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To Arlette Herzig and Robert Logan
   - Bari Logan

Anna, Jack, George and my parents
   - David Bowden

Anne, Sam and Isabel
   - Ralph Hutchings

And

To the Memory of an Esteemed Colleague

Professor R. M. H. (Bob) McMinn
Preface

This fifth edition of *McMinn's Colour Atlas of Foot and Ankle Anatomy*, heralds 35 years of publication and brings some significant changes and most immediate to note is the new title, *McMinn's Color Atlas of Lower Limb Anatomy*, which we feel reflects more truly the overall direction and content of the book.

Originally intended as an illustrated reference book for chiropodists and podiatrists in training, over the ensuing years it has become equally popular with radiologists, physiotherapists, sports injury consultants, vascular and orthopaedic surgeons. The book has therefore become an accepted standard text on the subject and continues to fill an important niche on medical library bookshelves worldwide, producing eight language editions: English, Chinese, Japanese, French, German, Dutch, Russian and Spanish.

For this fifth edition, a third co-author David Bowden joins the team and adds his specialist clinical knowledge and expertise in the field of radiology by adding a new 30 page chapter dedicated to *Imaging of the Lower Limb*, using state-of-the-art technology. Thus providing the opportunity to visualise key anatomical structures as they appear in the living subject in comparison to the illustrations of bones and detailed anatomical preparations provided elsewhere in the book.

Bari Logan adds a scattering of nine new pages of annotated illustrations of anatomical preparations, with accompanying notes.

We hope that these new additions and overall review of the text will be appreciated and that the book will continue in its popularity as an important contribution to medical education at both pre-clinical and postgraduate level.

Bari M Logan
Siegershausen, Switzerland
David J Bowden
Cambridge, UK
March 2017
McMinn’s Legacy of Illustrated Anatomy Books

Bari Logan entered the academic post of Prosector to the department of Anatomy, The Royal College of Surgeons, of England, London, in January 1977. At that time, ‘Bob’ McMinn held the Chair as Sir William Collins Professor of Human and Comparative Anatomy and Ralph Hutchings was the Chief Medical Scientific Officer and departmental photographer.

In April of the same year, an evening reception was held at the College for a group of distinguished medical fraternity by Wolfe Medical Publications to launch a new book entitled A Colour Atlas of Human Anatomy by the authors McMinn & Hutchings who had spent the previous 2 years working on the project.

2nd Ed—1988
3rd Ed—1993
4th Ed—1998
5th Ed—2003
6th Ed—2008
7th Ed—2013

Instantly considered by many to be a visually stunning production, it was without doubt a pioneering book in the field of human anatomy, having many novel concepts in both composition and design that would later be adopted by other authors and become standard format in many new illustrated texts on the subject.

The book, 352 pages, was unusually large in size and contained over 700 high quality colour photographs of almost natural size, bones, detailed dissections (prosections), and exquisite anatomical preparations depicting the entire human body taken of specimens hitherto unseen beyond the closely guarded confines of the dissecting room and anatomical museum. Essentially designed as a general reference work for the medical profession, the book rapidly became a best-seller, quickly producing 25 foreign language editions and attaining over 4 million copies in sales worldwide, it won numerous awards and gained much international academic acclaim.

The book remains in print today, 40 years on and in its seventh edition (2013), but since the fourth edition, under entirely new authorship, direction and content, although the name ‘McMinn’ remains in the title for posterity.

Following on from the enormous success of A Colour Atlas, the publisher Peter Wolfe approached ‘Bob’ McMinn and Ralph Hutchings in early 1979 with the idea of producing a new illustrated text to suit the specific educational needs of dental students, for whom the Royal College of Surgeons ran popular postgraduate courses.

Wolfe’s proposal was timely because, within the College, the renovation and reorganization of the Wellcome Museum of Anatomy and Physiology, founded by the famous Australian anatomist R. (Ray) J. Last in (1947), was well underway; a particular pressing need, identified by Bari Logan, was to prepare for display a range of detailed head and neck prosections and preparations, for which the collection was lacking.

Thus, the co-authorship trio of McMinn, Hutchings and Logan was formed and within a two-year period produced their first book together in 1981.

A Colour Atlas of Head and Neck Anatomy
Wolfe Medical Publications:
McMinn/Hutchings/Logan
Designed for dental students
English, French, German, Italian, Japanese, Korean, Portuguese, Spanish
2nd Ed—1994
3rd Ed—2004
4th Ed—2009
5th Ed—2017

Over the next 17 years, there followed a fairly rapid succession of books, despite the retirement of Ralph Hutchings in 1981, ‘Bob’ McMinn in 1983, academic career move of Bari Logan to Cambridge in 1987 and further complications along the way of various changes to publishers through company takeovers, each having additional authorship commitments on other new books.

Key to this speedy turnover was the ability to combine individual talent in a very harmonious way, work to a logical regime and keep within a strict timeframe whilst always maintaining an essential keen eye for detail.
A Colour Atlas of Foot and Ankle Anatomy
Wolfe Medical Publications: McMinn/Hutchings/Logan
Designed for Podiatrists and Chiropodists
English, Chinese, Dutch, French, German, Japanese, Russian, Spanish
2nd Ed—1995
3rd Ed—2004
4th Ed—2012
5th Ed—2017 Lower Limb Anatomy

A Colour Atlas of Applied Anatomy
Wolfe Medical Publications: McMinn/Hutchings/Logan
Designed for clinicians (The anatomy of approaches for surgical and clinical procedures.)
English, Japanese
Out of Print

Picture Tests in Human Anatomy
Wolfe Medical Publications: McMinn/Hutchings/Logan
Designed for medical students taking practical exams
English, French, German, Japanese, Portuguese, Serbo-Croatian, Spanish
Out of Print

The Human Skeleton: a Photographic Manual in Colour
Wolfe Medical Publications: McMinn/Hutchings/Logan
Designed for medical students (fold down, full size skeleton pictures and individual bones)
English, Danish, French, German, Greek, Japanese, Portuguese, Spanish
2nd Edition—2007

McMinn’s Functional and Clinical Anatomy
Mosby: McMinn/Gaddum-Rosse/Hutchings/Logan
Designed for medical students
English, Italian, Greek
Out of Print

The Concise Handbook of Human Anatomy
Manson Publishing: McMinn/Hutchings/Logan
Designed for sixth form students entering a medical career
English, German, Portuguese
2nd Ed—2017
McMinn’s Concise Human Anatomy
CRC Press (Taylor & Francis)
Heylings/Carmichael/Leinster/Saada

Functional and Clinical, included a fourth co-author, Penelope Gaddum-Rosse, a distinguished physiologist, and work began on the project in 1987 as a text originally intended for the nursing profession and appropriately entitled, Anatomy and Physiology for Nurses, with the publishers Wolfe. However, following a takeover of Wolfe Medical Publications by Mosby Year Book Europe, who already had an extensive nursing book list which included both, physiology and anatomy titles, the manuscript was shelved for a number of years until a decision on its fate was finally reached in 1993 with the proposal for ‘Bob’ McMinn to re-edit the entire text and tailor it more to the needs of pre-clinical and postgraduate medical students. ‘Bob’ completed the task in just under one year and, interestingly, it is considered to be the best written of all the McMinn books.

Their final book together was published in 1998.
'Bob' was the inspirational driving force behind each book and, from start of the project, would clearly outline overall content and specific illustrative requirements for each chapter producing rough sketches or photocopies with accompanying detailed lists of all the most important anatomical structures needed to be clearly seen in the resulting pictures.

Bari would interpret this information, produce his own notes and drawings and carry out the various detailed prosections or anatomical preparations working to the specific camera lens angle and overall framed view required.

Ralph spent infinite time setting-up lighting, establishing correct camera exposure settings and, by using full format colour film, produced images of exceptional quality and depth in detail.

Sporadic photographic sessions were held, often late evenings and weekends, under the ‘eagle eye’ of ‘Bob’ who would advise on the camera angle and ensure that all the structures essential to identify were displayed in their correct anatomical positions.

Since the first publication, over the ensuing 36 years to date (2017), the seven books produced by the trio, have thus far, created 17 English editions and 13 foreign language editions: Chinese, Danish, Dutch, French, German, Greek, Italian, Japanese, Korean, Portuguese, Russian, Serbo-Croatian and Spanish, with total sales exceeding well over 1 million copies worldwide.

Four of the books remain popular and still in print: Head & Neck, 5th edition; Foot & Ankle, 5th edition, now more appropriately retitled Lower Limb Anatomy; Human Skeleton, 2nd edition; and the Concise Handbook – 2nd edition, which now has a new publisher and authorship, and to conform with the other surviving publications ‘McMinns’ prefixed in the title.

Overall, a remarkable literary achievement in such a specialized field and only made possible by the unique visionary authorship and guidance of ‘Bob’ McMinn, whose legacy of Illustrated books on the subject of human anatomy has not only made a significant contribution to medical education in general, but also to the grateful appreciation and applause of thousands of aspiring students throughout the world.
The authors are indebted to the following:

- Prof Adrian Dixon, Prof Harold Ellis and Dr Robert Whitaker for help and expert advice on lower limb lymphatics.
- Dr Ian G. Parkin, Clinical Anatomist, University of Cambridge UK, for expert anatomical knowledge.
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- Mel Lazenby, Lucie Whitehead and the late Martin Watson (2008), Department of Anatomy, University of Cambridge UK, for the preservation of anatomical material.
- Adrian Newman, Ian Bolton and John Bashford, Anatomy Visual Media Group (AVMG), Department of Physiology, Developmental Neuroscience, University of Cambridge UK, for new edition photographs and digital expertise.

**Radiographs**

- Dr Oscar Craig p.21B.
- Dr Kate Stevens p.31C.


**Dissection/anatomical preparation credits**

The following individuals are credited for their skilled in preparing the following anatomical material illustrated in this book:

- Mrs Carmen Bester: page 90A.
- Ms Lynette Nearn: pages 91B, 166.
- Dr David H Tompsett: pages 30B, 33BC and 39D.
Preservation of Cadavers

Long-term preservation of the cadavers, utilized for the majority of anatomical dissections (prosections) illustrated in this book, was by standard embalming technique, using an electric motor pump set at a constant pressure rate of 15 p.s.i. Perfusion was achieved through the arterial system via femoral artery cannulation of one leg and return drainage of the accompanying vein.

On acceptance of 20 litres of preservative fluid by pump, local injection of those areas not visibly affected was carried out by automatic syringe.

On average, 30 litres of preservative fluid was used to preserve each cadaver.

Immediately following embalming, cadavers were encapsulated in thick-gauge, clear polythene bags and cold stored at a temperature of 10.6° C at 40 percent humidity for a minimum period of 16 weeks before dissection. This period of storage allowed preservative fluid to thoroughly saturate the body tissues, resulting in a highly satisfactory state of preservation.

The chemical formula for the preservative fluid (Logan et al., 1989) is:

Methylated spirit 64 over proof 12.5 litres
Phenol liquefied 80% 2.5 litres
Formaldehyde solution 38% 1.5 litres
Glycerine BP 3.5 litres
Total = 20 litres

The resultant working strength of each constituent is:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylated spirit</td>
<td>55%</td>
</tr>
<tr>
<td>Glycerine</td>
<td>12%</td>
</tr>
<tr>
<td>Phenol</td>
<td>10%</td>
</tr>
<tr>
<td>Formaldehyde solution</td>
<td>3%</td>
</tr>
</tbody>
</table>

The advantages of using this particular preservative fluid are:

1. A state of soft preservation is achieved, benefiting dissection techniques.
2. The low formaldehyde solution content obviates excessive noxious fumes.
3. A degree of natural tissue colour is maintained, benefiting photography.
4. Mould growth does not occur on either whole cadavers thus preserved or their subsequent dissected (prosected) and stored parts.

SAFETY FOOTNOTE

Since the preparation of the anatomical material used in this book, there have been substantial major changes to health and safety regulations concerning the use of certain chemical constituents in preservative (embalming) fluids. It is essential, therefore, to seek official local health and safety advice and guidance if intending to adopt the above preservative fluid.

The Greek adjective ‘peroneal’ is now replaced by the Latin ‘fibular’ for various muscles, vessels, nerves, and structures; For example: Fibularis tertius instead of Peroneus tertius; Fibular artery instead of Peroneal artery; Common fibular nerve instead of Common peroneal nerve; Inferior fibular retinaculum instead of Inferior peroneal retinaculum.

Again, for this new edition, to ease in the new terminology for those used to working from older texts, the term peroneal is included italicized in brackets, e.g., Deep fibular (peroneal) nerve.

Also note, Flexor accessorius is now known as quadratus plantae.

This terminology conforms to the International Anatomical Terminology—Terminologia Anatomica—created in 1988 by the Federative Committee on Anatomical Terminology (FCAT) and approved by the 56 Member Associations of the International Federation of Associations of Anatomists (IFAA). Stuttgart: Thieme ISBN 3-13-115251-6.
Orientation Guides

Superior (dorsal)
Inferior (plantar)
Coronal plane
Transverse (axial) plane
Sagittal plane
Posterior (proximal)
Anterior (distal)
Superior (proximal)
Coronal plane
Transverse (axial) plane
Sagittal plane
Inferior (distal)
Lateral view
Lower limb, pelvis and hip

Lower limb survey
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From behind 2
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From the lateral side 6

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Gluteal region
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Surface features 15
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Hip joint
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Lower limb survey

Bones, muscles and surface landmarks of the left lower limb, from the front
Bones of the left lower limb, from the front

Muscles of the left lower limb, from the front

Surface landmarks of the left lower limb, from the front

- The main parts or regions of the lower limb are the gluteal region (consisting of the hip at the side and the buttock at the back), the thigh, the knee, the leg, the ankle and the foot. The term leg properly refers to the part between the knee and the foot, although it is commonly used for the whole lower limb.
- The hip bone consists of three bones fused together—the ilium (3), ischium (5) and pubis (4)—and forms a pelvic girdle. The two hip bones or girdles unite with each other in front at the pubic symphysis (p. 18, B33), and at the back they join the sacrum at the sacro-iliac joints (p. 18, A7 and p. 19, C6), so forming the bony pelvis.
- The femur (11) is the bone of the thigh; the tibia (18) and fibula (22) are the bones of the leg.
- The acetabulum (6) of the hip bone and the head of the femur (7) form the hip joint (p. 18, A12 and 14, B18 and 20, C18 and 20).
- The condyles of the femur (12 and 13) and tibia (15 and 16) together with the patella (14) form the knee joint.
- The head of the fibula (20) forms a small joint with the tibia, the superior tibiofibular joint. The inferior tibiofibular joint, properly called the tibiofibular syndesmosis (a type of fibrous joint), is a fibrous union between the tibia and fibula just above the ankle joint.
- The ankle is the lower part of the leg in the region of the ankle joint (pp. 60, 62, 64 and 66).
- The lower ends of the tibia (18) and fibula (22) articulate with the talus of the foot to form the ankle joint (pp. 60 and 62).
- The body of a long bone is commonly called the shaft.
- The adjective ‘peroneal’ (Greek, see p. 49) is now replaced by the Latin ‘fibular’ for various vessels and nerves, e.g., common fibular nerve instead of common peroneal nerve. See notes on New Terminology on p. xiii.

For details of limb muscles, nerves and arteries, see the Appendix:

Muscles—pp. 116–121, including Figs 2–7.
Nerves—pp. 122–123, including Figs 8 and 9.
Arteries—pp. 136 and 137, including Figs 27 and 28.
Lower limb survey

Bones, muscles and surface landmarks of the left lower limb, from behind
1 Sacrum
2 Iliac crest
3 Ilium
4 Pubis
5 Ischium
6 Rim of acetabulum
7 Head
8 Neck
9 Greater trochanter
10 Lesser trochanter
11 Body
12 Lateral condyle
13 Medial condyle
14 Lateral condyle
15 Medial condyle
16 Body
17 Medial malleolus
18 Head
19 Neck
20 Body
21 Lateral malleolus
22 Foot
23 Gluteus maximus
24 Iliotibial tract
25 Sciatic nerve
26 Biceps femoris
27 Semimembranosus
28 Semitendinosus
29 Tibial nerve
30 Common fibular (peroneal) nerve
31 Medial head
32 Lateral head
33 Soleus
34 Sural nerve
35 Small saphenous vein
36 Tendo calcaneus
37 Fold of buttock (gluteal fold)
38 Hamstring muscles
39 Popliteal fossa

- The curved fold of the buttock (37) does not correspond to the straight (but oblique) lower border of gluteus maximus (23).
- The tendons of gastrocnemius (31 and 32) and soleus (33) join to form the tendo calcaneus (36), known commonly as the Achilles’ tendon.
- The muscles on the back of the thigh with prominent tendons—semimembranosus (27), semitendinosus (28) and biceps femoris (long head, 26)—are known commonly as the hamstrings (see the note on p. 29).
Lower limb survey

Bones, muscles and surface landmarks of the left lower limb, from the medial side
At the ankle the great saphenous vein (16), the longest vein in the body, passes upwards in front of the medial malleolus (10). At the knee it lies a hand’s breadth behind the medial border of the patella (6). It ends by draining into the femoral vein (p. 24, 12 and 18).

A Bones of the left lower limb, from the medial side
B Muscles of the left lower limb, from the medial side
C Surface landmarks of the left lower limb, from the medial side
Lower limb survey

Bones, muscles and surface landmarks of the left lower limb, from the lateral side
1 Iliac crest  
2 Sacrum  
3 Hip bone  
4 Hip joint  
5 Head  
6 Greater trochanter  
7 Body  
8 Lateral epicondyle  
9 Lateral condyle  
10 Patella  
11 Knee joint  
12 Superior tibiofibular joint  
13 Lateral condyle  
14 Body  
15 Head  
16 Neck  
17 Body  
18 Lateral malleolus  
19 Inferior tibiofibular joint  
20 Ankle joint  
21 Foot  
22 Tensor fasciae latae  
23 Gluteus medius  
24 Gluteus maximus  
25 Iliotibial tract  
26 Vastus lateralis  
27 Biceps femoris  
28 Common fibular (peroneal) nerve  
29 Tibialis anterior  
30 Extensor digitorum longus  
31 Fibularis (peroneus) longus  
32 Soleus  
33 Gastrocnemius  
34 Tendo calcaneus  
35 Tibial tuberosity  
36 Patellar ligament

- The common fibular (peroneal) nerve (28), the only palpable major nerve of the lower limb, can be felt as it passes downward and forward across the neck of the fibula (16).

**A** Bones of the left lower limb, from the lateral side  
**B** Muscles of the left lower limb, from the lateral side  
**C** Surface landmarks of the left lower limb, from the lateral side
Male pelvic viscera and vessels

Seen on the right side in a sagittal section, after removal of most of the peritoneum (serous membrane)
The section is mostly in the midline; small bowel, large bowel and peritoneum (serous membrane) have been removed but the whole of the anal canal and the lower part of the left levator ani muscle have been preserved to show the external anal sphincter (as in the female section, p. 12).

1 Rectum
2 Cut edge of levator ani
3 External anal sphincter covering anal canal
4 Anus, above arrowhead
5 Perineal body
6 Bulbospongious overlying corpus spongiosum
7 Corpus spongiosum, the part of the penis containing the urethra
8 Spongy part of urethra, within the corpus spongiosum
9 Corpus cavernosum of penis
10 Deep dorsal vein of penis, draining back to the vesicoprostatic venous plexus, the sponge-like tissue sectioned here in front of the prostate
11 Pubic symphysis
12 Superior vesical artery
13 Corpus cavernosum of penis
14 Prostate and prostatic part of urethra
15 Left seminal vesicle, cut in section
16 Bladder, with urethral openings marked with arrows
17 Left ureter
18 Left ductus (vas) deferens
19 Right ductus (vas) deferens
20 Inferior epigastric vessels
21 External iliac artery
22 External iliac vein
23 Internal iliac artery
24 Internal iliac vein
25 Ureter
26 Body of fifth lumbar vertebra
27 Fifth lumbar intervertebral disc
28 Promontory of sacrum
29 Sacrum
30 Coccyx
31 Cauda equina within sacral canal
32 Posterior wall of rectus sheath
33 Rectus abdominis
34 Rectovesical pouch

• The ureters (17, 25) conduct urine from the kidneys to the bladder (16) where it is stored until sensation of volume dictates expulsion via the single tube of the urethra (8), the extent of its full length seen here laying within the bisected shaft of the penis (7).
• The single prostate gland (14) and the paired seminal vesicles (15, left) are accessory secretory sex glands, which produce most of the volume of seminal fluid.
• The prostate gland (14), normally the size of a chestnut, lies just below the bladder (16) and opens into the urethra (8); the seminal vesicles (15, left) open into the ductus (vas) deferens (18, 19), which conduct sperm from the epididymis of each testis to the urethra (8) on ejaculation.
• The rectum (1) is the terminal part of the large intestine (colon) where faeces collect prior to defecation via the anus (4), the opening and closing of which is controlled by the muscles that form the external sphincter (3). The space between the rectum (1), prostate gland (14) and seminal vesicles (15, left) is known as the rectovesical pouch (34).
Female pelvic viscera and vessels

Seen on the right side in a sagittal section, after removal of most of the peritoneum (serous membrane)
The section is mostly in the midline; small bowel, large bowel and much of the peritoneum (serous membrane) have been removed but the whole of the anal canal and the lower part of the left levator ani muscle have been preserved to show the external anal sphincter (as in the male section, p. 10).

