterally and the urogenital perineum inferiorly. Within these fatty spaces run the pudendal vessels and nerves. They are significant as a potential site of abscess formation, which can complicate sepsis of the rectum or anal canal.

Case 4.14



Case 4.14

A Right psoas

B Right iliacus

C Right vastus lateralis

D Left obturator externus

E Left gluteus minimus

Coronal MRI of the hips.

The psoas arises from the transverse processes, vertebral bodies and intervertebral discs of T12–L5. The iliacus arises from the iliac fossa. Both muscles insert on the lesser trochanter of the femur.

The vastus lateralis is the most lateral of the quadriceps and is seen in this image lateral to the femur.

The obturator externus is an adductor of the thigh. It arises from the outer surface of the obturator membrane and inserts onto the greater trochanter of the femur.

The gluteus minimus arises from the ileus to insert in the greater trochanter of the femur. It medially rotates the thigh.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 165–167.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 290.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 290.

Case 4.15

Case 4.15

A Right femoral artery

B Right obturator internus

C Left ischium

D Left tensor fasciae latae

E Right ischioanal fossa

Axial MRI of the pelvis at the level of the neck of femur.

The external iliac artery passes into the anterior part of the thigh beneath the inguinal ligament. Its name changes at this point to the femoral artery. In this image, we can identify the femoral vein medial to the artery and the femoral nerve lateral to the femoral artery (mnemonic NAVY).

Obturator internus arises from the internal surface of obturator membrane and the posterior bony margins of obturator foramen. It inserts in the medial surface of the greater trochanter of femur.

The tensor fasciae latae arises from the anterior part of the iliac crest and the fascia lata, by which it is enveloped. It becomes continuous with the iliotibial tract.

The ischioanal fossa is wedge shaped and filled with fat. It is crossed by the inferior rectal nerve and artery. It has Alcock's canal in its lateral wall which contains the internal pudendal vessels and the pudendal nerve.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 162–164.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 291.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 355.

- **Question 5:**

Question 5: Coronal T1-weighted MRI of the pelvis

Answer: Left pectineus muscle

- The pectineus muscle adducts, flexes, and assists medial rotation of the thigh.
- It is an anterior muscle that attaches to the superior pubic ramus superiorly and the pectineal line of the femur (beneath the lesser trochanter) inferiorly.

Question 19:

■ Question 19: T1-weighted axial MRI of the pelvis

Answer: Right iliacus muscle

- The iliacus muscle sits in the inner aspect of the iliac bone, lateral to the inferior part of psoas major.
- It attaches to the superior two thirds of the iliac fossa and joins the psoas tendon to form the iliopsoas, which inserts onto the lesser trochanter of the femur. It is innervated by the femoral nerve.
- Its function is to flex the thigh and stabilise the hip joint.

- **Question 45:**

Question 45: T1-weighted coronal MRI of the pelvis

Answer: Right acetabulum

- The hip bones (ilium, ischium, and pubis) unite to form the acetabulum.
- It has a smooth concave surface and is marked by a depression in its inferior portion called the acetabular notch.
- It is covered by a C-shaped layer of fibrocartilaginous labrum, which deepens the acetabulum and increases articular surface area with the femoral head.

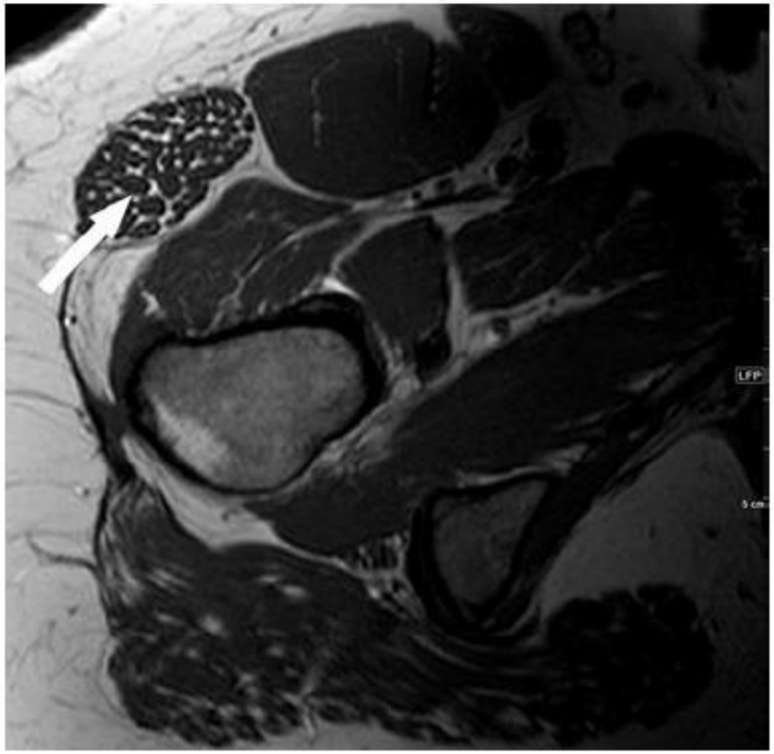
Question 46:

Question 46: Coronal MRI arthrogram of the right hip

Answer: Right ligamentum teres femoris (ligament of the head of the femur)

- The ligamentum teres femoris is a flat band that spans across the hip joint from acetabular notch to the fovea capitis femoris.
- It contains the acetabular branch of the medial circumflex femoral artery.
- Please distinguish between the ligamentum teres femoris from the ligamentum teres uteri and the ligamentum teres hepatis.

- **Question 49:**

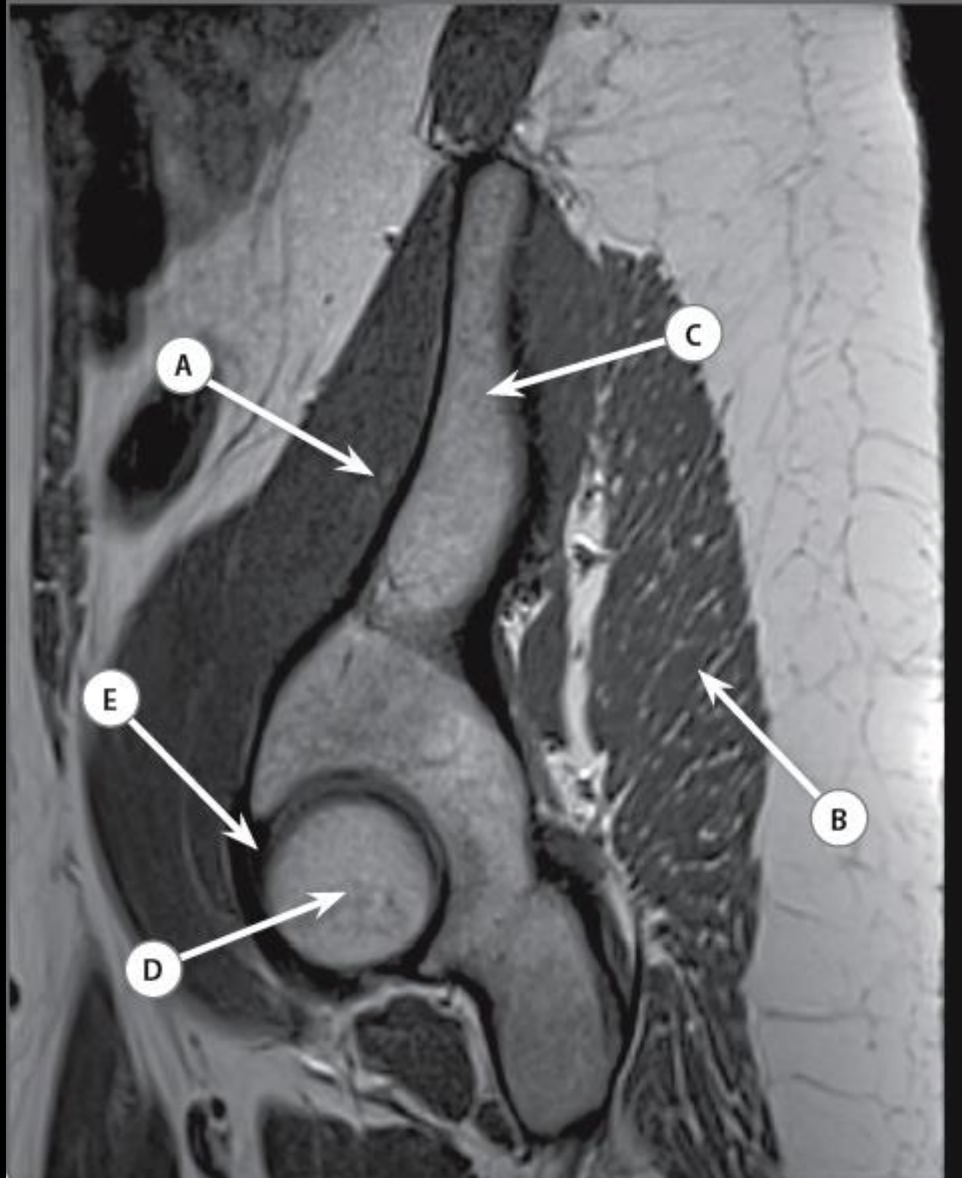


Question 49: T1-weighted axial MRI of the right hip

Answer: Right tensor fasciae latae

- The tensor fasciae latae is a muscle found on the lateral aspect of the thigh. It originates from the iliac crest and inserts into the iliotibial tract.
- It is characterised by patchy fatty areas on axial imaging; thus, look for areas of low attenuation on CT and high signal on T1- and T2-weighted MRI.

Case 14.7



Case 14.7

A Iliacus muscle

B Gluteus maximus muscle

C Ilium

D Femoral head

E Anterior superior acetabular labrum

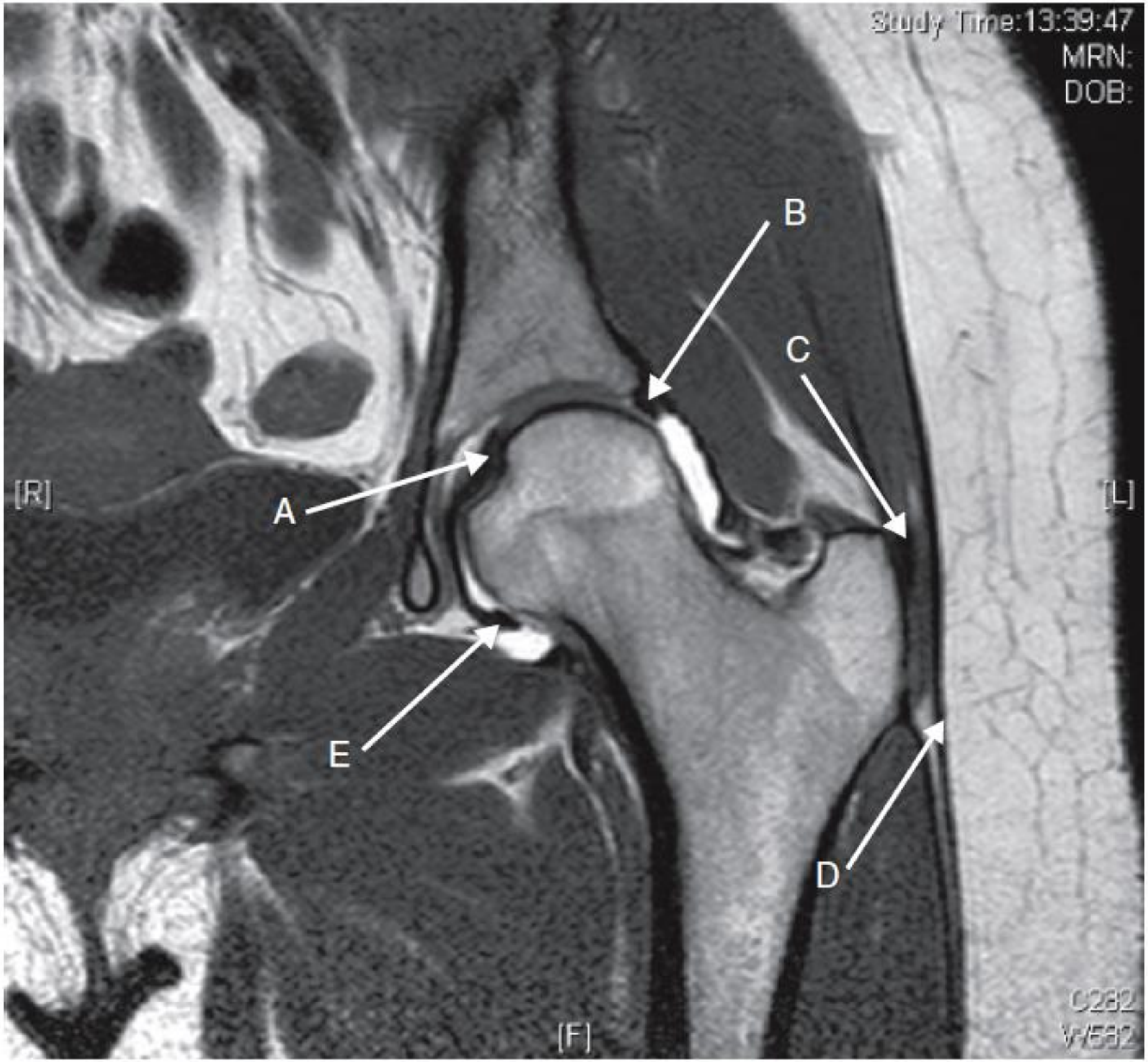
MR imaging of the hip allows adequate visualisation of the labrum. Optimal evaluation is with MR arthrography, which involves direct injection of contrast into the joint under fluoroscopy guidance followed by acquisition of MRIs. It is important to remember that the acetabulum is a three-dimensional structure, hence different planar acquisitions allow evaluation of different aspects of the labrum:

- Axial – posterior and anterior labrum
- Sagittal – superior and inferior labrum
- Coronal – lateral labrum

The labrum, a cartilaginous structure, returns low signal intensity on all MR sequences – remember, fatty marrow is high signal on T1- weighted images.

Iliacus originates from the iliac blade and runs on the anterior surface of the ilium, where it conjoins with psoas major to form the iliopsoas tendon.

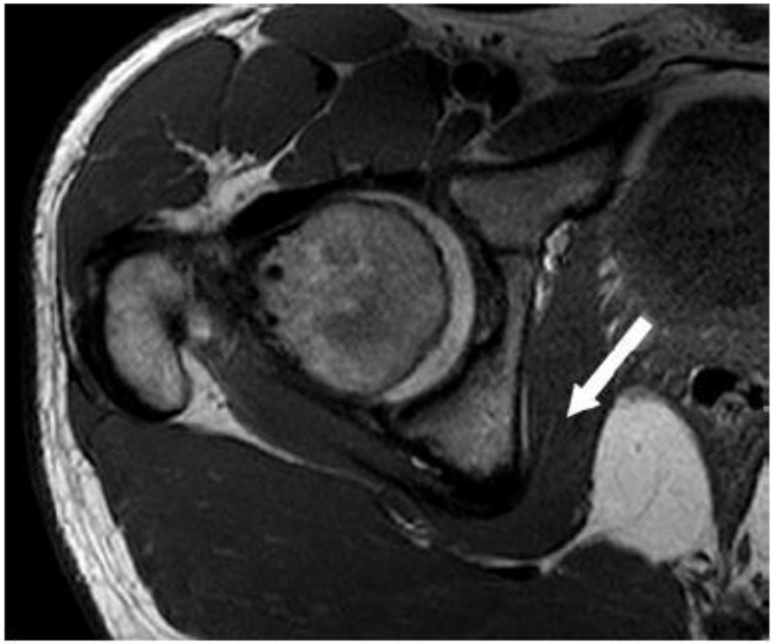
Case 2.1



2.1 Coronal T1-weighted MR left hip

(a) Ligamentum teres. This strong ligament inserts into the fovea centralis of the femoral head along with important nutrient vessels.
(b) Acetabular labrum. This incomplete fibrocartilaginous ring contributes to hip joint stability. It may undergo traumatic or degenerative tearing leading to hip pain, instability and mechanical symptoms such as clicking.
(c) Gluteus medius tendon. This is an important abductor and lateral rotator of the hip that inserts upon the lateral and posterior facets of the greater trochanter.
(d) Iliotibial band (ITB) or tract. This long dense fascial band is a continuation of the tensor fascia lata muscle. It may undergo friction with resultant thickening and inflammation as it passes over the greater trochanter, producing painful, proximal ITB friction syndrome.
(e) Transverse part of the ilio-femoral ligament. The ilio-femoral ligament is a thickening of the joint capsule and is the strongest of the three hip ligaments, the other two being the ischio-femoral and pubo-femoral ligaments.

Question 18:



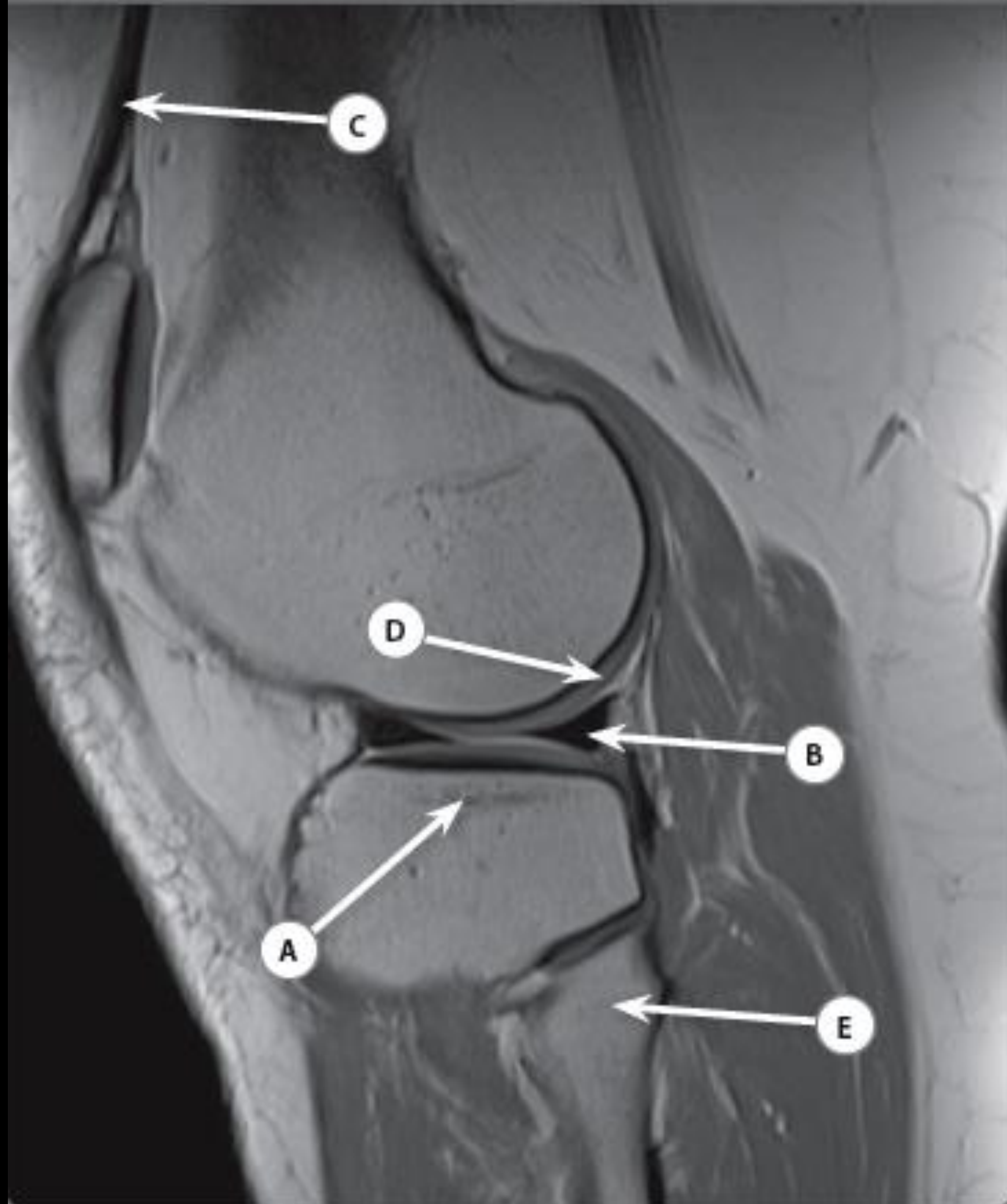
■ Question 18: Axial MRI of the right hip

Answer: Right obturator internus muscle

- The obturator internus muscle originates from the obturator membrane.
- It traverses the lesser sciatic foramen and inserts onto the greater trochanter of the femur.

KNEE

Case 10.3



Case 10.3

A. Lateral tibial plateau (condyle)

B. Posterior horn of lateral meniscus

C. Quadriceps tendon

D. Articular cartilage of lateral femoral condyle

E. Head of fibula

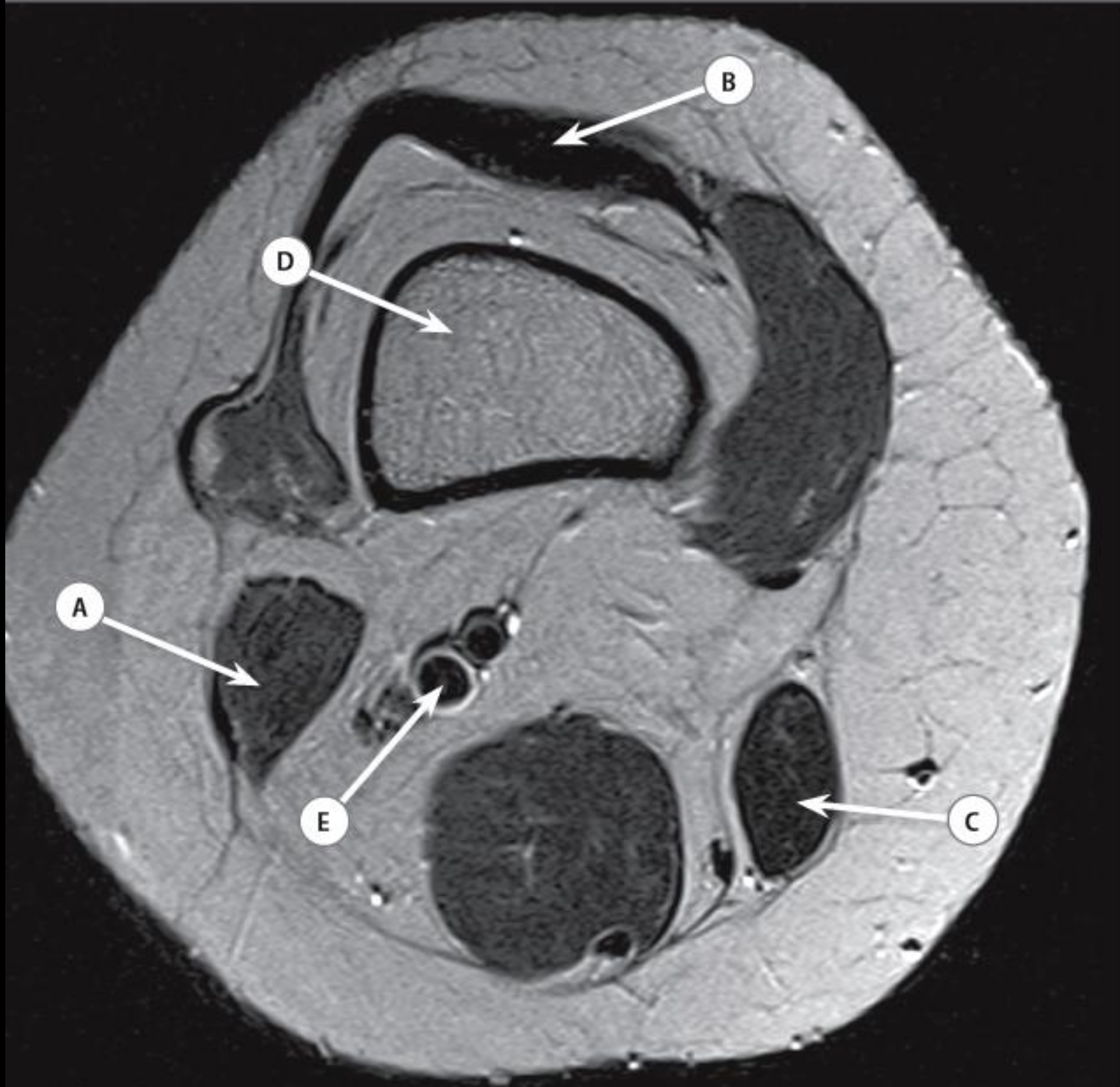
Orientating sagittal images of the knee can be difficult. However, the key clue on this image is the visualisation of the head of fibula, which lies lateral to the tibia.

Being aware of this finding will enable the rest to fall into place:

1. visualised meniscus = lateral meniscus
2. tibia = lateral tibial condyle
3. femur = lateral femoral condyle

(D) is something of a trick question and is reliant on your understanding of MR signal in the region of articulations. Remember, fatty marrow will return high T1-weighted signal, the cortex will return no T1-weighted signal (black) and the cartilage lining the articular surface will return intermediate signal intensity.

Case 12.11



Case 12.11

A Biceps femoris muscle

B Quadriceps tendon

C Sartorius muscle

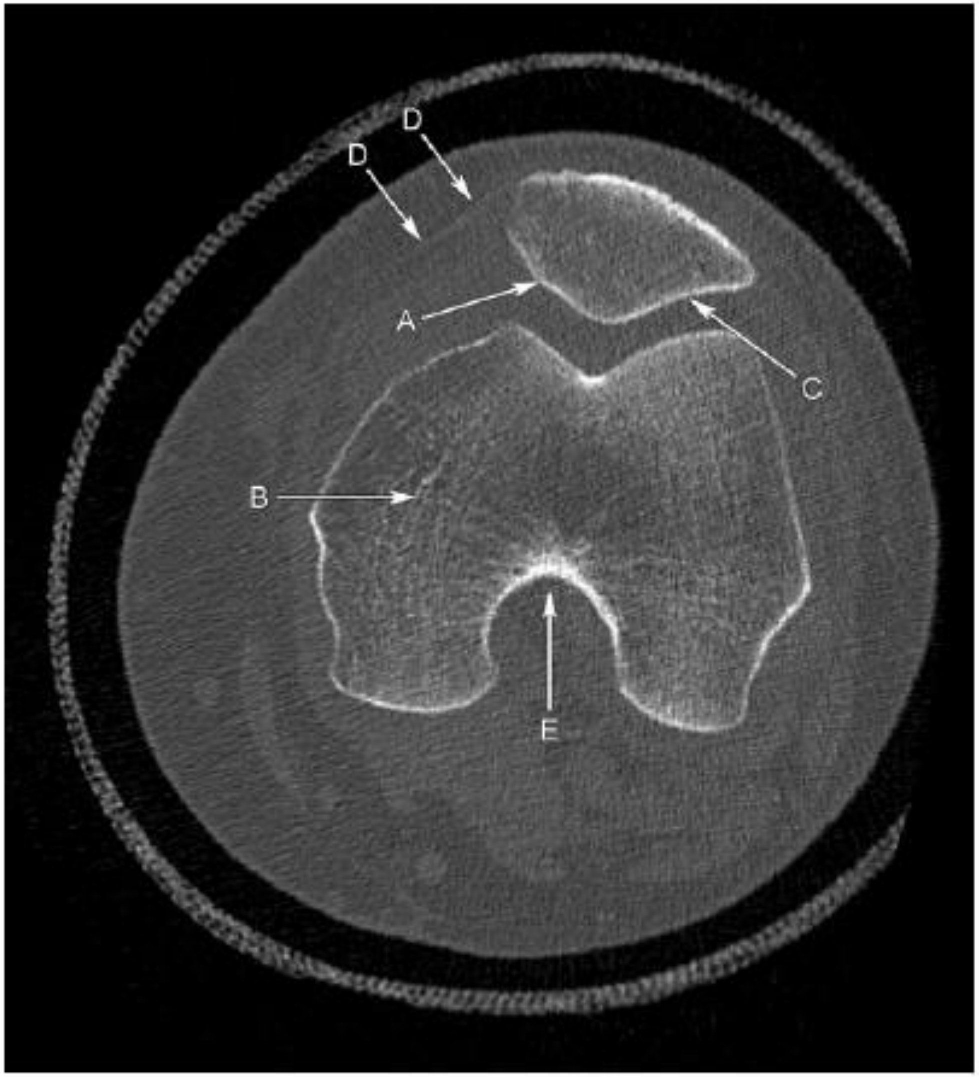
D Femur

E Popliteal vein

Quadriceps femoris is subdivided into four heads comprising: rectus femoris (superficially); vastus intermedius; vastus lateralis; and vastus medialis (all deep). All four muscles have a conjoined attachment to the patella via the quadriceps tendon.

The popliteal artery and vein lie within the floor of the popliteal fossa with the vein being more superficial – an easy way to remember this is from ultrasound scans for suspected deep venous thrombosis, in which the more superficial vein is compressible in normal patients.

Question 7.17



Name the structures labelled **A** to **E**.

7.17 Axial CT of the left knee

A Left medial patella facet.
B Left medial femoral condyle.
C Left lateral patella facet.
D Left medial patellar retinaculum.
E Left intercondylar notch.