1 Rectum
2 Cut edge of left levator ani
3 External anal sphincter covering anal canal
4 Perineal body (central perineal tendon)
5 Anus, above arrowhead
6 Labium majus
7 Labium minus
8 Clitoris
9 Pubic symphysis
10 Urethra, surrounded by sphincter urethrae
11 Bladder, arrow points to right ureter
12 Vagina
13 Cervix of uterus
14 Body of uterus
15 Left ureter
16 Piriformis
17 Anterior ramus of S1 nerve
18 External iliac vein
19 External iliac artery
20 Right ureter
21 Internal iliac vessels and branches
22 Ovarian vessels
23 Round ligament of uterus
24 Vesico-uterine pouch
25 Recto-uterine pouch (of Douglas)
26 Body of fifth lumbar vertebra
27 Fifth lumbar intervertebral disc
28 Promontory of sacrum
29 Sacrum
30 Coccyx
31 Sacral canal
32 Inferior epigastric vessels
33 Peritoneum overlying rectus abdominis [see 32–33, p. 10]
34 Iliacus
35 Psoas major
36 Right ovary
37 Right uterine (fallopian tube)
38 Right broad ligament

- The vagina (12) is the lower part of the female reproductive tract and lies in a central position between, anteriorly, the bladder (11) and, posteriorly, the rectum (1); superiorly, it connects the lower end of the uterus (the cervix) (13) with, inferiorly, the margin of the vaginal orifice and the labium majus (6) and labium minus (7).
- The urethra (10) in the female is much shorter in length, being only 4 cm, compared to that in the male, usually 18 cm; from the bladder it opens into the vaginal vestibule a few centimetres behind the clitoris (8). The space between the bladder (11) and the uterus (14) is known as the vesico-uterine pouch (24) and between the uterus (14) and the rectum (1) the recto-uterine pouch (of Douglas) (25).
- The body of the uterus (14) is pear shaped and normally lies over the bladder (11); from its sides the broad ligament (38, right) extends to the lateral walls of the pelvis. These help to keep the uterus in a central position.
- The ovaries (36, right) are suspended by part of the broad ligament (mesovarium) close to the lateral walls of the pelvis and are the main female reproductive organs; they produce cyclic steroid hormones as well as ovum (egg cells). The open ends of the uterine (fallopian) tubes (37, right) are positioned close to the ovaries, thus enabling discharged ova to freely enter them.
Gluteal region  *Sciatic nerve and other gluteal structures of the right side*

Most of gluteus maximus (1) has been removed (as have the veins that accompany arteries) to show the underlying structures, the most important of which is the sciatic nerve (14 and 15). The key to the region is the piriformis muscle (2): the superior gluteal artery (3) and nerve (4) emerge from the pelvis above piriformis, while all other structures leave the pelvis below piriformis. Apart from the sciatic nerve (14 and 15), these include the inferior gluteal nerve (6) and artery (22) and the posterior femoral cutaneous nerve (16).

1. Gluteus maximus
2. Piriformis
3. Superior gluteal artery
4. Superior gluteal nerve
5. Gluteus medius
6. Inferior gluteal nerve
7. Gluteus minimus
8. Greater trochanter of femur
9. Gemellus superior
10. Obturator internus
11. Gemellus inferior
12. Obturator externus
13. Quadratus femoris
14. Common fibular (peroneal) part of sciatic nerve
15. Tibial
16. Posterior femoral cutaneous nerve
17. Ischial tuberosity
18. Sacrotuberous ligament
19. Nerve to obturator internus
20. Internal pudendal artery
21. Pudendal nerve
22. Inferior gluteal artery
The interrupted lines divide the gluteal region into four quadrants. The surface marking of the lower border of piriformis (the dotted line) is on a line drawn from the midpoint between the posterior superior iliac spine (9) and the coccyx (7) to the top of the greater trochanter of the femur (3). From the midpoint of this line, a curved line (convex laterally) to midway between the ischial tuberosity (6) and the greater trochanter (3) indicates the course of the upper part of the sciatic nerve, indicated here in yellow.

- The superior gluteal nerve runs between gluteus medius and minimus and ends in tensor fasciae latae, supplying all three muscles.
- The inferior gluteal nerve passes straight back into gluteus maximus, supplying that muscle only.
- In the gluteal region the sciatic nerve is a flattened band about 1 cm broad. Its two parts (A14 and 15) are usually closely bound together in the gluteal region and the back of the thigh (p. 27, B10). In the popliteal fossa at the back of the knee (p. 32, A) they separate into the common fibular (peroneal) nerve, which supplies the front of the leg and dorsum of the foot, and the tibial nerve, which supplies the back of the leg and sole of the foot.

1 Iliac crest
2 Gluteus medius
3 Greater trochanter of femur
4 Gluteus maximus
5 Fold of buttock
6 Ischial tuberosity
7 Tip of coccyx
8 Natal cleft
9 Posterior superior iliac spine
10 Sciatic nerve
Gluteal region

Left gluteal region and ischio-anal region, with gluteus maximus and gluteus medius cut through and portions reflected laterally

1. Posterior layer of lumbar fascia overlying erector spinae
2. Sacrum
3. Coccyx
4. Gluteus maximus
5. Gluteus medius
6. Gluteus minimus
7. Piriformis
8. Gemellus superior
9. Obturator internus
10. Gemellus inferior
11. Greater trochanter of femur
12. Obturator externus
13. Quadratus femoris
14. Vastus lateralis
15. Iliotibial tract
16. Upper part of adductor magnus (adductor minimus)
17. Biceps femoris (long head)
18. Semitendinosus
19. Adductor magnus
20. Gracilis
21. Ischial tuberosity
22. Sacrotuberous ligament
23. Common fibular (peroneal) part of sciatic nerve
24. Tibial part of sciatic nerve
25. Posterior femoral cutaneous nerve
26. Internal pudendal artery
27. Pudendal nerve
28. Levator ani
29. External anal sphincter
30. Anal margin
31. Anococcygeal body
32. Superior gluteal artery, vein and nerve
33. Inferior gluteal artery, vein and nerve
34. Pudendal canal (arrowed)
35. Inferior rectal artery, vein and nerve
Gluteal region

Right gluteal region and ischio-anal region, with most of gluteus maximus removed

1 Posterior layer of lumbar fascia overlying erector spinae
2 Sacrum
3 Coccyx
4 Gluteus maximus
5 Gluteus medius
6 Gluteus minimus
7 Piriformis
8 Gemellus superior
9 Obturator internus
10 Gemellus inferior
11 Greater trochanter of femur
12 Obturator externus
13 Quadratus femoris
14 Vastus lateralis
15 Iliotibial tract
16 Upper part of adductor magnus (adductor minimus)
17 Biceps femoris (long head)
18 Semitendinosus
19 Adductor magnus
20 Gracilis
21 Ischial tuberosity
22 Sacrotuberous ligament cut and turned down
23 Common fibular (peroneal) part of sciatic nerve
24 Tibial part of sciatic nerve
25 Posterior femoral cutaneous nerve
26 Internal pudendal artery
27 Pudendal nerve
28 Levator ani
29 External anal sphincter
30 Anal margin
31 Anococcygeal body
32 Inferior rectal artery, vein and nerve
Hip joint  *Left hip bone and femur, with sacrum and coccyx*

**A**  Left hip bone and femur, with sacrum and coccyx, from the front

1. Sacral promontory
2. Ala of sacrum
3. Second anterior sacral foramen, for anterior ramus of S2 nerve
4. Apex of sacrum
5. First coccygeal vertebra, with transverse process
6. Fused coccygeal vertebrae
7. Sacroiliac joint
8. Sacroiliac joint
9. Tubercle of iliac crest
10. Anterior superior iliac spine, for inguinal ligament and sartorius
11. Iliac fossa, a term also applied to the lower lateral region of the anterior abdominal wall
12. Anterior inferior iliac spine, for part of rectus femoris
13. Arcuate line of ilium, forming part of the pelvic brim
14. Rim of acetabulum, the socket for the head of the femur (26)
15. Iliopubic eminence, site of union between ilium and superior ramus of the pubis (17)
16. Pectineal line (pecten) of pubis
17. Superior ramus of pubis
18. Pubic tubercle, a palpable landmark
19. Pubic crest, for rectus abdominis
20. Obturator foramen
21. Body of pubis
22. Inferior ramus of pubis
23. Site of union of pubic and ischial rami (22 and 24)
24. Ramus of ischium
25. Ischial tuberosity, best seen from behind (C16)
26. Head of femur
27. Neck, the part of the femur most commonly fractured
28. Greater trochanter. Gluteus medius and minimus are attached to its front and lateral side
29. Intertrochanteric line, for the capsule of the hip joint and not to be confused with the intertrochanteric crest on the back of the bone (C23)
30. Tip of lesser trochanter, best seen from behind (C25)
31. Shaft of femur
32. Ischial spine
33. Pubic symphysis

**B**  Radiograph. (The translucent areas are gas shadows in the large intestine.)
C | Left hip bone and femur, with sacrum and coccyx, from behind

1. Sacral canal
2. Second posterior sacral foramen, for posterior ramus of S2 nerve
3. Sacral hiatus, the lower opening of the sacral canal and here unusually high
4. Apex of sacrum
5. First coccygeal vertebra, with below it the fused second to fourth coccygeal vertebrae
6. Sacroiliac joint
7. Posterior inferior iliac spine
8. Posterior superior iliac spine
9. Iliac crest
10. Ilium, outer surface
11. Greater sciatic notch
12. Site of fusion of ilium and ischium
13. Rim of acetabulum, the socket which receives the head of the femur (19)
14. Ischial spine, separating the greater and lesser sciatic notches (11 and 15)
15. Lesser sciatic notch
16. Ischial tuberosity, which bears the weight when sitting
17. Ramus of ischium joining inferior ramus of pubis
18. Body of pubis
19. Head of femur, making the hip joint with the acetabulum of the hip bone (13)
20. Neck, labeled along the site of attachment of the capsule of the hip joint, which does not extend as far as the intertrochanteric crest (23)
21. Trochanteric fossa for obturator externus
22. Greater tuberosity whose curved upper margin receives piriformis and obturator internus
23. Intertrochanteric crest
24. Quadratus tubercle, for quadratus femoris
25. Lesser trochanter, for psoas major with fibers from iliacus just below it
26. Gluteal tuberosity, receiving part of the attachment of gluteus maximus (the rest is attached to the fascia lata, the deep fascia of the thigh)
27. Shaft of femur

D | Left hip joint capsule (male), from the front, with all surrounding muscles removed except for obturator externus

23. Anterior inferior iliac spine
24. Inguinal ligament
25. Iliopubic eminence
26. Spermatic cord
27. Iliofemoral ligament, like an inverted V, reinforcing and blending with the front of the capsule
28. Pubofemoral ligament, reinforcing and blending with the more medial part of the capsule
29. Obturator externus
30. Intertrochanteric line
31. Greater trochanter
32. Lesser trochanter
Muscles producing movements at the hip joint consist of the following:

- **Flexion** (moving the thigh forward and upward toward the abdomen): psoas and iliacus, with rectus femoris, sartorius, tensor fasciae latae, pectineus, adductor longus and adductor brevis.
- **Extension** (moving the thigh backward): gluteus maximus, semimembranosus, semitendinosus, long head of biceps and ischial part of adductor magnus.
- **Abduction** (moving the thigh laterally away from the midline): gluteus medius, gluteus minimus, with tensor fasciae latae and piriformis.
- **Adduction** (moving the thigh medially toward the midline): adductor longus, adductor brevis, adductor magnus, pectineus, gracilis and quadratus femoris.
- **Medial rotation** (rotating the thigh inward in the long axis of the limb): anterior fibres of gluteus medius and gluteus minimus, with tensor fasciae latae. (Electromyography does not support the long-held view that psoas major is a medial rotator.)
- **Lateral rotation** (rotating the thigh outward in the long axis of the limb): obturator externus, obturator internus and gemelli, piriformis, quadratus femoris, gluteus maximus and sartorius.
- The coronal section of the joint in C demonstrates the thickness of the capsule (C15) but does not of course show the ligaments that reinforce the outside of the capsule (iliofemoral at the front, and pubofemoral and ischiofemoral below and behind).
The head of the femur (18) sits in the hip bone’s acetabulum (20), which is deepened at the periphery by the fibrous acetabular labrum (19). Note the hyaline cartilage on the joint surfaces (21 and 22), and the capsule (15) whose circular fibers (zona orbicularis, 17) keep it close to the neck of the femur (16). Gluteus medius (5) and gluteus minimus (6) converge on to the greater trochanter (7), and below the head and neck of the femur (18 and 16), the tendon of psoas major (2) and some muscle fibres of iliacus (3) are passing backward to reach the lesser trochanter on the back of the bone. Compare major features in the section with the radiograph.
## Thigh, knee and leg

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Thigh

Front of the right thigh (female), superficial structures of the femoral triangle

1 Patella
2 Tendon of quadriceps femoris
3 Vastus medialis
4 Rectus femoris
5 Vastus lateralis
6 Sartorius
7 Gracilis
8 Great saphenous vein
9 Adductor longus
10 Adductor brevis
11 Pectineus
12 Femoral vein
13 Femoral artery
14 Femoral canal (arrowed)
15 Femoral nerve
16 Iliacus
17 Tensor fascia latae
18 Iliotibial tract
19 Anterior superior iliac spine
20 Position of inguinal ligament
21 External oblique aponeurosis

The inguinal ligament (20):
• Attaches (like a bow string) taught between the anterior superior iliac spine (superolaterally) and the pubic tubercle (inferomedially) of that side of the pelvis
• Has an adult length between 12–14 cm
• Inclines at an angle between 35–40 degrees

The femoral triangle:
• Boundaries are the inguinal ligament (20), medial border of sartorius (6) and medial border of adductor longus (9)
• Is shaped like a gutter
• From lateral to medial, contains the key structures, femoral nerve (15), artery (13), vein (12) and canal (14)

The femoral canal (14):
• Opens into the peritoneal cavity via the femoral ring behind the inguinal ligament
• Is approximately 4 cm in length in adults
• Forms the most medial compartment of the femoral sheath
• Gives passage for lymphatic channels from the lower limb into the pelvis
• By providing space, allows the femoral vein to expand and thus increase venous drainage to the lower limb

The femoral pulse:
• Can be located and palpated below the inguinal ligament and midway between the anterior superior iliac spine and the pubic symphysis (p. 26 B)
Thigh

Back of the right thigh (female) and gluteal region

1. Common fibular (peroneal) nerve
2. Tibial nerve
3. Popliteal vein
4. Popliteal artery
5. Semitendinosus
6. Semimembranosus
7. Adductor magnus
8. Gracilis
9. Long head of biceps femoris
10. Short head of biceps femoris
11. Iliotibial tract
12. Posterior cutaneous femoral nerve
13. Gluteus maximus
14. Position of sciatic nerve
15. Site for intramuscular injection (the upper outer quadrant)

**Gluteal intramuscular injection**

The bulky gluteus maximus muscle (13) with gluteus medius underneath is a possible site for intramuscular injections, but it is of course absolutely vital to choose the correct position for injection in order to avoid damaging the sciatic nerve (14).

The proper site is usually described as the upper outer quadrant of the gluteal region (15).

In estimating the four quadrants by vertical and horizontal lines through the midpoint of the region, it must be remembered that the most upper boundary of the region is the iliac crest, not the most prominent part of the bulge of the buttock or a suntanned bikini line, which are both far too low.

Only by choosing the properly defined quadrant can injury to the sciatic nerve be avoided. (See p. 15 for detailed description.)

The needle should enter either gluteus maximus or the adjacent part of gluteus medius.

**The popliteal fossa:**
- Is a diamond-shaped area at the back of the knee

**Upper boundaries are:**
- Lateral side, biceps femoris (with common fibular (peroneal) nerve behind it)
- Medial side, semimembranosus (with tendon of semitendinosus behind it)

**Lower boundaries are:**
- Laterally, the lateral head of gastrocnemius and plantaris
- Medially, the medial head of gastrocnemius

**Key structures within the fossa are:**
- Superficial to deep, the tibial nerve, popliteal vein and popliteal artery (See also p. 38.)
**Thigh**  *Front of the right upper thigh (female)*

Part of the fascia lata (deep fascia of the thigh, 14) has been removed to display the femoral vessels and nerve and the adjacent muscles. The femoral nerve (21), artery (20), vein (18) and canal (17) lie in that order from lateral to medial beneath the inguinal ligament (19). The great saphenous vein (12) passes through the saphenous opening (16) in the fascia lata to enter the femoral vein (18); a number of smaller veins enter the great saphenous just before it joins the femoral.

• The femoral pulse can be felt midway between the anterior superior iliac spine and the midline pubic symphysis (the midinguinal point or femoral point).

### A  Inguinal and femoral regions, in the female

### B  Palpation of femoral pulse

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Anterior superior iliac spine | External oblique aponeurosis | Cut edge of rectus sheath | Rectus abdominis | Superficial epigastric vein | Superficial inguinal ring | Round ligament of uterus | Mons pubis | Gracilis | Adductor longus | Pectineus | Great saphenous vein | Superficial external pudendal vessels | Fascia lata | Accessory saphenous vein | Lower edge of saphenous opening | Position of femoral canal | Femoral vein | Inguinal ligament | Femoral artery | Femoral nerve | Medial | Intermediate | Fascia lata | Tensor fasciae latae |

* Various superficial veins (5, 13, 15, 25) run into the great saphenous vein (12); this helps to distinguish the great saphenous from the femoral vein (18), which superficially at this level receives only the great saphenous itself. See p. 76 for further details of the great saphenous vein.
* Although arising at the front of the thigh, the profunda femoris artery (C24) is the main supply to muscles on the back of the thigh as well as those on the front.
* The adductor canal, which is triangular in cross section, is bounded in front by sartorius (24), laterally by vastus medialis, and behind by adductor longus (10) (above) and adductor magnus (below). The contents of the adductor canal are the femoral artery and vein (20 and 18), the saphenous nerve (C25) and the nerve to vastus medialis (C20).
In this deeper dissection, the removal of part of sartorius (3) displays the profunda femoris artery (24). The femoral artery (9) passes in front of adductor longus (18); the profunda (24) passes behind it. Separation of the adjacent borders of pectineus (13) and adductor longus (18) allows the anterior division of the obturator nerve (15) to be seen in front of adductor brevis (17). The medial circumflex femoral artery (12) disappears backward between pectineus (13) and the tendon of psoas (hidden behind the uppermost part of the femoral artery (upper 9). The lateral circumflex femoral artery (11, which often arises directly from the femoral artery, as here, and not from the profunda) courses laterally and supplies adjacent muscles. Branches of the femoral nerve (8) include the saphenous nerve (25), which will run as far as the medial side of the foot.
**Thigh** *Lower right thigh, medial side*

The lower part of sartorius (3) has been displaced medially to open up the lower part of the adductor canal and expose the femoral artery (4) passing through the opening in adductor magnus (6) to enter the popliteal fossa behind the knee and become the popliteal artery.

1. Gracilis  
2. Adductor magnus  
3. Sartorius  
4. Femoral artery  
5. Saphenous nerve  
6. Opening in adductor magnus  
7. Vastus medialis and nerve  
8. Rectus femoris  
9. Iliotibial tract  
10. Quadriceps tendon  
11. Patella  
12. Medial patellar retinaculum  
13. Lowest (horizontal) fibres of vastus medialis  
14. Saphenous branch of descending genicular artery

(A) From the front and medial side
The section is viewed as when looking upward from knee to hip. The three vastus muscles (1, 3, 5) envelop the femur (2) at the front and sides, and rectus femoris (4) at this level is narrow and is becoming tendinous. The femoral vessels (20) are between vastus medialis (1) and adductor magnus (12), approaching the adductor magnus opening (13), and the profunda femoris vessels (11) lie close to the back of the femur (2). The sciatic nerve (10) is deeply placed between biceps (8, 9) laterally and semimembranosus (14) and semitendinosus (15) medially.

- The muscles commonly called the hamstrings span both the hip and knee joints: they arise from the ischial tuberosity and run to the upper end of the tibia and fibula, and consist of semitendinosus, semimembranosus, and the long head of biceps. The short head of biceps is not a hamstring; although it joins the long head, it arises from the back of the femur and hence does not span the hip joint. Semitendinosus is named from the long tendon at its lower end. Semimembranosus is named from the broad tendinous origin at its upper end.
**Knee joint**  *Left knee joint*

Flexion of the knee, as in B, exposes a much larger area of the femoral condyles (4, 7) than is seen in extension (as in A and C). In B the medial and lateral menisci (18, 22) lie between the condyles of the femur and tibia (4, 9; 7, 12), with the anterior cruciate ligament (19) passing backward and laterally from the upper surface of the tibia to the medial surface of the lateral condyle of the femur. Compare the MR image in C with the dissection in B.

In D the joint has been opened up by cutting through the quadriceps muscle (26) and the patellar ligament (30) and turning laterally the large flap which includes the patella (28), in order to show the joint cavity from the front and the margins of the suprapatellar bursa (27), which is in direct continuity with the cavity of the knee joint.

- The lateral ligament (B24, properly called the fibular collateral ligament) is a rounded cord about 5 cm long, passing from the lateral epicondyle of the femur (B8) to the head of the fibula (B14).
- The medial ligament (B17, properly called the tibial collateral ligament) is a broad flat band about 12 cm long passing from the medial epicondyle of the femur (B3) to the medial side of the medial condyle of the tibia (B9) and to an extensive area of the medial surface below the condyle. At the side it fuses with the medial meniscus (B18; see also p. 33, B18 and 19); the lateral ligament (B24) does not fuse with the lateral meniscus (B22), to which the tendon of popliteus has an attachment (p. 33, C28).
- For notes on the cruciate ligaments and menisci, see p. 32.
Coronal magnetic resonance image (MRI)

Opened up from the front, with the knee joint in extension and the patella turned laterally

1. Shaft of femur
2. Adductor tubercle
3. Medial epicondyle
4. Medial condyle
5. Base of patella
6. Apex of patella
7. Lateral condyle
8. Lateral epicondyle
9. Medial condyle of tibia
10. Tibial tuberosity
11. Shaft
12. Lateral condyle
13. Superior tibiofibular joint (with capsule in B)
14. Head
15. Neck
16. Shaft
17. Medial ligament
18. Medial meniscus
19. Anterior cruciate ligament
20. Anterior meniscofemoral ligament
21. Posterior cruciate ligament
22. Lateral meniscus
23. Popliteus tendon
24. Lateral ligament
25. Biceps tendon
26. Quadriceps femoris
27. Margins of suprapatellar bursa
28. Posterior surface of patella
29. Infrapatellar fat pad
30. Patellar ligament
31. Deep infrapatellar bursa
The joint in B is partly flexed, showing less of the articular surfaces of the femoral condyles (4, 6) than in A. In B the posterior cruciate ligament (20) spills over onto the uppermost part of the posterior surface of the tibia. The attachment of the medial meniscus (19) to the medial ligament (18) is clearly seen; the lateral meniscus (23) has no attachment to the lateral ligament (24) but gives rise to the posterior meniscofemoral ligament (22), which lies on the surface of the posterior cruciate ligament (20), here obscuring the anterior meniscofemoral ligament (27). The view in C demonstrates the shapes of the medial and lateral menisci (19, 23), the tibial attachments of the anterior and posterior cruciate ligaments (21, 20) and the anterior and posterior meniscofemoral ligaments (27, 22), which pass respectively in front of and behind the posterior cruciate ligament (20).
• The cruciate ligaments are named from their attachments to the tibia.
• The anterior cruciate ligament (C21), from the front of the upper surface of the tibia, passes upward, backward and laterally to become attached to the medial side of the lateral condyle of the femur (p. 30, B19).
• The posterior cruciate ligament (C20), from the back of the upper surface and the very top of the posterior surface of the tibia, passes upward, forward and medially to become attached to the lateral side of the medial condyle of the femur (p. 30, B21).
• The anterior and posterior meniscofemoral ligaments (C27, C22) arise from the back of the lateral meniscus and run upward and forward like a two-pronged fork embracing the posterior cruciate ligament (C20) at its front and back and fusing with it.
• The C-shaped fibrocartilaginous menisci (C19 and C23) are attached by their ends (the horns of the menisci) to the intercondylar area of the upper surface of the tibia.
• Muscles producing movements at the knee joint include the following:
  - Flexion (bending the leg backwards): semimembranosus, semitendinosus, biceps, gracilis, sartorius, gastrocnemius and popliteus.
  - Extension (straightening the flexed knee): vastus medialis, vastus intermedius, vastus lateralis, rectus femoris, and tensor fasciae latae and gluteus maximus acting via the iliobibial tract.
  - Medial rotation of the flexed leg (rotating the leg medially in the long axis of the leg): semimembranosus, semitendinosus, gracilis, sartorius and popliteus.
  - Lateral rotation of the flexed leg (rotating the leg laterally in the long axis of the leg): biceps.
• Because of the shape of the articulating surfaces and the tension in the ligaments, there is some medial rotation of the femur on the tibia toward the end of extension (assuming the tibia to be fixed); this is the so-called ‘locking of the knee joint’. To begin flexion, popliteus ‘unlocks’ the joint by causing some lateral rotation of the femur on the tibia (assuming the tibia to be fixed); the other flexors can then carry on the movement.
Knee joint

Coronal section through the left knee joint (male), from the front

The knee joint:
- Is a hinge joint
- Is the largest synovial joint in the body
- Is formed by the unions of the two condyles of the femur (17, 18) and the two condyles of the tibia (7, 15) along with the patella, which articulates solely with the condyles of the femur
- Provides movements of flexion, extension and small degree of rotation

The tibial (medial) collateral ligament (8):
- Runs from the medial epicondyle of the femur to the upper part of the medial surface of the tibia
- Is a broad, flat, band-like structure approximately 12 cm in length (See p. 30 for a more detailed description.)

The fibular (lateral) collateral ligament:
- Passes from the lateral epicondyle of the femur to the apex of the head of the fibula
- Is a rounded structure approximately 5 cm in length (See p. 30 for a more detailed description.)

The anterior and posterior cruciate ligaments (10, 11):
- Are main factors that hold the femur and tibia together within the knee joint
- Are strong bands which cross each other in the shape of an 'X' when viewed from the side as in a sagittal section
- Pass from the inside surfaces of the femoral condyles to the central intercondylar area on the upper surface of the tibia
- Are covered by synovial membrane at their fronts and sides but not at the back (See p. 33 for a more detailed description.)
**Knee joint**

*Sagittal section I through the left knee joint (female), from the left*

**The fibrous capsule (26):**
- Covers all aspects of the knee joint except at the front where its place is taken by the patella and patellar ligament
- Is lined by a synovial membrane

**The infrapatellar fat pad (18):**
- Pushes the synovial membrane backwards below the patella to fill up the gap between the femoral and tibial epicondyles

**The medial and lateral (19) meniscus:**
- Are main factors that hold the femur and tibia together outside the capsule of the knee joint
- Lay on top of the articular surfaces of the tibia
- Are C-shaped in appearance when viewed from above
- Are composed of fibrocartilage, which is thick at the periphery and very thin toward the centre
- Are not covered by synovial membrane
- Are attached by the ‘horns’ of their ‘C’ shape to the intercondylar area of the tibia near to the cruciate ligaments
- The medial meniscus is also firmly attached to the medial cruciate ligament
- The lateral meniscus is not attached to the lateral cruciate ligament
- Fill up space between the curved femoral condyles and flat articular surfaces of the tibia and help spread synovial fluid over the bones
- Act as shock absorbers and bear over half the weight transmitted across the joint
Knee joint

Sagittal section II through the left knee joint (female), from the left

The patella (17):
- Is situated within the tendon of quadriceps femoris (18)
- Is the largest sesamoid bone in the body
- Is held at a constant distance from the upper surface of the tibia by the patellar ligament (15)
- Slides over the femoral condyles as the knee joint bends
- Never comes into contact with the tibia

The suprapatellar bursa (19):
- Communicates with the synovial cavity of the knee joint
- Extends behind the tendon of quadriceps femoris (18) for three finger-breadths above the upper border of the patella
- May fill with excessive synovial fluid when the knee joint is injured resulting in ‘fluid on the knee’ that may be drained by needle aspiration

1. Soleus
2. Plantaris (tendon)
3. Tibial nerve
4. Popliteal vein
5. Popliteus
6. Gastrocnemius
7. Deep
8. Superficial
9. Fibrous capsule of knee joint
10. Shaft of tibia
11. Tuberity
12. Medial meniscus
13. Anterior cruciate ligament
14. Posterior cruciate ligament
15. Patellar ligament
16. Prepatellar bursa
17. Patella
18. Tendon of quadriceps femoris
19. Suprapatellar bursa
20. Articular cartilage
21. Popliteal surface of femur
22. Popliteal artery
23. Popliteal pad of fat
24. Shaft of femur
25. Infrapatellar fat pad extending into infrapatellar fold
26. Semitendinosus
27. Semimembranosus
28. Sciatic nerve
29. Vastus intermedius
30. Rectus femoris

View from the left
Knee joint

_Sagittal section III through the left knee joint (female), from the left_

1. Superficial fascia
2. Deep fascia
3. Gastrocnemius medial head
4. Medial condyle (plateau) of tibia
5. Medial meniscus
6. Articular cartilage
7. Medial condyle of femur
8. Suprapatellar bursa
9. Fibrous capsule of knee joint
10. Tendon of medial head of gastrocnemius
11. Tendon of semitendinosus
12. Semimembranosus
13. Adductor magnus
14. Femoral artery
15. Vastus medialis

The articular cartilage (6):
- Formed on the distal ends of the femoral and tibial condyles, is hyaline cartilage
- Is lubricated by synovial fluid within the knee joint cavity that is normally no more in quantity than a mere 0.5 ml

Principle muscles producing knee joint movement are:
- Flexion (bending)
  - Hamstrings, gastrocnemius and popliteus
- Extension (straightening)
  - Quadriceps femoris
- Medial rotation
  - of tibia, when semi-flexed: semimembranosus and semitendinosus
- Lateral rotation
  - of tibia, when semi-flexed: biceps femoris
  - See p. 33 for more detailed description.

Arterial supply to the knee joint is from the:
- Descending genicular branches of the femoral artery
- Middle and inferior genicular branches of the popliteal artery
- Anterior and posterior branches of the anterior tibial artery
- Circumflex fibular artery
- Descending branch of the lateral circumflex femoral artery

Nerve supply to the knee joint is from the:
- Obturator nerve
- Femoral nerve
- Tibial nerve
- Common fibular (peroneal) nerve
Knee joint

Popliteal fossa and back of the knee

In A the fascia that forms the roof of the fossa and the fat within it have been removed. At the upper part of the fossa, biceps (10) is on the lateral side with the common fibular (peroneal) nerve (9) at its posterior border, and semimembranosus (3) with semitendinosus (4) overlying it are on the medial side. At the lower part of the fossa, the medial head of gastrocnemius (15) is on the medial side, whereas on the lateral side plantaris (11) lies just above the lateral head of gastrocnemius (12). Of the principal structures within the fossa, the tibial nerve (7) is the most superficial, with the popliteal vein (6) behind it and the popliteal artery (5) deep to the vein.

In the lateral view in B, the ridge formed by the iliotibial tract (18) lies above (anterior to) the tendon of biceps (10), at the lateral boundary of the popliteal fossa (25). Below the head of the fibula (24) the common fibular (peroneal) nerve (9) is palpable and can be rolled against the neck of the bone.
Knee joint

**Popliteal fossa and back of the knee**

Most of gastrocnemius, soleus and other muscles have been removed to display popliteus (6) and the posterior surface of the knee joint capsule (13), which is reinforced by the tendinous fibers of semimembranosus (11) that form the oblique popliteal ligament (12).

C  Palpation of the right popliteal pulse

- The deep position of the popliteal artery (A5)—deep to the popliteal vein (A6), which in turn is deep to the tibial nerve (A7)—makes feeling the popliteal pulse difficult. It is best felt from the front, grasping the sides of the knee with both hands, placing the thumbs beside the patella and pressing the tips of the fingers deeply into the midline of the fossa.

D  Right popliteus muscle and knee joint capsule, from behind

- The slender arcuate popliteal ligament (D7) arches over popliteus (D6) as it enters the joint capsule to reach the lateral side of the lateral condyle of the femur.

1 Adductor magnus
2 Capsule overlying medial condyle of femur
3 Medial head of gastrocnemius
4 Plantaris
5 Lateral head of gastrocnemius
6 Popliteus
7 Arcuate popliteal ligament
8 Head of fibula
9 Soleus
10 Popliteal vessels and tibial nerve
11 Semimembranosus
12 Oblique popliteal ligament
13 Capsule of knee joint
14 Popliteal surface of femur
Leg and foot survey

**Muscles and superficial vessels and nerves of the left leg and foot**

Skin, subcutaneous tissue and most of the deep fascia have been removed, and different aspects of the same specimen are shown. Lateral to the medial (subcutaneous) surface (A2) and anterior border of the tibia is the largest muscle of the front of the leg, tibialis anterior (A6, C6), which becomes tendinous in the lower part of the leg and has the tendons of extensor hallucis longus (A7) and extensor digitorum longus (A8) lateral to it. On the medial side the bulk of gastrocnemius (A3, B3) and the underlying soleus (A4) overlie the flexor muscles whose tendons pass behind the medial malleolus (B9)—tibialis posterior (B19), flexor digitorum longus (B18) and flexor hallucis longus (B16), in that order from front to back. On the lateral side, fibularis (peroneus) longus (C23) largely overlies fibularis (peroneus) brevis (C25); their tendons pass behind the lateral malleolus (C10). At the back gastrocnemius (D3) has been detached at its upper end to show the underlying soleus (E4), which in turn has been detached with plantaris (E31) in F to display the underlying flexor muscle—tibialis posterior (F19), the deepest muscle, which is overlapped by flexor hallucis longus (F16) on the lateral side and flexor digitorum longus (F18) on the medial side.
1 Patellar ligament (lower edge)  
2 Medial surface of tibia  
3 Gastrocnemius  
4 Soleus  
5 Great saphenous vein  
6 Tibialis anterior  
7 Extensor hallucis longus  
8 Extensor digitorum longus  
9 Medial malleolus  
10 Lateral malleolus  
11 Sartorius  
12 Gracilis  
13 Semitendinosus  
14 Saphenous nerve  
15 Tendo calcaneus  
16 Flexor hallucis longus  
17 Tibial nerve and posterior tibial vessels  
18 Flexor digitorum longus  
19 Tibialis posterior  
20 Iliotibial tract  
21 Biceps femoris  
22 Common fibular (peroneal) nerve  
23 Fibularis (peroneus) longus  
24 Superficial fibular (peroneal) nerve  
25 Fibularis (peroneus) brevis  
26 Fibularis (peroneus) tertius  
27 Extensor digitorum brevis  
28 Semimembranosus  
29 Small saphenous vein  
30 Sural nerve  
31 Plantaris  
32 Tibial nerve  
33 Popliteal vein overlying artery  
34 Fascia over popliteus

D From behind  
E From behind, with gastrocnemius detached  
F From behind, with gastrocnemius, plantaris and soleus detached
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Surface landmarks of the foot

Surface landmarks of the left foot
Definitions of movements are as follows:

- **Extension**: from the Latin for straightening out, but as far as the ankle and foot are concerned it means bending the foot and/or toes upwards, which is also known as dorsiflexion.
- **Flexion**: from the Latin for bending. In the ankle and foot it means bending the foot and/or toes downwards, which is also known as plantarflexion.
- **Abduction**: from the Latin for moving away. In the foot it means spreading the toes apart (the corresponding movement of the fingers is much more extensive).
- **Adduction**: from the Latin for moving toward. In the foot it means drawing the toes together.
- **Inversion**: from the Latin for turning in—turning the foot so that the sole faces more inwards (medially).
- **Eversion**: from the Latin for turning out—moving the foot so that the sole faces more outwards (laterally) (a more limited movement than inversion).

For further details see pp. 85 and 107.

A  From the front and above (dorsal surface, dorsum)
B  From behind
C  From the front, in inversion
D  From the front, in eversion with abduction of toes
E  From below (plantar surface, sole)
F  Imprint of sole when weight-bearing (viewed through a glass plate)
Surface landmarks of the foot

A From the medial side
B In dorsiflexion (extension)
C In plantarflexion (flexion)
D From the lateral side
E In dorsiflexion (extension)
F In plantarflexion (flexion)

1 Tendo calcaneus
2 Flexor hallucis longus
3 Posterior tibial artery and tibial nerve
4 Flexor digitorum longus and tibialis posterior
5 Medial malleolus
6 Great saphenous vein and saphenous nerve
7 Tibialis anterior
8 Extensor hallucis longus
9 Head of first metatarsal
10 Sesamoid bone
11 Tuberosity of navicular
12 Sustentaculum tali
13 Tuberosity of calcaneus
14 Small saphenous vein and sural nerve
15 Fibularis (peroneus) longus and brevis
16 Lateral malleolus
17 Extensor digitorum brevis
18 Extensor digitorum longus
19 Tuberosity of base of fifth metatarsal
20 Head of fifth metatarsal
• Pulsation in the dorsalis pedis artery (p. 80, 14) is normally palpable between the tendons of extensor hallucis longus (8) and extensor digitorum longus (18), on a line from the midpoint between the medial and lateral malleoli to the proximal end of the first intermetatarsal space. However, the artery is absent in about 12% of feet (see p. 85).

• Pulsation in the posterior tibial artery (3) is normally palpable behind the medial malleolus (5), 2.5 cm in front of the medial border of the tendo calcaneus.

• The sustentaculum tali (12) is palpable about 2.5 cm below the tip of the medial malleolus (5).
Skeleton of the foot  Bones of the left foot, from above
The talus and calcaneus remain articulated with each other but the remainder have been disarticulated.

- **Bones of the tarsus**
  - Calcaneus
  - Talus
  - Navicular bone
  - Cuboid bone
  - Medial, intermediate and lateral cuneiform bones

- **Bones of the metatarsus**
  - First to fifth metatarsal bones, numbered from medial to lateral

- **Bones of the toes or digits**
  - Phalanges—a proximal and a distal phalanx for the great toe; proximal, middle and distal phalanges for each of the second to fifth toes

- The **hindfoot** consists of the talus and calcaneus.
- The **midfoot** consists of the navicular, cuboid and cuneiform bones.
- The **forefoot** consists of the metatarsal bones and phalanges.
- **Sesamoid bones**—two always present in the tendons of flexor hallucis brevis. For others see pp. 50, 52.

- **Origin and meaning of some names associated with the foot** are as follows (some older names for bones are given in parentheses):
  - **Tibia:** Latin for a flute or pipe; when held upside down, the shin bone has a fanciful resemblance to this wind instrument.
  - **Fibula:** Latin for a pin or skewer; the long thin bone of the leg. Adjective fibular or peroneal, which is from the Greek for pin (see the last note on p. 3).
  - **Tarsus:** Greek for a wicker frame, in the basic framework for the back of the foot.
  - **Metatarsus:** Greek for beyond the tarsus; the forepart of the foot.
  - **Talus** (astragalus): Latin (Greek) for one of a set of dice; viewed from above the main part of the talus has a rather square appearance.
  - **Calcaneus** (os calcis, calcaneum): From the Greek for heel; the heel bone.
  - **Navicular** (scaphoid): Latin (Greek) for boat-shaped; the navicular bone roughly resembles a saucer-shaped coracle.
  - **Cuboid:** Greek for cube-shaped.
  - **Cuneiform:** Latin for wedge-shaped.
  - **Phalanx:** Greek for a row of soldiers; a row of bones in the toes. Plural phalanges.
  - **Sesamoid:** Greek for shaped like a sesame seed.
  - **Digitus:** Latin for finger or toe. Digiti and digitorum are the genitive singular and genitive plural—of the toe(s).
  - **Hallux:** Latin for the great toe. Hallucis is the genitive singular—of the great toe.
  - **Dorsum:** Latin for back; the upper surface of the foot. Adjective dorsal.
  - **Plantar:** Adjective from planta, Latin for the sole of the foot.
Skeleton of the foot  Articulated bones of the left foot

A

B
Ossification of foot bones

All the tarsal bones are ossified from one primary center: calcaneus at the third fetal month, talus at the sixth fetal month, cuboid just before or just after birth, lateral cuneiform at 1 year, medial cuneiform at 2 years, intermediate cuneiform and navicular at 3 years.

The calcaneus is the only tarsal bone to have a secondary center: a thin plate of bone on the posterior surface, appearing at about 7 years and fusing during puberty.

The metatarsal bones and phalanges have primary centers for their shafts at the second to fourth fetal months, and one secondary center at the base of the first metatarsal and bases of all the phalanges but at the heads of the other metatarsals. These begin to ossify at 2 to 6 years and fuse at about 18 years.

All dates given are subject to considerable variation, and ossification tends to occur earlier in females.

- During the preparation of dried bones, the hyaline cartilage on articulating surfaces is lost, so that when rearticulating bones an exact fit is not possible. The thickness of the cartilage on joint surface is best appreciated in sections of bones, as on pp. 20, 21 and 100–112.
- The talus (2) is the uppermost foot bone, forming the ankle joint with the tibia and fibula. For details see pp. 58, 67.
- The calcaneus (1) is the most posterior and the largest foot bone, forming the heel. For details see pp. 68, 69.
- The navicular bone (3) lies in front of the talus, on the medial side of the foot. For details see p. 70.
- The cuboid bone (7) lies in front of the calcaneus, on the lateral side of the foot. For details see p. 70.
- The three cuneiform bones—medial, intermediate and lateral (4, 5 and 6)—lie in front of the navicular bone. For details see p. 71.
- The first, second and third metatarsal bones (8, 9 and 10) are in front of the three cuneiforms, and the fourth and fifth metatarsal bones (11 and 12) are in front of the cuboid bone. For details see pp. 72, 73.
- The phalanges (13–17) are the bones of the toes. Each proximal phalanx articulates with the head of a metatarsal bone. Each phalanx has a base (at the proximal end), body and head (at the distal end). The body is convex on the dorsal (upper) surface, and concave on the plantar surface. See pp. 48, 56.
Attachments of muscles and major ligaments to the bones of the left foot

1. Tendo calcaneus
2. Plantaris
3. Area for bursa
4. Extensor digitorum brevis
5. Calcaneocuboid part
6. Calcaneonavicular part
7. Fibularis (peroneus) brevis
8. Fibularis (peroneus) tertius
9. Fourth
10. Third
11. Second
12. First
13. Abductor hallucis
14. Extensor hallucis brevis
15. Extensor hallucis longus
16. Extensor digitorum longus and brevis
17. Extensor digitorum longus
18. First
19. Second
20. Third
21. Abductor digiti minimi
22. Flexor digitorum brevis
23. Quadratus plantae
24. Long plantar ligament
25. Plantar calcaneocuboid (short plantar) ligament
26. Plantar calcaneonavicular (spring) ligament
27. Tibialis posterior
28. Tibialis anterior
29. Flexor hallucis brevis
30. Flexor digiti minimi brevis
31. Adductor hallucis
32. Flexor hallucis longus
33. Flexor digitorum longus
34. Opponens digiti minimi (occasional part of 30)
35. Fibularis (peroneus) longus
**Sesamoid and accessory bones**

**Sesamoid bones**
The patella is by far the largest sesamoid bone in the lower limb, and its close association with tendons and a bony joint (the knee) gives a conceptual focus as to the function of sesamoid bones.

*In the foot:*
- They usually vary in shape and size but in general are ovoid and normally only a few millimeters in diameter (p. 50, B18).
- They are not always ossified but may consist of fibrous tissue or cartilage, or a combination of all three.
- They are usually found embedded in tendons at the point where the tendons angle acutely around bony surfaces to their point of insertion (p. 100, 16 and p. 101, 33).
- Sesamoids have articular cartilage on the surface which is in direct relationship to the bone that they are proximate to.