The patella is the largest sesamoid bone in the body. The posterior surface is divided into medial and lateral facets. The medial facet is usually the smaller of the two. On MRI it is worth inspecting the facet surfaces for evidence of bone oedema as this can be a good marker for recent patella dislocation.

There are a few ways to work out which knee is being imaged when the side is not marked on the film. The position of the long saphenous vein is very helpful; it is seen on the left side of this image. Another good clue is that the medial patella facet is generally shorter and more vertical than the lateral patella facet. As CT orientation is standardized, it is therefore possible to tell that this image is of a left knee.

Question 47:

Question 47: Coronal proton density MRI of the knee

Answer: Medial collateral ligament

- The medial collateral ligament (MCL) can be seen as a complete structure on one slice unlike the lateral collateral ligament, which is seen on two or three slices.
- The MCL appears as a uniform low intensity (black) structure.
- It originates from the medial femoral epicondyle and inserts onto the medial tibial condyle.
- The MCL is firmly attached to the medial meniscus, which is why injuries to these structures often occur together.

Question 5.19

This is an axial MRI of the left knee.
Name the structures labelled A to E.

5.19 Axial PD MRI of the left knee

A Medial retinaculum.
B Patella.
C Lateral retinaculum.
D Popliteal vein.
E Popliteal artery.

The strong fibrous tissue planes found on the medial and lateral sides of the patella are known as the medial retinaculum and lateral retinaculum, respectively. They act to stabilize the patella during flexion and extension. The lateral retinaculum is an extension of the fibrous aponeurosis of the vastus lateralis muscle. The medial retinaculum is an extension of the fibrous aponeurosis of the vastus medialis muscle.

The popliteal artery is a continuation of the superficial femoral artery and lies deep to the popliteal vein.

Question 9.14

This is an MRI of the right knee.
Name the structures labelled **A** to **E**.

9.14 Sagittal T1 MRI of the right knee

A Quadriceps tendon.
B Patella tendon.
C Hoffa's fat pad (infrapatella fat pad).
D Posterior horn of the lateral meniscus.
E Tendon of popliteus.

The quadriceps tendon inserts into the superior patella and is formed by the convergence of the four quadriceps muscles (the vastus intermedius, vastus medialis, vastus lateralis and rectus femoris).

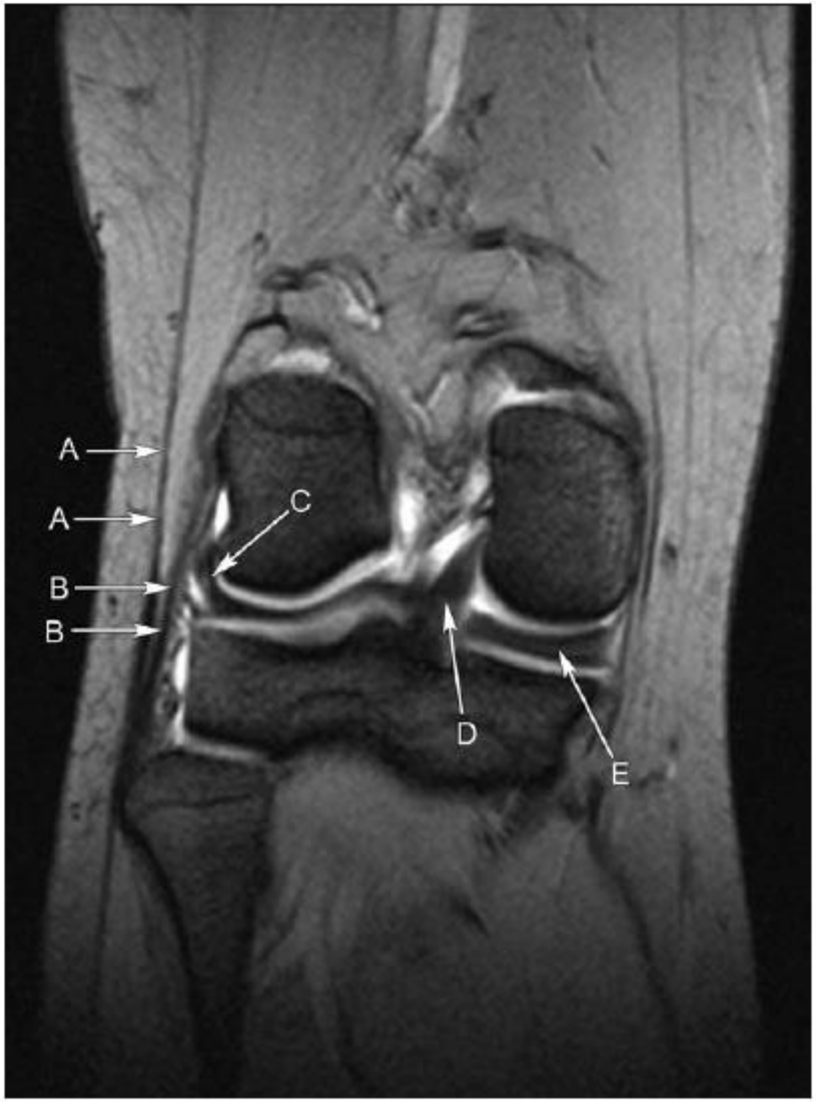
The patella tendon runs from the apex and the posterior surface of the patella to the tibial tuberosity. The posterior surface of the patella tendon is separated from the synovial membrane of the joint by the infrapatella fat pad (known as Hoffa's fat pad).

The medial and lateral menisci of the knee are cartilaginous structures, which act to deepen the articular surface of the tibial plateau and contribute to the structural integrity of the knee during flexion and extension. The medial and lateral menisci are anatomically and functionally different from each other. Some key differences are outlined below:

1. The medial meniscus is C-shaped, and the lateral is closer to circular (O-shaped).
2. The posterior horn of the medial meniscus is much wider than the anterior horn. The lateral meniscus has almost uniform width.
3. The medial meniscus attaches to the joint capsule and deep fibres of the medial collateral ligament. The lateral meniscus attaches to the joint capsule but does not attach to the lateral collateral ligament. It does, however, have an additional attachment to the medial femoral condyle via meniscofemoral ligaments.
4. The lateral meniscus is normally twice as mobile as the medial meniscus (up to 10 mm movement physiologically).

Both menisci normally give a low signal on both T1- and T2-weighted MRI. It is more common to injure the medial meniscus than the lateral meniscus.

Question 10.7



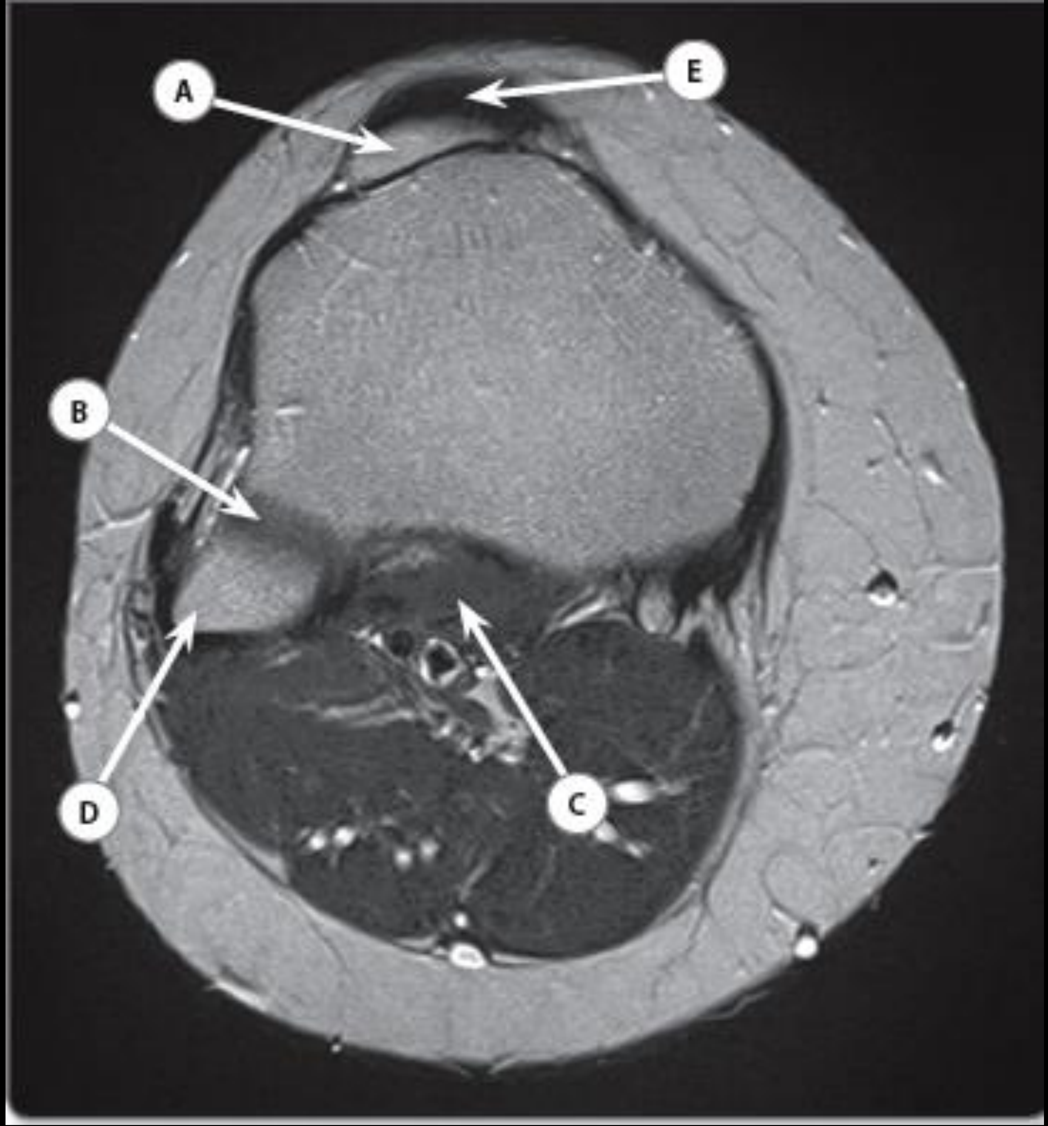
This is a coronal MRI of the right knee.
Name the structures labelled **A** to **E**.

10.7 Coronal T2 MRI of the right knee

A Iliotibial band.
B Lateral collateral ligament (or fibula collateral ligament).
C Popliteus tendon.
D Posterior cruciate ligament.
E Medial meniscus.

The iliotibial band is a longitudinal fibrous reinforcement of the fascia lata. It originates from the region of the anterior superior iliac spine and extends along the lateral thigh before attaching onto the lateral condyle of the tibia (Gerdy's tubercle). This band is crucial to the stability of the knee joint. In sport, the repeated rubbing of the iliotibial band against the lateral femoral epicondyle can cause inflammation and leads to iliotibial band syndrome, a common cause of lateral knee pain.

Case 9.7



E	Name the distal insertion site for the structure labelled E.	

Case 9.7

A Hoffa's (infrapatellar) fat pad

B Proximal tibiofibular joint

C Popliteus muscle

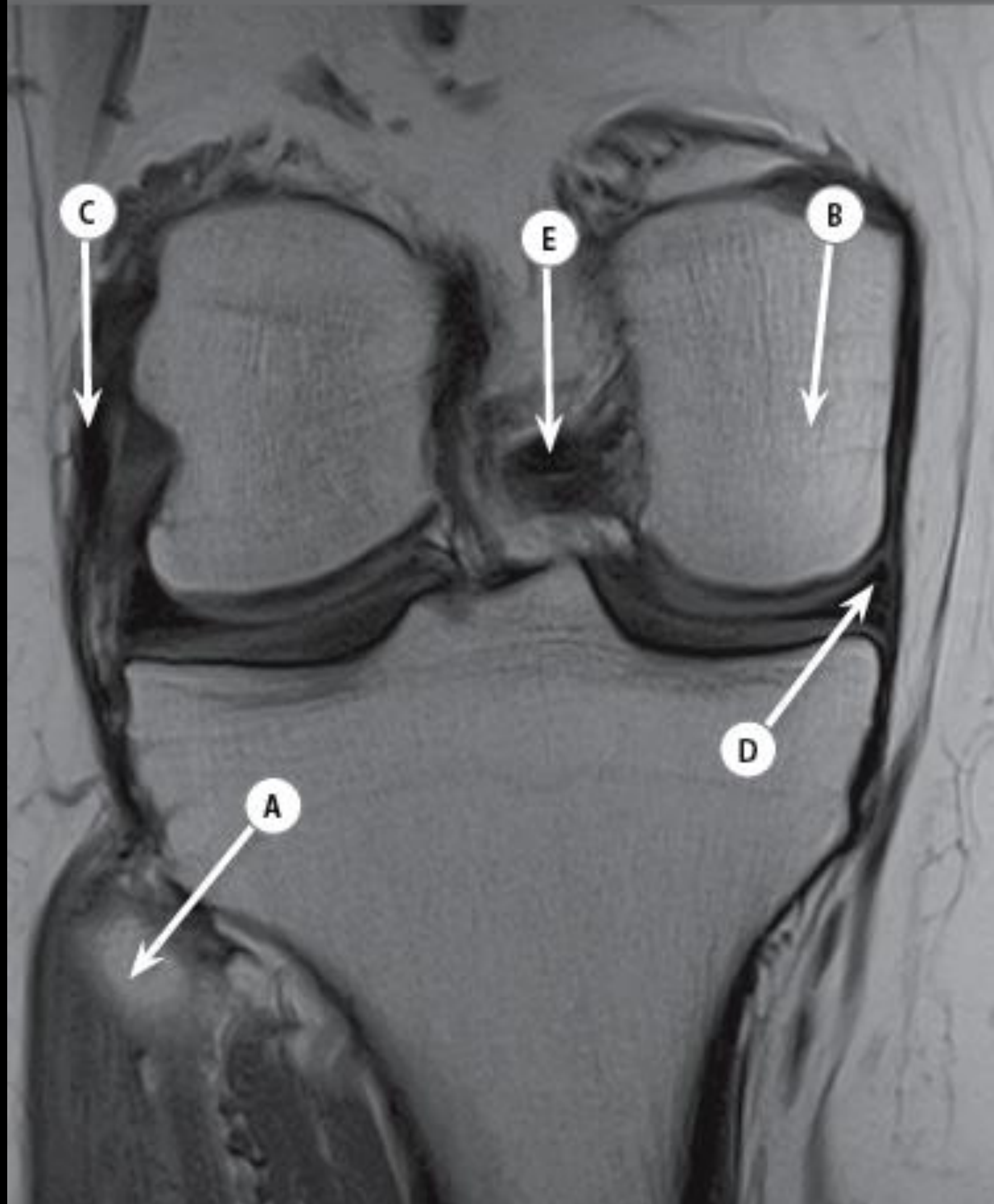
D Head of fibula

E Tibial tuberosity

This question has been purposefully constructed to aid in actual examination technique.

1. Identify the anatomical region of the image – the proximal tibiofibular joint is visualised, thus allowing you to be confident that you are below the level of the patella, enabling you to answer B/D.
2. E – the structure returns low signal suggestive of tendinous origin. From point 1, you know that the image is below the patella – this should make you think of the patellar tendon which attaches to the tibial tuberosity.
3. A – this structure demonstrates isointense signal relative to fatty marrow and the subcutaneous fat. It is bounded by the tibial cortex posteriorly and the patellar tendon anteriorly. Remember, the image is below the level of the patella, hence you should think of Hoffa's fat pad.
4. C – the popliteus muscle originates from the lateral femoral condyle and inserts into the posteromedial tibia, thus crossing the midline of the joint anterior to the posterior tibial vessels.

Case 11.9



Case 11.9

A Head of fibula

B Medial femoral condyle

C Lateral (fibular) collateral ligament

D Medial meniscus

E Posterior cruciate ligament

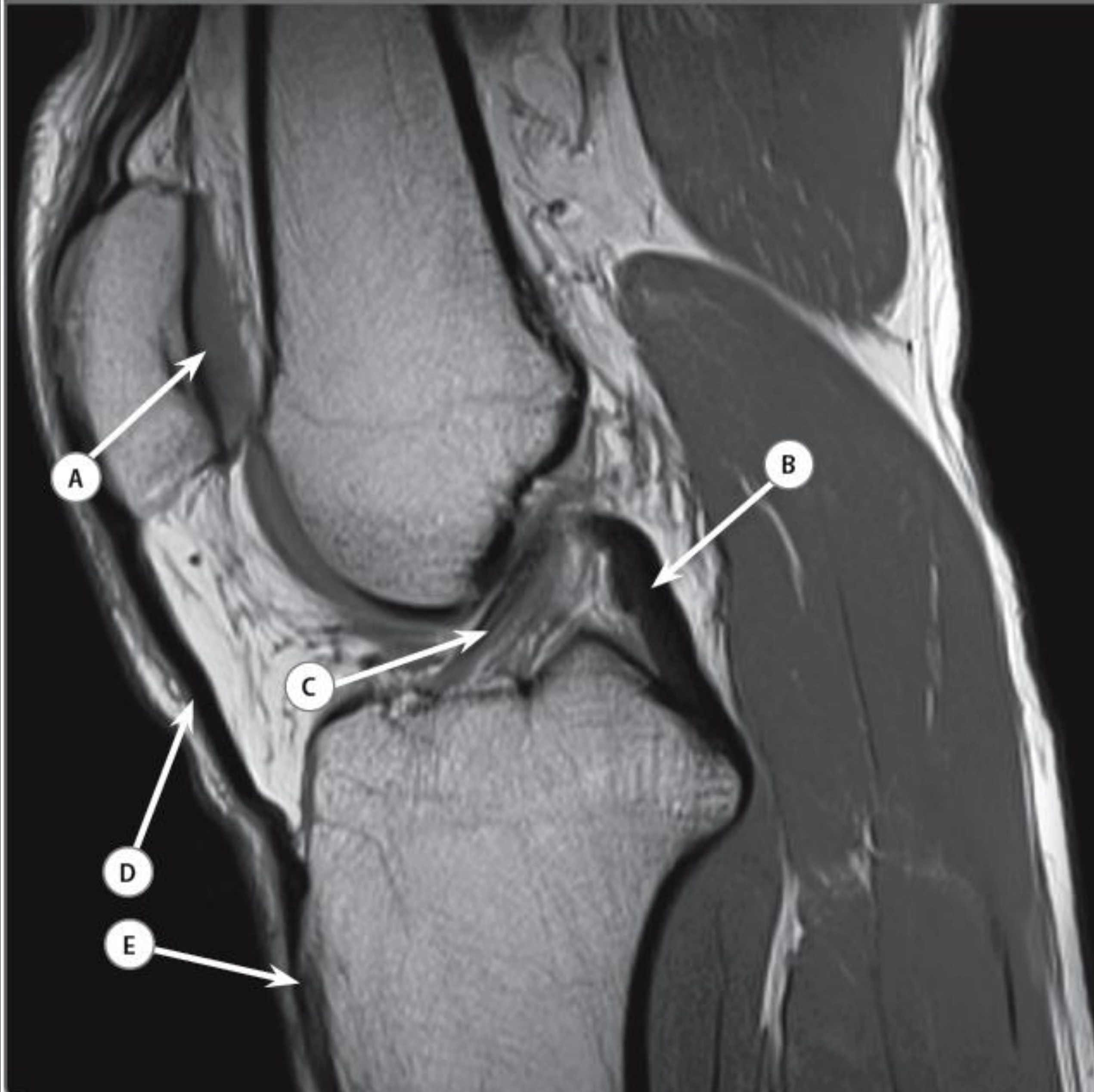
A useful tool for being able to differentiate between the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL) is:

- ACL demonstrates striations
- PCL returns a more uniform low signal and is thicker than the ACL

The head of fibula is (just) visible in this image, thus allowing you to orientate yourself and confidently label (D) as the medial meniscus and (B) as the medial femoral condyle.

The lateral collateral ligament is composed of multiple structures including the biceps femoris tendon, the fibular collateral ligament and the iliotibial band.

Case 13.14



Case 13.14

A Articular cartilage of the patella

B Posterior cruciate ligament

C Anterior cruciate ligament

D Patellar tendon

E Tibial tuberosity

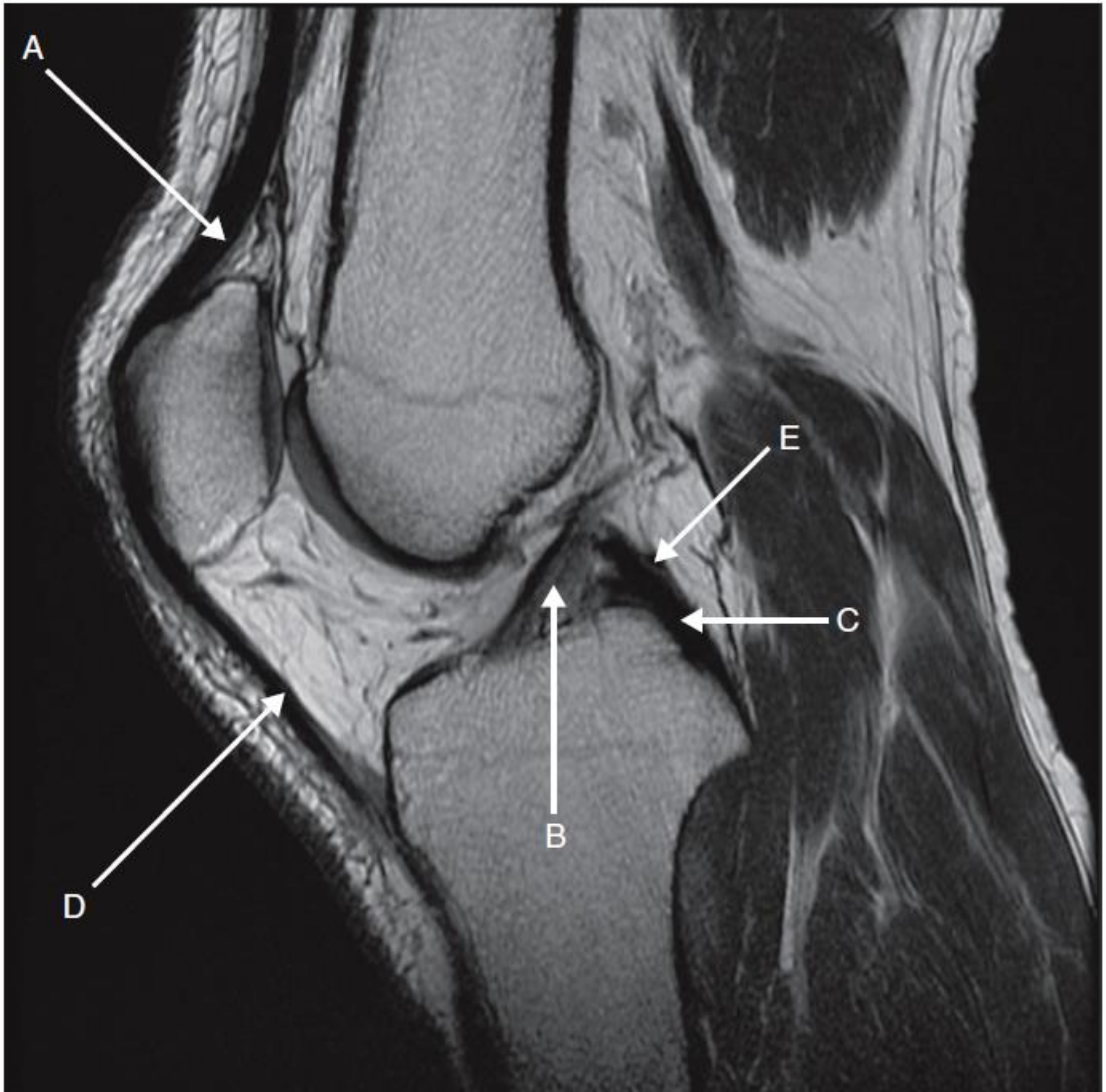
The anterior cruciate ligament (ACL) inserts anteriorly on the tibia, whereas the posterior cruciate ligament (PCL) inserts posteriorly. Each has a different appearance on MRI, with the ACL being striated and the PCL returning homogeneously low signal.

The mnemonic 'drink ALe in the PM' will help you remember the relationship of the cruciate ligaments in the knee joint.

- Anterior cruciate is Lateral
- Posterior cruciate is Medial

The patellar tendon arises from the inferior pole of the patella and inserts into the tibial tuberosity.

Case 1.3



1.3 Sagittal T1-weighted MR knee

(a) Quadriceps tendon. This is formed by the combination of the vastus medialis, vastus intermedius, vastus lateralis and rectus femoris tendons. Rupture of this structure results in loss of knee extension.

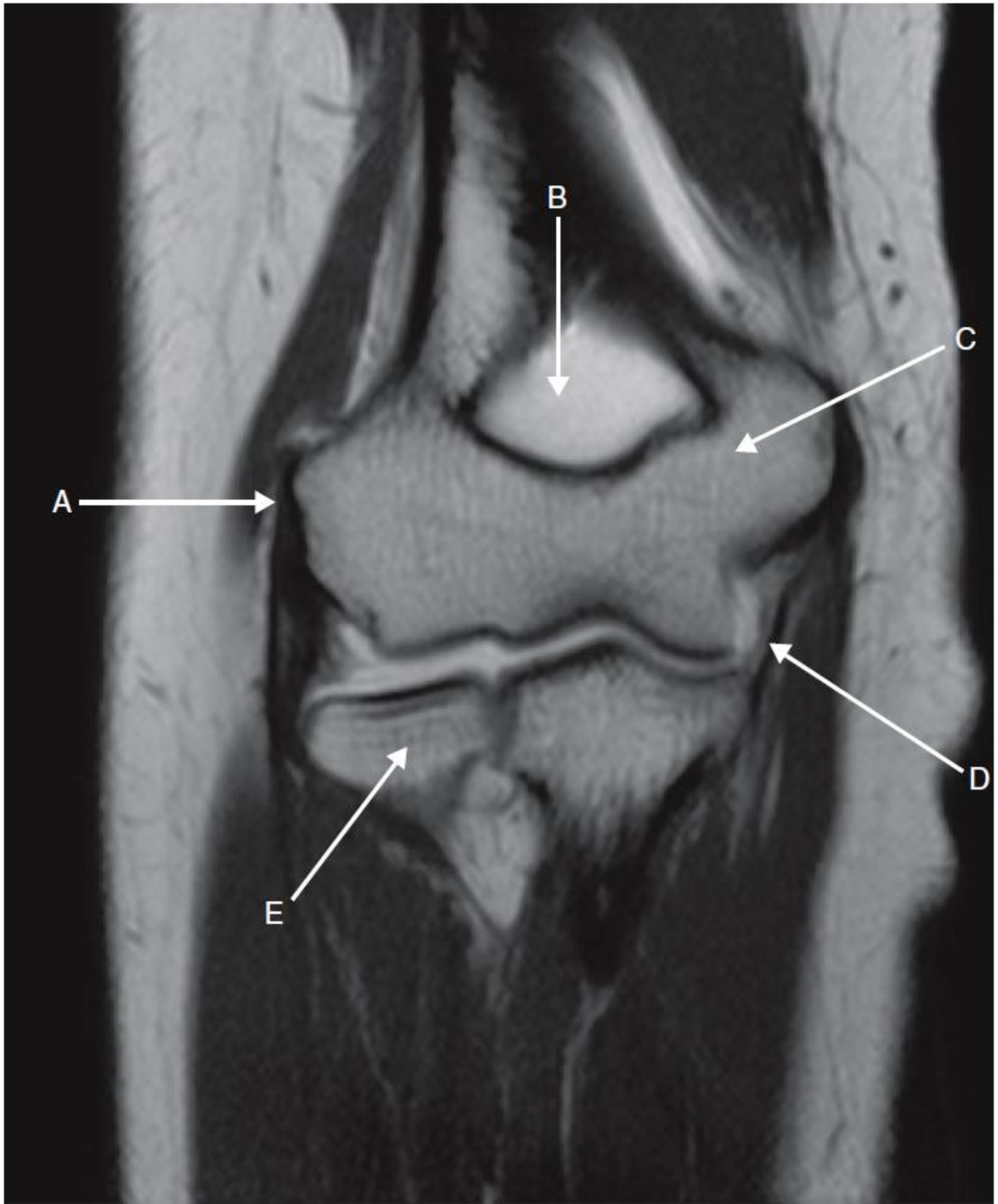
(b) Anterior cruciate ligament (ACL). This is an important central stabilizer of the knee joint, limiting anterior tibial translation. Failure of the ACL may occur due to tears at the origin or within the mid-substance, or less commonly following avulsion of the footprint antero-lateral to the anterior tibial spine.

(c) Posterior cruciate ligament (PCL). The PCL is a strong ligament with a recently described 4-bundle structure. Tears of this ligament most commonly occur in the mid-substance.

(d) Patellar tendon. This inserts onto the tibial tuberosity. In the clinical setting of recurrent lateral patellar dislocation, the patellar tendon insertion is surgically medialized by a procedure called a 'Tibial tuberosity transfer'. This reduces the degree of lateral patellar migration during knee flexion.

(e) Posterior mensico-femoral ligament (of Wrisberg). Either the posterior (Wrisberg) or anterior (Humphrey) mensico-femoral ligaments are present in 80% of knees. They stabilize the posterior horn of the lateral meniscus and must not be mistaken for displaced meniscal tear fragments on sagittal MRI images.