Although not proved, it is thought that sesamoid bones protect tendons from wear and, by their strategic position to joints, alter the angle of insertion of a tendon into bone and thus provides a greater mechanical advantage to the joint.

**Accessory bones**
Bones within the human body gradually begin to form during the early developmental phases of the fetus by the initial formation of central areas of ossification within the cartilaginous and membranous skeleton. These ossified areas continue to grow, unite and eventually form solid adult bones, some during late childhood and some as late as early adulthood.

On occasions, however, the centres of ossification fail to fuse completely, often at the ends of bones, and thus a separate (accessory or supernumerary) bone is formed.

The foot is a common place for accessory bones to form, and there are common sites for them to occur. It is important to be aware of their possible presence because on a radiographic image they can be easily mistaken for a fractured bone or ‘chip’.

**Common accessory bones in the foot are:**
- **Dorsum of foot**
  - Os intercuneiforme
  - Os talonaviculare dorsale
  - Os calcaneus secondarius
  - Os intermetatarsal I
- **Posterior part of foot**
  - Os trigonum
- **Lateral part of foot**
  - Os calcaneus secondarius
  - Os vesalianum pedis
- **Medial part of foot**
  - Os tibiae externum (Os naviculare accessorium)
  - Os sustentaculi
- **Plantar aspect (sole) of foot**
  - Pars peronea metatarsalis I
  - Os cuboides secondarius
Skeleton of the foot  Articulated bones of the left foot

A  From the medial side

B  From the lateral side
• When standing (as can be seen from the imprint of a wet foot on the floor or when viewed through a glass plate—see p. 45, F) the parts of the foot in contact with the ground are the heel, the lateral margin of the foot, the pads under the metatarsal heads and the pads under the distal part of the toes.
• The medial margin of the foot is not normally in contact with the ground because of the height of the medial longitudinal arch (see pp. 56 and 57). In flat foot the medial arch is lower with an increasingly large imprint on the medial side.
• The body weight when standing is borne by the tuberosity of the calcaneus and the heads of the metatarsals, especially the first (with the sesamoid bones underneath it) and the fifth. As the foot bends forward in walking the other metatarsal heads take increasingly more of the load. With further raising of the heel the toe pads become pressed to the ground and so take some of the weight off the metatarsals.
• Although the forearm and hand have many muscles similar in name and action to those of the leg and foot, their normal use in everyday life is different. In the upper limb the muscles work from above to produce intricate movements of the thumb and fingers in a free limb. In the lower limb the toes must be stabilized on the ground so that muscles can work from below to produce the propulsive movements of walking.
Skeleton of the foot

Bones of the left longitudinal arches, transverse tarsal joint and other joints

A Bones of the medial longitudinal arch, from above

B Bones of the lateral longitudinal arch, from the lateral side
- The bones of the medial longitudinal arch (A) are the calcaneus, talus, navicular, the three cuneiforms and the medial three metatarsal bones.
- The bones of the lateral longitudinal arch (B) are the calcaneus, cuboid and the two lateral metatarsal bones.
- The transverse arch is formed by the cuboid and cuneiform bones and the adjacent parts of the five metatarsals (those of each foot forming one half of the whole arch). At the level of the metatarsal heads the arched form is no longer present.
- The medial longitudinal arch is higher than the lateral.
- Although the shape of the individual bones determines the shapes of the arches, the maintenance of the arches in the stationary foot (standing in the normal upright position) depends largely on the ligaments in the sole (where they are larger and stronger than those on the dorsum). As soon as movement occurs the long tendons and small muscles of the sole assume importance in maintaining the curved forms.
- The many joints of the foot contribute to its function as a flexible lever, and the word arch suggests an architectural rigidity that does not exist.
- On the medial side the plantar calcaneonavicular ligament (spring ligament) is of particular importance in supporting the head of the talus, and other structures that help to maintain the medial arch include the plantar aponeurosis, flexor hallucis longus, tibialis anterior and posterior, and the medial parts of flexor digitorum longus and brevis.
- The transverse tarsal joint (midtarsal joint) is the collective name for two joints—the calcaneocuboid joint, and the talonavicular part of the talocalcaneonavicular joint.

1. Calcaneus
2. Talus
3. Navicular
4. Medial cuneiform
5. Intermediate cuneiform
6. Lateral cuneiform
7. First metatarsal
8. Second metatarsal
9. Third metatarsal
10. Phalanges of great toe
11. Phalanges of second toe
12. Phalanges of third toe
13. Cuboid
14. Fourth metatarsal
15. Fifth metatarsal
16. Phalanges of fourth toe
17. Phalanges of fifth toe
18. Talocalcaneal joint
19. Talonavicular part of talocalcaneonavicular joint
20. Cuneonavicular joint
21. Intercuneiform joints
22. Tarsometatarsal joints (cuneometatarsal and cuboideometatarsal)
23. Intermetatarsal joints
24. Metatarsophalangeal joints
25. Interphalangeal joints
26. Calcaneocuboid joint
27. Cuboideonaviclar joint
28. Cuneocuboid joint
Foot bones *Left talus*

A From above
(proximal) Posterior
Medial ← Lateral (left)
Anterior (distal)

B From below
(proximal) Posterior
Lateral (left) ← Medial
Anterior (distal)

C From the medial side
(dorsal) Superior
Posterior (proximal) ← Anterior (distal)
Inferior (plantar)

D From the lateral side
(dorsal) Superior
Anterior (distal) ← Posterior (proximal)
Inferior (plantar)
Foot

From the front

From behind

1 Head with articular surface for navicular
2 Neck
3 Trochlear surface of body, for inferior surface of tibia
4 Surface for medial malleolus
5 Medial tubercle
6 Groove for flexor hallucis longus tendon
7 Lateral tubercle
8 Surface for lateral malleolus
9 Anterior calcanean articular surface
10 Surface for plantar calcaneonavicular (spring) ligament
11 Middle calcanean articular surface
12 Sulcus tali
13 Posterior calcanean articular surface
14 Lateral process

Talus
- The uppermost foot bone, forming the ankle joint with the tibia and fibula.
- Formerly known as the astragalus.
- Articular facets on the upper surface and sides for the tibia and fibula, on the under surface for the calcaneus, and on the anterior surface (head) for the navicular.
- Unique among the foot bones in having no muscles attached to it.
Foot bones *Left talus and the lower ends of the tibia and fibula*

A The talus, tibia and fibula, articulated, from the front

B The tibia from the lateral side

C The fibula from the medial side
The talus, tibia and fibula, articulated, from behind

1. Anterior surface of tibia
2. Medial malleolus of fibula
3. Anterior border of tibia
4. Triangular subcutaneous area of fibula
5. Lateral malleolus of fibula
6. Trochlear surface of body of talus
7. Head of talus
8. Interosseous border of fibula
9. Fibular notch of tibia
10. Articular (lateral) surface of medial malleolus of tibia
11. Interosseous border of fibula
12. Surface for interosseous tibiofibularis ligament of fibula
13. Articular (medial) surface of lateral malleolus of tibia
14. Malleolar fossa of fibula
15. Posterior border of tibia
16. Posterior surface of tibia
17. Groove for flexor hallucis longus tendon
18. Groove for tibialis posterior tendon
19. Groove for fibularis (peroneus) brevis tendon
20. Inferior surface of tibia

The talus, tibia and fibula, articulated, from below

1. Anterior
2. Medial malleolus of fibula
3. Anterior border of tibia
4. Triangular subcutaneous area of fibula
5. Lateral malleolus of fibula
6. Trochlear surface of body of talus
7. Head of talus
8. Interosseous border of fibula
9. Fibular notch of tibia
10. Articular (lateral) surface of medial malleolus of tibia
11. Interosseous border of fibula
12. Surface for interosseous tibiofibularis ligament of fibula
13. Articular (medial) surface of lateral malleolus of tibia
14. Malleolar fossa of fibula
15. Posterior border of tibia
16. Posterior surface of tibia
17. Groove for flexor hallucis longus tendon
18. Groove for tibialis posterior tendon
19. Groove for fibularis (peroneus) brevis tendon
20. Inferior surface of tibia
Foot bones

Left talus and the lower ends of the tibia and fibula, with ligamentous attachments in the ankle region

A The talus, tibia and fibula, articulated, from the front

B The tibia from the lateral side

C The fibula from the medial side

(proximal) Superior

Medial ↔ Lateral (left)

Inferior (distal)
The attachment of the capsule of the ankle joint is indicated by the dashed line, and that of the talocalcaneonavicular joint is indicated by the dotted line.

E The tibia and fibula, articulated, from below

1 Medial (deltoid) ligament
2 Anterior tibiofibular ligament
3 Anterior talofibular ligament
4 Calcaneofibular ligament
5 Interosseous membrane
6 Interosseous tibiofibular ligament
7 Posterior tibiofibular ligament
8 Fibularis (peroneus) tertius
9 Flexor hallucis longus
10 Posterior talofibular ligament
11 Deep part of medial (deltoid) ligament

- The interosseous tibiofibular ligament (B and C, 6) is the main bond of union of the inferior tibiofibular joint.
Foot bones

Left talus and the lower ends of the tibia and fibula

A The talus and tibia, articulated, from the medial side

B The talus and tibia, disarticulated, from the medial side
**C** The talus, tibia and fibula, articulated, from the lateral side

1. Medial surface
2. Medial malleolus of tibia
3. Neck of talus
4. Head of talus
5. Surface for medial malleolus
6. Anterior surface of tibia
7. Triangular subcutaneous surface
8. Lateral malleolus of tibia
9. Surface for lateral malleolus

**D** The talus disarticulated from the tibia and fibula, from the lateral side

1. Medial surface
2. Medial malleolus of tibia
3. Neck of talus
4. Head of talus
5. Surface for medial malleolus
6. Triangular subcutaneous surface
7. Lateral malleolus of tibia
8. Surface for lateral malleolus
Foot bones

Left talus and the lower ends of the tibia and fibula, with ligamentous attachments in the ankle region

A The talus and tibia, articulated, from the medial side

B The talus and tibia, disarticulated, from the medial side
The attachment of the capsule of the ankle joint is indicated by the dashed line, and that of the talocalcaneonavicular joint is indicated by the dotted line.

C The talus, tibia and fibula, articulated, from the lateral side

1 Medial (deltoid) ligament
2 Deep part of medial (deltoid) ligament
3 Anterior tibiofibular ligament
4 Anterior talofibular ligament
5 Calcaneofibular ligament
6 Posterior tibiofibular ligament

D The talus disarticulated from the tibia and fibula, from the lateral side by the dotted line.
Foot bones *Left calcaneus*

1. Posterior surface
2. Dorsal surface
3. Posterior articular surface for talus
4. Sulcus calcanei
5. Sustentaculum tali
6. Middle articular surface for talus
7. Anterior articular surface for talus
8. Articular surface for cuboid
9. Fibular (peroneal) trochlea
10. Lateral process
11. Medial process
12. Plantar surface
13. Anterior tubercle
14. Groove for flexor hallucis longus tendon
15. Medial surface
16. Lateral surface
17. Tubercle for calcaneofibular ligament
18. Surface for bursa
19. Surface for tendo calcaneus
20. Surface for fibrofatty tissue
21. Medial
22. Lateral
23. Talocalcanean part of medial (deltoid) ligament
24. Interosseous talocalcanean ligament
25. Inferior extensor retinaculum
26. Cervical ligament
27. Extensor digitorum brevis
28. Calcaneocuboid part
29. Calcaneonavicular part of bifurcate ligament
The capsule of the talocalcanean joint is indicated by the dashed line, and that of the talocalcanean part of the talocalcaneonavicular joint is indicated by the dotted line.

**Calcaneus**
- The largest foot bone, forming the heel.
- Formerly known as the calcaneum or os calcis.
- Articular facets on the upper surface for the talus and on the anterior surface for the cuboid.
- Prominent sustentaculum tali projecting medially.
- When the talus and calcaneus are articulated, the sulcus tali (see p. 52, B12) and sulcus calcanei (4) form the tarsal sinus (sinus tarsi).
Foot bones

**Left navicular bone**

1. Dorsal surface
2. Proximal surface for talus
3. Distal surface for cuneiforms
4. Plantar surface
5. Tuberosity
6. Facet for medial cuneiform
7. Facet for intermediate cuneiform
8. Facet for lateral cuneiform

**Navicular bone**
- Formerly known as the scaphoid bone.
- Posterior articular facet for the talus; anterior articular facet for the three cuneiforms.

**Left cuboid bone**

9. Dorsal surface
10. Medial surface
11. Proximal surface for calcaneus
12. Lateral surface
13. Distal surface
14. Plantar surface
15. Groove for fibularis (peroneus) longus tendon
16. Tuberosity
17. Surface for lateral cuneiform
18. Surface for navicular
19. Facet for sesamoid bone in fibularis (peroneus) longus tendon
20. Facet for fifth metatarsal
21. Facet for fourth metatarsal

**Cuboid bone**
- Posterior articular facet for the calcaneus; anterior articular facet for the fourth and fifth metatarsals.
- Groove on the undersurface for the tendon of fibularis (peroneus) longus.
Articulated left cuneiform bones (medial, intermediate and lateral)

Left medial cuneiform bone

Cuneiform bones
- Medial (the largest), intermediate (the smallest) and lateral.
- Situated between the navicular and the first three metatarsals.

1. Medial surface
2. Distal surface for first metatarsal
3. Area for tendon of tibialis anterior
4. Proximal surface for navicular
5. Lateral surface
6. Surface for second metatarsal
7. Surface for intermediate cuneiform
8. Area for fibularis (peroneus) longus tendon
9. Medial surface
10. Surface for medial cuneiform
11. Distal surface for second metatarsal
12. Lateral surface
13. Surface for lateral cuneiform
14. Proximal surface for navicular
15. Medial surface
16. Surfaces for second metatarsal
17. Surface for intermediate cuneiform
18. Proximal surface for navicular
19. Lateral surface
20. Surface for cuboid
21. Surface for fourth metatarsal
22. Distal surface for third metatarsal

Left intermediate cuneiform bone

Left lateral cuneiform bone
Foot bones

The metatarsal bones are articulated with each other but have been disarticulated from the cuneiform and cuboid bones, which have been rotated to show the surfaces that articulate with the metatarsals. For orientation, see articulated foot (p. 50).

1 Surface of medial cuneiform for first metatarsal
2 Surface of intermediate cuneiform for second metatarsal
3 Surface of lateral cuneiform for third metatarsal
4 Surface of cuboid for fourth metatarsal
5 Surface of cuboid for fifth metatarsal

- The base of the third metatarsal articulates with the lateral cuneiform and the bases of the second and fourth metatarsals.
- The base of the fourth metatarsal articulates with the lateral cuneiform and the cuboid and the base of the fifth metatarsal.
- The base of the fifth metatarsal articulates with the cuboid and the base of the fourth metatarsal.
Metatarsal bones

- First to fifth, leading to each toe and each with a base (at the proximal or ankle end), body or shaft, and head (at the toe end). Bases of first three articulate with cuneiform bones; bases of fourth and fifth articulate with the cuboid. Heads articulate with bases of proximal phalanges.
- The second, third and fourth metatarsals are longer than the first and fifth; the first is the shortest and the thickest.
- The second metatarsal is the longest bone and its base is recessed between the medial and lateral cuneiforms as well as articulating with the intermediate cuneiform (forming a Keystone). Thus, the second metatarsal is the most rigid of the metatarsals.
- The cuneiforms and bases of the metatarsals are wedge shaped to help form a bony arch.

Refer to an articulated foot (p. 50) and note the following:

The base of the first metatarsal articulates with the medial cuneiform. There is normally a bursa but not a joint between the bases of the first and second metatarsals. The base of the second metatarsal articulates with all three cuneiforms and with the base of the third metatarsal. This second metatarsal base extends more proximally than the first and third bases—an interlocking device that prevents side-to-side movement.
Skin and superficial connective tissue have been removed to show the superficial vessels and nerves lying on the deep fascia (1). In A the medial side of the dorsal venous arch (14) joins the medial marginal vein of the foot to form the great saphenous vein (5), which runs up in front of the medial malleolus (7). The medial and lateral branches of the superficial fibular (peroneal) nerve (8 and 9) pass down on to the dorsum, supplemented on the medial side by the saphenous nerve (6) and on the lateral side by the sural nerve (18). The end of the deep fibular (peroneal) nerve (13) perforates the deep fascia to run to the first toe cleft.

1 Deep fascia
2 Tendon of tibialis anterior (under fascia)
3 Tendon of extensor digitorum longus (under fascia)
4 Medial surface of tibia (under fascia)
5 Great saphenous vein
6 Saphenous nerve
7 Medial malleolus
8 Medial branch of superficial fibular (peroneal) nerve
9 Lateral branch of superficial fibular (peroneal) nerve
10 Lateral malleolus
11 A perforating vein
12 Proper dorsal digital nerve of great toe
13 Medial terminal branch of deep fibular (peroneal) nerve
14 Dorsal venous arch
15 Dorsal digital nerve to second cleft
16 Dorsal digital nerve to third cleft
17 Dorsal digital nerve to fourth cleft
18 Sural nerve

- The skin of the first toe cleft is supplied by the deep fibular (peroneal) nerve (A13); the skin of the other clefts is supplied by the superficial fibular (peroneal) nerve (A8 and 9).
- The skin behind the ankle and at the back of the heel is supplied on the medial side by the saphenous nerve (A6, from the femoral nerve) and the medial calcaneal branches (B8) of the tibial nerve, and on the lateral side by the sural nerve (B2, also from the tibial nerve).
- The saphenous nerve (A6) on the medial side of the foot supplies skin as far forward as the metatarsophalangeal joint of the great toe.
- The sural nerve (A18) on the lateral side of the foot supplies skin as far forward as the side of the fifth toe.
- The skin of the medial side of the dorsum of the foot, including the region of the medial malleolus, is part of the fourth lumbar dermatome (Fig. 9, p. 153). The fifth lumbar dermatome includes the rest of the dorsum, and the first sacral dermatome includes the lateral side of the foot and the lateral malleolar region.
- The great saphenous vein (A5) passes upward in front of the medial malleolus (A7).
- The small saphenous vein (B3) passes upward behind the lateral malleolus (B11).
B  Superficial vessels and nerves of the left lower leg and foot, from behind

In B the most obvious structure is the tendo calcaneus (Achilles tendon, 6), running down to be attached to the back of the calcaneus (9). The small saphenous vein (3) and sural nerve (2) with their tributaries and branches are behind the lateral malleolus (11). On both sides but especially the medial, there are some typical perforating veins (5), piercing the deep fascia to form communications between the superficial and deep veins. The posterior arch vein (4) unites several of the perforators on the medial side.

1 Deep fascia
2 Sural nerve
3 Small saphenous vein
4 Posterior arch vein
5 A perforating vein
6 Tendo calcaneus (under fascia)
7 Medial malleolus
8 Medial calcanean nerve
9 Posterior surface of calcaneus
10 Fibrofatty tissue of heel
11 Lateral malleolus

C  Axial cross section of the left leg above the level of the upper part of B

The section in C is viewed from below, looking from the ankle toward the knee. Tibialis posterior (13) is the deepest of the calf muscles (immediately behind the interosseous membrane, 5) with the tibial nerve (19) behind it and the posterior tibial vessels (20) more medially, between flexor digitorum longus (21) and soleus (14). The fibular (peroneal) artery (12) is adjacent to flexor hallucis longus (11) behind the fibula (8). Note the (unlabeled) dilated veins within and deep to soleus (14); they are the site for potentially dangerous deep venous thrombosis. In the anterior compartment, in front of the interosseous membrane (5), the anterior tibial vessels (3) and deep fibular (peroneal) nerve (4) are between tibialis anterior (2) and extensor hallucis longus (6).

1 Tibia
2 Tibialis anterior
3 Anterior tibial vessels
4 Deep fibular (peroneal) nerve
5 Interosseous membrane
6 Extensor hallucis longus
7 Extensor digitorum longus
8 Fibula
9 Superficial fibular (peroneal) nerve
10 Fibularis (peroneus) longus and brevis
11 Flexor hallucis longus
12 Fibular (peroneal) artery
13 Tibialis posterior
14 Soleus
15 Gastrocnemius
16 Plantaris tendon
17 Sural nerve
18 Small saphenous vein
19 Tibial nerve
20 Posterior tibial vessels
21 Flexor digitorum longus
22 Saphenous nerve
23 Great saphenous vein
Lower leg and foot

This medial view emphasizes the position of the great saphenous vein (3) in front of the medial malleolus (5), with branches of the saphenous nerve (4) lying both in front of and behind the vein. There are perforating veins (9) behind the malleolus and joining the posterior arch vein (12) and a large medial calcanean branch (10) of the tibial nerve running down to the skin of the heel.

- In the specimen shown on pp. 74–77 some of the superficial veins are rather dilated and tortuous, but this has served to emphasize the posterior arch vein and perforating veins.
- The perforating veins (A9, B8) serve as communications between the superficial veins (above the deep fascia) and deep veins (below the fascia). Many of these communicating vessels possess valves that direct the flow of blood from superficial to deep; venous return from the limb is then brought about by the pumping action of the muscles (which are all below the deep fascia). If the valves become incompetent or the deep veins are blocked, pressure in the superficial veins increases and they become varicose (from the Latin for an enlarged and tortuous vessel).
- Perforating veins are variable in number and position but the most constant in the lower leg (A9) are near the posterior border of the tibia, one just below and one just above the medial malleolus (A5). The posterior arch vein (A12) unites these and perhaps other perforators and drains usually into the great saphenous vein below the knee.

1 Deep fascia
2 Medial surface of tibia
3 Great saphenous vein
4 Saphenous nerve
5 Medial malleolus
6 Dorsal venous arch
7 Proper dorsal digital nerve of great toe
8 Abductor hallucis (under fascia)
9 A perforating vein
10 Medial calcanean nerve
11 Tendo calcaneus (under fascia)
12 Posterior arch vein

Superficial vessels and nerves of the left lower leg and foot, from the medial side
The medial and lateral branches of the superficial fibular (peroneal) nerve (1 and 2) run on to the dorsum of the foot. Behind the lateral malleolus (7) are the small saphenous vein (5) and sural nerve (4). The tendon of fibularis (peroneus) longus (3) shines through the deep fascia above the malleolus.

- The superficial veins of the dorsum include dorsal digital and dorsal metatarsal veins, which join a dorsal venous arch (B12). The ends of the arch join medial and lateral marginal veins that run upward to become the great and small saphenous veins, respectively. (In A there is no obvious medial marginal vein, but there is a lateral marginal vein in B10.)
- The deep veins run with the deep arteries. The larger arteries in the leg are usually accompanied by a pair of veins (venae comitantes).
- Lymph vessels, resembling narrow, thin-walled veins, accompany many arteries and veins, both superficial and deep. There are no lymph nodes in the foot; most of the lymphatic drainage of the lower limb is to inguinal nodes, but some lymphatic vessels drain into six or seven nodes that lie in the fat of the popliteal fossa. (Occasionally there is a single node beside the upper end of the anterior tibial artery in front of the interosseous membrane.)
- For details of the lymphatic system of the lower limb see pp. 163–167.

1 Medial branch of superficial fibular (peroneal) nerve
2 Lateral branch
3 Deep fascia over fibularis (peroneus) longus tendon
4 Sural nerve
5 Small saphenous vein
6 Tendo calcaneus (under fascia)
7 Lateral malleolus
8 A perforating vein
9 Extensor digitorum brevis (under fascia)
10 Lateral marginal vein
11 Abductor digiti minimi (under fascia)
12 Dorsal venous arch

B Superficial vessels and nerves of the left lower leg and foot, from the lateral side
Deep fascia of the foot

Deep fascia of the right lower leg and foot, from the front and the right

1. Deep fascia of leg
2. Superior extensor retinaculum
3. Medial malleolus
4. Inferior extensor retinaculum
5. Tendon of tibialis anterior
6. Tendons of extensor digitorum longus
7. Tendon of extensor hallucis longus
8. Deep fascia of dorsum of foot
9. Extensor digitorum brevis
10. Abductor digiti minimi
11. Tendon of fibularis (peroneus) brevis
12. Inferior fibular (peroneal) retinaculum
13. Tendon of fibularis (peroneus) longus
14. Lateral malleolus
All superficial tissues, including vessels and nerves, have been removed to display the deep fascia. It is thickened in places to form the retinacula (2, 4—see notes), which keep tendons in their proper places; compare with the dissections on pp. 80–83 in which the fascia has been removed to leave only the retinacula. Here, with all the deep fascia intact, tendons and muscles can be seen shining through it.

- The retinacula of the ankle and foot are localized thickenings of deep fascia, which keep tendons in place.
- There are two extensor retinacula (superior and inferior), a flexor retinaculum and two fibular (peroneal) retinacula (superior and inferior).
- The superior extensor retinaculum (2) is a band about 4 cm broad and is attached to the lower ends of the anterior borders of the tibia and fibula (see pp. 80, A7 and 76, A12).
- The inferior extensor retinaculum (4) is shaped like a letter Y lying on its side (see pp. 80, A9; 82, A15; and 83, B13). The common stem of the Y is on the lateral side and is attached to the upper surface of the calcaneus in front of the sulcus calcanei. The tendons of extensor digitorum longus and fibularis (peroneus) tertius (with a common synovial sheath) pass beneath it. The upper band of the Y continues upward and medially from the common stem over the deep fibular (peroneal) nerve and anterior tibial vessels, then forms a loop to enclose the extensor hallucis longus tendon (within a synovial sheath), finally becoming attached to the medial malleolus after passing either superficial or deep to the tendon of tibialis anterior (within a synovial sheath). The lower band of the Y continues downward and medially from the common stem, passing over the terminal branches of the deep fibular (peroneal) nerve, the dorsalis pedis vessels and the tendons of extensor hallucis longus (within a synovial sheath) and tibialis anterior, to blend with the plantar aponeurosis overlying abductor hallucis.
- For the flexor retinaculum, see p. 82.
- For the fibular (peroneal) retinacula, see p. 83.
Dorsum and back of the foot

Most of the deep fascia has been removed, leaving only the retinacula (7 and 9). The most prominent structures are the long tendons of the extensor muscles (2, 3 and 4) running down from the leg; the synovial sheaths surrounding the tendons in this specimen (which is also shown on pp. 82 and 83) have been emphasized by blue tissue. Extensor digitorum brevis (13, with extensor hallucis brevis, 12—see notes) is the only muscle to arise on the dorsum of the foot.

- Extensor digitorum longus (4) has four tendons that pass to the second, third, fourth and fifth toes.
- Extensor digitorum brevis (13) has four tendons that pass to the great, second, third and fourth toes. The part of the muscle that serves the great toe is known as extensor hallucis brevis (12).
- The dorsal digital expansions (extensor expansions, 20) are derived from the tendons of extensor digitorum longus (4) as they pass over the metatarsophalangeal joints onto the dorsum of the proximal phalanges. They are each triangular in shape with the apex directed distally. On the second, third and fourth toes the basal angles of the expansions receive tendons from two interossei and one lumbrical muscle, and the central part of the base receives a tendon of extensor digitorum brevis (13). On the fifth toe one interosseus and one lumbrical tendon are attached. The central part of the apex is inserted into the base of the middle phalanx, while two collateral parts run farther forward to be inserted into the base of the distal phalanx (see p. 52, A16 and 17).
- The order of the structures that pass beneath the superior extensor retinaculum and in front of the ankle joint from the medial to the lateral side is: Tibialis anterior tendon (with a synovial sheath) (2) Extensor hallucis longus tendon (with no synovial sheath) (3) Anterior tibial artery and veins (hidden between Deep fibular (peroneal) nerve) 1 / 3 and 4 Extensor digitorum longus tendon (with no synovial sheath) (4) Fibularis (peroneus) tertius tendon (with no synovial sheath) (hidden by 4)
Superficial dissection of the back of the right lower leg and foot

Palpation of the dorsalis pedis pulse. The dorsalis pedis pulse can be felt on a line from midway between the malleoli (5 and 10) toward the first toe cleft.

Palpation of the posterior tibial pulse. The posterior tibial pulse can be felt behind the medial malleolus (10) and 2.5 cm in front of the Achilles tendon (4).

The deep fascia has been removed, leaving only the flexor and fibular (peroneal) retinacula (6, 7 and 9). The Achilles tendon (4) passes down to the back of the calcaneus (8). Flexor tendons (11, 12 and 15) lie behind the medial malleolus (10) and fibular (peroneal) tendons (1) behind the lateral malleolus (5).

1. Fibularis (peroneus) longus overlapping fibularis (peroneus) brevis
2. Soleus
3. Sural nerve
4. Tendo calcaneus (Achilles tendon)
5. Lateral malleolus
6. Superior fibular (peroneal) retinaculum
7. Inferior
8. Posterior surface of calcaneus
9. Flexor retinaculum
10. Medial malleolus
11. Tibialis posterior
12. Flexor digitorum longus
13. Posterior tibial artery and venae comitantes
14. Tibial nerve
15. Flexor hallucis longus
16. Medial calcanean nerve
17. Plantaris tendon

For the order of the structures behind the medial malleolus, see the notes on the flexor retinaculum on p. 82.
Dorsum and sides of the foot

The synovial sheaths of tendons have been emphasised by blue tissue. The deep fascia has been removed, leaving the flexor retinaculum (12), with part of the inferior extensor retinaculum (15) also visible in this view. The posterior tibial vessels (4) and the tibial nerve (5) lie between the tendons of flexor digitorum longus (3) in front and flexor hallucis longus (6) behind. The prominent muscle on the medial side of the sole is abductor hallucis (14).

Superficial dissection of the right lower leg and foot, from the medial side

1 Medial surface of tibia
2 Tibialis posterior
3 Flexor digitorum longus
4 Posterior tibial artery and venae comitantes
5 Tibial nerve
6 Flexor hallucis longus
7 Soleus
8 Plantaris tendon
9 Tendo calcaneus
10 Medial calcaneal nerve
11 Posterior surface of calcaneus
12 Flexor retinaculum
13 Medial malleolus
14 Abductor hallucis
15 Inferior extensor retinaculum
16 Tibialis anterior
17 Extensor hallucis longus
18 Medial process of tuberosity of calcaneus

- The flexor retinaculum (12) passes from the medial malleolus to the medial process of the tuberosity of the calcaneus (18).
- Deep to the retinaculum are four connective tissue compartments—three for tendons and one for neurovascular structures. The order of the structures behind the medial malleolus from before backwards is:
  - Tibialis posterior tendon (2, within a synovial sheath)
  - Flexor digitorum longus tendon (3, within a synovial sheath)
  - Posterior tibial artery and venae comitantes (4)
  - Tibial nerve (5)
  - Flexor hallucis longus tendon (6, within a synovial sheath).
The synovial sheaths of tendons have been emphasized by blue tissue. The two extensor retinacula (12 and 13) and the two fibular (peroneal) retinacula (14 and 15) have been preserved. The tendon of fibularis (peroneus) brevis (4) runs down to the fifth metatarsal, while that of fibularis (peroneus) longus (5) disappears to pass into the sole. Extensor digitorum brevis (16) forms a fleshy mass on the lateral side of the dorsum, and is crossed by the tendons of extensor digitorum longus (3) and fibularis (peroneus) tertius (17).

The superior fibular (peroneal) retinaculum (14) passes from the lateral malleolus (11) to the lateral surface of the calcaneus (9). Deep to the retinaculum are the tendons of fibularis (peroneus) brevis (4) and fibularis (peroneus) longus (5) (both within a single synovial sheath). The brevis tendon is in front of the longus tendon.

The inferior fibular (peroneal) retinaculum (15) continues backwards and downwards from the common stem of the inferior extensor retinaculum (13) to the lateral surface of the calcaneus (9), with an intermediate attachment to the fibular (peroneal) trochlea (see p. 68, B9). Deep to the retinaculum above and in front of the trochlea is the fibularis (peroneus) brevis tendon (4, within its own synovial sheath), while below and behind the trochlea is the fibularis (peroneus) longus tendon (5, within its own synovial sheath).
Deep nerves and vessels of the right foot, from the front and right

The retinacula and most of the extensor tendons have been removed. The anterior tibial artery (11) of the leg continues into the dorsum as the dorsalis pedis artery (14), accompanied by the deep fibular (peroneal) nerve (12 and 13). The lowest part of the anterior tibial artery gives off medial and lateral tarsal branches (24), and the dorsalis pedis gives off the arcuate artery (17) and the first dorsal metatarsal artery (15).
1. Tibialis anterior
2. Extensor hallucis longus
3. Extensor digitorum longus
4. Lateral branch of superficial fibular (peroneal) nerve
5. Fibularis (peroneus) brevis
6. Fibularis (peroneus) longus
7. Subcutaneous surface of fibula
8. Interosseous membrane
9. Lateral malleolar artery and venae comitantes
10. Perforating branch of fibular (peroneal) artery
11. Anterior tibial artery
12. Deep fibular (peroneal) nerve
13. Medial terminal branch of 12
14. Dorsalis pedis artery
15. First dorsal metatarsal artery
16. Deep plantar artery
17. Arcuate artery
18. Extensor digitorum brevis (hallucis brevis to great toe)
19. Dorsal digital expansion
20. Dorsal digital artery
21. Fourth dorsal interosseus
22. Abductor digiti minimi
23. Interosseous branch of 26
24. Lateral tarsal vessels
25. Nerve to extensor digitorum brevis
26. Lateral terminal branch of 12
27. Lateral malleolus
28. Lateral malleolar arterial rete
29. Anterior talofibular ligament

- As the anterior tibial artery (11) crosses the lower margin of the tibia at the ankle joint it becomes the dorsalis pedis artery (14).
- After giving off medial and lateral tarsal branches (24) the dorsalis pedis artery (14) ends by dividing into the first dorsal metatarsal and the arcuate arteries (15 and 17).
- The first dorsal metatarsal artery (15) gives off a deep plantar (perforating) branch (16) that passes into the sole between the two heads of the first dorsal interosseus muscle to complete the plantar arch with the deep part of the lateral plantar artery (see p. 93, B20).
- The arcuate artery (17) gives off the other three dorsal metatarsal arteries, and all the metatarsal arteries give dorsal digital branches.
- Sometimes the perforating branch of the fibular (peroneal) artery (10), which anastomoses with the lateral tarsal and arcuate arteries (24 and 17), is large and replaces the dorsalis pedis artery, which is absent in about 12% of feet.
- Theoretically each side of each toe has a dorsal digital artery and a plantar digital artery but the individual vessels soon become merged into an anastomotic network.
- For a summary of the branches of the dorsalis pedis artery, see p. 154.
Deep dissection of the dorsum

Joints beneath the talus of the left foot
The talus has been removed from the left foot and turned upside down to lie adjacent, so exposing the reciprocal joint surfaces. At the back the concave posterior articular surface of the talus (27) forms the talocalcanean joint with the convex posterior articular surface of the calcaneus (9). At the front are the various parts of the talocalcaneonavicular joint (see notes). The convex middle and anterior surfaces of the talus (28 and 29) articulate with the concave middle and anterior surfaces of the calcaneus (13 and 14), with part of the anterior surface of the talus (30) articulating with cartilage in the upper surface of the spring ligament (15). The convex head of the talus (31) articulates with the concave posterior surface of the navicular bone (17).

- Apart from the joints of the toes, the most important joints of the rest of the foot are those related to the talus.
- Above the talus is the ankle joint (properly known as the talocrural joint), between the trochlear surface of the talus and the lower ends of the tibia and fibula.
- Below the talus there are two separate joints. Toward the back is the talocalcanean joint (alternatively known as the subtalar joint—but see below), between the posterior articular surfaces of the lower part of the talus (27) and upper part of the calcaneus (9). In front is the talocalcaneonavicular joint, which is a two-part joint between the front of the head of the talus (31) and the navicular (17) (the talonavicular part of this joint), and the articulations of the undersurface of the talus (28–30) with the anterior and middle facets on the upper surface of the calcaneus (14 and 13) and the upper surface of the plantar calcaneonavicular (spring) ligament (15) (the talocalcanean part of this joint).
- Unfortunately there is some confusion of terminology, for clinicians frequently use ‘subtalar joint’ as a collective name for both joints beneath the talus, not just the posterior one.
Sole of the foot

*Plantar aponeurosis of the left foot*
Skin and subcutaneous tissue have been removed to show the thick central part of the plantar aponeurosis (9) and the thinner medial and lateral parts (10 and 11). The numerous strands and septa of fibrous tissue that attach the aponeurosis to the overlying tissues have not been removed to make a tidy dissection; they are an important part of the anatomy of the sole, binding adjacent tissues together.

• Nerve supplies in the sole include the following:
  Cutaneous: the medial plantar nerve supplies the medial part of the sole and the medial three and a half toes; the lateral plantar nerve supplies the lateral part of the sole and lateral one and a half toes.
  Muscular: the medial plantar nerve supplies abductor hallucis, flexor hallucis brevis, flexor digitorum brevis and the first lumbrical; the lateral plantar nerve supplies all the other small muscles of the sole.
  For details of nerve branches, see pp. 152 and 153.
• The skin under the heel and on the lateral part of the sole is part of the first sacral dermatome, with the fifth lumbar dermatome including the rest of the sole (Fig. 9, p. 153).
• The superficial surface of the plantar aponeurosis is not smooth as in most textbook drawings, but roughened by the attachment of numerous fibrous septa forming loculations that hold the fatty subcutaneous tissues and skin in place when weight-bearing. They are well shown toward the back and sides of the dissection illustrated here.
**Sole of the foot  First layer structures**

The plantar aponeurosis (2):
- Extends from the medial and lateral tubercles of the calcaneus
- Divides at the distal end and forms five slips at the front, one slip for each toe
- Fuses with the fibrous flexor sheaths and metatarsophalangeal joint capsules
- Helps to preserve the longitudinal arches of the foot

The medial plantar nerve (8):
- Supplies the medial part of the side of the foot and the medial three and a half toes

The lateral plantar nerve (5):
- Supplies the lateral part of the sole of foot and lateral one and a half toes

1. Medial process of tuberosity of calcaneus
2. Central part of plantar aponeurosis
3. Fibrous septi forming loculations
4. Flexor digitorum brevis
5. Lateral plantar nerve
6. Lateral plantar artery
7. Fourth common plantar digital nerve
8. Medial plantar nerve
9. Abductor hallucis
10. Flexor hallucis brevis
11. Flexor hallucis longus
12. First
13. Third
14. Fourth
15. Flexor digiti minimi brevis
16. Abductor digiti minimi
17. Proper plantar digital nerve of fifth toe
18. Superficial digital branch of medial plantar artery
19. Proper plantar digital nerve of great toe
20. Fibrous flexor sheath
21. Proper plantar digital nerves of first cleft
22. Superficial transverse metatarsal ligament
Lower leg and sole of foot

Deep medial structures and second layer from the right and slightly below

The **tendo calcaneus** (Achilles tendon) (18):
- Is the thickest tendon in the body and receives muscle fibres from both gastrocnemius and soleus
- Inserts into the middle of the back of the calcaneus
- May be tested for ankle jerk just above its insertion into the calcaneus
- Under excessive exertion is prone to tear (rupture) usually above its insertion into calcaneus, producing a palpable gap as fibres of the tendon ‘roll-up’ like a window roller blind

The **posterior tibial artery** (12):
- Can be palpated behind the medial malleolus of the tibia approximately 2.5 cm in front of the medial border of the tendo calcaneus (Achilles tendon) (18)

The **great saphenous vein** (14):
- Runs in front of the medial malleolus of the tibia

The **small saphenous vein**:
- Runs behind the lateral malleolus of the fibula
The plantar aponeurosis has been removed. The central muscle is flexor digitorum brevis (19), with abductor hallucis (21) on the medial side and abductor digiti minimi (16) on the lateral side. The most prominent tendon is that of flexor hallucis longus (23). Digital branches of the medial and lateral plantar nerves (1, 2, 10, 11 and 14) run forward toward the toes, and the deep branch of the lateral plantar nerve (17), which supplies many of the deeper muscles, curves deeply into the sole. See also Fig. 4, p. 150.

- The muscles of the sole are usually classified in four layers, as seen in progressively deep dissection:
  - **First layer**: abductor hallucis (A21), flexor digitorum brevis (A19) and abductor digiti minimi (A16).
  - **Second layer**: Quadratus plantae (B19) and the four lumbrical muscles (B7–10), with the tendons of flexor digitorum longus (B4) and flexor hallucis longus (B1).
  - **Third layer**: flexor hallucis brevis (p. 94, A8), adductor hallucis (p. 94, A6 and 7) and flexor digiti minimi brevis (p. 94, A14).
  - **Fourth layer**: three plantar and four dorsal interosseus muscles (p. 95, B5–11), with the tendons of tibialis posterior (p. 95, B27) and fibularis (peroneus) longus (p. 95, B24).

The successive layers do not completely obscure one another; for example, the third plantar and fourth dorsal interossei (A13 and 12) are seen as soon as the plantar aponeurosis has been removed. (The layers refer to layers of muscles; the plantar aponeurosis is not itself the first layer but overlies it.)

- It may be functionally more useful to classify the muscles into medial, lateral and intermediate groups:
  - **Medial group**, for the great toe: abductor hallucis, flexor hallucis brevis, adductor hallucis and the tendon of flexor hallucis longus
  - **Lateral group**, for the fifth toe: abductor digiti minimi and flexor digiti minimi brevis
  - **Intermediate group**, for the second to fifth toes: flexor digitorum brevis, quadratus plantae, the tendons of flexor digitorum longus and the interossei
**B** Second layer of muscles of the left sole

Flexor digitorum brevis has been removed (but the abductors of the great and little toes, 27 and 16, remain) to display quadratus plantae (19) joining flexor digitorum longus (4) as it divides into its four tendons, from which the lumbrical muscles arise (7–10). The deep branch of the lateral plantar nerve (18) curls round the lateral side of quadratus plantae (19) to reach the deeper part of the sole, and numerous other muscular and digital (cutaneous) branches of the medial and lateral plantar nerves (26 and 22) are visible. Synovial sheaths of flexor tendons have been emphasized by blue tissue. See also Fig. 5, p. 150.

- Although flexor hallucis longus (B1) passes to the great toe on the medial side of the foot, it arises from the fibula on the lateral side of the leg. The tendon crosses over in the sole, deep to flexor digitorum longus (B4, toward the back of the sole).
- The lateral and medial plantar nerves and vessels (B20, 22 and 26) pass between the first and second layers of muscles. The deep branch of the lateral plantar nerve (A17, B18) and the deep branch of the artery, which becomes the lateral plantar arch (B17), curl deeply round the lateral border of quadratus plantae (B19).