Case 2.8

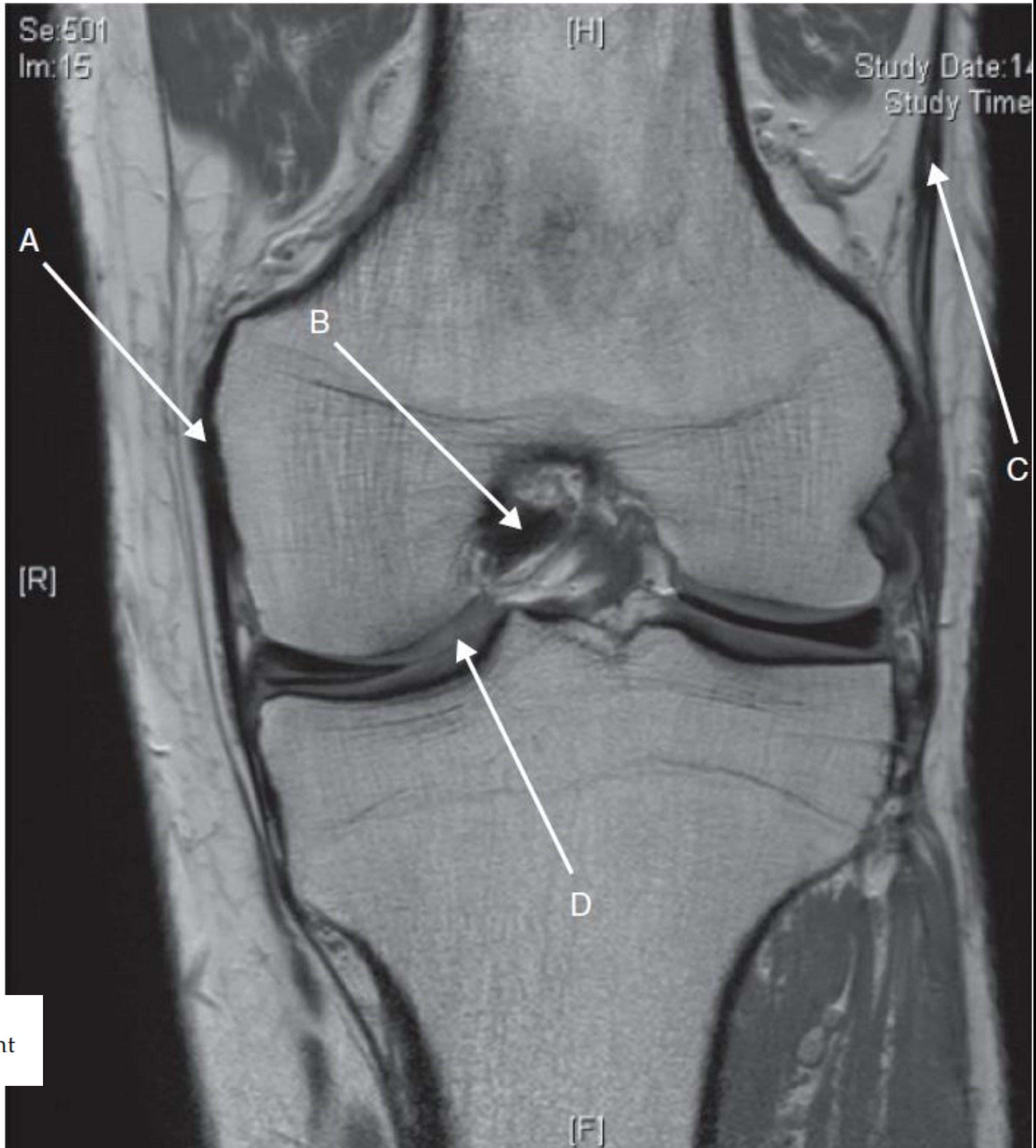


2.8 Coronal T1-weighted MR elbow

(a) Common extensor origin. This is made up of the common origin of the extensor digitorum communis, extensor carpi ulnaris and extensor carpi radialis brevis tendons. Tendinopathy and partial tearing of this structure is seen with chronic microtrauma (overuse) in a condition referred to as 'tennis elbow'.
(b) Olecranon process. This is the olecranon recess, which is occupied by the olecranon process when the elbow is extended. It is a common location for intra-articular bodies which may result in a block to extension.

(c) Medial epicondyle. This bony prominence of the humerus bears the attachment of the common flexor origin. The ulnar nerve courses over its posterior surface within the ulnar tunnel.
(d) Ulnar (or medial) collateral ligament (UCL). This is an important ligament complex, composed of three bundles that act to stabilize the elbow joint and resist valgus stress. Tears of the UCL are associated with throwing sports such as cricket and baseball.
(e) Radial head. This articulates with the capitellum. Fractures of the radial head and neck are common following falls onto the outstretched arm.

Case 4.2



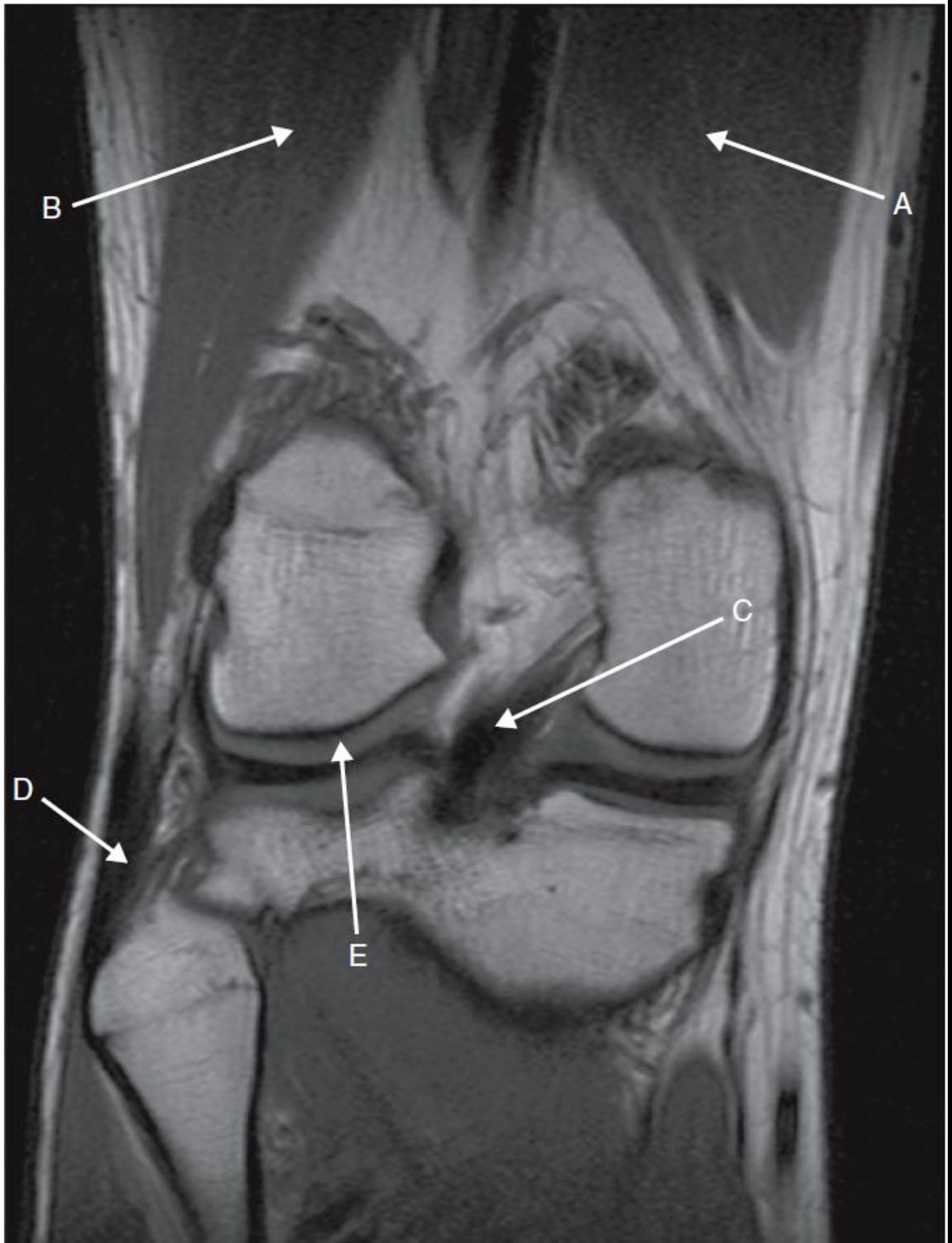
(e)	Which normal variant is present on this image?

4.2 Coronal T1-weighted MR knee

(a) Medial collateral ligament (MCL). This important ligament arises from the medial femoral condyle and inserts on the medial tibial diaphysis and resists valgus stress of the knee.
(b) Posterior cruciate ligament. This strong ligament arises from the lateral surface of the medial femoral condyle and inserts on the posterior intercondylar fossa of the tibia. It is a central stabilizer of the knee resisting posterior tibial translation.
(c) Iliotibial band (ITB). This long structure originates from the fascia of the iliotibial tract and inserts on Gerdy's tubercle on the antero-lateral tibia. Distally it may undergo repetitive friction over the lateral border of the lateral femoral condyle to produce painful distal ITB friction syndrome.
(d) Articular cartilage of medial tibial plateau. This thick layer of hyaline cartilage is composed of four zones or layers. During the evolution of osteoarthrosis the chondral layers may undergo softening, fibrillation, fissures and progressive thinning, ultimately resulting in full-thickness cartilage loss and sclerosis of the exposed sub-chondral bone.
(e) Discoid lateral meniscus. The lateral meniscus is broad, spanning the whole width of the lateral tibio-femoral compartment. This normal variant, if present, is frequently bilateral and should be examined carefully due to the high incidence of degenerative tears with this variant.

When looking at the coronal image of the knee without the fibula in view, the medial aspect is determined by the relative abundance of subcutaneous fat compared with the lateral aspect.

Case 8.2



8.2 Coronal T1-weighted MR right knee

(a) Vastus medialis muscle.
(b) Vastus lateralis muscle.
(c) Anterior cruciate ligament. There is an aide memoire for remembering the orientation of the cruciate ligaments.

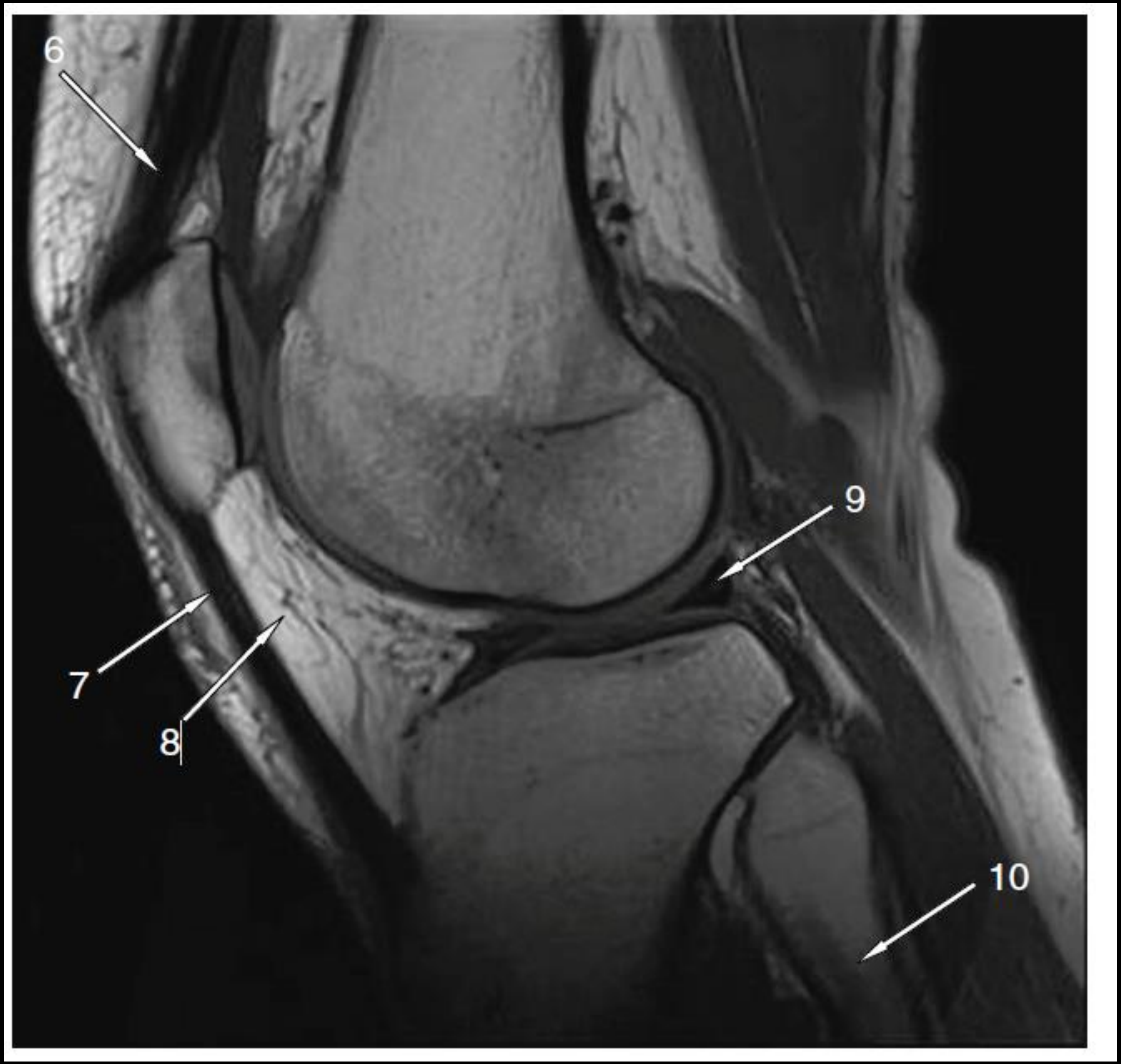
The anterior cruciate ligament is extrasynovial, intracapsular and arises from the intercondylar notch in the tibia and rises towards the anterior aspect of the lateral femoral condyle. Anterior – Backwards, Upwards and Laterally (ABUL).

The posterior cruciate ligament is intrasynovial, extracapsular and arises from the posterior tibial plateau and rises towards the posterior aspect of the medial femoral condyle. Posterior – Upwards, Medially and Forwards (PUMF).

(d) Conjoined tendon. The conjoined tendon is the combination of the lateral collateral ligament and biceps femoris tendon inserting onto the fibular head. The lateral stabilizing ligaments comprise:

Superficial layer – iliotibial band anteriorly merging with the biceps femoris tendon posteriorly
Intermediate layer – postero-lateral collateral ligament
Deep layer – popliteus tendon.

(e) Hyaline cartilage of lateral femoral condyle.

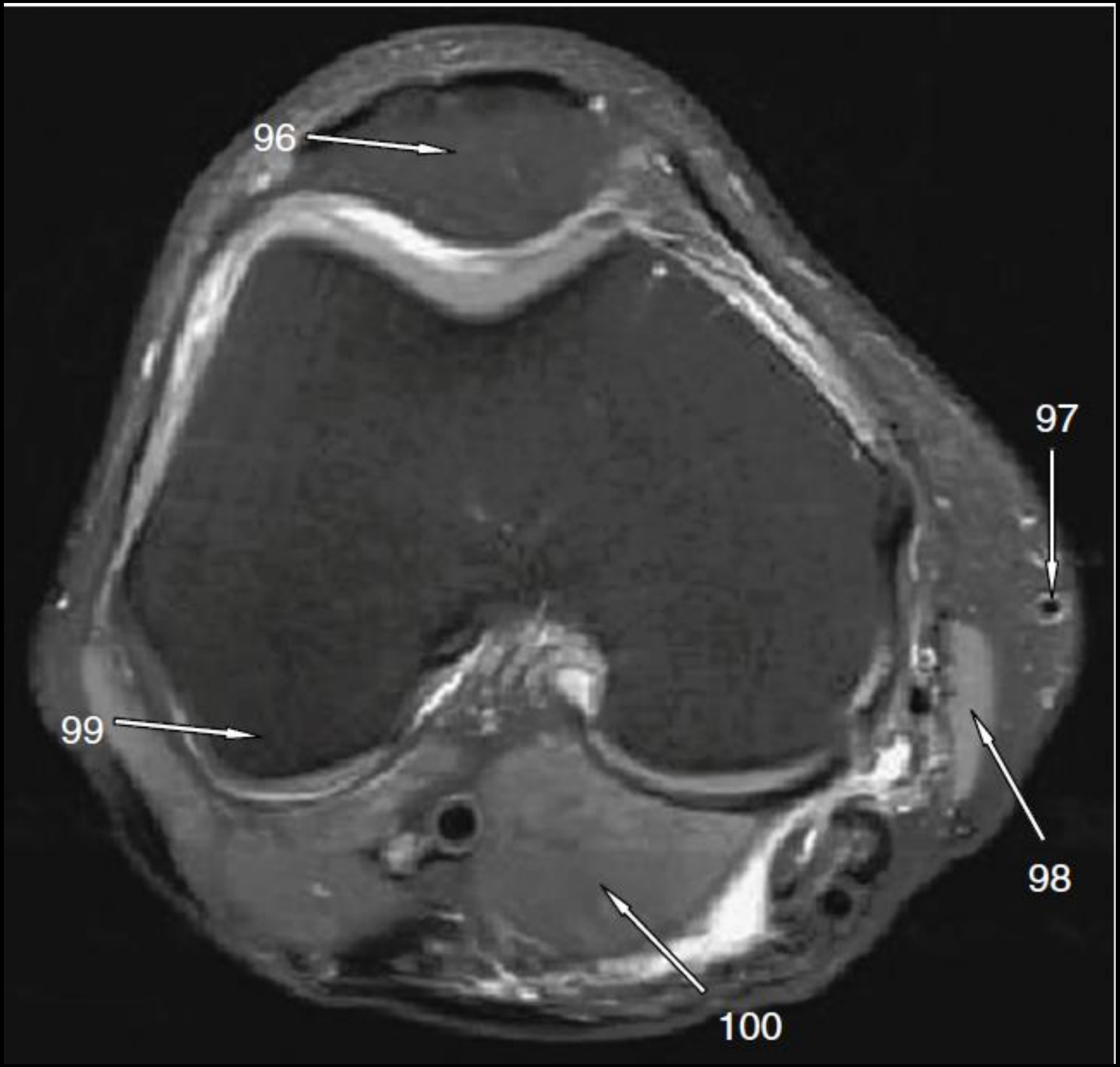


6
7
8
9
10

MRI Knee

6. Quadriceps tendon
7. Patellar ligament
8. Hoffa’s fat pad (or infrapatellar fat pad)
9. Posterior horn of lateral meniscus
10. Neck of fibula

This sagittal MRI of the knee is taken through the fibular head; therefore, the meniscus must be the lateral meniscus.

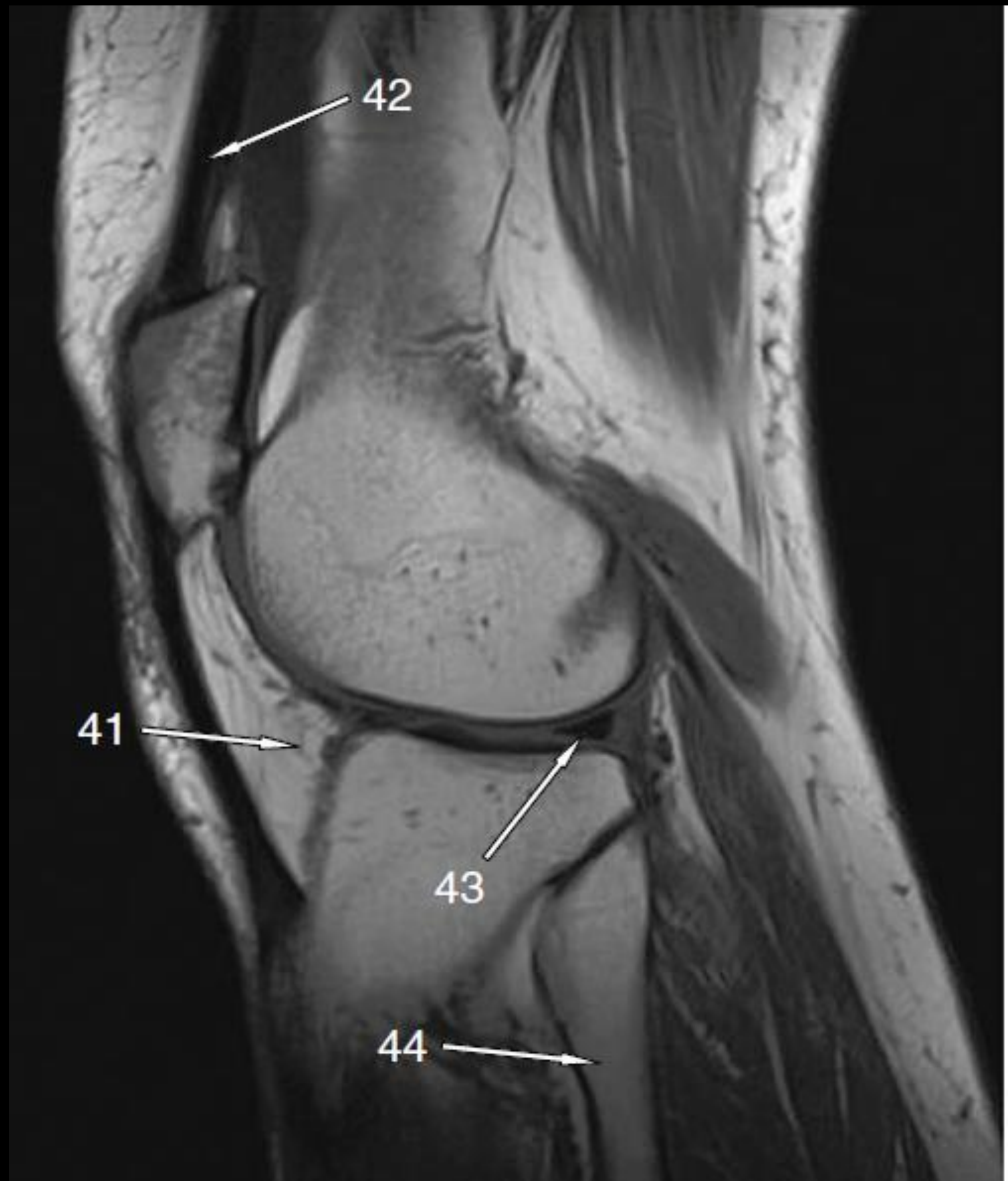

96
97
99
98
100

MRI Knee

96. Patella
97. Great saphenous vein
98. Sartorius muscle
99. Lateral condyle of femur
100. Medial head of gastrocnemius

Identifying medial and lateral on an axial knee may be a bit tricky. Try to identify the great saphenous vein – a superficial vessel on the medial aspect in a thicker layer of superficial fat than the lateral side of the knee.

If the menisci are visible on an axial section, the medial meniscus can be identified as the larger of the two.



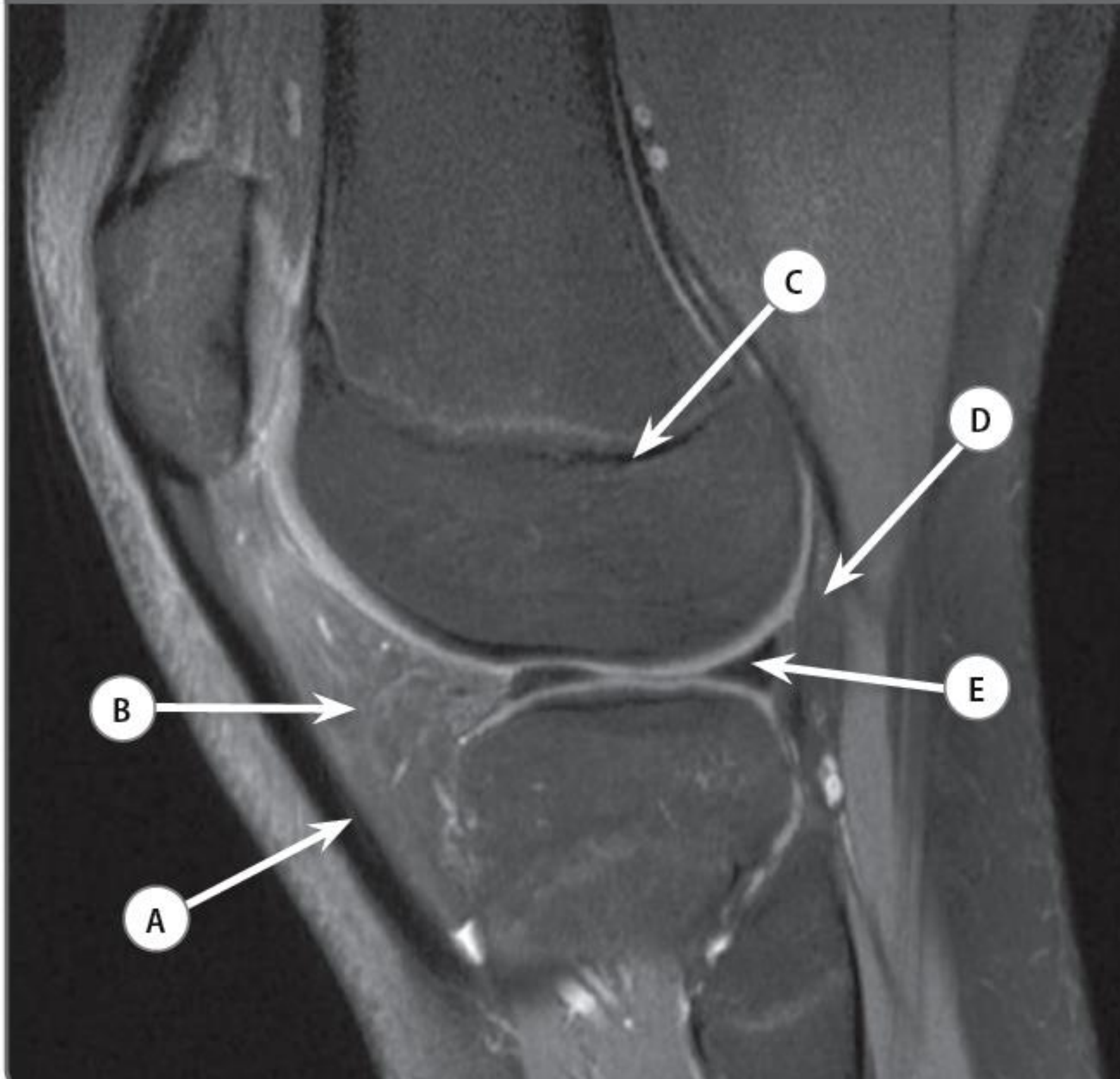
Name the structure that can be damaged if a fracture occurs at 44.

MRI Knee

41. Hoffa’s fat pad
42. Quadriceps tendon
43. Lateral meniscus
44. Neck of fibula
45. Common peroneal nerve

As the fibula is visible in this image, one can deduce that the meniscus demonstrated is the lateral meniscus. The common peroneal nerve winds around the head of the fibula and is prone to damage resulting in loss of dorsiflexion (foot drop).

Case 6.10



Case 6.10

A Patella tendon

B Hoffa's fat pad

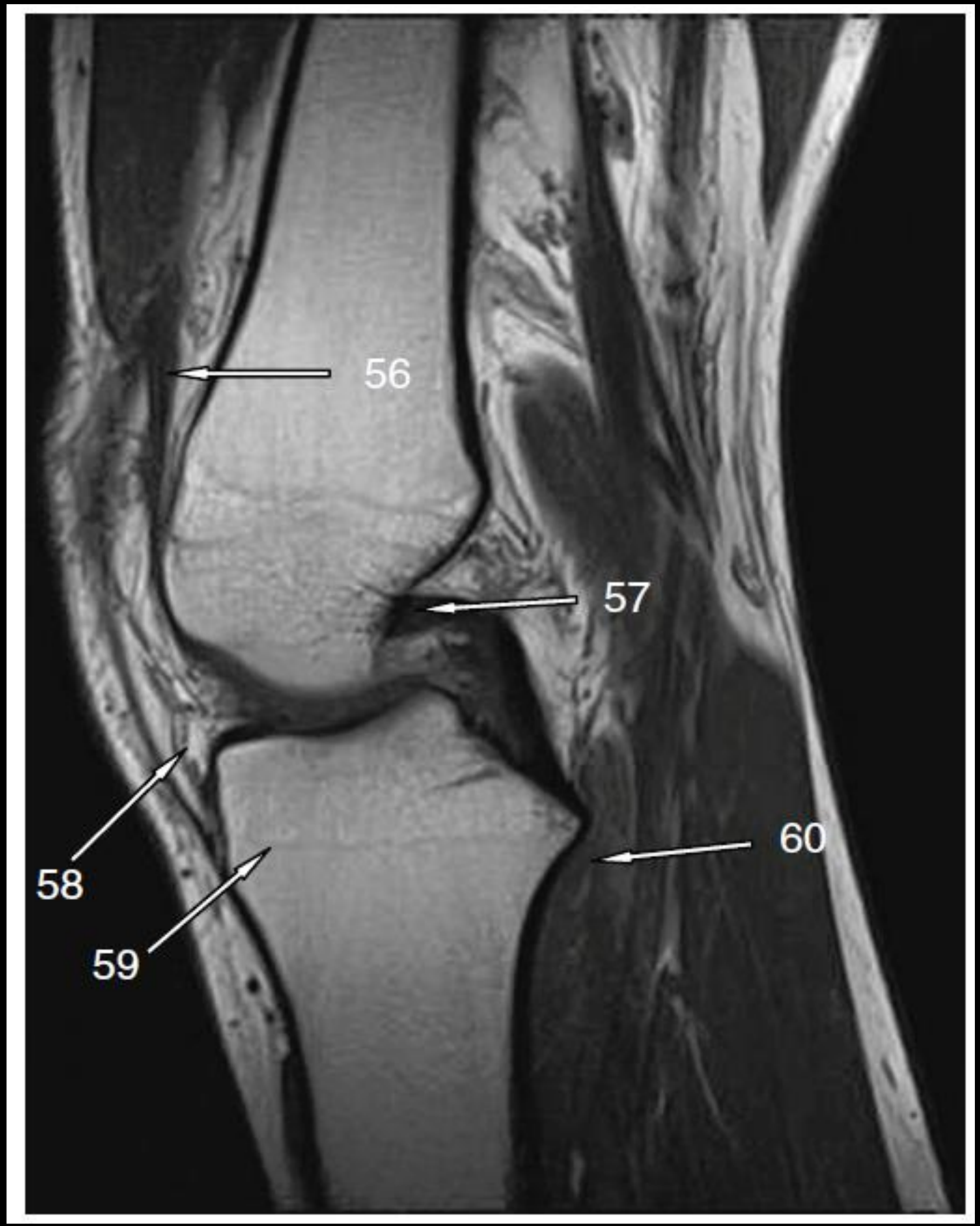
C Distal femoral physis

D Popliteus tendon

E Posterior horn of the lateral meniscus

Sagittal MRI of the knee.