1 Flexor hallucis longus
2 Fibrous flexor sheath
3 Flexor digitorum brevis
4 Flexor digitorum longus
5 Proper plantar digital nerve of great toe
6 Flexor hallucis brevis
7 First lumbral
8 Second lumbral
9 Third lumbral
10 Fourth lumbral
11 Fourth plantar metatarsal artery
12 Fourth dorsal interosseus
13 Third plantar interosseus
14 Proper plantar digital nerve of fifth toe
15 Flexor digiti minimi brevis
16 Abductor digiti minimi
17 Plantar arch
18 Deep branch of lateral plantar nerve
19 Quadratus plantae
20 Lateral plantar artery
21 Nerve to abductor digiti minimi
22 Lateral plantar nerve
23 Fourth common plantar digital nerve
24 Nerve to quadratus plantae
25 Nerve to flexor digitorum brevis
26 Medial plantar artery overlying nerve
27 Abductor hallucis
28 Nerve to flexor hallucis brevis
29 First common plantar digital nerve
30 Nerve to first lumbral
Sole of the foot

A Third layer of muscles of the left sole

Most of the flexors and abductors have been removed, displaying the two heads of adductor hallucis (6 and 7), flexor hallucis brevis (8, which divides to pass to either side of the great toe), flexor digiti minimi brevis (14) and interossei (9–11). The deep branch of the lateral plantar nerve (17) is accompanied by the plantar arch (16) (from the lateral plantar artery, 19). See also Fig. 6, p. 151.

- For a summary of the medial and lateral plantar nerves, see p. 153.
- The third common plantar digital nerve (from the medial plantar nerve) frequently has a communicating branch with the (fourth) common plantar digital branch of the lateral plantar nerve, but it was not present in the specimens dissected here.
- Branches of the lateral plantar nerve (A20, B21) to various interosseus muscles (A9–11, B5–11) can be seen but have been left unlabeled.
- The plantar arch (B18) is the deep continuation of the lateral plantar artery (B20), which is the larger terminal branch of the posterior tibial artery. The arch is completed by anastomosis with the deep plantar (perforating) branch of the first dorsal metatarsal artery (see p. 84, 15). The arch gives off four plantar metatarsal arteries (as in B15 and 16), which divide to give plantar digital branches to the sides of adjacent toes. There are separate branches for the medial side of the great toe and lateral side of the fifth toe.
- The medial plantar artery (A24, B23), smaller than the lateral and subject to considerable variation, does not take part directly in the formation of the arch. It usually anastomoses with the plantar digital branch to the medial side of the great toe, and gives off superficial digital branches that anastomose with the first three plantar metatarsal arteries.

1 Flexor hallucis longus
2 Flexor digitorum longus
3 Flexor digitorum brevis
4 Fibrous flexor sheath
5 Long vinculum
6 Transverse head of adductor hallucis
7 Oblique head
8 Flexor hallucis brevis
9 Second plantar interosseus
10 Fourth dorsal interosseus
11 Third plantar interosseus
12 Fourth plantar metatarsal artery
13 Abductor digiti minimi
14 Flexor digiti minimi brevis
15 Nerve to flexor digiti minimi brevis
16 Plantar arch
17 Deep branch of lateral plantar nerve
18 Nerve to adductor hallucis
19 Lateral plantar artery
20 Lateral plantar nerve
21 Quadratus plantae
22 Medial plantar nerve
23 Abductor hallucis
24 Medial plantar artery
25 Nerve to abductor hallucis
26 Tuberosity of navicular
27 Tibialis anterior
Fourth layer of muscles of the left sole

Most of the smaller muscles have been removed, leaving only the three plantar interossei (7, 9 and 11) and the four dorsal interossei (5, 6, 8 and 10). The tendon of tibialis posterior (27) passes mainly to the tuberosity of the navicular (26), and the tendon of fibularis (peroneus) longus (24) crosses the sole obliquely from the lateral to the medial side. The end of the synovial sheath of flexor hallucis longus (1) has been emphasized by blue tissue. See also Fig. 7, p. 151.

- Viewed from the sole, both plantar and dorsal interossei (B5–11) are visible; they lie side by side, not (as might be expected from their names) with the plantar group completely overlying and obscuring the dorsal. (But, on the dorsum only dorsal interossei are seen between the metatarsals—as on p. 80, A15–18.)

The plantar interossei adduct toes and the dorsal interossei abduct them at the metatarsophalangeal joints, the reference line or axis for these movements being the line of the second toe. The mnemonics PAD and DAB are the usual aids to recalling which group does what.

The great toe and the fifth toe each have their own abductor muscle; the great toe also has its own adductor to draw it nearer the second toe. It follows that there must be a plantar interosseus for each of the third, fourth and fifth toes so that they can be adducted toward the axial line. The second toe has no plantar interosseus, but it has two dorsal interossei, one on each side so that it can be abducted to either side of its own neutral position. The third and fourth toes both have one of each interosseus.

- For other and probably more important actions of the interossei, see p. 107.
- For a summary of the medial and lateral plantar arteries, see p. 169.

1 Flexor hallucis longus
2 Fibrous flexor sheath
3 Flexor digitorum longus
4 Flexor digitorum brevis
5 First dorsal
6 Second dorsal
7 First plantar
8 Third dorsal
9 Second plantar
10 Fourth dorsal
11 Third plantar
12 Flexor digiti minimi brevis
13 Abductor digiti minimi
14 First plantar metatarsal artery
15 Second plantar metatarsal artery
16 Third plantar metatarsal artery
17 Fourth plantar metatarsal artery
18 Plantar arch
19 Deep branch of lateral plantar nerve
20 Lateral plantar artery
21 Lateral plantar nerve
22 Medial plantar artery
23 Medial plantar nerve
24 Fibularis (peroneus) longus
25 Tibialis anterior
26 Tuberosity of navicular
27 Tibialis posterior
28 Abductor hallucis
29 Quadratus plantae
Ligaments of the foot

From the right and above

A

From the lateral side

B

1. Tibia
2. Medial malleolus
3. Medial (deltoid) ligament of ankle joint
4. Anterior tibiofibular ligament
5. Lateral malleolus
6. Calcaneus
7. Anterior talofibular ligament
8. Trochlear surface of talus (ankle joint capsule removed)
9. Head of talus (under capsule of talonavicular part of talocalcaneonavicular joint)
10. Cervical ligament
11. Calcaneocuboid joint
12. Dorsal calcaneocuboid ligament
13. Calcaneocuboid part of bifurcate ligament
14. Calcaneonavicular part of bifurcate ligament
15. Dorsal cuneonavicular ligaments
16. Dorsal tarsometatarsal ligaments
17. Dorsal metatarsal ligaments
18. Tuberosity of base of fifth metatarsal
19. Capsule of first metatarsophalangeal joint
20. Tendon of extensor hallucis longus
21. Collateral ligament
22. Calcaneofibular ligament
23. Long plantar ligament
24. Tendon of fibularis (peroneus) longus
25. Interosseous membrane
26. Posterior tibiofibular ligament
27. Tibial slip of 28
28. Posterior talofibular ligament
29. Groove for flexor hallucis longus tendon on talus and sustentaculum tali
30. Posterior tibiotalar part
31. Tibiocalcanean part (deltoid) of medial deltoid ligament
32. Groove for tibialis posterior tendon
33. Groove for fibularis (peroneus) brevis tendon
In A the foot is plantarflexed, showing part of the trochlear (superior articular) surface of the talus (8), with the front of the deltoid ligament (3) on the medial side and the anterior tibiofibular ligament (4) on the lateral side. The cervical ligament (10) passes upward and medially from the upper surface of the calcaneus to the undersurface of the talus, and in front of it are the two parts of the bifurcate ligament (13 and 14) with a small dorsal calcaneocuboid ligament (12) more laterally. Other dorsal ligaments (15, 16 and 17) connect adjacent bones.

In B the anterior talofibular ligament (7) and calcaneofibular ligament (22) are seen, with some of the smaller dorsal ligaments (12–17), and so is the posterior part of the long plantar ligament (23) in the sole.

In C the posterior talofibular ligament (28) runs transversely (so it is not seen in the lateral view in B); it has a tibial slip (27), which merges with the inferior transverse ligament, the name given to the lower part of the posterior tibiofibular ligament (26).

- On the medial side of the ankle joint there is a single medial (deltoid) ligament (A3) (although it has several parts, as on p. 98, A2–5), but on the lateral side there is no single lateral ligament but three separate ligaments: the anterior and posterior talofibular ligaments (A7 and B7, C28) and the calcaneofibular ligament (B22 and C22).
Ligaments of the foot

On the medial side of the ankle the various parts of the medial (deltoid) ligament (2–5) merge with one another. The tendon of tibialis posterior (7) is mainly attached to the tuberosity of the navicular (8), while that of tibialis anterior (13) runs to the medial cuneiform and the base of the first metatarsal.

1 Medial malleolus
2 Posterior tibiotalar part
3 Tibiocalcanean part
4 Anterior tibiotalar part
5 Tibionavicular part
6 Sustentaculum tali
7 Tibialis posterior
8 Tuberosity of navicular
9 Long plantar ligament
10 Dorsal cuneonavicular ligament
11 Talonavicular ligament
12 Dorsal ligaments of first tarsometatarsal joint
13 Tibialis anterior
14 Capsule
15 Collateral ligament of first metatarsophalangeal joint
16 Sesamoid bone
17 Flexor hallucis longus
18 Collateral ligament of interphalangeal joint
19 Extensor hallucis longus
Part of the long plantar ligament (9) has been cut away to show the tendon of fibularis (peroneus) longus (10) lying in the groove on the cuboid. Medial to the posterior part of the long plantar ligament is the short plantar (plantar calcaneocuboid) ligament (17), and medial to that is the spring (plantar calcaneonavicular) ligament (18). At the anterior part of the foot the deep transverse metatarsal ligaments (4) keep the heads of the metatarsals and the bases of the toes from spreading apart.

- The medial sides of the medial cuneiform and the base of the first metatarsal receive the attachment of the tibialis anterior tendon (A13); the lateral sides of the same two bones receive the attachment of the fibularis (peroneus) longus tendon (B10).
- The plantar calcaneocuboid ligament (B17), commonly called the short plantar ligament, is largely under cover of the long plantar ligament (B9), which with the groove on the cuboid bone forms an osseofibrous tunnel for the fibularis (peroneus) longus tendon (B10).
- The plantar calcaneonavicular ligament (B18), passing from the sustentaculum tali of the calcaneus to the navicular and commonly called the spring ligament although it is not elastic, is an important support for the head of the talus in the talocalcaneonavicular joint (p. 87, 15).
Sections of the foot  
Sagittal sections of the right foot

In A the section passes through the metatarsal and phalanges of the great toe (12, 14 and 15) and the sustentaculum tali of the calcaneus (7); the section is too far medial to show any other part of the calcaneus. The plantar calcaneonavicular (spring) ligament (8) stretches between the sustentaculum tali (7) and the navicular (9), with the tendons of tibialis posterior (2) and flexor digitorum longus (3) giving support below the ligament. The bulky muscle below the sustentaculum tali is abductor hallucis (19). Note one of the sesamoid bones (16) beneath the head of the first metatarsal (12).

A  
Through the medial part of the talus, sustentaculum tali of the calcaneus and the great toe, from the lateral side

1  Tibia  
2  Tibialis posterior  
3  Flexor digitorum longus  
4  Tibial nerve  
5  Flexor hallucis longus  
6  Talus  
7  Sustentaculum tali  
8  Plantar calcaneonavicular (spring) ligament  
9  Navicular  
10  Tibialis anterior  
11  Medial cuneiform  
12  First metatarsal  
13  Extensor hallucis longus  
14  Proximal phalanx  
15  Distal phalanx  
16  Sesamoid bone  
17  Flexor hallucis brevis  
18  Proper plantar digital nerve of great toe  
19  Abductor hallucis  
20  Medial plantar nerve and vessels
In B the section again passes through the bones of the great toe but more laterally, showing the two joints beneath the talus—the talocalcanean part of the talocalcaneonavicular joint (27) and the talocalcanean joint (24)—with the interosseous talocalcanean ligament (25) in between. The lowest part of the calcaneus is the medial process of the tuberosity (38). Note the bursa (39) between the Achilles tendon and the upper part of the calcaneus, and the additional sesamoid bone (33) under the head of the first phalanx of the great toe.

• For further details of the great toe, see p. 112.
Sections of the foot  *Sagittal sections of the right foot*

In A in the sagittal plane through the second metatarsal (22), small parts of the cuboid and medial cuneiform (17 and 19) lie underneath parts of the navicular and intermediate cuneiform (16 and 18). This is because of the shapes of the bones that form the transverse arch of the foot; compare with the view from below of the bones of the articulated foot on p. 50, B. The thick plantar aponeurosis (34) overlies flexor digitorum brevis (33) with, toward the back, part of abductor digiti minimi (37), whose origin extends unexpectedly far medially.

**A Through the second toe, from the lateral side**

1. Tibialis anterior
2. Extensor hallucis longus
3. Tibia
4. Tibialis posterior
5. Flexor hallucis longus
6. Tendo calcaneus
7. Ankle joint
8. Talus
9. Lateral tubercle of talus
10. Talocalcanean joint
11. Calcaneus
12. Interosseous talocalcanean ligament
13. Talocalcanean part of talocalcaneonavicular joint
14. Plantar calcaneonavicular (spring) ligament
15. Talonavicular part of talocalcaneonavicular joint
16. Navicular
17. Cuboid
18. Intermediate cuneiform
19. Medial cuneiform
20. Extensor digitorum brevis
In B through the sagittal plane of the fifth metatarsal (47), the tendon of fibularis (peroneus) longus (42) is seen coursing obliquely under the cuboid (17); compare with 10 on p. 98.

21 Extensor digitorum longus tendon to second toe
22 Second metatarsal
23 Proximal
24 Middle
25 Distal
26 Transverse head of adductor hallucis
27 Oblique head
28 Plantar arch
29 Second lumbral overlying flexor digitorum longus tendon to second toe
30 Flexor digitorum longus tendon to third toe
31 Flexor digitorum brevis tendon to second toe
32 Second common plantar digital nerve
33 Flexor digitorum brevis
34 Plantar aponeurosis
35 Lateral plantar nerve and vessels
36 Quadratus plantae
37 Abductor digiti minimi
38 Medial process of tuberosity of calcaneus
39 Bursa
40 Lateral branch of superficial fibular (peroneal) nerve
41 Fibula
42 Fibularis (peroneus) longus
43 Fibularis (peroneus) brevis
44 Lateral process of tuberosity of calcaneus
45 Calcaneocuboid joint
46 Cuboideometatarsal joint
47 Fifth metatarsal
48 Flexor digiti minimi brevis
49 Metatarsophalangeal joint of fifth toe

B Through the fifth toe, from the medial side
Sections of the foot

Axial sections and images of the right lower leg and foot

A Axial section 6 cm above the ankle joint
B Axial section through the ankle joint
C Oblique section 5 cm below the ankle joint
Above the ankle in A, fibularis (peroneus) brevis (20) is behind the fibula (19) with the tendon of fibularis (peroneus) longus (21) lying laterally, but at the lower levels in B and C the tendon of fibularis (peroneus) longus (21) is behind that of fibularis (peroneus) brevis (20). The lowest part of flexor hallucis longus (4) is seen arising from the fibula (19).

At the level of the medial malleolus (24) in B, the tendon of tibialis posterior (8) lies adjacent to the bone, with the tendon of flexor digitorum longus (7) immediately behind it. The posterior tibial vessels (6) and the tibial nerve (5) intervene between the flexor digitorum tendon (7) and the tendon of flexor hallucis longus (4). At the front of the medial malleolus (24) in B, note the great saphenous vein (10), and in front of the talus (25) the dorsalis pedis artery (26) and deep fibular (peroneal) nerve (13) lie between the tendons of extensor hallucis longus (15) and extensor digitorum longus (16).

In the oblique section in C, the cuboid (47) lies in front of the calcaneus (30), and at a lower level the tendon of fibularis (peroneus) longus (21) will pass underneath the cuboid. On the medial side behind the medial cuneiform (37), the very tip of the tuberosity of the navicular (36) receives the main attachment of tibialis posterior. The tendons of flexor hallucis longus (4) and flexor digitorum longus (7) are more laterally placed.

The sections A, B and C are viewed from above, looking from the knee toward the ankle.

1 Tendo calcaneus
2 Plantaris
3 A tributary of great saphenous vein
4 Flexor hallucis longus
5 Tibial nerve
6 Posterior tibial vessels
7 Flexor digitorum longus
8 Tibialis posterior
9 Saphenous nerve
10 Great saphenous vein
11 Tibia
12 Tibialis anterior
13 Deep fibular (peroneal) nerve
14 Anterior tibial vessels
15 Extensor hallucis longus
16 Extensor digitorum longus
17 Superficial fibular (peroneal) nerve
18 Fibular (peroneal) vessels
19 Fibula
20 Fibularis (peroneus) brevis
21 Fibularis (peroneus) longus
22 Small saphenous vein
23 Sural nerve
24 Medial malleolus
25 Talus
26 Dorsalis pedis artery
27 Anterior talofibular ligament
28 Lateral malleolus
29 Posterior talofibular ligament
30 Calcaneus
31 Quadratus plantae
32 Lateral plantar nerve and vessels
33 Abductor hallucis
34 Medial calcanean nerve
35 Medial plantar nerve and vessels
36 Tip of tuberosity of navicular and tibialis posterior
37 Medial
38 Intermediate \( \text{cuneiform} \)
39 Lateral
40 First
41 Second \( \text{metatarsal base} \)
42 Third
43 Fourth
44 First dorsal interosseus
45 Deep plantar artery
46 Extensor digitorum brevis
47 Cuboid
48 Abductor digiti minimi
49 Ankle joint
Sections of the foot

*Coronal sections of the left ankle joint and foot (in plantarflexion)*

**A** Through the posterior part of the talus, from behind

**B** About 1 cm in front of A, through the talocalcanean part of the talocalcaneonaviculcral joint, from behind
These coronal sections through the ankle joint (5) emphasize how the talus (6) is gripped between the two malleoli (27 and 4). In A the interosseous talocalcanean ligament (25) lies between the talus (6) and calcaneus (24), while in B the section has passed through the part of the sustentaculum tali (10), which forms the talocalcanean part of the talocalcaneonavicular joint (29). In the center of the sole in both sections, flexor digitorum brevis (17) overlies quadratus plantae (16); the fusion of plantae with the tendon of flexor digitorum longus (14) is shown in B, where the tendon of flexor hallucis longus (15) has come to lie deep to the digitorum tendon (compare with the dissection B on p. 93 and the section B on p. 110).

- Joints, muscles and movements:
  - At the ankle joint
    - Dorsiflexion: tibialis anterior, extensor hallucis longus, extensor digitorum longus and fibularis (peroneus) tertius
    - Plantarflexion: gastrocnemius, soleus, plantaris, tibialis posterior, flexor hallucis longus and flexor digitorum longus
  - At the talocalcanean and talocalcaneonavicular joints
    - Inversion: tibialis anterior and tibialis posterior
    - Eversion: fibularis (peroneus) longus, fibularis (peroneus) brevis and fibularis (peroneus) tertius
  - At the other small joints of the foot there are minor degrees of gliding or rotatory movements. At the transverse tarsal joint (p. 57) a small amount of inversion and eversion occurs, but by far the greater part of these important movements takes place at the two joints beneath the talus. To visualize inversion and eversion, imagine the talus held firmly between the tibia and fibula, and the whole of the rest of the foot swivelling inwards or outwards underneath the talus. These movements do not take place at the ankle joint, which essentially only allows dorsiflexion and plantarflexion.
  - The actions of muscles on the toes are indicated by their names, but the part played by the interossei and lumbricals requires some explanation (apart from the abduction and adduction produced by the interossei and referred to on p. 95). Briefly the interossei and lumbricals work together to flex the metatarsophalangeal joints and extend the interphalangeal joints; these apparently contradictory actions on different joints by the same muscles can be explained as follows.
  - The interossei (both plantar and dorsal) are attached mainly to the sides of the proximal phalanges but also into the dorsal digital expansions; the lumbricals are usually attached entirely to the expansions. Because of the position of these attachments in relation to the axis of movement of the metatarsophalangeal joints, the interossei and lumbricals plantarflex these joints.
  - Because the lumbrical attachments and parts of the interosseous attachments are to the basal angles of the expansions, the line of pull is transmitted to the dorsal surfaces of the toes distal to the metatarsophalangeal joints, and so the interphalangeal joints are extended.
  - In most feet the interosseous attachment to the expansion is minimal, and it is the lumbricals that are mainly responsible for assisting the long and short extensor tendons in extending the toes, keeping them straight and stabilized against the pull of the flexors, which tend to make them buckle, especially during the push-off phase of walking when flexor hallucis longus and flexor digitorum longus are contracting strongly.
Sections of the foot  *Oblique axial sections of the left foot*

The plane of section is shown in the small illustration. The surfaces A and B have been separated and are viewed like two pages in an open book.

Between the tarsal bones in A, the various joint cavities, outlined in black and numbered with Roman figures, are explained in the notes below.

In B the navicular (9) is seen between the talus (2) and the three cuneiforms (10–12). Note how the base of the second metatarsal (15) projects more proximally than the bases of the first and third metatarsals (14 and 16). On the lateral side the cuboid (13) articulates at the back with the very small part of the calcaneus (8) seen in this section, and at the front with the bases of the fourth and fifth metatarsals (17 and 18). Parts of all the interosseus muscles (four dorsal and three plantar, 20–26) are identified in the forefoot.

1. Ankle joint
2. Talus
3. Fibularis (*peroneus*) brevis
4. Fibularis (*peroneus*) longus
5. Interosseous talocalcanean ligament
6. Extensor digitorum brevis
7. Cervical ligament
8. Calcaneus
9. Navicular
10. Medial
11. Intermediate cuneiform
12. Lateral cuneiform
13. Cuboid
14. First metatarsal base
15. Second metatarsal base
16. Third metatarsal base
17. Fourth metatarsal base
18. Fifth metatarsal base
19. Deep plantar branch of first dorsal metatarsal artery
20. First dorsal interosseus
21. Second dorsal interosseus
22. First plantar interosseus
23. Third plantar interosseus
24. Second plantar interosseus
25. Fourth plantar interosseus
26. Third plantar interosseus
27. Flexor digiti minimi brevis
28. Abductor digiti minimi
29. Head of second metatarsal
30. Head of third metatarsal
31. Inferior extensor retinaculum

- The cavities of a number of synovial joints in the foot are continuous with one another to the extent that there are normally six synovial cavities associated with the tarsal bones:
  - I. The talocalcanean joint cavity
  - II. The talocalcaneonavicular joint cavity
  - III. The calcaneocuboid joint cavity
  - IV. The cuboideonavicular and cuneometatarsal joint cavity
  - V. The cuneonavicular and cuneometatarsal joint cavity
  - VI. The medial cuneometatarsal joint cavity
- Parts of all the above cavities can be seen in the foot sectioned here; they are indicated by the black lines in A and numbered as above. (The cuboideonavicular joint is usually a fibrous union, but in this specimen it is synovial and continuous with the cuneonavicular joint cavity.)
Sections of the foot  

Coronal sections of the tarsus of the right foot

Both sections are viewed from behind, looking from the heel toward the toes.

In A the section has passed through the talonavicular joint, so displaying the posterior (proximal) surface of the navicular (7). A small part of the cuboid (8) has been sliced off, leaving cartilage on the more lateral part of its posterior (calcanean) surface. The plantar aponeurosis (14) overlies flexor digitorum brevis (15), with abductor hallucis (21) on the medial side and abductor digiti minimi (12) laterally. Quadratus plantae (16) lies centrally, with the tendons of flexor hallucis longus (18) and flexor digitorum longus (19) more medially placed at this level.

In B at the level of the posterior (navicular) surfaces of the cuneiform bones, the tendon of flexor hallucis longus (18) is now passing deep to the digitorum tendon (19). The tendon of fibularis (peroneus) longus (11) is turning laterally under the cuboid (27), where a little more distally it will become covered by the long plantar ligament (29) (compare with the dissection on p. 99).

1  Tibialis anterior
2  Extensor hallucis longus
3  Dorsalis pedis artery
4  Deep fibular (peroneal) nerve
5  Extensor digitorum longus
6  Extensor digitorum brevis
7  Posterior articular surface of navicular (for talus)
8  Posterior articular surface of cuboid (for calcaneus)
9  Anterior tip of calcaneus
10 Fibularis (peroneus) brevis
11 Fibularis (peroneus) longus
12 Abductor digiti minimi
13 Lateral plantar nerve and vessels
14 Plantar aponeurosis
15 Flexor digitorum brevis
16 Quadratus plantae
17 Plantar calcaneocuboid (short plantar) ligament
18 Flexor hallucis longus
19 Flexor digitorum longus
20 Medial plantar nerve and vessels
21 Abductor hallucis
22 Tibialis posterior
23 Plantar calcaneonavicular (spring) ligament
24 Medial
25 Intermediate cuneiform
26 Lateral
27 Cuboid
28 Tuberosity of fifth metatarsal
29 Long plantar ligament
Coronal sections of the right metatarsus

Both sections are viewed from behind, looking toward the toes. The metatarsals are numbered in Roman figures. On the dorsum the tendons of extensor digitorum longus to the appropriate toes are numbered L2–L5, and those of extensor digitorum brevis B2–B4 (recall that the brevis tendon to the great toe is named extensor hallucis brevis, 2). Similarly in the sole the flexor digitorum longus tendons are numbered L2–L5, with the lumbral muscles that arise from those tendons numbered U1–U4. The various interosseus muscles between and below the metatarsals have not been labeled.

In B note the sesamoid bones (18) under the head of the first metatarsal (I), with the tendon of flexor hallucis longus (8) between them.

A Through the middle of the metatarsal shafts

B Through the heads of the first and fifth metatarsals
Great toe *The dorsum, nail and sections of the great toe*
A  Dorsum of the right great toe
B  Nail
C  Nail bed of the left great toe
D  Sagittal section of the right great toe, from the lateral side
E  Coronal section of the distal phalanx of the right great toe

1  Nail wall
2  Nail fold
3  Eponychium
4  Lunule
5  Body
6  Free border of nail
7  Occult border of nail
8  Root
9  Germinal matrix of nail bed
10  Sterile matrix of nail bed
11  Head of first metatarsal
12  Capsule of metatarsophalangeal joint
13  Attachment of extensor hallucis brevis
14  Proximal phalanx
15  Capsule of interphalangeal joint
16  Attachment of extensor hallucis longus
17  Distal phalanx
18  Septa of pulp space
19  Attachment of flexor hallucis longus
20  Plantar ligament of interphalangeal joint
21  Flexor hallucis longus
22  Sesamoid bone
# Imaging of the lower limb

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Lumbar spine *Plain radiographic and CT anatomy*

1. Body of L1 vertebra
2. 12th rib
3. Pedicle of L2 vertebra
4. Inferior endplate of L3 vertebra
5. Superior endplate of L4 vertebra
6. Inferior articular process of L3 vertebra
7. Facet joint between L3 and L4 vertebrae
8. Superior articular process of L4 vertebra
9. Pars interarticularis
10. Neural foramen between L4 and L5 vertebrae
11. Wing of ilium
12. Body of S1 vertebra
13. Spinous process of L3 vertebra
14. Intervertebral disc space
15. Sacral ala
16. Second sacral neural foramen
17. Sacroiliac joint
18. Spinous process of S1
19. Transverse process of L4 vertebra
20. Sacral crest
21. Coccyx

Lateral (A) and anteroposterior (B) plain radiographs

Lateral (C) and anteroposterior (D) volume-rendered CT images
Lumbar spine  MRI anatomy—sagittal

- The typical appearances of normal plain radiographic anatomy result from the superimposition of structures in both the lateral (A) and frontal (B) projections. The characteristic “owl’s face” appearance of vertebrae on the frontal view (B) is accounted for by the “eyes” being formed by the pedicles (B3), and “beak” by the spinous process (B13); disruption of this normal appearance may be seen in disease, such as following tumour metastasis to the spine and in cases of trauma.

- (C) and (D) represent VRT (“Volume Rendered Technique”) images acquired following computer-aided post-processing of Computed Tomographic (CT) data, a technique using X-rays. VRT images enable the selective visualization of bones and soft tissues which may subsequently be manipulated in three dimensions, an invaluable tool to the radiologist and surgeon. Virtual dissection, in which selected parts of anatomy are removed from images and which was used to obtain the images shown, can also be used to facilitate examination of inaccessible structures in three dimensions.

- Magnetic resonance imaging (MRI) provides detailed information on the soft tissues and bone marrow via the use of radio waves and strong magnetic fields, which may be manipulated in a variety of ways to selectively examine different tissue types. (D) demonstrates a “T2 weighted” image in which fluid, such as cerebrospinal fluid and that within the nucleus pulposus of intervertebral discs, appears bright (“high signal”). In “T1 weighted” images such as (E) fluid appears dark, while fat—such as that in the epidural space—is bright. Normal fat conversion of bone marrow occurs during ageing and is seen to manifest as relatively high signal within the vertebral bodies.
Axial MR imaging of the spine, such as shown in images A–C, is invaluable in the assessment of intervertebral disc disease; herniation of disc material from the nucleus pulposus through the annulus fibrosus may compress the spinal cord (if occurring above the level of the cauda equina) or nerve roots either within the spinal canal or neural exit foramina.
Imaging of the lower limb

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Pelvis  Plain radiographic anatomy

- Among others, Julius Wolff (1836–1902), a German surgeon and anatomist, described the process by which organization of bone occurs in response to the stresses placed upon it as a result of gravity and dynamic forces—subsequently known as "Wolff's Law". This may be clearly seen in the organization and distribution of trabeculae (cancellous bone), a relatively lightweight form of bone that has a high surface area to mass ratio and that plays a key role in bone strength.

- Trabeculae can be seen to organize themselves in distinct patterns, which are well illustrated in the proximal femur (E). Classically, five groups of trabeculae (E4-8) can be reliably identified as a result of the compressive and tensile forces placed upon them. Long periods of inactivity (e.g. bed rest, spaceflight), in addition to age-related loss of bone mass (osteopaenia, osteoporosis), may result in weakening of trabeculae with resultant "insufficiency fractures". The femoral neck, as well as sacrum, pelvic bones and vertebral bodies, are commonly involved and such fractures are a major source of morbidity.
**Pelvis  Male and female pelvis, sacrum**

- Sex differences in the anatomy of the male and pelvis can be readily identified, although due to variation in the female pelvis (of which at least four types can be described—gynaecoid (50%), anthropoid (25%), android (20%) and platypelloid (5%)—not all may be seen in every individual.

- Classically, the following features may be seen:
  - Wider infrapubic angle (A1), >90 degrees in females, <90 degrees in males
  - Circular/oval pelvic inlet (females), heart-shaped (males)
  - Oval obturator foramen (females), rounded (males)
  - Wider sciatic notch (females)
  - Shorter, more triangular sacrum (females)
  - More anteriorly facing acetabulum (females)

---

1. Body of L5 vertebra
2. Sacrum
3. Wing of ilium
4. Greater sciatic notch
5. Ischial spine
6. Lesser sciatic notch
7. Head of femur
8. Roof of acetabulum
9. Ramus of ischium
10. Obturator foramen (en face)
11. Coccyx
12. Posterior superior
13. Posterior inferior
14. Gas within rectum
15. Gluteus minimus
16. Gluteus medius
17. Gluteus maximus
18. Right wing of ilium
19. Sacroiliac joint
20. Sacral ala
21. Second sacral foramen
22. Multifidus/iliocostalis lumborum
23. S2 nerve root
24. S1 nerve root
Pelvis  Developmental changes within the pelvis

- Ossification of the pelvic bones progresses throughout infancy and childhood, with fusion not typically completing until 20–25 years of age. The pattern of ossification is predictable, depending on age, and may therefore be used to assess for delayed skeletal development.
- The triradiate cartilage (E1) represents the synchondrosis of the ilium, ischium and pubic bones and is an important landmark in the ultrasound assessment of infants for the presence of developmental dysplasia of the hip; in this condition, abnormal development of a shallow acetabulum occurs and predisposes the individual to subsequent subluxation and dislocation of the hip joint. If undetected, mobility may be affected in addition to the development of early-onset degenerative joint disease.
- Fusion of the iliac crest apophysis (apophysis = separate centre of ossification attached to a tendon or muscle, not forming part of a joint) is amongst the last to occur (I10), and can be seen to progress in a predictable pattern from laterally to medially.
Pelvis  MRI anatomy of the pelvis

A) Coronal T1-weighted MR image of the pelvis

1. Subcutaneous fat
2. Gluteus medius
3. Gluteus minimus
4. Acetabulum
5. Iliacus
6. Psoas major
7. L5 vertebra
8. S1 vertebra
9. Urinary bladder
10. Medial wall of acetabulum
11. Iliac crest
12. Articular cartilage
13. Fovea capitis
14. Femoral epiphysis
15. Epiphyseal line
16. Circumflex femoral vessels
17. Neck of femur
18. Greater trochanter of femur
19. Iliotibial band
20. Vastus lateralis
21. Obturator externus
22. Pectineus
23. Adductor minimus
24. Adductor brevis
25. Gracilis
26. Pubic tubercle
27. Superficial femoral artery
28. Iliopsoas tendon
29. Great saphenous vein
30. External iliac artery and vein

- Given the prevalence of chronic hip pain and the relative insensitivity of plain radiographs in the detection of pathology, MR imaging plays a critical role in assessment of the articular cartilage, periarticular bone and associated soft tissues.

- Fluoroscopically-guided injection of gadolinium-based contrast media into the hip joint space enables further evaluation, in particular of the articular cartilage and acetabular labrum. This is demonstrated in figures B-E, in which additional information on the structure of the various cartilaginous and ligamentous structures may be clearly seen.
Pelvis  MRI anatomy of the hip

Axial T1 (C) and arthrogram (D) MR images of the left hip

Coronal T1 (E) and arthrogram (F) MR images of the left hip

1 Rectus abdominis
2 Iliopsoas
3 Sartorius
4 Rectus femoris
5 Tensor fascia lata
6 Gluteus medius
7 Greater trochanter of femur
8 Neck of femur
9 Quadratus femoris
10 Gluteus maximus
11 Obturator externus
12 Obturator internus
13 Head of femur
14 Ischium
15 Pubis
16 Vastus lateralis
17 Ligamentum teres (round ligament)
18 Anterior labrum
19 Joint capsule
20 Joint space (distended by contrast medium)
21 Perilabral sulcus
22 Posterior labrum
23 Transverse acetabular ligament
24 Acetabulum
25 Gluteus minimus
26 Gluteus medius
27 Superior labrum
28 Superior perilabral recess
29 Zona orbicularis
Recent years have seen a paradigm shift in techniques used in the assessment of the vasculature. Previously, digital subtraction angiography (DSA) was widely used in a diagnostic role, requiring puncture of a vessel, placement of an indwelling catheter, and injection of radiopaque contrast media (B).

Notwithstanding the radiation burden to the patient, the use of such a technique also involved the attendant risks and potential complications of vascular puncture as well as adverse reactions to relatively high doses of iodine-based contrast media.

Although still used in a therapeutic role (e.g. angioplasty), DSA has essentially been replaced by noninvasive techniques in the investigation of patients for potential vascular disease.

Computed tomographic angiography (CTA) is a minimally invasive technique involving the use of CT imaging in conjunction with iodine-based contrast media, injected via a small cannula typically sited within a peripheral vein. This is in contrast to DSA, in which a specialized catheter requires placement either close to or within the vessel of interest itself and which uses significantly higher volumes of contrast media.

Evaluation of the data acquired allows assessment for the development of significant atherosclerotic disease, in particular the presence of stenoses (narrowings) of vessels that may require subsequent treatment, as well as assessment for vascular integrity in the context of trauma and haemorrhage.

Volume rendered technique (VRT) images may also be produced from datasets, thereby providing three dimensional information not available using DSA (C, D). Figure (C) clearly shows the relationship of the femoral artery to the femoral head posteriorly; this is of clinical use in the context of the acute management of major trauma to the leg, in which direct compression of the artery against the femoral head posteriorly may be employed to temporarily reduce or stop haemorrhage prior to definitive management.

Magnetic resonance angiography (MRA) is a further technique which employs gadolinium-based contrast media and avoids the use of ionizing radiation (A). In certain circumstances, using special techniques, the use of contrast media may be avoided entirely via the evaluation of the physical properties of flowing blood in a strong magnetic field. This is less commonly used in the evaluation of the vasculature of the lower limb, however, and is more prone to image artefact, which may make interpretation challenging.

Maximum intensity projection (MIP) images, such as in (A), are employed in both CTA and MRA. In this technique, only the points of highest signal (MR) or radiodensity (CT) are displayed, thereby allowing the rapid evaluation of a large body area but without the three dimensional information provided by VRT images.
Arterial anatomy  

Arterial anatomy of the hip

B  Anteroposterior digital subtraction angiogram of the right hip
C  Anteroposterior (C) and lateral (D) volume-rendered CT angiogram images of the right hip
D  Lateral T1-weighted Maximum Intensity Projection (MIP) MR angiogram of the pelvis

1  Abdominal aorta
2  Common iliac artery
3  External iliac artery
4  Femoral artery
5  Lateral circumflex femoral artery
6  Profunda femoris
7  Perforating artery
8  Internal iliac artery
9  Anterior division of internal iliac artery
10 Posterior division of internal iliac artery
11 Superficial epigastric artery
**Thigh**  *MRI anatomy of the thigh—coronal*

A B C  Coronal T1-weighted MR images of the left thigh

D  Volume-rendered CT image of the left leg, medial view

1 Vastus lateralis
2 Vastus intermedius
3 Shaft of femur
4 Vastus medialis
5 Adductor magnus
6 Sartorius
7 Gracilis
8 Great saphenous vein
9 Femoral artery
10 Femoral vein
11 Lateral condyle of femur
12 Medial condyle of femur
13 Semitendinosus
14 Sciatic nerve
15 Semimembranosus
16 Biceps femoris
17 Lateral head of gastrocnemius
18 Medial head of gastrocnemius
19 Head of femur
20 Neck of femur
21 Lesser trochanter of femur
22 Patella

(various anatomical landmarks and labels)
**Thigh** MRI anatomy of the thigh—axial

**F G H**
Axial T1-weighted MR images of the left thigh

**E** Volume-rendered CT image of the left femur, anterior view

1. Sartorius
2. Rectus femoris
3. Vastus lateralis
4. Vastus intermedius
5. Vastus medialis
6. Femur
7. Sciatic nerve
8. Gluteus maximus
9. Biceps femoris (long head)
10. Semitendinosus
11. Adductor magnus
12. Adductor minimus
13. Adductor brevis
14. Profunda femoris and deep femoral vein
15. Adductor longus
16. Gracilis
17. Great saphenous vein
18. Femoral artery
19. Femoral vein
20. Semimembranosus
21. Biceps femoris (short head)
22. Greater trochanter of femur
23. Lesser trochanter of femur
24. Femoral shaft (diaphysis)
25. Distal metaphysis
26. Patella
27. Medial condyle of femur
28. Lateral condyle of femur
**Knee** Plain radiographic anatomy

1. Femur
2. Patella
3. Lateral epicondyle of femur
4. Lateral condyle of femur
5. Lateral condyle of tibia
6. Head of fibula
7. Neck of fibula
8. Proximal shaft of fibula
9. Intercondylar eminence
10. Intercondylar fossa
11. Medial condyle of femur
12. Medial epicondyle of femur
13. Medial condyle of tibia
14. Prefemoral fat pad
15. Suprapatellar bursa
16. Quadriceps fat pad
17. Quadriceps tendon
18. Infrapatellar fat pad (of Hoffa)
19. Patellar tendon
20. Tibial tuberosity
21. Femoral condyles (en face)
22. Medial patellar facet
23. Medial trochlear facet
24. Trochlea
25. Lateral trochlear facet
26. Lateral patellar facet

- The “skyline” or “sunrise” view of the patellofemoral joint as shown in (C) is used most often to evaluate for the development of degenerative joint disease, assessment for possible fractures and for the evaluation of femoral trochlear dysplasia in which an abnormally shallow or flattened trochlear surface predisposes individuals to dislocation of the patella.

- As seen in (C), the normal lateral trochlear facet is steeper and longer than that on the medial side; despite this, lateral dislocation of the patella is far more common than medial dislocation, in part due to the biomechanic forces at the time of injury. Disruption of the medial patellofemoral ligaments frequently occurs, resulting in subsequent instability that may necessitate surgical intervention.

- As demonstrated in (D3), traumatic injury to the knee, in particular the head and neck of the fibula, may also result in injury to the common fibular nerve as it passes lateral to the bone where it is vulnerable to crushing forces. As a result, disabling weakness to the muscles of the calf may occur, resulting in foot drop and paraesthesia (skin sensory changes).
Knee  MRI anatomy of the knee—sagittal

1 Lateral condyle of femur
2 Fibular collateral ligament
3 Common fibular (peroneal) nerve
4 Biceps femoris tendon
5 Soleus
6 Head of fibula
7 Tibialis anterior
8 Lateral condyle of tibia
9 Lateral meniscus
10 Infrapatellar fat pad (of Hoffa)
11 Biceps femoris
12 Lateral head of gastrocnemius
13 Extensor digitorum longus
14 Tibialis posterior
15 Anterior head of lateral meniscus
16 Posterior head of lateral meniscus
17 Popliteal artery and vein
18 Tibial nerve
19 Popliteus
20 Anterior cruciate ligament
21 Posterior cruciate ligament
22 Semimembranosus
23 Medial head of gastrocnemius
24 Patella tendon
25 Patella
26 Quadriceps tendon
27 Quadriceps fat pad
28 Prefemoral fat pad
29 Suprapatellar bursa
30 Femoral articular cartilage
31 Vastus medialis
32 Medial condyle of femur
33 Oblique popliteal ligament/joint capsule
34 Posterior horn of medial meniscus
35 Medial condyle of tibia
36 Anterior horn of medial meniscus

Sagittal T1-weighted MR images of the left knee
Knee  MRI anatomy of the knee—coronal and axial

A B Coronal T1-weighted MR images of the left knee

C D Axial T1-weighted MR images of the left knee

1  Vastus medialis  14  Anterior cruciate ligament
2  Femur  15  Posterior cruciate ligament
3  Vastus lateralis  16  Articular cartilage
4  Iliotibial tract  17  Medial condyle of tibia
5  Lateral condyle of femur  18  Popliteus
6  Lateral inferior genicular artery  19  Medial meniscus
7  Lateral meniscus  20  Medial collateral ligament
8  Fibularis (peroneus) longus  21  Medial condyle of femur
9  Head of fibula  22  Sartorius
10  Lateral condyle of tibia  23  Popliteal vein
11  Anterior ligament of the fibular head  24  Popliteal artery
12  Lateral intercondylar tubercle  25  Biceps femoris, short head
13  Medial intercondylar tubercle  26  Biceps femoris tendon

27  Soleus  28  Popliteus
29  Medial head of gastrocnemius  30  Great saphenous vein
31  Semimembranosus tendon  32  Posterior horn of medial meniscus
33  Medial head of gastrocnemius  34  Posterior meniscofemoral ligament (of Wrisberg)
35  Lateral head of gastrocnemius  36  Patellar ligament
37  Medial trochlear facet  38  Trochlea
39  Lateral trochlear facet  40  Fibular (lateral) collateral ligament
41  Joint capsule  42  Biceps muscle and tendon
43  Common fibular (peroneal) nerve
44  Tibial nerve  45  Semitendinosus tendon
46  Gracilis tendon  47  Sartorius
48  Tibia  49  Infrapatellar fat pad (of Hoffa)
Knee  
Arterial anatomy of the knee—DSA, CT

- In general, in clinical practice the term *peroneal* (Greek origin) is favoured over the term *fibular* (Latin orig.) as preferred by anatomists, when describing the muscles, nerves and vessels of the lower limb. Throughout this chapter, both may be considered synonymously but with the latter favoured.