For further discussion, see Chapter 4, Cases 4.7–4.11

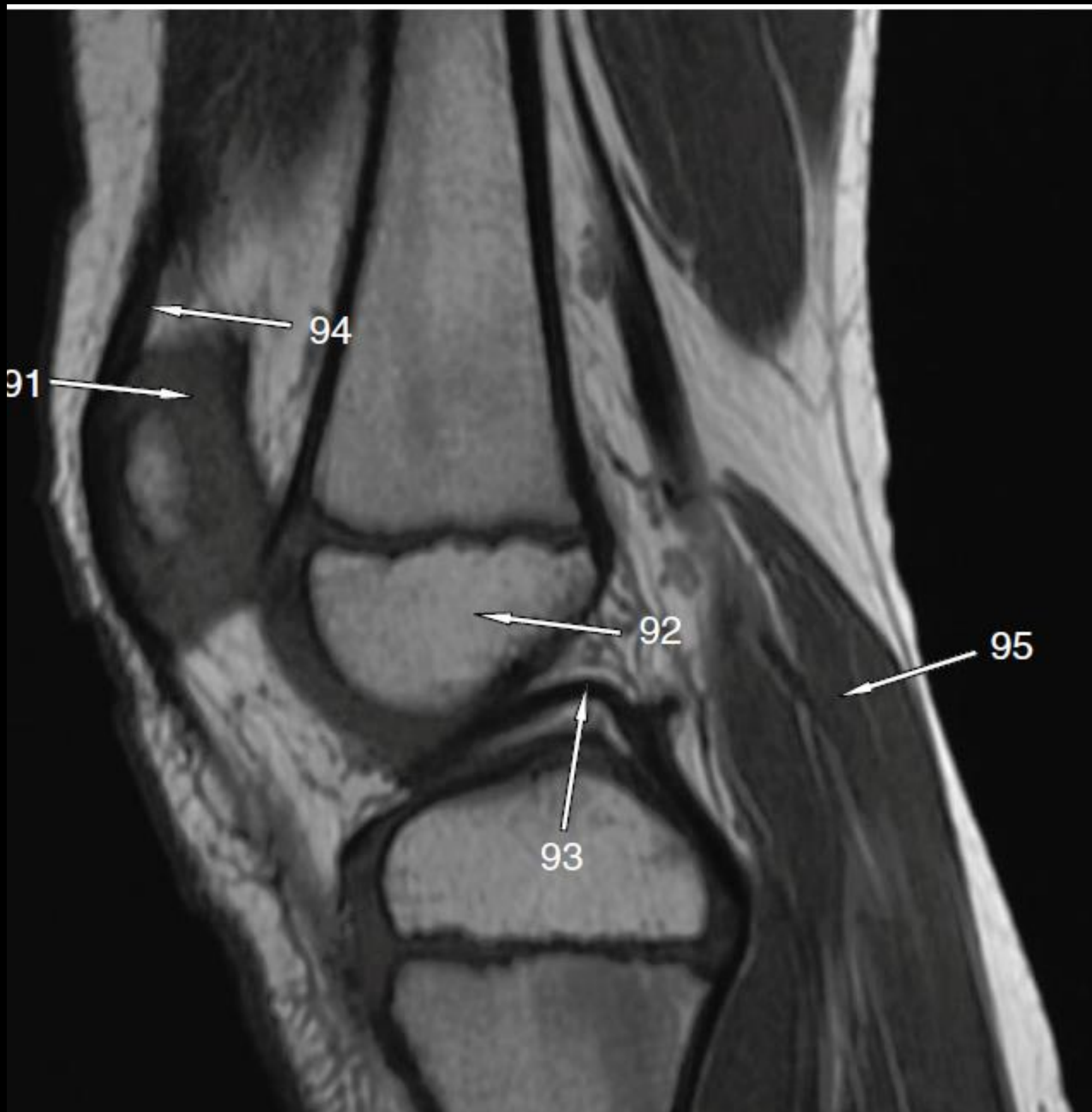

56
57
58
59
60

MRI Knee

56. Quadriceps tendon
57. Posterior cruciate ligament
58. Hoffa's (infrapatellar) fat pad
59. Tibia (proximal physis)
60. Popliteus muscle

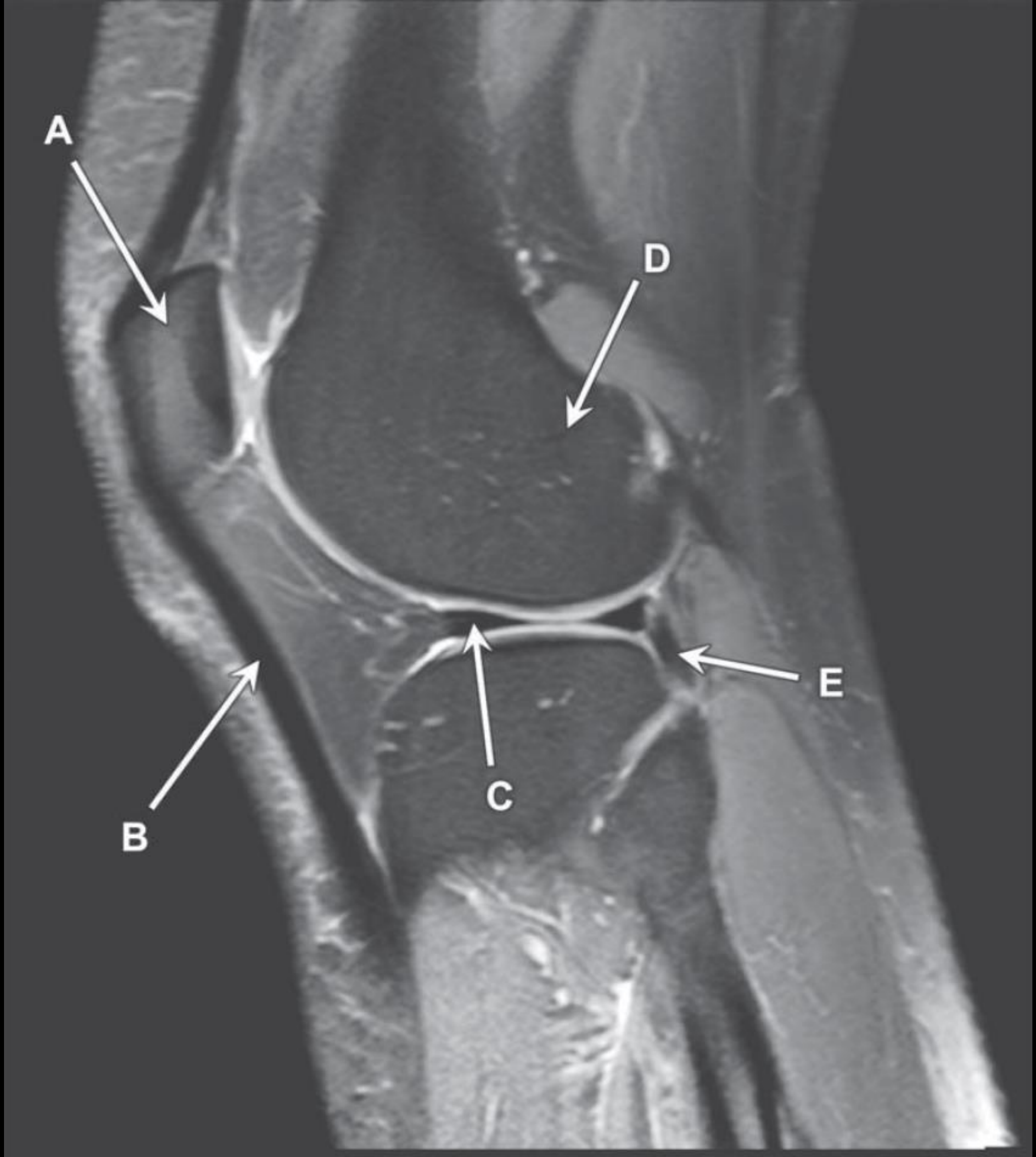
Anterior and posterior cruciate ligaments are named according to their tibial origins.

Remember *AL*, *PM*: *A*nterior cruciate goes *L*ateral and *P*osterior cruciate goes *M*edial.


94
91
92
95
93

MRI Knee

91. Patella (unossified cartialage)
92. Distal femoral epiphysis
93. Posterior cruciate ligament
94. Quadriceps tendon
95. Gastrocnemius

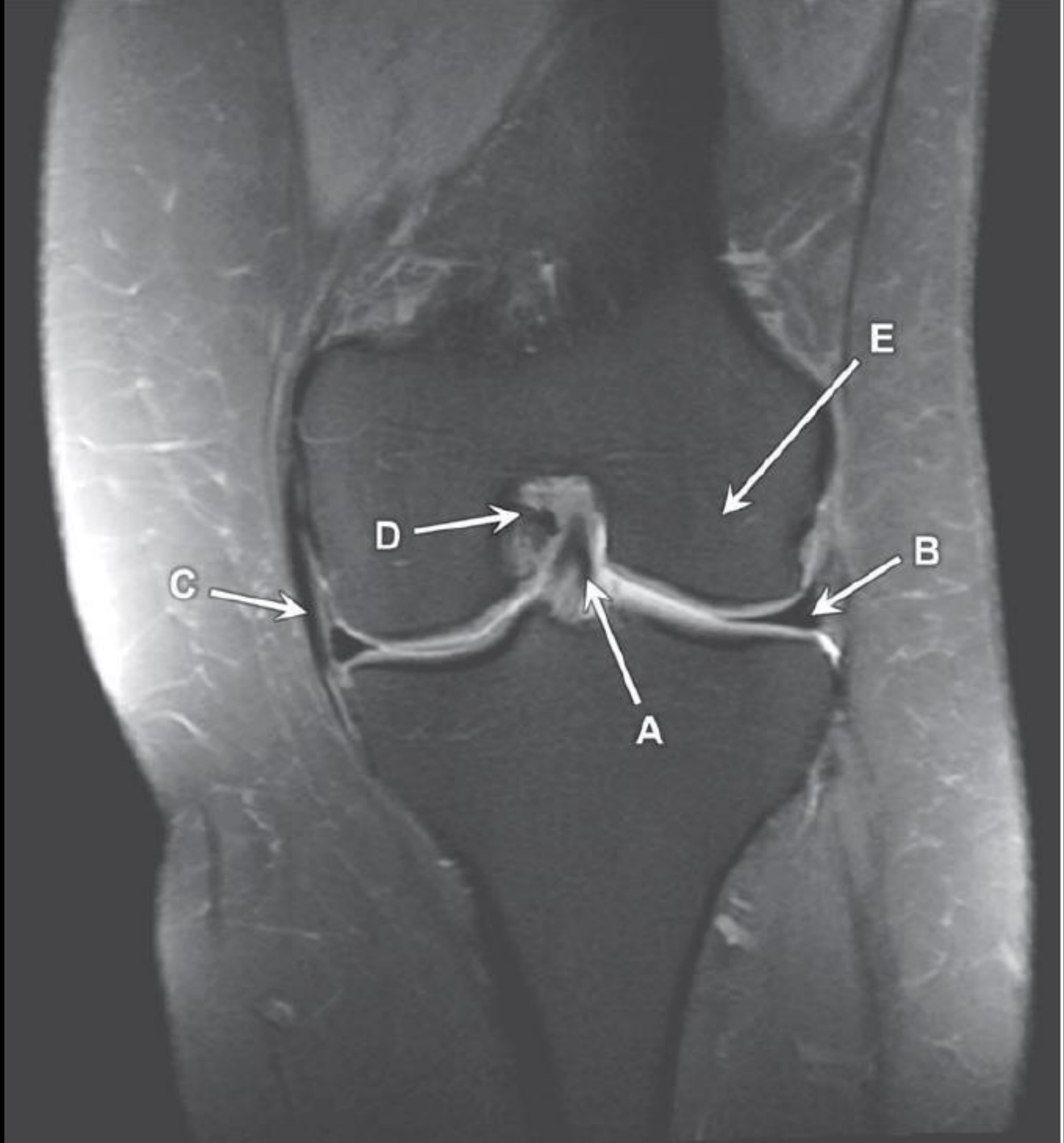

A
D
E
C
B

Case 3

MRI knee. T2W (with fat-suppression). Sagittal section.

1. Patella
2. Patellar tendon
3. Anterior horn of the lateral meniscus
4. Lateral femoral condyle
5. Popliteus tendon

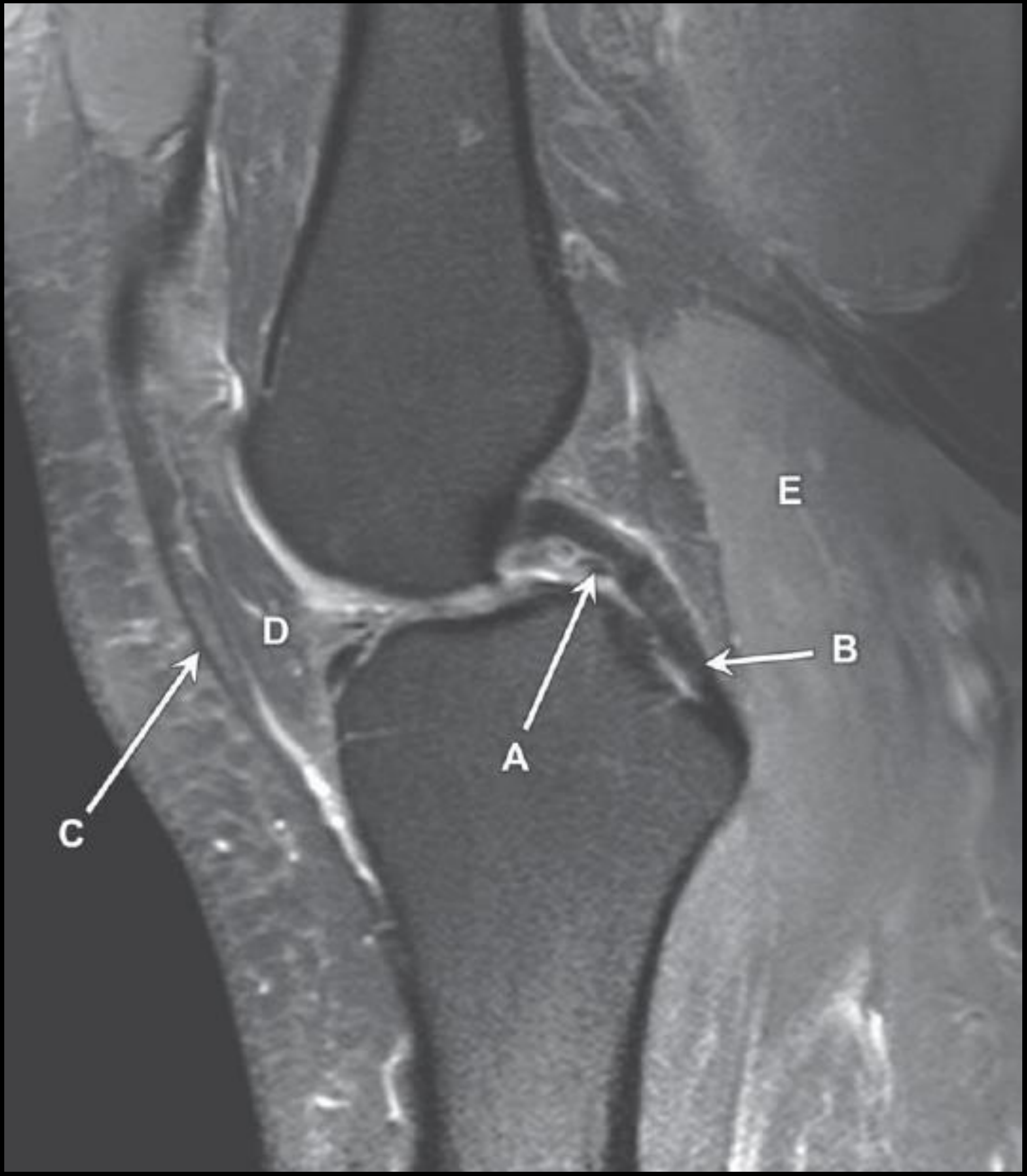
As the fibula is included in the image, this must be the lateral part of the knee.


E
D
B
C
A

Case 15

MRI knee. T1W coronal section.

1. Anterior cruciate ligament
2. Lateral meniscus
3. Medial collateral ligament
4. Posterior cruciate ligament
5. Lateral femoral condyle


E
D
B
A
C

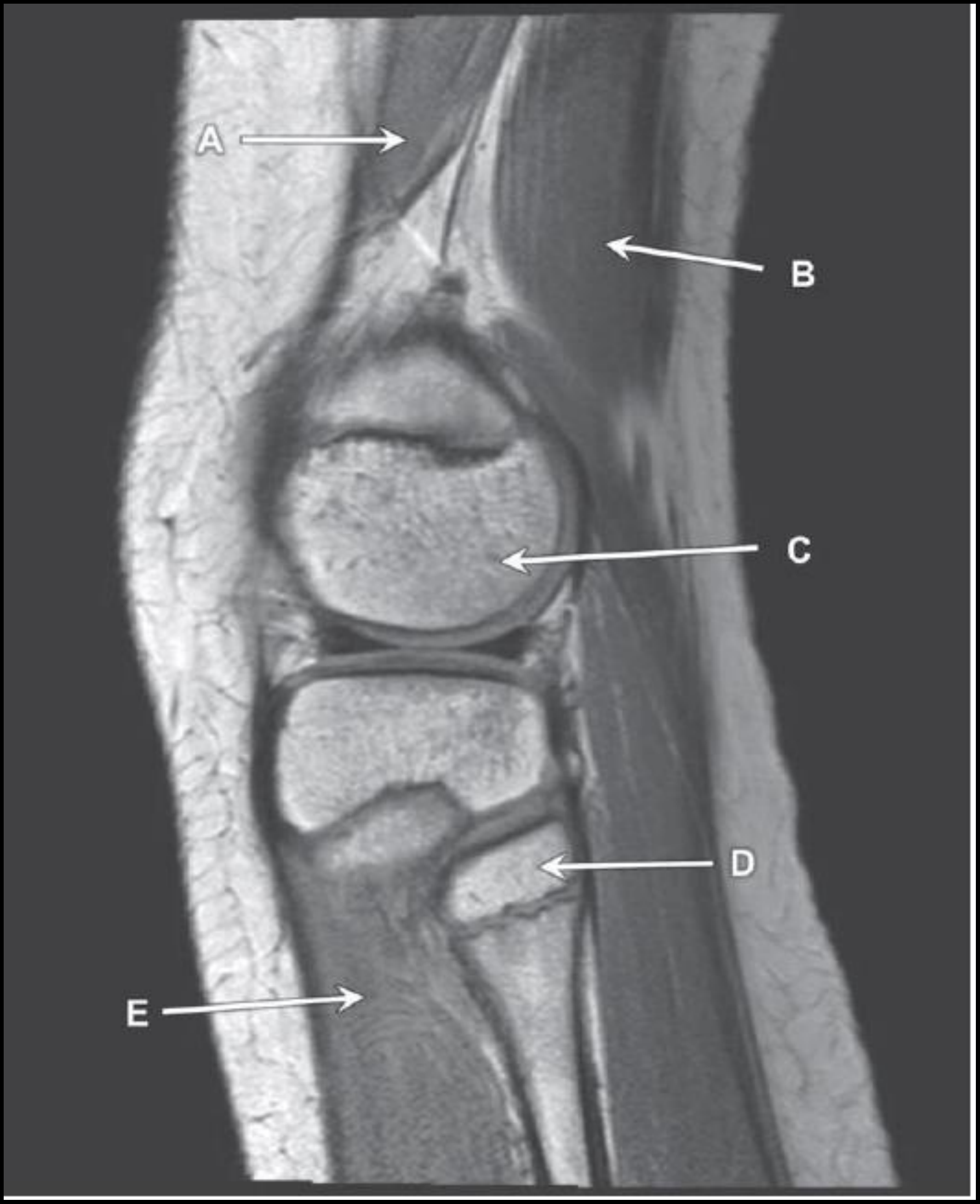
Case 11

MRI knee. T2W sagittal section.

1. Meniscofemoral ligament (of Humphrey)
2. Posterior cruciate ligament
3. Patellar retinaculum
4. Hoffa's fat pad
5. Medial head of gastrocnemius

The meniscofemoral ligament (when visible) has two main variants and names: when passing anterior to the posterior cruciate ligament, it is called the ligament of Humphrey; when passing posterior to the posterior cruciate, it is called the ligament of Wrisberg.

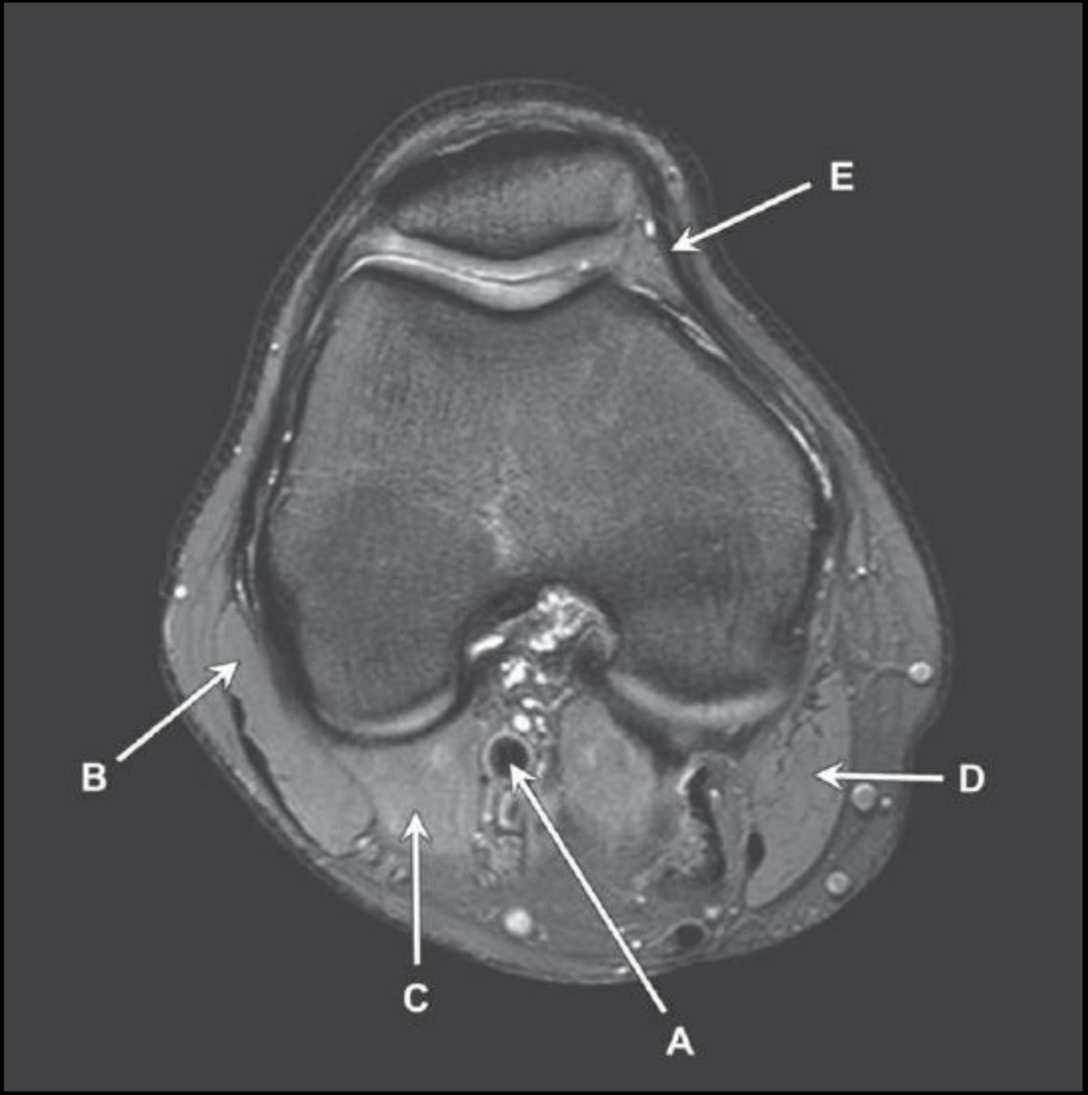
We know the gastrocnemius seen is the medial head as the posterior cruciate lies just medial to the midline of the knee.


A
B
C
D
E

Case 18

MRI knee. T1W sagittal section.

1. Vastus lateralis muscle
2. Biceps femoris muscle
3. Lateral condyle of femur
4. Head of fibula
5. Tibialis anterior muscle


E
B
D
C
A

Case 9

MRI knee. T2W axial image.

1. Popliteal artery
2. Biceps femoris muscle
3. Lateral head of gastrocnemius muscle
4. Sartorius muscle
5. Medial patellofemoral ligament/ medial retinaculum

You should beware ghosting artefacts on MR images. These are displaced reduplications of some or part of the image and occur in the phase encoding direction. They occur due to movement mostly and are often seen on the sort of image shown in question 9 in which the popliteal artery appears both above and below its true position. (This is not shown on the image in this exam.)

Question 1.17 This is an MRI of the right knee.

Name the structures labelled **A** to **E**.

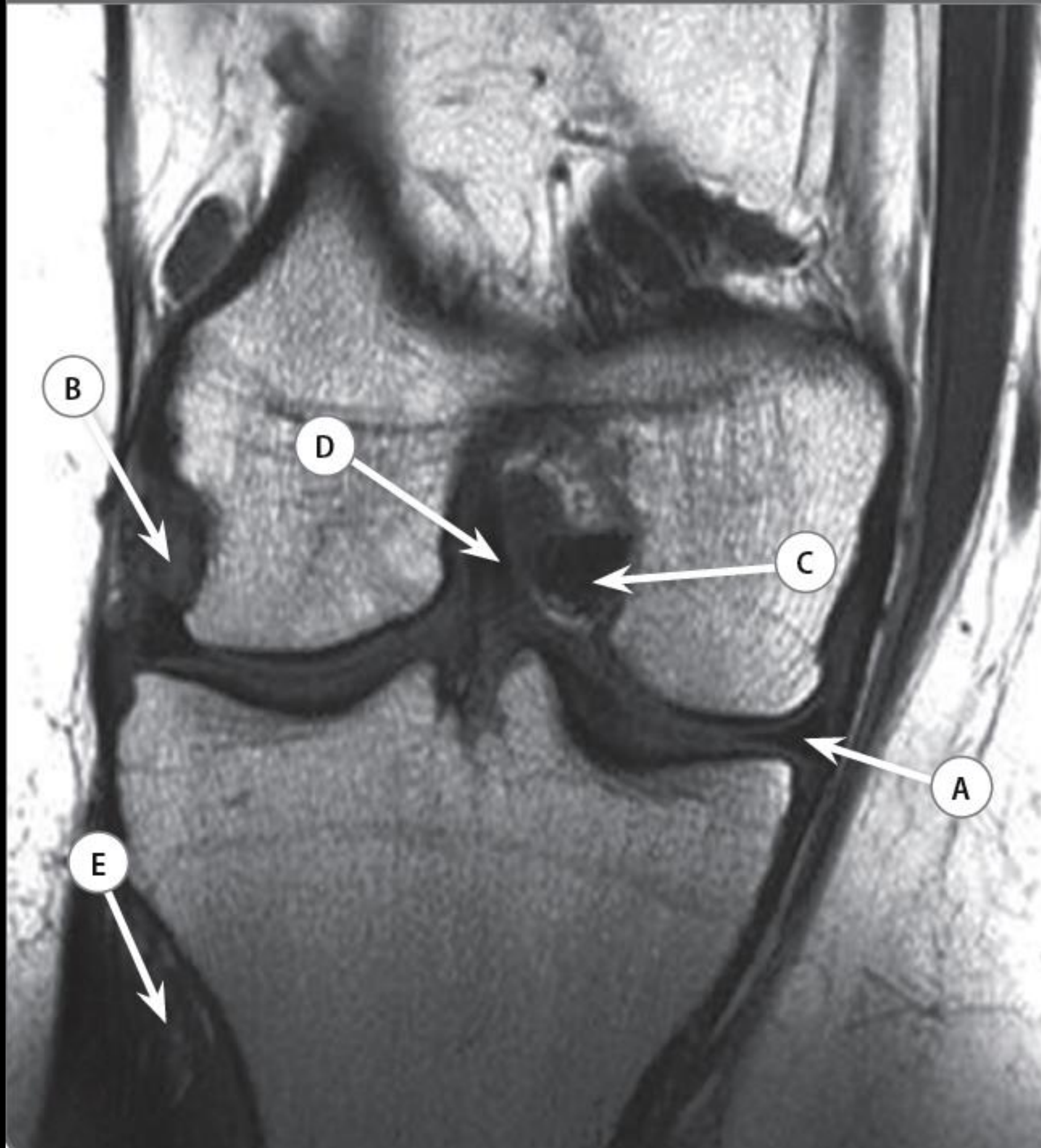
1.17 Sagittal proton density MRI of the right knee

A Quadriceps tendon.
B Patella tendon.
C Hoffa's fat pad (infrapatellar fat pad).
D Anterior cruciate ligament.
E Posterior cruciate ligament.

The quadriceps tendon connects the quadriceps muscles to the superior surface of the patella. The patella tendon connects the inferior surface of the patella to the tibial tuberosity. Like the fibres of external oblique muscle in the anterior abdominal wall, the direction of the fibres of the anterior cruciate ligament can be remembered by the analogy of 'hands in your pockets', originating from the medial surface of the lateral femoral condyle to attach anterior to the intercondyloid eminence of the tibia. The fibres of the posterior cruciate ligament run in the opposite direction to the anterior cruciate ligament and extend from the posterior intercondylar area of the tibia to the lateral surface of the medial femoral condyle.

The infrapatellar fat pad (Hoffa's fat pad) is an intracapsular structure situated posterior to the patellar tendon and is routinely visualized on MRI of the knee. It is important to be familiar with its appearance, as it can be commonly injured and may be the only site of pathology.

Case 4.9



Case 4.9

A Medial meniscus

B Popliteus tendon

C Posterior cruciate ligament

D Anterior cruciate ligament

E Tibialis anterior

Coronal MRI of the knee.

The knee joint is a synovial joint which consist of two condylar femorotibial components and a saddle-shaped patellofemoral component. On a plain film, the fibula can be used to distinguish between the medial and lateral femoral condyles/epicondyles. When given a coronal MRI like this one where the fibula is not seen, remember that the lateral condyle is flatter ('lat-flat').

The menisci of the knee joint are C-shaped semilunar rings of fibrocartilage found between the articular surfaces of the femur with the tibia. In cross section, these structures appear triangular.

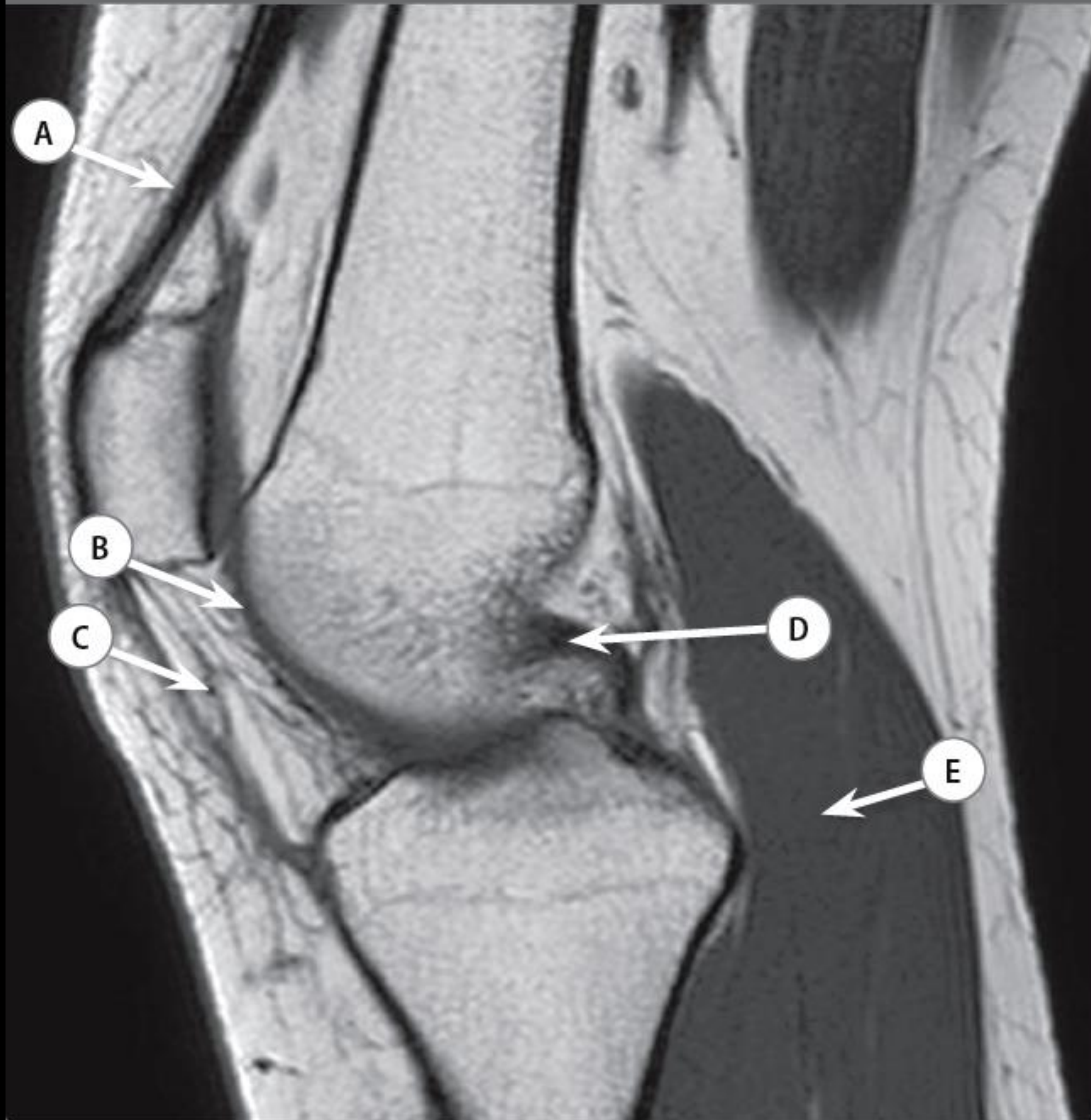
Again we see the popliteal groove of the lateral femoral condyle and the tendon of the popliteus.

The anterior and posterior cruciate ligaments are intrasynovial and extracapsular. They are seen in this level in the intercondylar notch of the femur where the posterior cruciate ligament lies medially and the anterior cruciate ligament laterally.

The tibialis anterior originates in the upper two-thirds of the lateral surface of the tibia and inserts into the medial cuneiform and the 1st metatarsal. Its acts to dorsiflex and invert the foot.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy. Edinburgh: Mosby, 2003: 224–225.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 296.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 367–369.

Case 4.10



Case 4.10

A Quadriceps tendon

B Articular cartilage of the medial femoral condyle

C Infrapatellar fat pad (Hoffa's fat pad)

D Posterior cruciate ligament

E Medial head of gastrocnemius

Sagittal MRI of the knee.

Extension of the knee joint occurs through contraction of the quadriceps. The force is translated through the quadriceps tendon, the patella and the patella tendon to the tibia.

The posterior cruciate ligament is primarily responsible for resisting posterior translation of the tibia. It arises from the inner aspect of the medial femoral condyle. It runs posteriorly to attach in a midline depression in the posterior margin of the tibial plateau. Note that the posterior cruciate ligament is composed of two subdivisions: a dominant anterolateral bundle and a small posteromedial band.

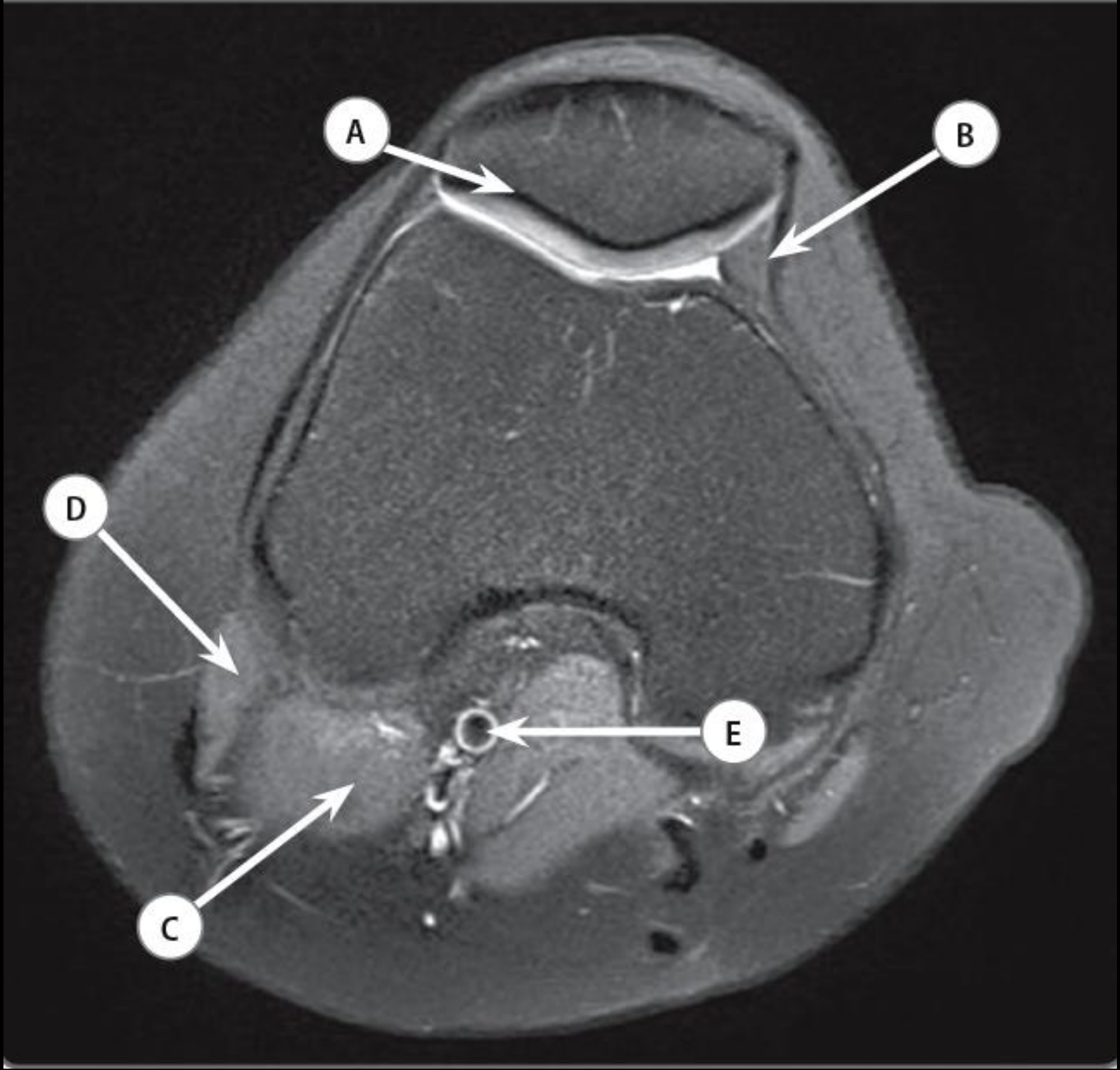
The insertion of the posterior cruciate ligament provides a clue as to which femoral condyle is seen in this image. Therefore when asked to identify the articular cartilage of the femoral condyle, you can confidently label it as medial condyle to score maximum points.

The infrapatellar fat pad (Hoffa's fat pad) is cylindrical in shape and is intracapsular. Disease in this region is not uncommon and therefore it is an area routinely visualised and reviewed on an MRI of the knee.

The gastrocnemius is the largest and most superficial of the calf muscles. It has two heads which arise from the medial and lateral condyles. It crosses the knee and ankle joints to insert via the Achilles tendon into the calcaneum. Again, make sure that it is identified as the medial head of gastrocnemius to gain maximum points.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy. Edinburgh: Mosby, 2003: 227.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 297.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 367–369.

Case 4.11



Case 4.11

A Lateral articular facet of the patella

B Medial retinaculum

C Lateral head of gastrocnemius

D Biceps femoris

E Popliteal artery

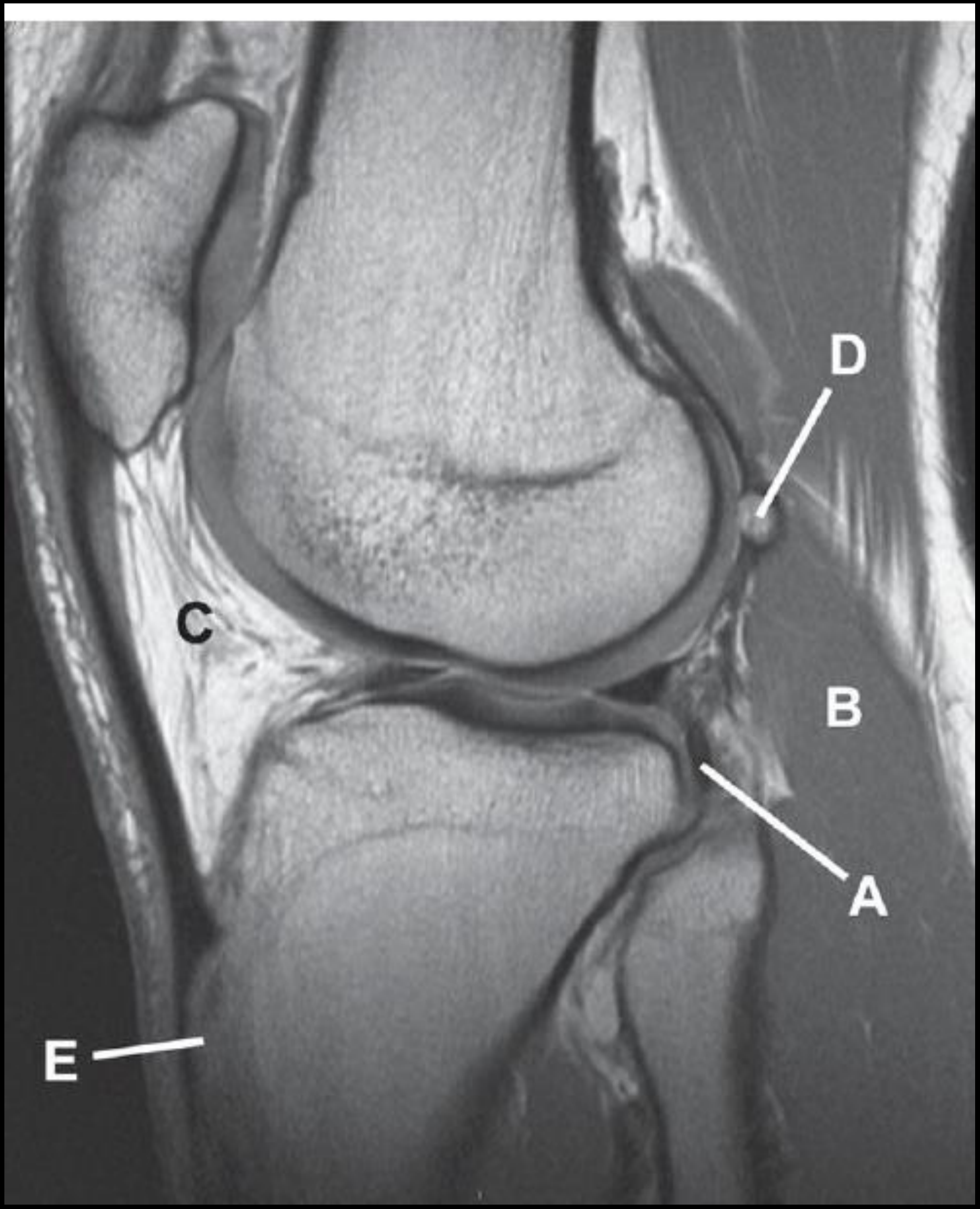
Axial T2-weighted fat sat MRI at the level of the patellofemoral articulation.

The articular surface of the patella has two facets: the lateral and the medial. The lateral articular facet is larger than the medial. Knowing this fact is key to identifying the other structures correctly.

The medial patellar retinaculum is part of the aponeurosis of vastus medialis. It runs between the patella and the medial condyle of the tibia and forms the anteromedial aspect of the fibrous capsule of the knee joint. This capsule is strengthened posteriorly by the two heads of gastrocnemius and by the oblique popliteal ligament. Laterally, it is strengthened by the iliotibial tract.

The biceps femoris is part of the hamstrings. Distally, it crosses the knee joint on the lateral side, to insert on to the head of the fibula.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 228.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 298.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 367–369.


D
C
B
A
E

Q11 Answers

a Popliteus tendon
b Lateral head of gastrocnemius
c Infrapatellar (Hoffa's) fat pad
d Fabella
e Tibial tuberosity

T1W MRI knee, lateral sagittal section

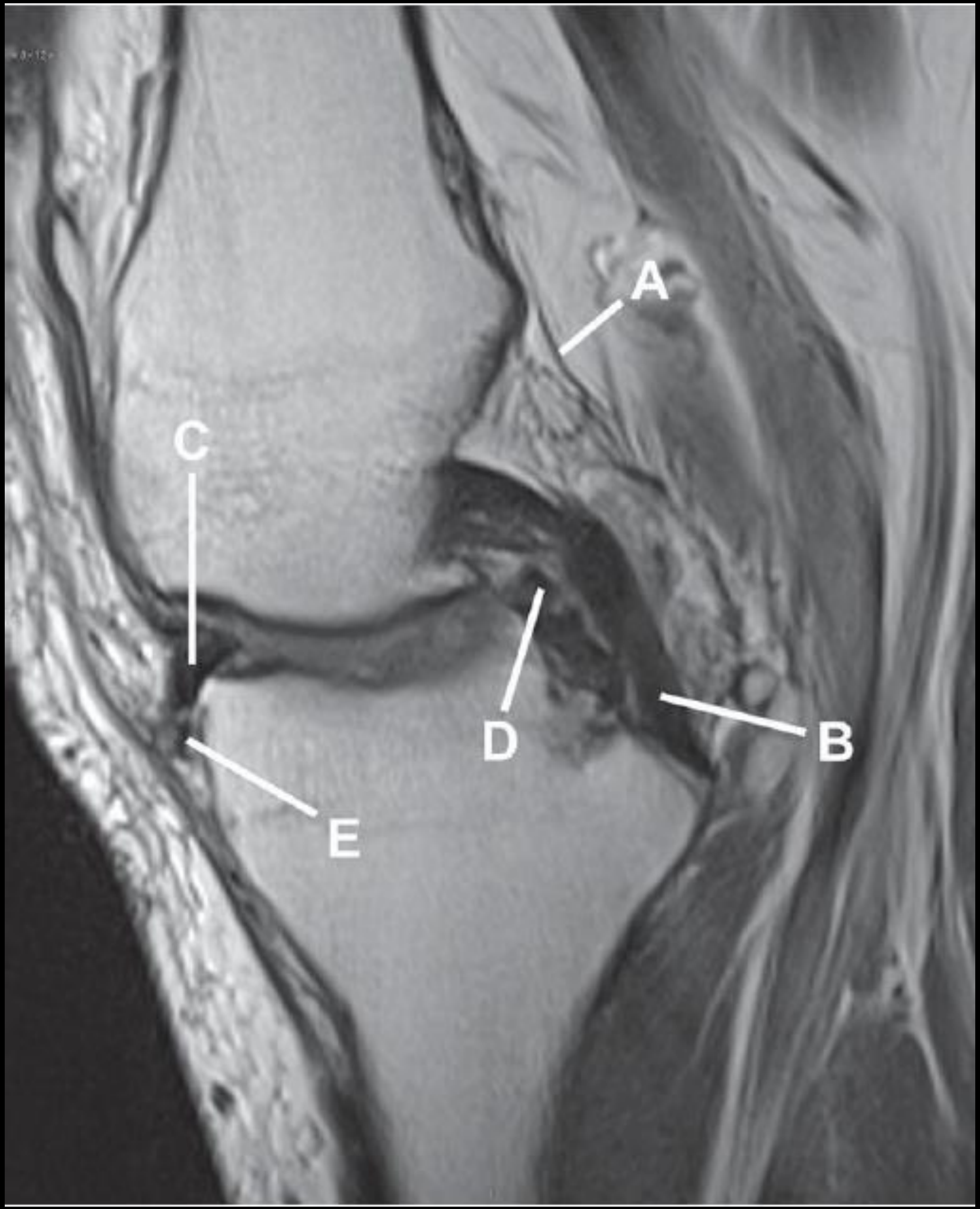
A spherical osseous or cartilaginous fabella (Latin for 'little bean'), is occasionally seen in the vicinity of the knee. The location can be variable though it is usually within the lateral head of gastrocnemius muscle, in the postero-lateral aspect of the knee.

The popliteus muscle has its inferior origin above the soleal line of the posterior tibia. It runs in a supero-lateral course to its tendinous insertion into the groove on the lateral femoral condyle. Further insertion sites are at the posterior fibular head and the posterior lateral meniscus and these act to buttress the postero-lateral aspect of the knee joint. The action of popliteus is as the primary internal rotator of the tibia on the femur and it is the only muscle to enter the knee joint capsule. It also acts to laterally rotate the femur on the fixed tibia effectively unlocking the knee to allow flexion of the extended knee.

The joint capsule contains a triangular, anterior fat-pad sitting deep to the patellar tendon and surrounded by synovium. This is the infrapatellar (Hoffa's) fat pad which contains the deep infra-patellar bursa within its inferior aspect.

The tibial tuberosity is the bony ridge on the anterior tibial border into which the quadriceps tendon inserts.

Seebacher JR, Inglis AE, Marshall JL, Warren RF. The Structure of the Posterolateral Aspect of the Knee. *J Bone Joint Surg [Am]* 1982; 64:536–541.


A
B
C
D
E

Q12 Answers

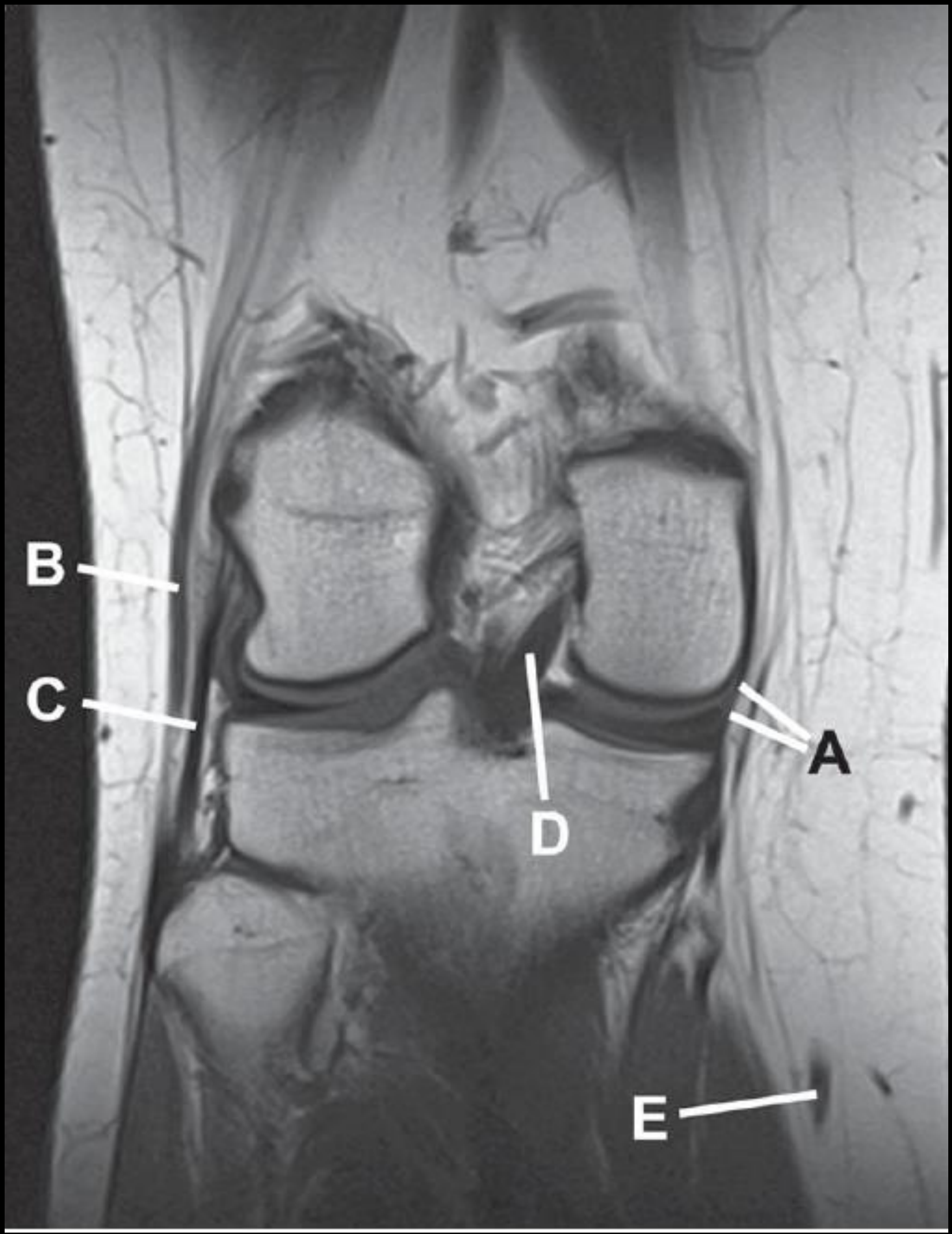
a Posterior knee joint capsule
b Posterior cruciate ligament
c Anterior horn of lateral meniscus
d Anterior meniscofemoral ligament (of Humphrey)
e Transverse ligament

T1W MRI of knee, oblique sagittal section

The cruciate ligaments lie entirely within the knee joint capsule and are principally involved in the provision of antero-posterior joint stability. They both achieve this by adjoining the side of the tibial intercondylar process to its contralateral femoral condyle and are named according to the location of their tibial insertions. The PCL passes upwards, forwards and medially from the lateral aspect of the posterior tibial spine to the lateral aspect of the medial condyle. The ACL passes upwards, backwards and laterally from the anterior aspect of the tibial spine to the medial aspect of the lateral condyle.

The menisci consist of two semi-lunar fibrocartilages which serve to deepen the tibial articular surface. The medial meniscus is the larger of the two and, unlike the lateral meniscus, is attached firmly to its respective collateral ligament.

The appearance of meniscal ligaments can mimic meniscal pathology if incorrectly identified. The posterior horn of the lateral meniscus is attached to the medial femoral condyle by means of a meniscofemoral ligament which frequently splits into two parts to pass around the PCL. If the dominant part passes anterior to the PCL then it is known as the ligament of Humphrey, and if it passes posterior it is the ligament of Wrisberg. Anterior meniscal horns are interconnected by the transverse ligament.



A
B
C
D
E

Q13 Answers

a Medial collateral ligament
b Tendon of biceps femoris
c Lateral collateral ligament
d Posterior cruciate ligament
e Long saphenous vein

T1W MRI of knee, coronal section

The medial collateral ligament is a band-like structure which connects the medial femoral epicondyle to the tibial condyle. The lateral collateral ligament, which is more cord like, connects the lateral femoral epicondyle to the head of the fibula and is separated from the lateral joint capsule by the tendon of popliteus muscle. Additional lateral stability is provided via the ilio-tibial tract and biceps femoris, which share a common (conjoint) tendinous insertion into the postero-lateral fibular head. The other name for this insertion is the arcuate ligament. The tendon of popliteus passes under this on its way to its attachment to the lateral aspect of the lateral condyle of the femur.

The long saphenous vein (also known as the great saphenous vein) runs up the medial aspect of the leg and thigh to drain into the femoral vein at the sapheno-femoral junction. The short saphenous vein arises from the lateral aspect of the dorsal venous arch and passes posterior to the lateral malleolus. It runs up the back of the calf to drain into the popliteal vein at the sapheno-popliteal junction. The short and long saphenous veins are the two main superficial venous channels in the leg.

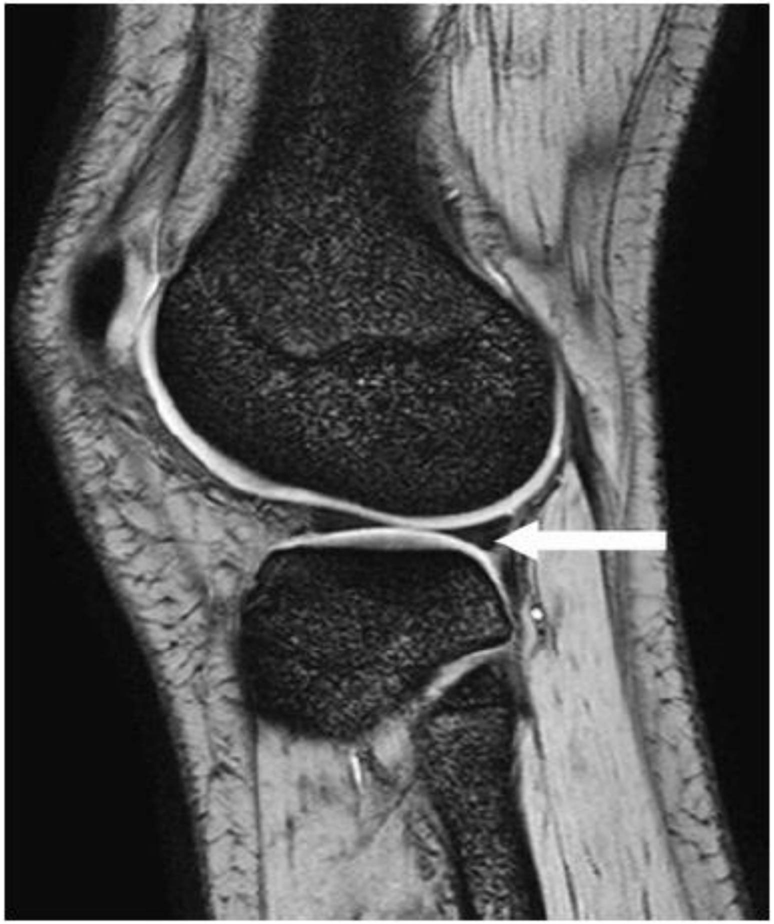
- Question 1:

■ Question 1: Sagittal MRI of the knee

Answer: Anterior cruciate ligament

- The anterior cruciate ligament extends from the anterior intercondylar notch to the posteromedial aspect of the lateral femoral condyle.
- There are two bands: anteromedial and posterolateral.
- Their main function is to prevent posterior displacement of the tibia on flexion/extension.
- It is seen as a low intensity black band on T1-weighted/proton density MRI.
- However, it may just be the anteromedial band that appears black.

■ Question 14:



Question 14: T1-weighted sagittal MRI of the knee

Answer: Posterior horn of the lateral meniscus

- The menisci are best seen on sagittal or coronal MRI and appear as black triangles. Degeneration or a tear will usually appear as high (bright) signal.
- It is important that your response to this question be precise. Because the fibula is seen on this slice, you can be sure that this is the lateral meniscus. Determining which is the anterior and posterior horn should be relatively straightforward.

- Question 33:

Question 33: Sagittal T2-weighted MRI of the knee

Answer: Patellar tendon

- On US, the patellar tendon appears as a slightly hyperreflective fibrous structure. On T1-weighted/proton density MRI, it is a low intensity (black) band.
- It runs from the patella to the tibial tuberosity.

FOOT

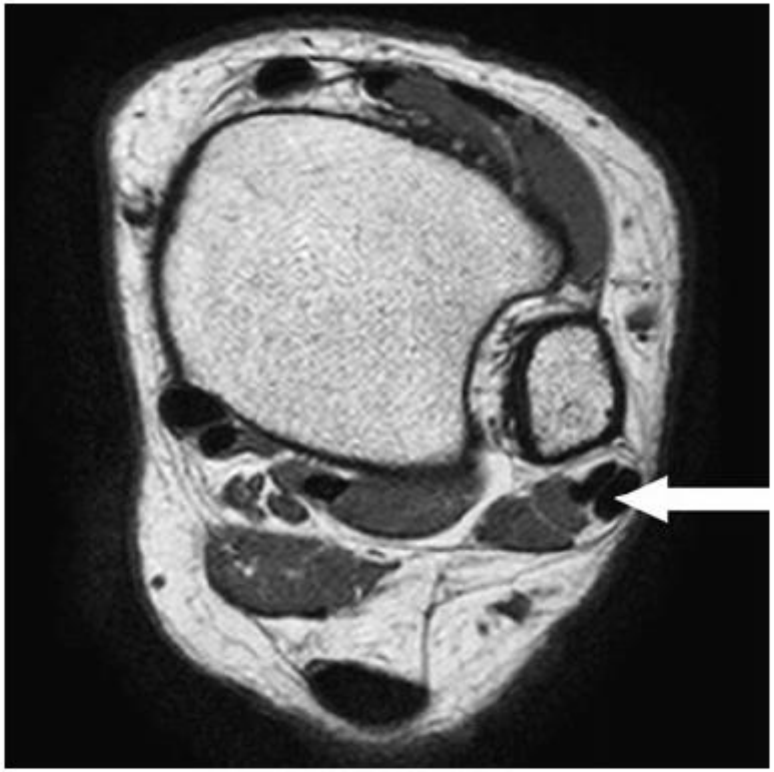
- Question 20:

Question 20: T1-weighted sagittal MRI of the ankle

Answer: Achilles tendon

- The Achilles tendon is the conjoined tendon of the gastrocnemius and soleus muscles.
- The musculotendinous junction is approximately 6 cm proximal to the insertion onto the posterior aspect of the calcaneum.
- On MRI, it appears as a low intensity (black) structure on T1-weighted and proton density sequences. On US, it appears as a thin (approximately 6 mm) reflective fibrous structure.
- Note the unfused distal tibial epiphysis, which indicates that this is a young patient.

- **Question 32:**

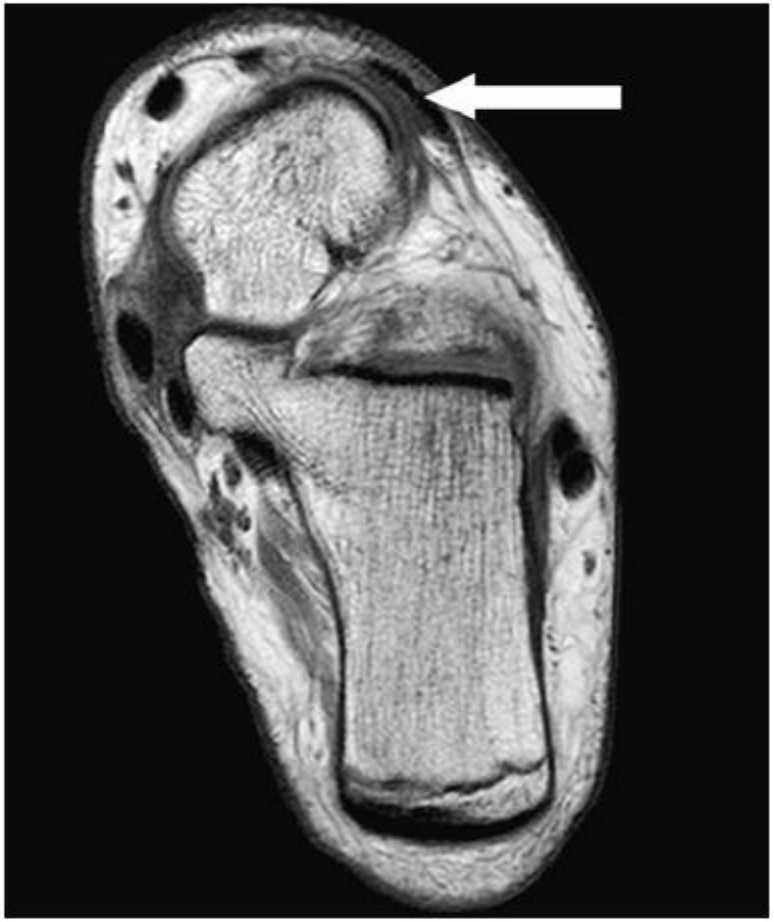


Question 32: T1-weighted axial MRI of the ankle

Answer: Left peroneus longus tendon

- There are two principal peroneus tendons: longus and brevis. There are several accessory peroneus tendons (e.g. peroneus tertius).
- They both run a lateral course posterior to the lateral malleolus.
- Peroneus longus is lateral to peroneus brevis.
- It runs inferior to the cuboid bone, crosses the foot, and inserts onto the base of the first metatarsal and medial cuneiform.
- Peroneus brevis inserts onto the base of the fifth metatarsal.

- **Question 42:**



■ Question 42: Axial oblique MRI of the ankle

Answer: Extensor digitorum longus

- There are four muscles in the anterior compartment of the lower leg: tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius.
- Extensor digitorum longus extends from the lateral condyle of the tibia to insert on the middle and distal phalanges of the second to fifth toes.
- It dorsiflexes the ankle.

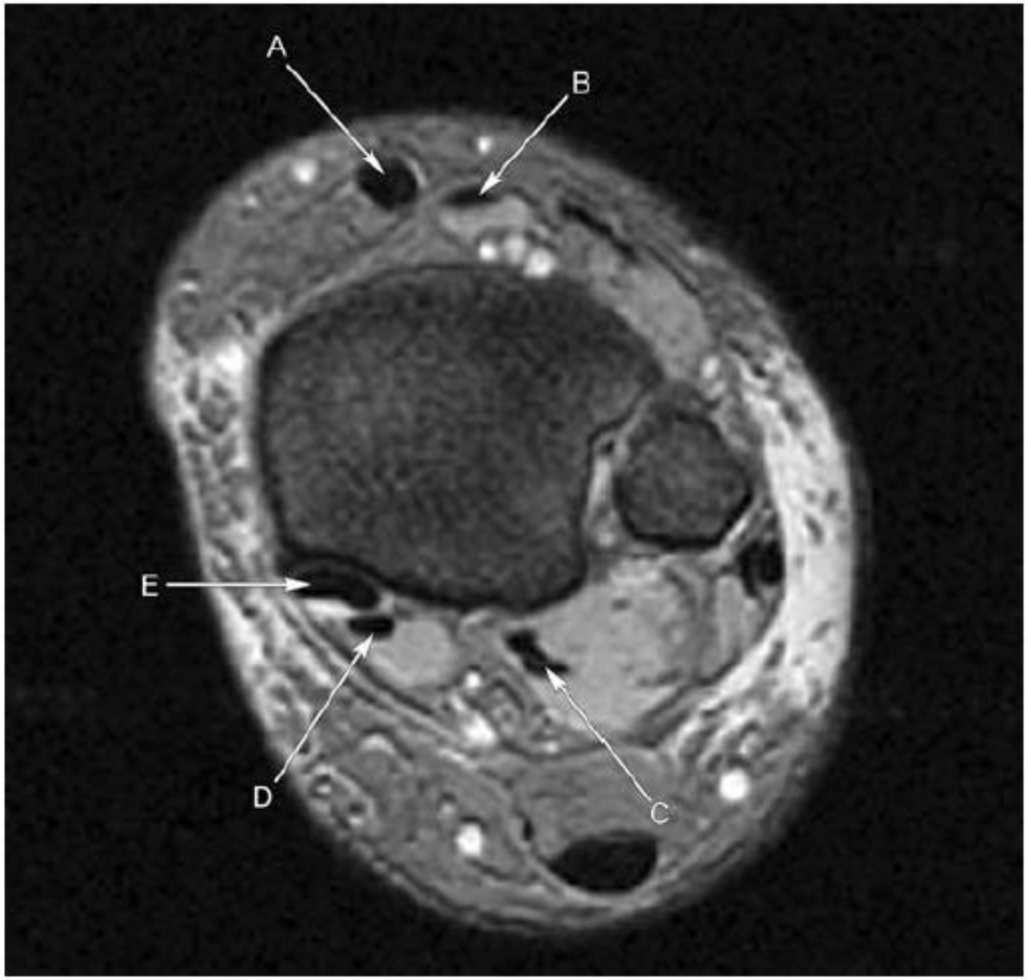
- **Question 48:**

Question 48: T1-weighted axial MRI of the ankle

Answer: Left flexor hallucis longus muscle

- There are three main flexor tendons found in the posterior lower leg: tibialis posterior, flexor digitorum longus, and flexor hallucis longus. This can be remembered by 'Tom, Dick, and Harry' (from medial to lateral).
- For the extensor tendons, it is Tom (tibialis anterior), Harry (extensor hallucis longus), and Dick (extensor digitorum longus) from medial to lateral.
- Flexor hallucis longus attaches to the base of the distal phalanx of the great toe.
- If the arrow is clearly pointing to the muscle belly (grey) or the tendon (black), then it is better to be precise in your answer. If you are unsure, you could leave off the muscle or tendon part of the answer.

Question 3.17



This is an axial MRI of the ankle.
Name the structures labelled **A** to **E**.

3.17 Axial STIR MRI of the left ankle

A Left tibialis anterior tendon.
B Left extensor hallucis tendon.
C Left flexor hallucis longus tendon.
D Left flexor digitorum longus tendon.
E Left tibialis posterior tendon.

The mnemonic for remembering the order of contents of the flexor retinaculum of the lower limb as it passes medial to the tibia is Tom, Dick, ANd, Harry, which corresponds to Tibialis posterior, flexor Digitorum longus, posterior tibial Artery, tibial Nerve and flexor Hallucis longus.

The soleus is one of the muscles of the posterior superficial compartment of the leg. On axial images of the ankle, the tibialis anterior is the most medial anterior tendon, as demonstrated. A mnemonic to remember the anterior tendons of the ankle joint from medial to lateral is Tom Hates Dick, corresponding to Tibialis anterior, extensor Hallucis longus and extensor Digitorum longus.

Question 10.9

This is a sagittal MRI of the right ankle.
Name the structures labelled **A** to **E**.

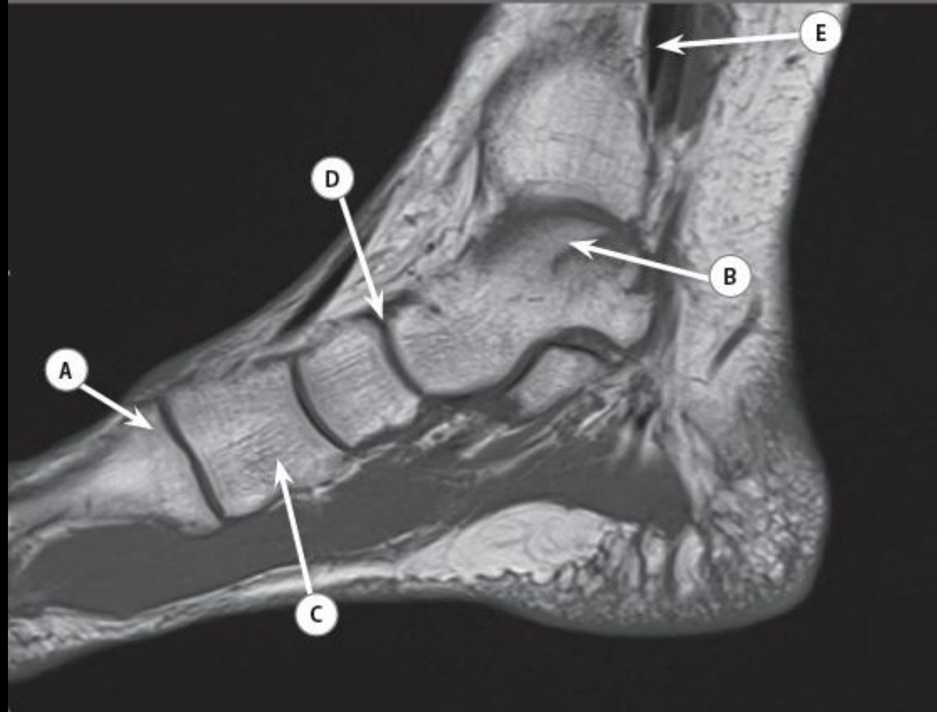
10.9 Sagittal T1 MRI of the right ankle

A Sinus tarsi.
B Navicular.
C Plantar aponeurosis.
D Calcaneum.
E Achilles tendon (calcaneal tendon).

The sinus tarsi is a cone-shaped anatomical space located in the lateral aspect of the foot between the inferolateral border of the talus and the superolateral border of the calcaneum. In healthy subjects the sinus tarsi is filled with fat, hence the high signal intensity seen on this T1-weighted image. It is an important area to review as sinus tarsi syndrome is a common cause of lateral hindfoot pain and instability.

The plantar aponeurosis is a strong fibrous fascial layer whose function is to stabilize the arch of the foot. It runs from the medial process of the calcaneal tuberosity to the heads of the metatarsal bones. The Achilles tendon is formed by the tendons of the soleus and gastrocnemius and inserts into the dorsal margin of the calcaneus. Rupture of the Achilles tendon typically occurs at the musculotendinous junction, located 2–6 cm above its insertion into the calcaneum.

Case 4.17



Case 4.17

QUESTION		WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	Name the structure labelled D.	
E	Name the structure labelled E.	

Case 4.17

A Base of first metatarsal (great toe)

B Dome of talus

C Medial cuneiform

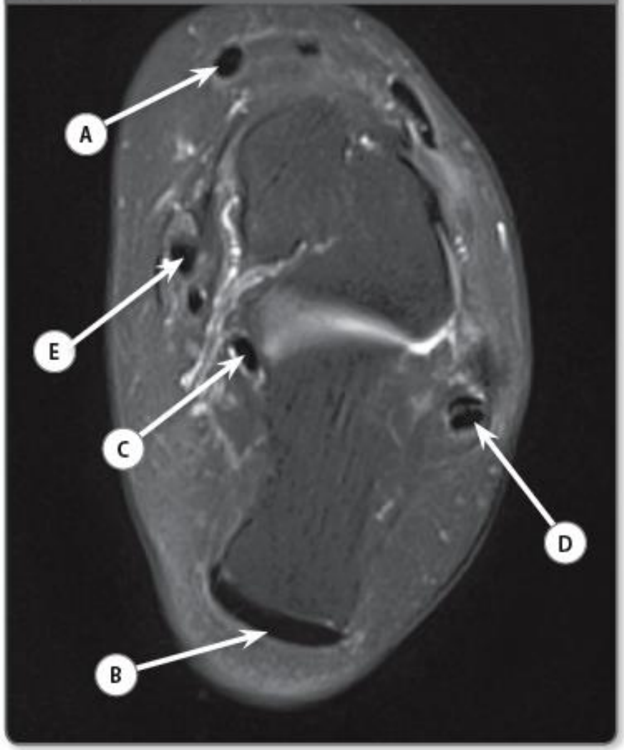
D Talonavicular joint

E Tibialis posterior tendon

One of the most difficult parts of the examination is being shown an image like the one in this case and having to orientate yourself with the information demonstrated on strictly one slice.

This sagittal image has several clues to indicate that the slice is taken through the medial aspect of the ankle and foot. The distal tibia is evident, as are the medial flexor tendons of the ankle – this should guide you to the location being medial. Remember that the talus is located superomedial to the calcaneum, just as the talonavicular joint is relative to the calcaneocuboidal articulation.

Case 2.6



Case 2.6 Axial MRI of the left ankle

	QUESTION	WRITE YOUR ANSWER HERE
A	Name the structure labelled A.	
B	Name the structure labelled B.	
C	Name the structure labelled C.	
D	What is the insertion site of the structure labelled D?	
E	Name the structure labelled E.	

Case 2.6

A Left tibialis anterior tendon

B Left Achilles tendon

C Left flexor hallucis longus tendon

D Base of the first metatarsal and medial cuneiform (left)

E Left tibialis posterior tendon

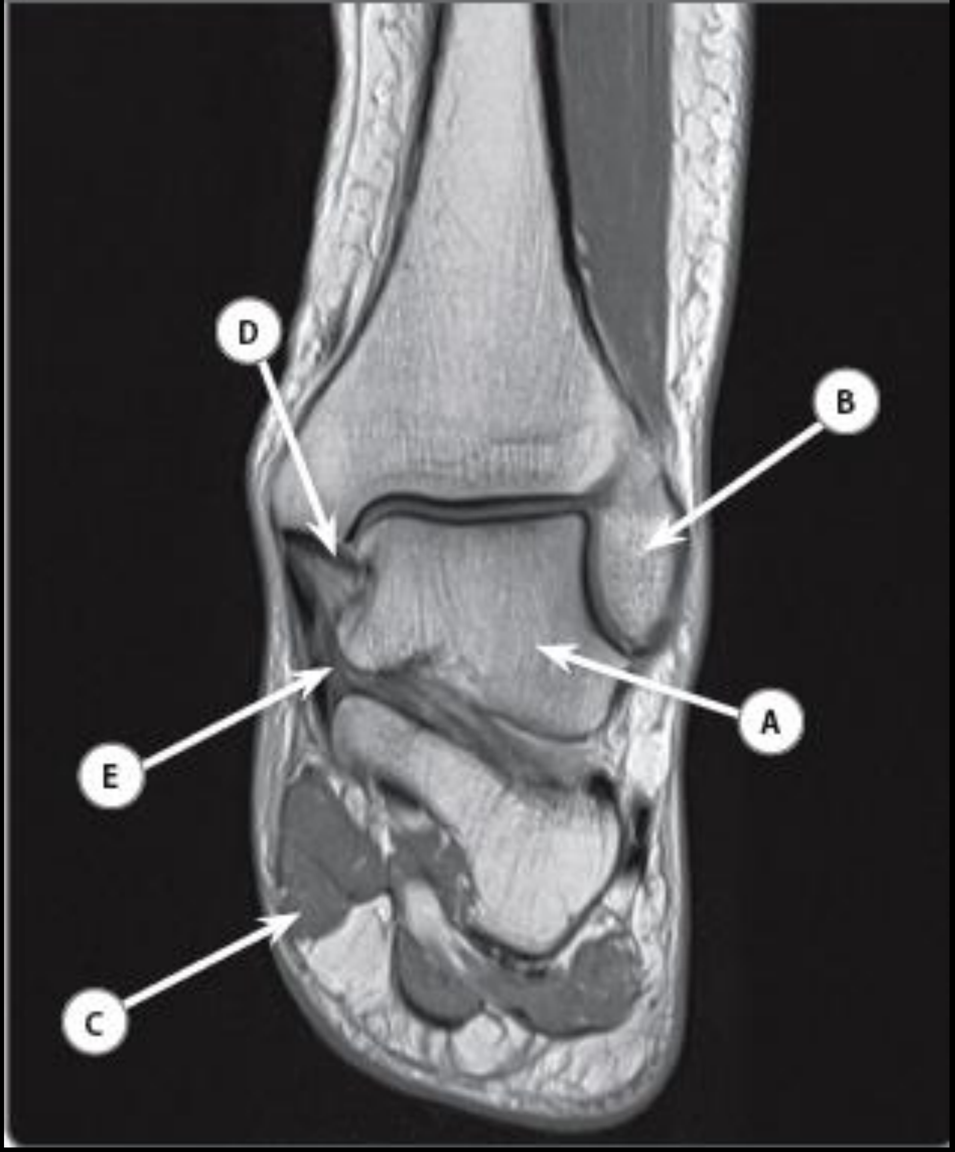
The position and names of the medial flexor tendons of the ankle can be easily remembered using the mnemonic 'Tom, Dick and Harry' which is representative of structures running from medial to lateral:

- Tom – posterior Tibial tendon
- Dick – flexor Digitorum longus tendon
- And – posterior tibial Artery
- Harry – flexor Hallucis longus tendon

The lateral ankle tendons comprise of the peroneal tendons – longus and brevis. The peroneus brevis tendon lies anterior (sometimes medial) to the peroneus longus tendon.

- Peroneus longus inserts into the base of the first metatarsal and medial cuneiform
- Peroneus brevis inserts into the base of the fifth metatarsal.

Case 7.4



Case 7.4

A Talus

B Lateral malleolus

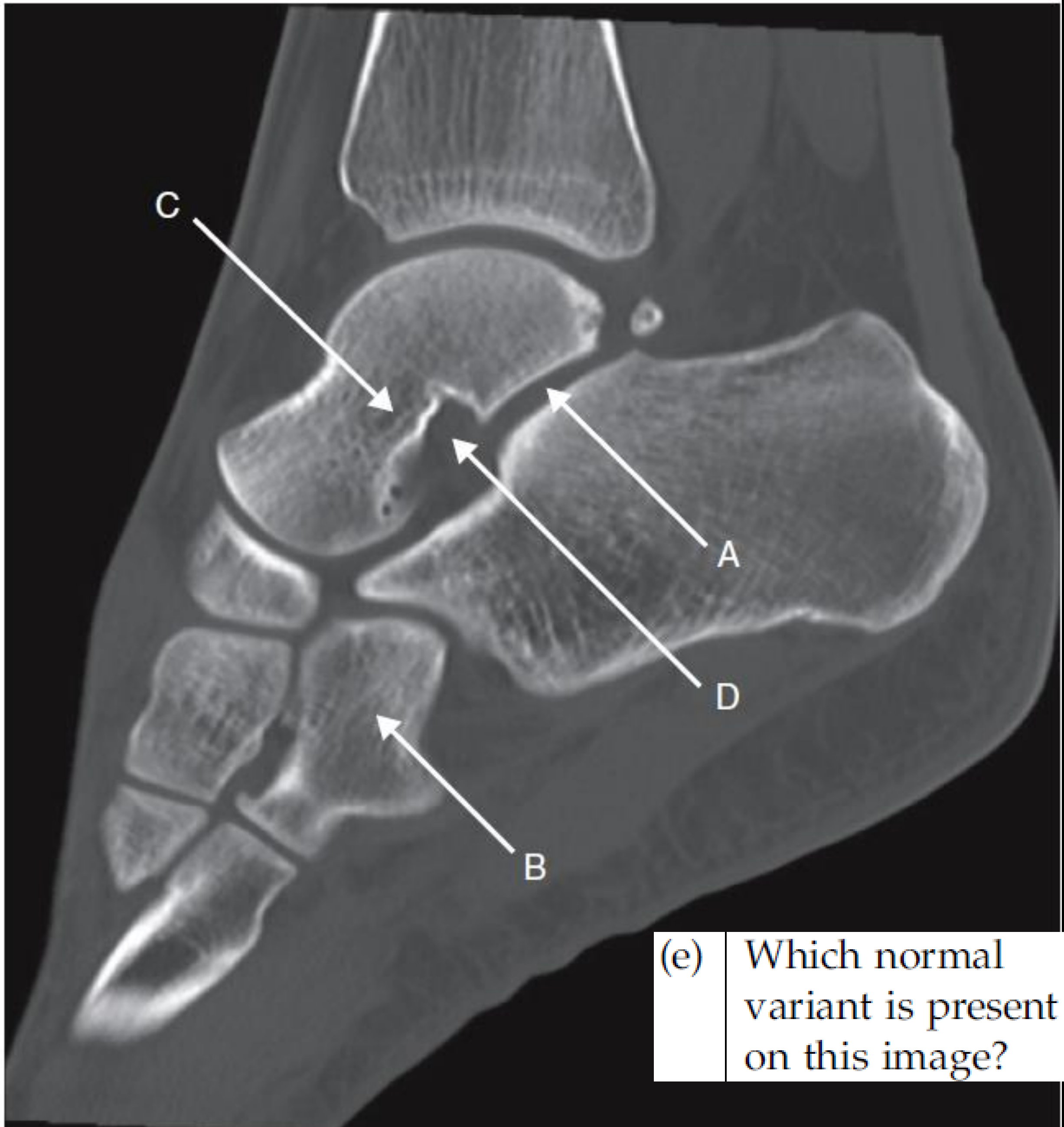
C Abductor hallucis muscle

D Deltoid ligament – deep band

E Deltoid ligament – superficial band

The deltoid ligament (medial collateral ligamentous complex) is found deep to the medial flexor tendons (tibialis posterior, flexor digitorum longus and flexor hallucis longus tendons – remember the mnemonic 'Tom, Dick and Harry'). It has several components, although the tibiotalar and tibiocalcaneal fibres are only routinely visualised on coronal MR. These are termed the deep and superficial bands respectively. The deep tibiotalar portion courses diagonally between the medial malleolus and the talus. The superficial tibiocalcaneal band runs more vertically, deep to the flexor retinaculum and superficial to the tibiotalar component of the ligament.

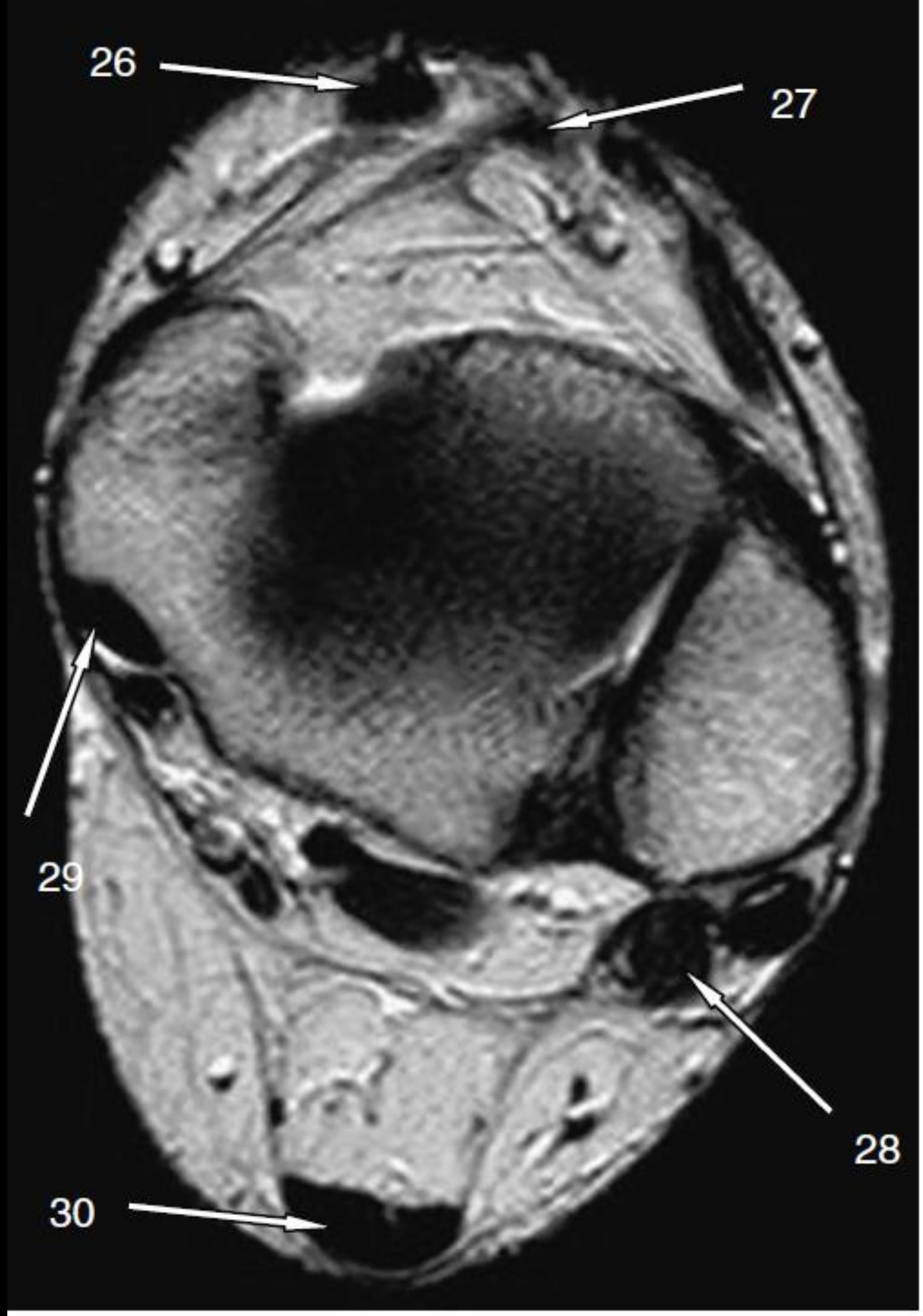
Case 6.1



(e)	Which normal variant is present on this image?

6.1 Sagittal CT ankle

(a) Posterior sub-talar joint (PSTJ). The PSTJ is a synovial joint formed by the articulation of the posterior articular facets of the talus and calcaneum. Intra-articular extension into the PSTJ is often seen in comminuted calcaneal compression fractures and represents an important factor in the surgical classification of these injuries.
(b) Cuboid. The cuboid possesses a proximal articular surface that only articulates with the calcaneum. Distally the cuboid articulates with the fourth and fifth metatarsals.
(c) Neck of the talus. The talar neck is an important review area when evaluating ankle radiographs and CT in the setting of trauma. Missed talar neck fractures can result in avascular necrosis of the talar dome due to its blood supply being derived from vessels that enter the talar head and travel proximally within the neck.
(d) The sinus tarsi. This is a fatty space beneath the talar neck and above the calcaneal body. The sinus tarsi also contains the cervical and interosseous ligaments along with traversing nerves and vessels. Inflammation and cyst formation in this space following trauma may produce a painful 'sinus-tarsi syndrome'.
(e) Os trigonum. This is present in 10% of individuals and when present, is bilateral in 50%. It may be present as a separate ossicle or be partly fused with the posterior talar process forming a synchrondrosis. The os trigonum may produce repetitive soft tissue impingment in the ankle due to repetitive plantar-flexion resulting in a painful 'os-trigonum syndrome'.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28
30

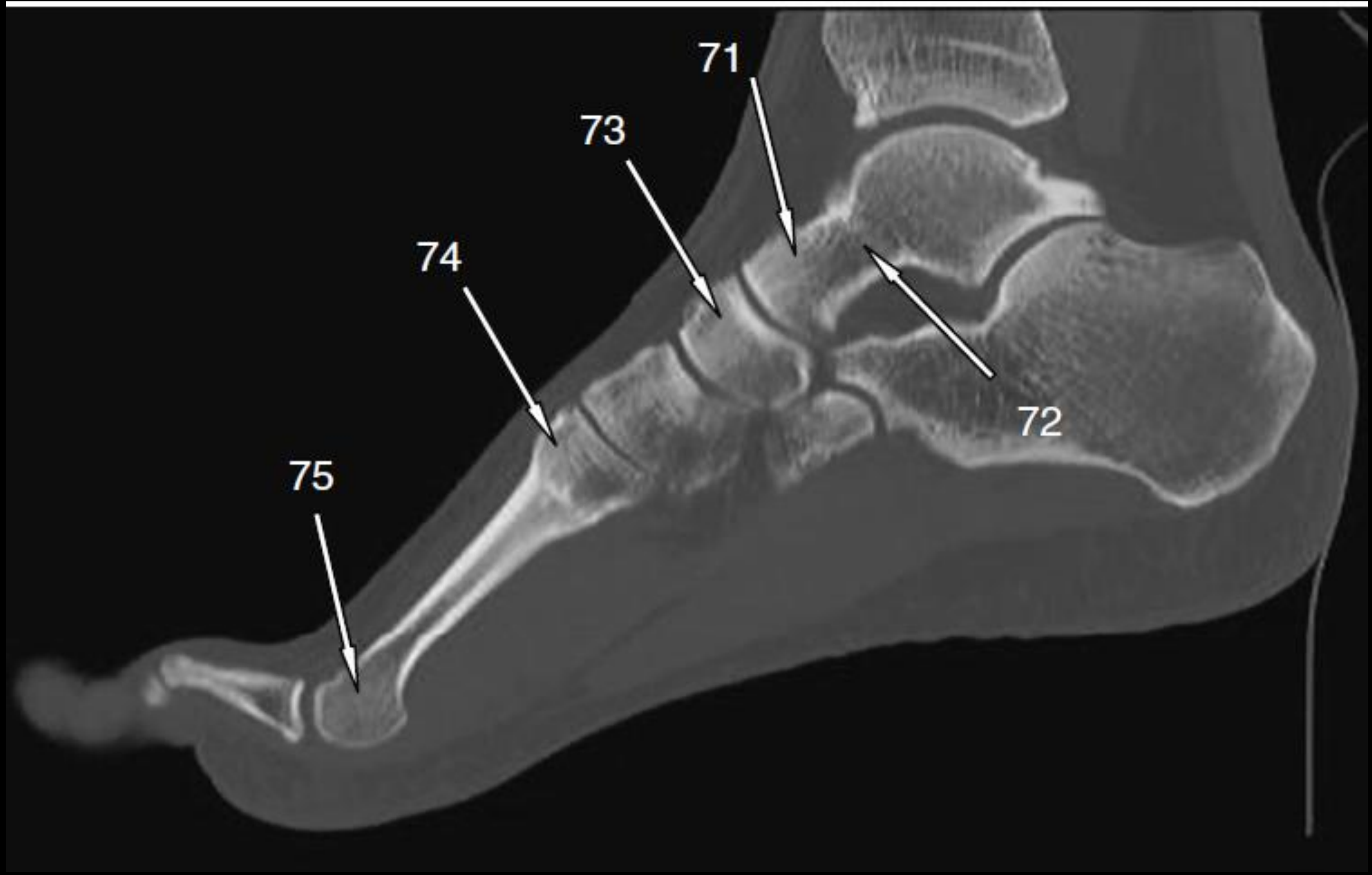
MRI Ankle

26. Tibialis anterior tendon (left)
27. Extensor hallucis longus tendon (left)
28. Peroneus brevis tendon (left)
29. Tibialis posterior tendon (left)
30. Achilles' tendon (left)

There is no marker on the case but you can work out that it is the left lower limb (fibula on the lateral aspect).

Remember the acronym *T*om *D*ick *H*arry (*T*ibialis posterior, flexor *D*igitorum longus, flexor *H*allucis longus) for the tendons posterior to the medial malleolus.

For the anterior tendons *T*om *H*arry *D*ick (*T*ibialis anterior, extensor *H*allucis longus, extensor *D*igitorum longus).


71
73
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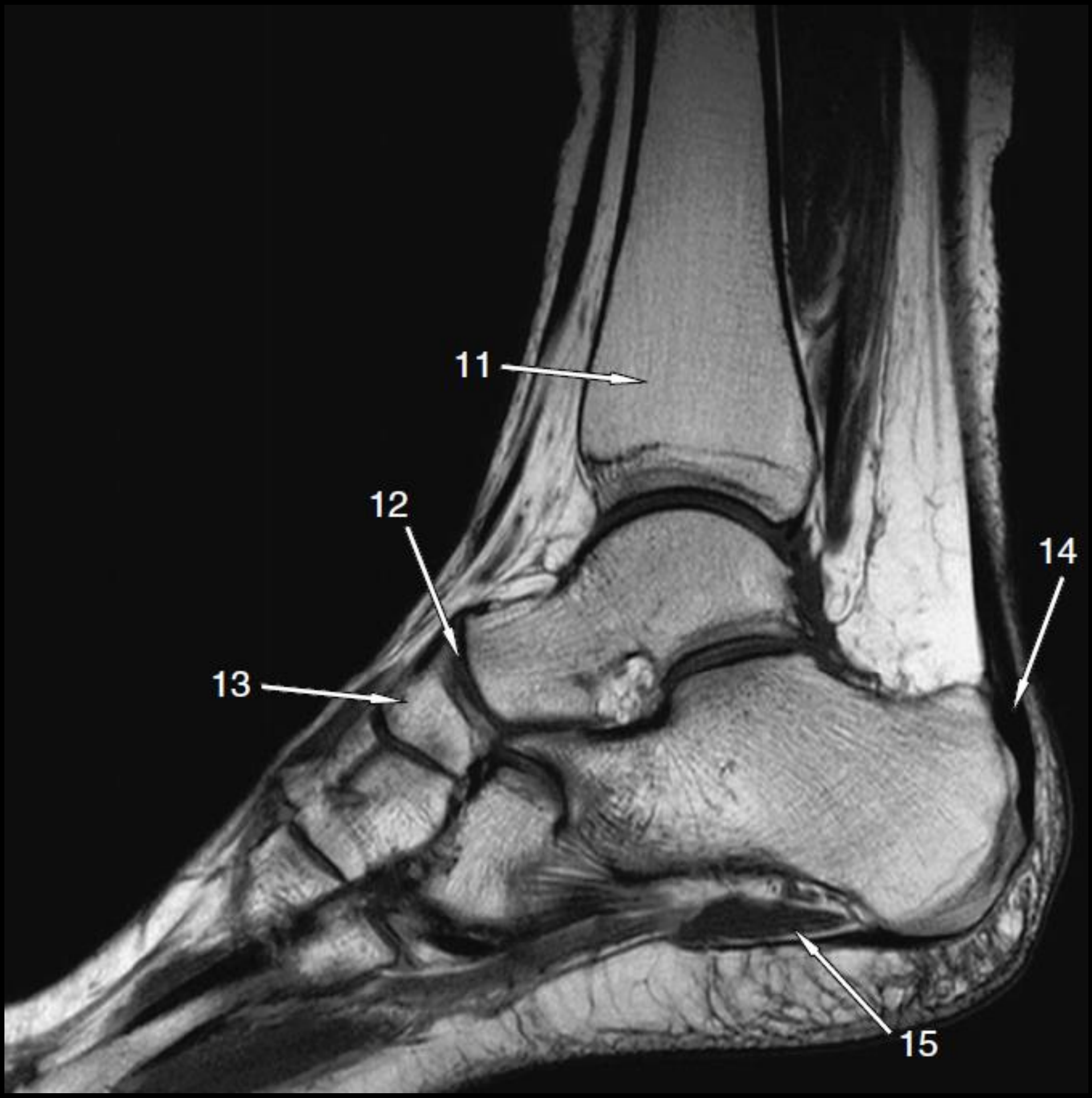
72

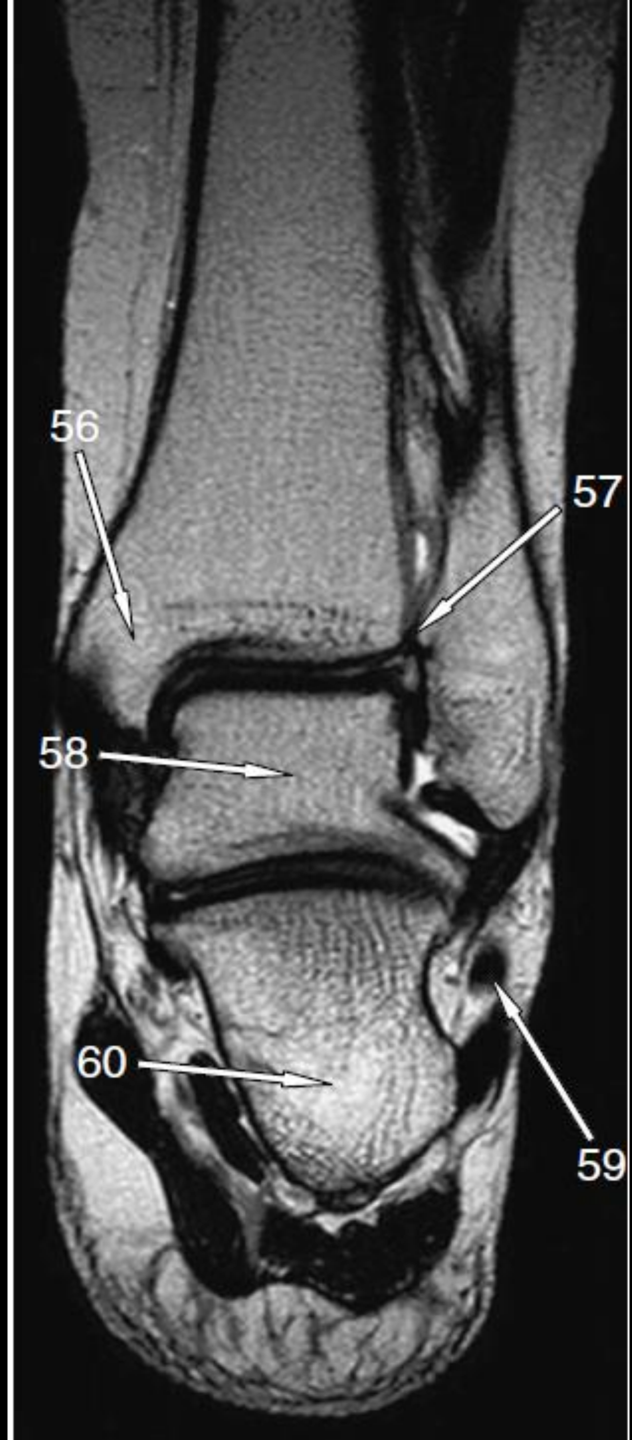
CT Foot

71. Head of talus
72. Neck of talus
73. Navicular bone
74. Base of first metatarsal
75. Head of first metatarsal


11
12
13
14
15

MRI Ankle

11. Tibia (distal metaphysis of)
12. Talonavicular joint
13. Navicular bone
14. Achilles' tendon
15. Abductor digiti minimi muscle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57
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59
60

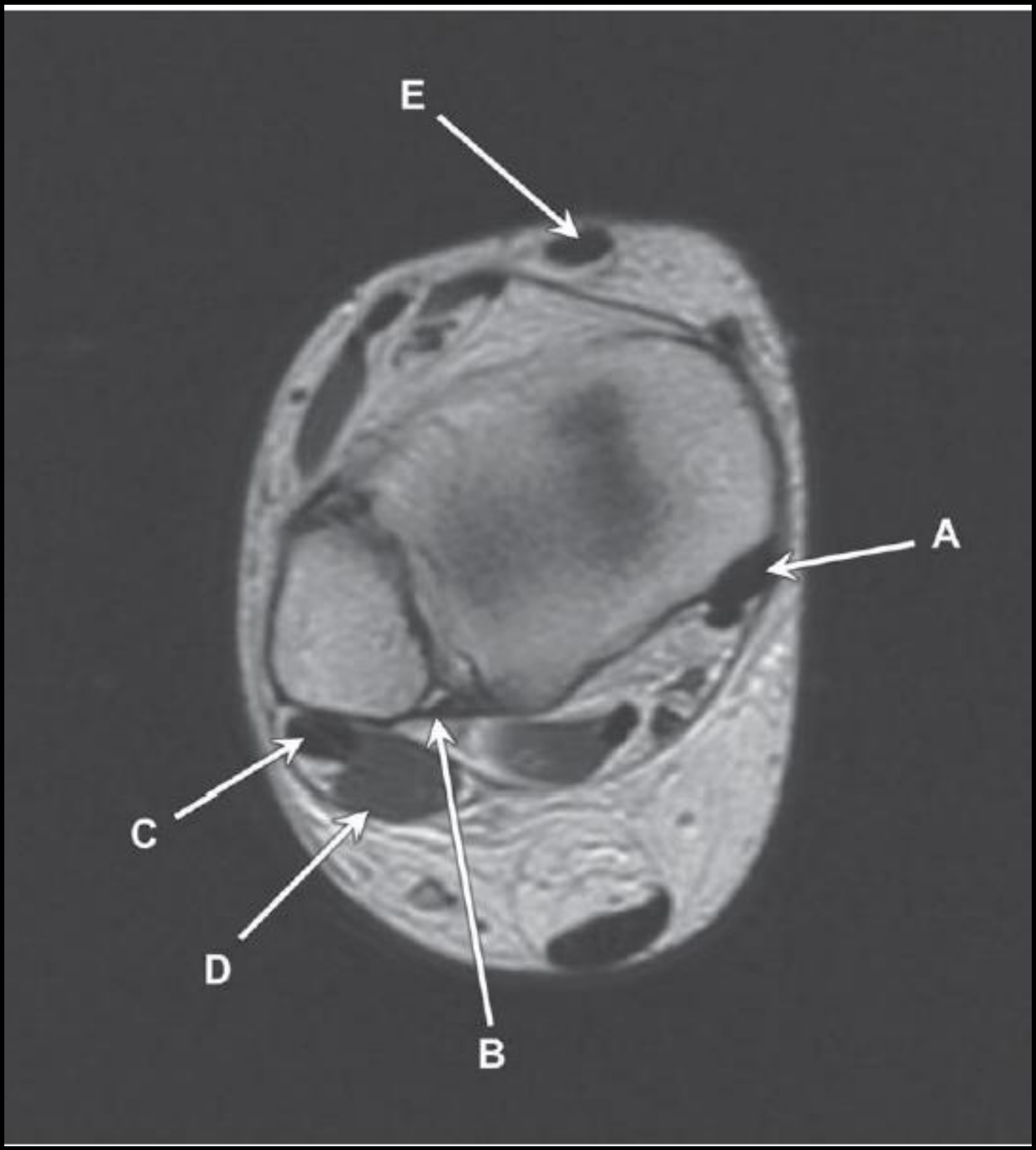
MRI Ankle

56. Medial malleolus of tibia
57. Inferior tibiofibular ligament
58. Talus
59. Tendon of peroneus brevis muscle
60. Calcaneum


51
55
52
53
54

MRI Ankle

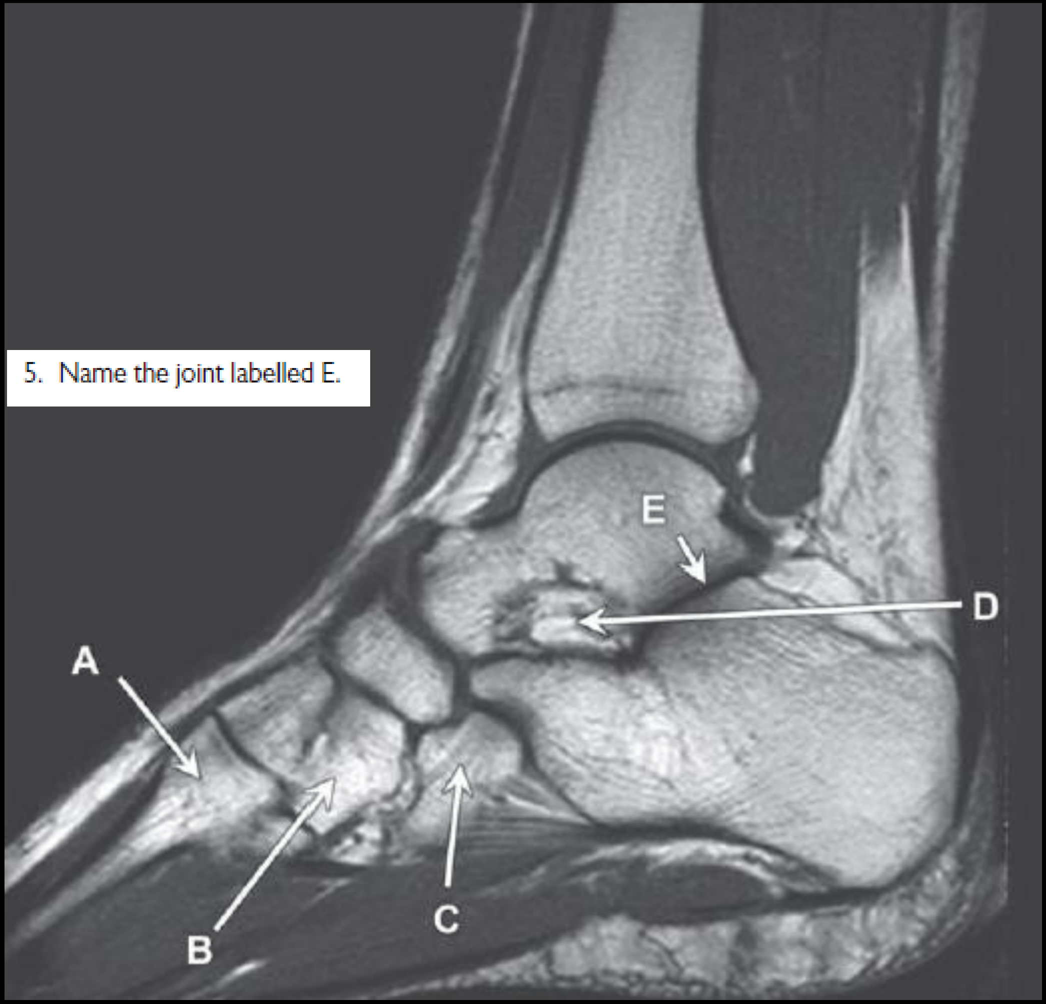
51. Achilles tendon
52. Calcaneum
53. Plantar fascia
54. Sesamoid bone at the first metatarsophalangeal joint
55. Sinus tarsi


E
A
C
D
B

Case 14

MRI ankle. T1W axial section.

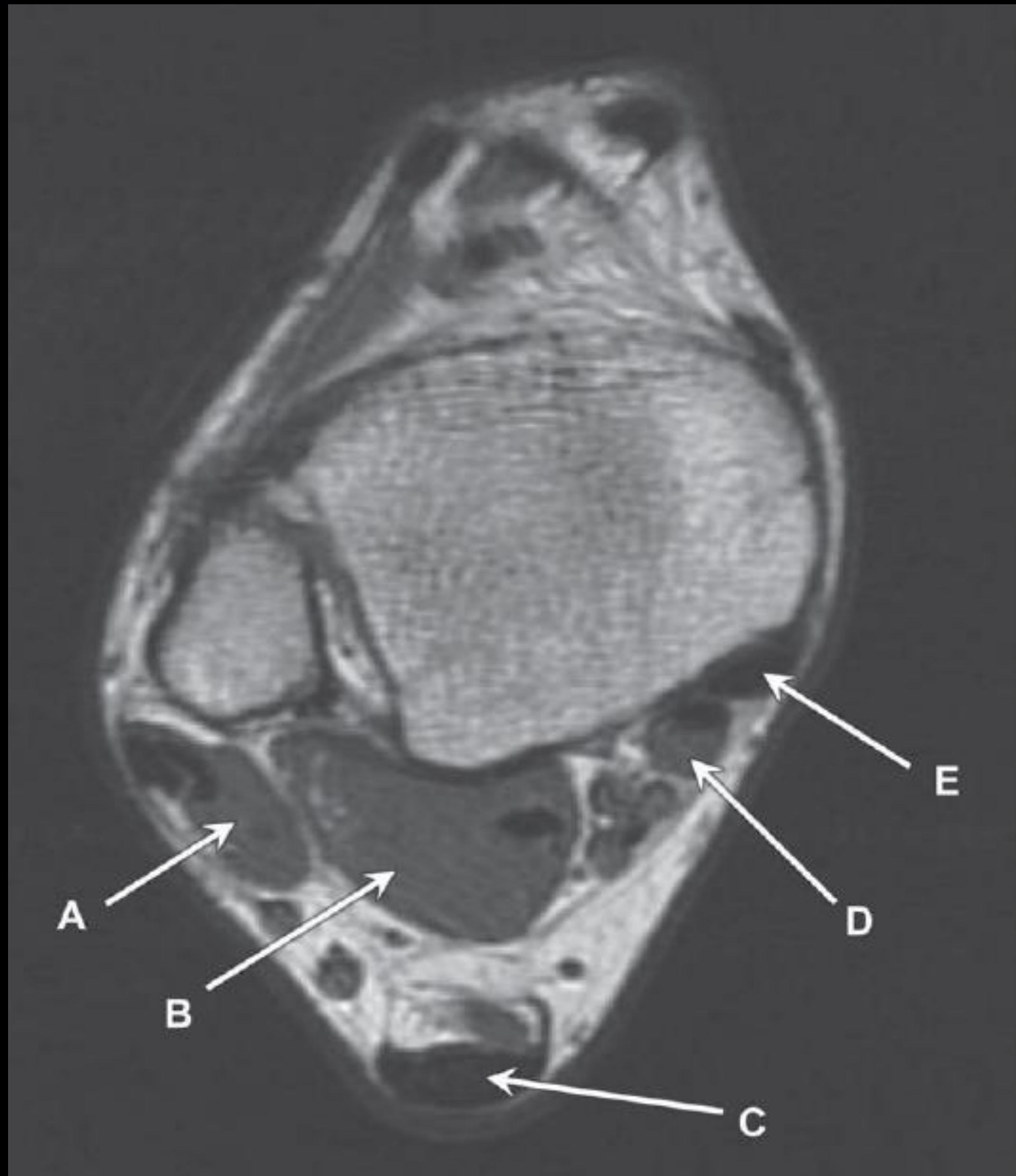
1. Tibialis posterior tendon
2. Posterior tibiofibular ligament
3. Peroneus longus tendon
4. Peroneus brevis muscle
5. Tibialis anterior tendon


5. Name the joint labelled E.
A
B
C
D
E

Case 4

MRI hindfoot. T2W sagittal section.

1. Base of second metatarsal
2. Lateral cuneiform
3. Cuboid
4. Sinus tarsi/ tarsal sinus
5. Posterior talocalcaneal/ subtalar joint


A
B
C
D
E

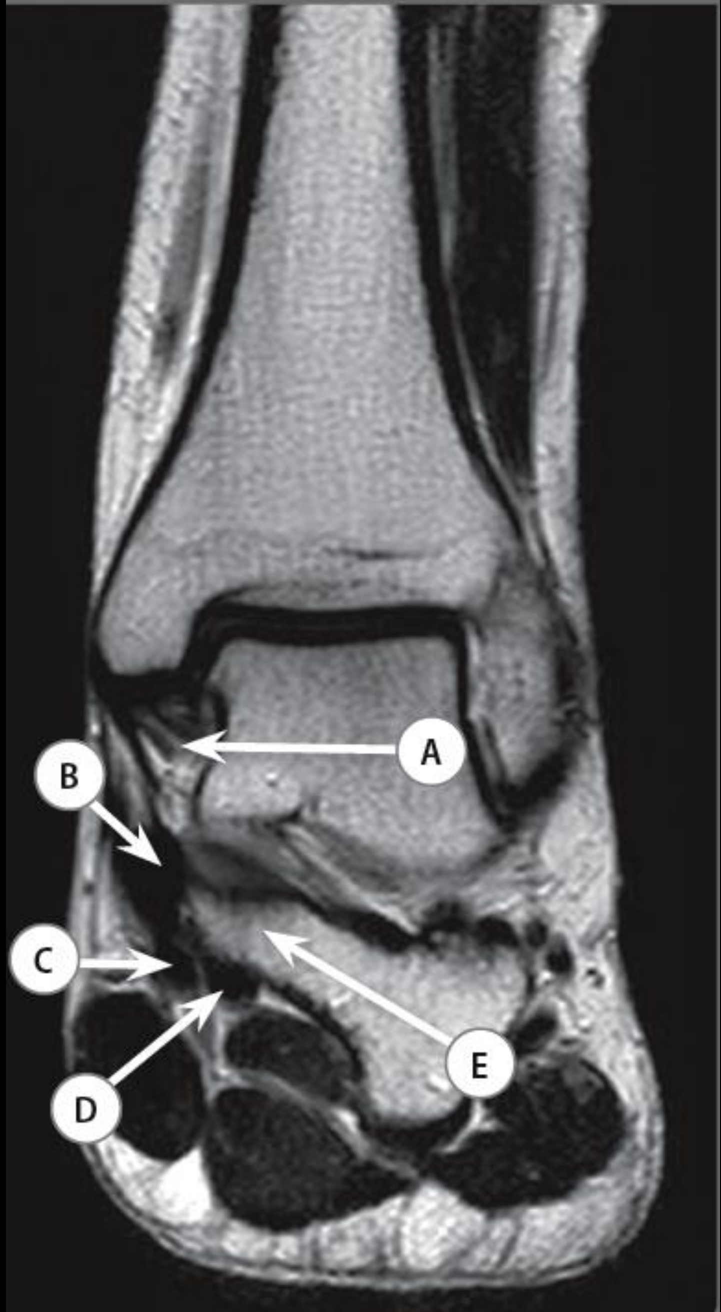
Case 17

MRI ankle. Axial section just superior to the mortise joint.

1. Peroneus brevis muscle
2. Flexor hallucis longus muscle
3. Achilles' tendon
4. Flexor digitorum longus muscle
5. Tendon of tibialis posterior muscle

The tendons and muscles of the lower limb are not as intimidating as they first seem and should be familiar to the candidate. Consult your favourite anatomy textbook and remember the mnemonic 'Tom, Dick and Harry' for structures E, D and B respectively (Tibialis posterior, flexor Digitorum longus, flexor Hallucis longus).

Case 4.5



Case 4.5

A The medial collateral ligament (deltoid ligament)

B Tibialis posterior tendon

C Flexor digitorum longus

D Flexor hallucis longus tendon

E Calcaneus (sustentaculum tali)

Coronal image of the ankle.

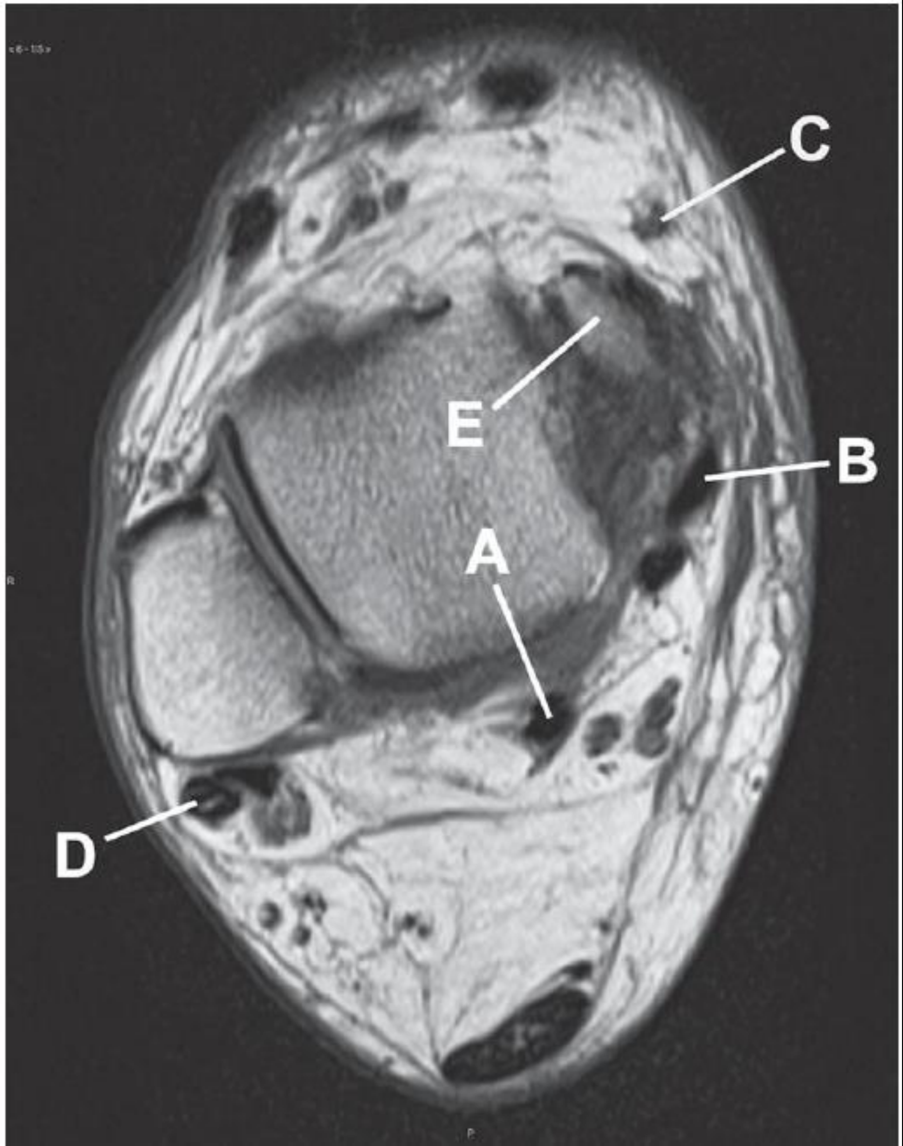
The deltoid ligament has five components: the anterior and posterior tibiotalar, the tibiocalcaneal, the tibiospring and the tibionavicular ligaments. The part of the deltoid ligament that is routinely visualised on coronal images is the deep part that arises from the posterior margin of the medial malleolus and attaches to the medial aspect of the talus.

The flexor retinaculum extends from the medial malleolus to the calcaneus and plantar fascia. The deep flexor muscles of the posterior compartment of the calf pass beneath the flexor retinaculum. They are surrounded by their synovial sheaths, the tibial nerve and the posterior tibial artery. 'Tom Dick and Harry', is a widely used mnemonic for remembering the position of these tendons. The calcaneus is the largest of the tarsal bones and has several features that can be identified. In this image the sustentaculum tali is labelled which lies on the medial side of the bone, below the middle talar facet. When an arrow points at a large, easily identifiable bone, consider whether you are asked to name a specific feature within the bone. Failure to do so may lead to unnecessary loss of marks.

Weir J, Abrahams P. Imaging Atlas of Human Anatomy, 4th edn. Edinburgh: Mosby, 2010: 206.
Ryan S, McNicholas M, Eustace SJ. Anatomy for Diagnostic Imaging, 3rd edn. Edinburgh: Saunders, 2010: 293–299.
Butler P, Mitchell AM, Ellis H. Applied Radiological Anatomy. Cambridge: Cambridge University Press, 1999: 377.

Q16

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the structure labelled D
e Name the structure labelled E



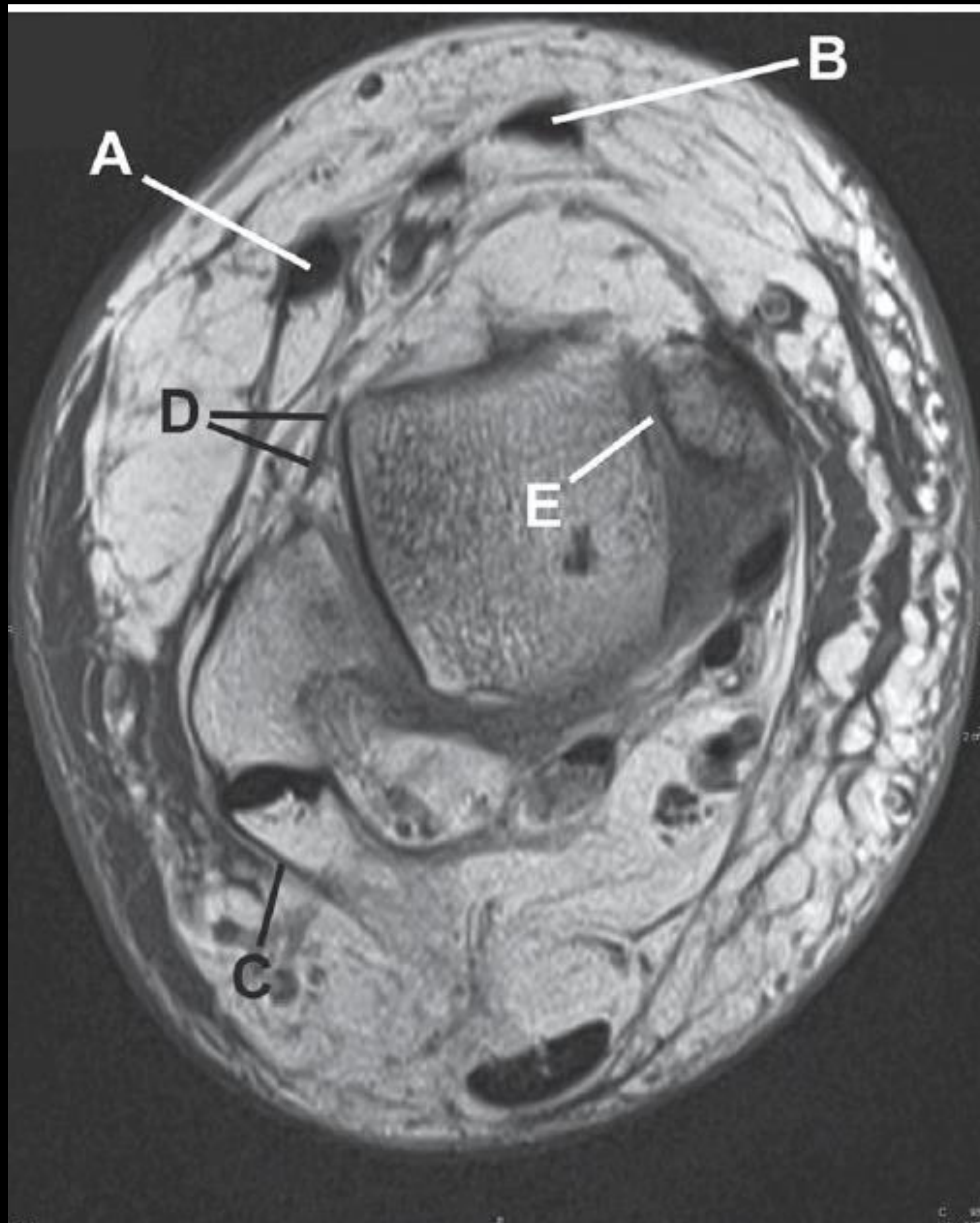
Q16 Answers

a Flexor hallucis longus tendon
b Tibialis posterior tendon
c Long saphenous vein
d Peroneus longus tendon
e Medial malleolus

T1W MRI of ankle, axial section

Tibialis posterior, flexor digitorum longus and flexor hallucis longus are three of the seven muscles of the posterior compartment of the leg (the remainder being gastrocnemius, soleus, popliteus and plantaris). All three take their origin from the middle third of the posterior tibia and/or fibula and insert onto the plantar aspect of the foot via long slender tendons that converge to pass behind the medial malleolus. Identifying which tendon is which is helped with the mnemonic 'Tom, Dick and Harry' (from medial to lateral the order in which they lie is TP, FDL and then FHL.)

The lateral (or peroneal) compartment contains the two peroneal muscles – longus and brevis. Peroneus longus tendon is the more superficial of the two above the ankle. Both muscles originate from the lateral aspect of the fibula and pass posterior to the lateral malleolus and beneath the peroneal retinaculum before inserting onto the 5th metacarpal (brevis) and medial cuneiform/1st metatarsal (longus). Insertion of the peroneus brevis tendon into the base of the 5th metatarsal renders this site susceptible to fracture in the context of ankle trauma. Despite its name, peroneus tertius is within the anterior compartment.


A
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Q17 Answers

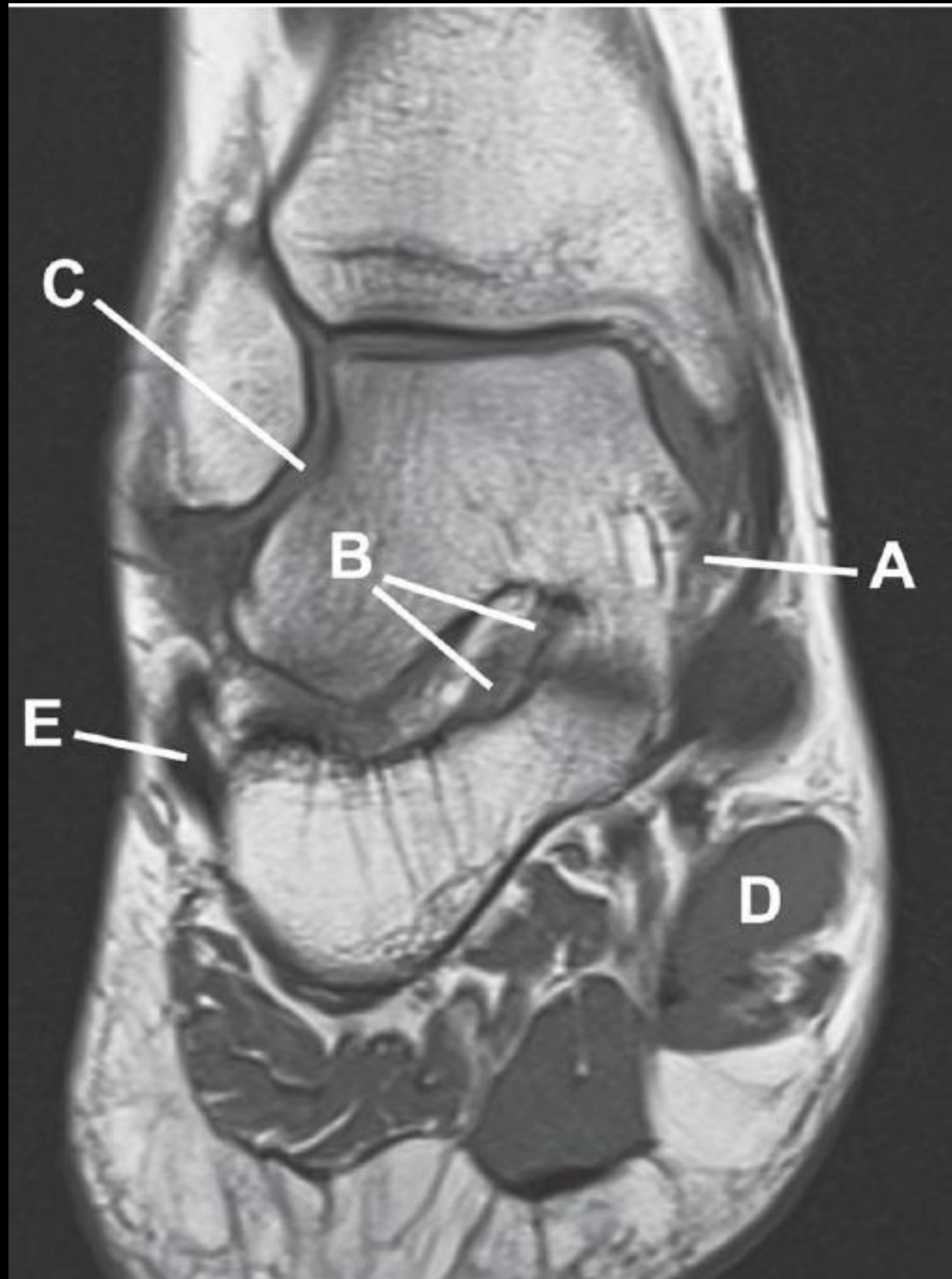
a Extensor digitorum tendon
b Tibialis anterior tendon
c Peroneal retinaculum
d Anterior inferior talofibular ligament
e Talotibial joint

T1W MRI of ankle, axial section

Tibialis anterior, extensor hallucis longus and extensor digitorum longus are three of the four anterior compartment muscles (the other being peroneus tertius) and originate from the anterior surface of the tibia and fibula. They form tendons above the ankle joint which pass anteriorly beneath the extensor retinaculum. Similar to their flexor counterparts their relative positions are constant in relation to each other at the ankle. Their configuration is slightly different however but this can be remembered using a variation on the mnemonic, which on this occasion is 'Tom, Harry and Dick' (from medial to lateral the order in which they lie is TA, EHL and then EDL).

Ligaments of the ankle joint are numerous and fall broadly into three groups:

1. The distal tibiofibular joint is classed as a syndesmosis and consists of anterior and posterior tibiofibular ligaments and the interosseous ligament which is a continuation of the interosseous membrane.
2. The medial (deltoid) ligament complex consists of (from anterior to posterior) the tibionavicular, tibiocalcaneal and posterior tibiotalar ligaments. The anterior portion of the deltoid ligament blends into the calcaneonavicular (or spring) ligament.
3. Three structures make up the lateral ligament complex and they are (from anterior to posterior) the anterior talofibular, calcaneofibular and posterior talofibular ligaments.


C
B
A
E
D

Q18 Answers

a Deep part of deltoid ligament
b Interosseous talocalcaneal ligament
c Talofibular joint
d Abductor hallucis muscle
e Peroneus longus tendon

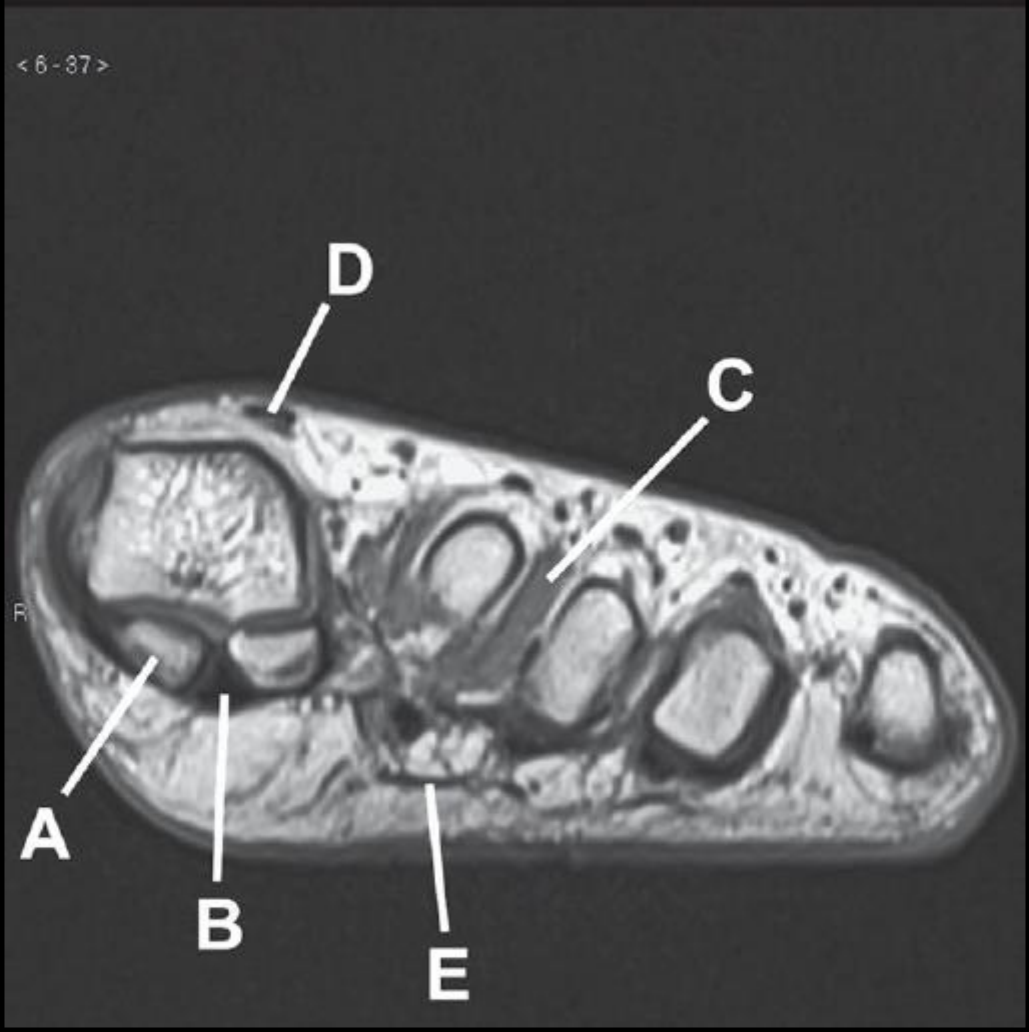
T2W MRI of ankle, coronal section

This image demonstrates the anatomy of the lateral and medial (deltoid) collateral ligaments of the ankle and the subtalar (hindfoot) joint. The ankle joint permits dorsiflexion and plantarflexion of the foot. Mobility of the subtalar joint supplements this by enabling inversion (in plantarflexion) and eversion (in dorsiflexion) of the forefoot.

Three superficial first-layer plantar muscles arise from the calcaneus. Medial to lateral they are: abductor hallucis, flexor digitorum brevis (similar in function to its upper limb counterpart flexor digitorum superficialis), and abductor digiti minimi. All of these muscles are supplied via the S2 nerve root.

Q19

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the level of the spinal nerve root supplying structure D
e Name the structure labelled E



Q19 Answers

a Sesamoid bone
b Tendon of flexor hallucis longus
c Interosseous muscle
d L5
e Plantar aponeurosis

MRI of foot at distal metatarsal level, coronal section

Two sesamoid bones are normally seen on the plantar aspect of the foot where flexor hallucis brevis inserts to the 1st metatarsal head. Between them runs the tendon of flexor hallucis longus.

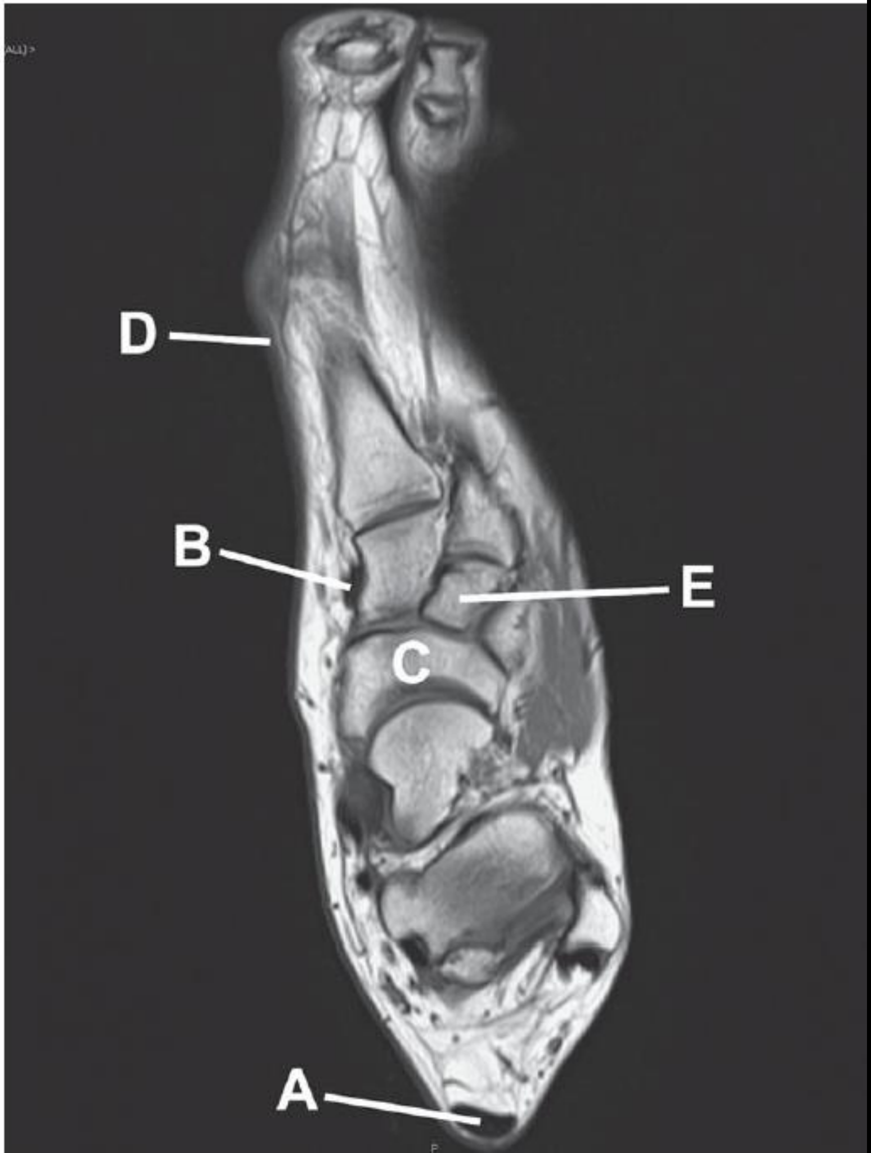
The muscles of the plantar aspect of the foot are divided in four layers, all of which lie deep to the plantar aponeurosis. They include the short flexors and abductors as well as the tendons of flexor digitorum longus and flexor hallucis longus. Interosseous muscles are arranged in a similar fashion as in the hands, comprising of plantar and dorsal layers which adduct and abduct the toes respectively (remember 'PAd' and 'DAb').

Extensor hallucis longus is supplied by the deep peroneal nerve and testing its function against resistance (e.g. standing on tip-toes) assesses the integrity of the anterior ramus of the L5 spinal nerve.

The plantar aponeurosis is a dense layer of collagen which extends across the sole of the foot. It arises from the medial side of the calcaneus to insert into the five metatarsophalyngeal joints and adds strength to the subcutaneous tissues of the sole.

Q20

a Name the structure labelled A
b Name the structure labelled B
c Name the structure labelled C
d Name the sensory dermatome at the site labelled D
e Name the structure labelled E



Q20 Answers

- **a** Achilles tendon
- **b** Tendon of tibialis anterior muscle
- **c** Navicular
- **d** L4
- **e** Intermediate cuneiform

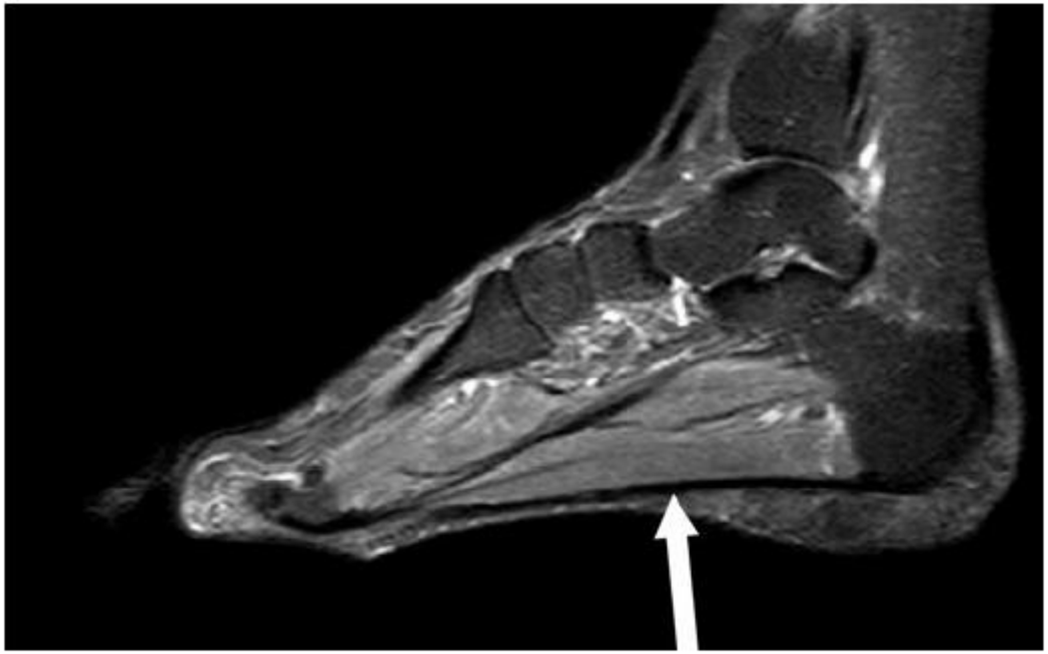
T1W MRI of medial foot, axial section

The seven tarsal bones are arranged in three rows. The proximal row consists of the talus and calcaneus. Distally there are the three cuneiform bones (medial, intermediate and lateral) which are positioned medially and the cuboid which is positioned laterally. The middle row consists of the navicular which is on the medial side and lies between the talus and cuneiforms. On the lateral aspect of the foot the calcaneum articulates directly with the cuboid.

Several of the calf muscles insert onto the tarsal bones. Gastrocnemius and soleus, the large superficial muscles of the posterior calf, coalesce to form the Achilles tendon which attaches to the posterior surface of the calcaneum (plantaris is a small, slender vestigial calf muscle which sometimes contributes to this, but is absent in a number of people). Tibialis anterior has tendinous attachments to both the medial cuneiform and the base of the first metatarsal. Peroneus longus attaches to the same bones but on the inferior aspect. Tibialis posterior has many attachments: to the medial condyle of the navicular; to all of the tarsal bones (except the talus); and to the bases of the 2nd, 3rd and 4th metatarsals.

The dermatomes of the foot divide it into three regions positioned medial to lateral. The L4 dermatome includes the great toe. The L5 dermatome incorporates the central foot and 2nd to 4th toes, while the S1 dermatome includes the little toe and lateral foot.

- **Question 8:**



Question 8: Sagittal MRI of the foot

Answer: Plantar fascia

- The plantar fascia (or plantar aponeurosis) is a strong fibrous layer that connects the calcaneal tuberosity to the heads of the metatarsal bones and supports the arch of the foot.
- It is well delineated on sagittal MRI studies and appears as a uniform hypointense band at the sole of the foot.