- Furthermore, although not routinely recognized by anatomists, in clinical practice—and in particular in the context of interventional radiology and vascular surgery—the term *tibioperoneal* (tibiofibular) trunk (F, G 6) is used to describe the short section of artery between the origin of the anterior tibial and posterior tibial/fibular (peroneal) arteries, frequently affected by atherosclerotic disease along with its neighbouring vessels.

- Although there is relatively little variation in iliac or femoral arterial anatomy, considerable variation exists in the anatomy of the distal popliteal artery, in particular, the level and pattern of origins of the fibular (peroneal), anterior tibial and posterior tibial arteries.

- Figures F, G and H demonstrate the commonest pattern, seen in up to 90% of individuals, in which the popliteal artery divides at the inferior border of the popliteal muscle, continuing as the tibioperoneal trunk which subsequently gives rise to the anterior tibial and fibular (peroneal) arteries.

- In the remaining 10%, at least nine variant patterns are recognized, of varying frequency; although the anterior tibial artery invariably represents the first division, this, in addition to the origin of the posterior tibial artery, may occur above the level of the knee joint. The tibial artery may also be hypoplastic (poorly developed) or absent completely, the blood supply to the foot being provided exclusively by the anterior tibial and fibular (peroneal) arteries and their branches.

- Such variation is not simply of academic interest: failure to recognize variant anatomy may have significant consequences when surgical or interventional procedures are planned that in extreme cases may impact on limb salvage.
**Knee**  *Arterial anatomy of the knee—CT, MRI*

![Volume-rendered CT image of the left knee, posterior view of popliteal fossa](imageA)

![Coronal Maximum Intensity Projection (MIP) CT angiogram of the left knee, viewed from anteriorly](imageB)

![Coronal Maximum Intensity Projection (MIP) MR angiogram of the left knee, viewed from anteriorly](imageC)

- Figure A, in addition to figures G and H on page 17, elegantly show the vulnerability of the popliteal artery to injury, in particular following traumatic posterior dislocation in which the artery may be compressed between the dislocated distal femur and posterior soft tissues; this may result in an acute and complete interruption to the lower leg blood supply requiring emergency intervention. A CT scan performed as part of trauma imaging protocols allows the rapid assessment of the lower limb vasculature in such cases.

- Certain individuals, due to variant anatomy, experience intermittent compression of the popliteal artery by the adjacent musculotendinous structures (most often the medial head of gastrocnemius) against the medial condyle of the femur. Magnetic resonance angiography (C) of the lower limbs allows the evaluation of the vasculature in such cases and enables the radiologist to determine the precise relationships of the popliteal vasculature and adjacent muscles due to much greater soft tissue contrast when compared with CT.
**Lower leg**  
*MRI anatomy of the lower leg—coronal*

1. Head of fibula  
2. Fibularis (peroneus) longus  
3. Fibularis (peroneus) brevis  
4. Lateral malleolus of fibula  
5. Tibialis posterior  
6. Tibial artery and nerve  
7. Soleus  
8. Medial head of gastrocnemius  
9. Flexor hallucis longus  
10. Lateral head of gastrocnemius
Lower leg  MRI anatomy of the lower leg—axial

A-D Axial T1-weighted MR images of the left calf

1. Tibia  
2. Tibialis anterior  
3. Extensor hallucis longus and extensor digitorum longus  
4. Fibularis (peroneus) longus and brevis  
5. Fibula  
6. Soleus  
7. Lateral head of gastrocnemius  
8. Tibialis posterior  
9. Posterior tibial artery and tibial nerve  
10. Medial head of gastrocnemius

11. Great saphenous vein  
12. Flexor digitorum longus  
13. Flexor hallucis longus  
14. Tibialis anterior tendon  
15. Extensor digitorum longus tendon  
16. Fibularis (peroneus) longus and brevis tendon  
17. Tibialis posterior tendon  
18. Fibularis (peroneus) longus tendon  
19. Fibularis (peroneus) brevis  
20. Tendo calcaneus (Achilles tendon)
**Ankle Plain radiographic anatomy**

A Lateral radiograph of the left ankle

B Anteroposterior radiograph of the left ankle

C Axial radiograph of the left calcaneus

1 Fibula
2 Tibia
3 Tendo calcaneus (Achilles tendon)
4 Posterior process of tibia
5 Posterior process of talus
6 Pre-Achilles fat pad (of Kager)
7 Posterior surface of calcaneus
8 Calcaneal tuberosity
9 Calcaneus
10 Subtalar (talocalcaneal) joint
11 Sustentaculum tali
12 Body of talus
13 Neck of talus
14 Anterior process of calcaneus
15 Head of talus
16 Calcaneocuboid joint
17 Talonavicular joint
18 Navicular
19 Cuboid
20 Tibiotalar joint
21 Cuneiform bones (en face)
22 Lateral malleolus of fibula
23 Talar dome
24 Medial malleolus of fibula
25 Medial cuneiform
26 Medial process of calcaneus
27 Base of fifth metatarsal
28 Groove for fibularis (peroneus) longus
29 Lateral process of calcaneus
Ankle  MRI anatomy of the ankle—sagittal

• The subtalar joint is a complex joint of the hindfoot comprised of the talocalcaneal joint posteriorly between the posterior talar and calcaneal facets (B16) and talocalcaneonavicular joint more anteriorly; the latter is formed by congruent articulations between the head of the talus, anterior and middle articular facets of the calcaneus and posterior articular facet of the navicular. Functionally, the subtalar joint plays a key role in imparting stability to the midfoot and hindfoot and allows pronation and supination, of importance when walking on uneven surfaces and during running.

• The sinus tarsi (B17) is a fat-filled space between the talus and calcaneus; its boundary is formed by the neck of the talus medially, calcaneus inferi ory and extensor retinaculum laterally. Contained within the sinus are the cervical and interosseous talocalcaneal ligaments, in addition to extensive nerve endings. Injury to the ligaments or haemorrhage within the sinus following trauma may result in instability, inflammation of synovium and the formation of scar tissue. The resultant symptoms of pain and persistent hindfoot instability are known as sinus tarsi syndrome and are particularly recognized in overweight individuals, those with ‘flat feet’ and in those with occupations predisposing them to repetitive injury.

• The tarsal tunnel (E18) lies medially within the ankle, has a boundary formed by the flexor retinaculum (laciniate ligament), talus and calcaneus and contains the posterior tibial neuromuscular bundle, tibialis posterior tendon and tendons of flexor digitorum longus and flexor hallucis longus. Swelling within the tunnel or compression from external sources—for example, due to the presence of accessory muscles (e.g. Flexor digitorum accessorius longus), tumours or scar tissue—may result in compression of the posterior tibial nerve or its branches. Those affected report pain and abnormal sensation along the medial foot and hallux, symptoms that are exacerbated by exercise. Surgical release by transecting the flexor retinaculum may be required to relieve symptoms.
Ankle MRI anatomy of the ankle—axial

E-H Axial T1-weighted MR images of the left ankle

1 Tibia
2 Tibialis anterior tendon
3 Extensor hallucis longus muscle and tendon
4 Extensor digitorum longus muscle and tendon
5 Fibular (peroneal) artery and vein
6 Fibula
7 Fibularis (peroneus) brevis
8 Fibularis (peroneus) longus tendon
9 Lesser (small) saphenous vein
10 Sural nerve
11 Soleus
12 Tendo calcaneus (Achilles tendon)
13 Tibial nerve
14 Posterior tibial artery and vein
15 Flexor retinaculum
16 Flexor digitorum longus muscle and tendon
17 Tibialis posterior tendon
18 Tarsal tunnel
19 Flexor hallucis longus muscle and tendon
20 Anterior tibial artery and deep fibular (peroneal) nerve
21 Medial malleolus of tibia
22 Talus
23 Lateral malleolus of tibia
24 Flexor hallucis longus tendon
25 Head of talus
26 Extensor hallucis longus tendon
27 Extensor digitorum brevis
28 Extensor retinaculum
29 Pre-Achilles fat pad (of Kager)
30 Flexor digitorum longus tendon
31 Deltoid ligament (tibiocalcaneal)
32 Deltoid ligament (tibiocalcaneovascular)
33 Great saphenous vein
34 Anterior talofibular ligament
Ultrasound evaluation of musculotendinous structures is now standard in the evaluation of those with musculoskeletal disease, due to its ease of availability, lack of expense, high resolution and the ability to image tendons and ligaments during active and passive movement.

Figures C and D demonstrate high resolution ultrasound images of the Achilles tendon (C19) in longitudinal and axial (transverse) orientations respectively. The ordered pattern of parallel collagen fibres are clearly seen as they course toward their insertion on the calcaneus (A6).
Foot  Plain radiographic anatomy

• Jacques Lisfranc de St. Martin (1790–1847) was a French surgeon and gynaecologist who served as a field surgeon in Napoleon’s army on the Russian front and whose name has been adopted in the description of the complex ligamentous structures of the forefoot. He became famous initially for his description of a novel and extremely rapid technique of forefoot amputation, involving disarticulation across the tarsometatarsal joints without the need for osteotomy. Such amputations became necessary (depending on one’s source) as a result either of injuries sustained by riders falling from their horses with a foot caught in stirrups or due to frostbite and gangrene as a consequence of the harsh Russian winter. Despite his skill and reputation, however, he was apparently not a popular man due to his pompous and pugnacious demeanour.

• Although terminology has been confused, the term Lisfranc joint complex is now used in clinical practice to describe the intricate complex of ligaments and articulations at the level of the tarsometatarsal joints (illustrated as G31). The term Lisfranc joint collectively refers to those at the base of the first and second metatarsals (H32), and the Lisfranc ligament is that which bridges the base of the second metatarsal and medial cuneiform (H33). This ligament, as well as the “keystone” wedging of the second metatarsal within the cuneiforms, is of key importance since it provides the only ligamentous support between the first and second metatarsals. Its disruption, which may follow both high velocity and apparently innocent trauma, results in marked weakness of the forefoot articulations and may lead to severe functional instability and subluxation across the tarsometatarsal joints. Unfortunately, plain radiographic findings, especially when acquired non-weightbearing, may be very subtle and such a pattern of injury is frequently missed on initial imaging. The subsequent chronic pain and development of disabling premature degenerative joint disease are therefore a major source of litigation.
Foot  MRI anatomy of the foot—coronal

1. Tibia
2. Extensor hallucis longus
3. Extensor digitorum longus
4. Sinus tarsi
5. Talocalcaneal interosseous ligament
6. Cervical ligament
7. Extensor retinaculum
8. Extensor digitorum brevis
9. Fibularis (peroneus) brevis
10. Abductor digiti minimi
11. Long plantar ligament (calcaneometatarsal)
12. Lateral plantar artery and nerve
13. Flexor digitorum brevis
14. Quadratus plantae
15. Plantar aponeurosis (medial part)
16. Abductor hallucis
17. Medial plantar artery and nerve
18. Tendon of flexor hallucis longus
19. Tendon of tibialis posterior
20. Deltoid ligament (tibiocalcaneal part)
21. Talus
22. Calcaneus
23. Navicular
24. Cuboid
25. Great saphenous vein
26. Tendon of tibialis anterior
27. Extensor hallucis brevis
28. Flexor hallucis longus tendon
29. Flexor hallucis brevis
30. Deep branches of medial plantar artery and nerve
31. Fibularis (peroneus) longus tendon
32. Base of fifth metatarsal
33. Lateral
34. Intermediate cuneiform
35. Medial
36. First
37. Second
38. Third metatarsal
39. Fourth
40. Fifth
41. Extensor hallucis longus tendon
42. Adductor hallucis
43. Flexor digitorum longus tendons
44. Plantar aponeurosis
45. Flexor digitorum brevis tendons
46. Lumbricals
47. Interossei
48. Extensor digitorum longus tendons
49. Sesamoid bones
50. Transverse arch
Foot  MRI anatomy of the foot—axial and sagittal

Axial T1-weighted MR images of the left foot, axial view

Sagittal T1-weighted MR images of the left foot, through the level of the first metatarsal

Lateral radiograph of the foot

- Figures F50 and J40 and J41 illustrate the transverse and longitudinal arches of the foot, which are formed by the configuration of the bones with support from the associated muscles, ligaments and tendons. The arches play a key role in supporting body weight, as well as aiding locomotion via their shock absorptive capacities and ability to provide leverage in a spring-like fashion.

- The transverse arch (F50) in reality forms a half-dome in the coronal plane, with a full arch seen when both feet are placed together. The medial longitudinal arch (J40) is the higher of the two longitudinal arches and is formed by the calcaneus, talus, navicular, cuneiforms and first three metatarsals. The lateral longitudinal arch is flatter—as evidenced by the mark left by wet feet on a floor—and is formed by the calcaneus, cuboid, fourth and fifth metatarsals.

- Loss of the medial longitudinal arch—which may be acquired or congenital in nature—results in pes planus (‘flat feet’). In adults, loss of function of the posterior tibialis tendon or muscle, which may occur due to a variety of causes, is an important cause. If untreated, pain, swelling and the development of premature degenerative joint disease may occur.
Foot  Vascular anatomy of the foot and ankle
Volume-rendered CT angiogram images of the left foot and ankle

A From above (dorsal surface)  B From the lateral side
C From posteriorly and below (plantar surface)  D From the medial side

1 Anterior tibial artery
2 Fibular (peroneal) artery
3 Lateral marginal vein
4 Metatarsal vein
5 Dorsal digital vein
6 Dorsal venous arch
7 First dorsal metatarsal artery
8 Valve within medial marginal vein
9 Medial marginal vein
10 Dorsalis pedis artery
11 Great saphenous vein
12 Posterior tibial artery
13 Lateral plantar artery
14 Lateral plantar vein
15 Venous plexus of sole
16 Medial plantar artery
17 Plantar arch
18 Metatarsal artery
19 Plantar digital vein

- Figures A–D represent CT angiographic images acquired following the injection of intravenous iodinated contrast medium. Because of the timing of image acquisition following injection, early filling of foot veins is also demonstrated (e.g. marginal, plantar and long saphenous veins, 8, 9, 11 and 14). Certain smaller veins, such as the lateral plantar vein (D14), are subsequently seen to fade out above the ankle because of the timing of imaging resulting in a reduced density of contrast medium within the flowing blood. If required, additional imaging following a short delay may be performed to further evaluate the venous system; this is rarely performed, however, due to the lesser importance of venous disease of the foot when compared with that involving the arteries.

- As with the lower leg, considerable variation in arterial and venous anatomy may be observed; in some cases, the posterior tibial artery is hypoplastic or absent completely, with blood supply to the feet being from branches of the anterior tibial, dorsalis pedis and fibular (peroneal) arteries. This is of clinical importance in the management of patients with peripheral vascular disease (atherosclerosis), who may require surgical intervention.
Foot  Paediatric anatomy

A: C  Volume-rendered CT images of the left foot and ankle

A  From above (dorsal surface)  B  From the medial side  C  From the lateral side

- Figures A–C demonstrate the developing foot in an 8-year-old paediatric patient. Due to the method of computerized reconstruction performed in this case, soft tissues and the foot outline are faintly visible overlying the bones. Numerous centres of ossification within the epiphyses of the longer bones are demonstrated (e.g. A10), which subsequently fuse with the adjacent metaphyses. The tarsal bones form from a single centre of ossification: the appearance of increased gaps between them arises from the radiolucency of cartilage from which the bones form rather than from widened joint spaces. In addition, irregularity of certain bones is a normal finding (e.g. calcaneus, C4) and should not be confused with pathology.
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Muscles

MUSCLES OF THE GLUTEAL REGION

Gluteus maximus
From the posterior gluteal line of the hip bone, the dorsal surface of the lower part of the sacrum and the side of the coccyx, the sacrotuberous ligament and the fascia over gluteus medius
To the iliotibial tract, with the deep fibres of the lower part attaching to the gluteal tuberosity of the femur
Inferior gluteal nerve, L5, S1, S2
Extension and lateral rotation of the hip joint

Gluteus medius
From the outer surface of the ilium between the posterior and anterior oblique lines
To the lateral surface of the greater trochanter of the femur
Superior gluteal nerve, L4, L5, S1
Abduction and medial rotation of the hip joint and prevention of adduction

Gluteus minimus
From the outer surface of the ilium between the anterior and inferior gluteal lines
To the anterior part of the lateral surface of the greater trochanter of the femur
Superior gluteal nerve, L4, S1
Abduction and medial rotation of the hip joint, and prevention of adduction

Skin
The skin of the dorsal and plantar surfaces of the foot differs in appearance and organization (Fig. 1).

Fig. 1 Schematic diagram comparing the structures present in the thin and hairy dorsal skin and those in the thick, hairless plantar skin of the foot. The epidermis has been partially reflected to show epidermal and dermal papillae.
Muscles

Fig. 2 Muscles: From the front. Superficial muscles on the right side of the body; deep muscles on the left side.

Piriformis
From the middle three pieces of the sacrum
To the upper border of the greater trochanter of the femur
Branches from L5, S1, S2
Abduction, lateral rotation and stabilization of the hip joint

Quadratus femoris
From the upper part of the outer border of the ischial tuberosity
To the quadrate tubercle of the intertrochanteric crest of the femur
Nerve to quadratus femoris, L4, L5, S1
Lateral rotation and stabilization of the hip joint

Obturator internus
From the inner surface of the obturator membrane and the adjacent anterolateral pelvic wall
To the greater trochanter of the femur, above and in front of the trochanteric fossa
Nerve to obturator internus, L5, S1, S2
Lateral rotation and stabilization of the hip joint

Gemellus superior and inferior
Superior from the dorsal surface of the ischial spine, inferior from the upper part of the ischial tuberosity
To the superior and inferior borders respectively of obturator internus
Nerves to obturator internus (superior) and quadratus femoris (inferior)
Assists obturator internus

Obturator externus
From the outer surface of the obturator membrane and the ischiopubic ramus
To the trochanteric fossa of the femur
Obturator nerve, L3, L4
Lateral rotator of the thigh

MUSCLES OF THE FRONT OF THE THIGH

Iliacus
From the upper two-thirds of the iliac fossa in the lower abdomen
To the psoas tendon and the femur below and in front of the lesser trochanter
Femoral nerve, L2, L3
Flexor of the hip, assisting psoas major

Psoas major
From the sides of the lumbar vertebrae and intervertebral discs
To the lesser trochanter of the femur
Branches from L1, L2, L3
Flexor of the hip

Tensor fasciae latae
From the anterior 5 cm of the outer lip of the iliac crest
To the iliotibial tract
Superior gluteal nerve, L4, L5, S1
Extensor of the knee and lateral rotator of the leg

Sartorius
From the anterior superior iliac spine
To the upper part of the medial surface of the shaft of the tibia in front of gracilis and semitendinosus
Femoral nerve, L2, L3
Flexor, adductor and lateral rotator of the hip

Rectus femoris
From the anterior inferior iliac spine (straight head) and the ilium above the rim of the acetabulum (reflected head)
To the base of the patella
Femoral nerve, L3, L4
Flexor of the hip and extensor of the knee

Vastus lateralis
From the upper part of the intertrochanteric line of the femur, anterior and inferior borders of the greater trochanter, lateral lip of the gluteal tuberosity and the upper part of the linea aspera
To the lateral border of the patella and the quadriceps tendon
Femoral nerve, L2, L3, L4
Extensor of the knee
Vastus medialis
From the lower part of the intertrochanteric line of the femur, the spiral line, the linea aspera, the upper part of the medial supracondylar line and the tendon of adductor magnus
To the medial border of the patella and the quadriceps tendon
Femoral nerve, L2, L3, L4
Extensor of the knee

Vastus intermedius
From the anterior and lateral surfaces of the upper two-thirds of the shaft of the femur
To the deep part of the quadriceps tendon
Femoral nerve, L2, L3, L4
Extensor of the knee

Articularis genus
From the anterior surface of the femur below vastus intermedius
To the apex of the suprapatellar bursa
Femoral nerve, L3, L4
Retraction of the bursa as the knee extends

MUSCLES OF THE MEDIAL SIDE OF THE THIGH

Pectineus
From the pectineal line of the pubis and bone in front of the line
To the femur on a line from the lesser trochanter to the linea aspera
Femoral nerve, L2, L3
Flexor, adductor and lateral rotator of the hip

Gracilis
From the body of the pubis and ischiopubic ramus
To the upper part of the medial surface of the shaft of the tibia, between sartorius and semitendinosus
Obturator nerve, L2, L3
Flexor, adductor and medial rotator of the thigh

Adductor brevis
From the body and inferior ramus of the pubis
To the shaft of the femur on a line from the lesser trochanter to the linea aspera and to the upper part of the linea
Obturator nerve, L2, L3, L4
Adductor of the thigh

Adductor longus
From the front of the pubis
To the middle part of the linea aspera
Obturator nerve, L2, L3, L4
Adductor of the thigh

Adductor magnus
From the lower lateral part of the ischial tuberosity and the ischiopubic ramus
To the shaft of the femur from the gluteal tuberosity along the linea aspera to the medial supracondylar line and to the adductor tubercle
Obturator nerve, L2, L3, L4 and sciatic nerve, L4, L5, S1
Adductor and lateral rotator of the thigh

MUSCLES OF THE BACK OF THE THIGH

Biceps femoris
From the medial facet of the ischial tuberosity with semimembranosus (long head) and from the linea aspera and lateral supracondylar line of the femur (short head)
To the head of the fibula
Sciatic nerve (tibial part to long head, common fibular (peroneal) part to short head), L5, S1
Flexion and lateral rotation of the knee and extension of the hip

Semitendinosus
From the medial facet of the ischial tuberosity, with the long head of biceps
To the upper part of the subcutaneous surface of the tibia, behind gracilis
Sciatic nerve (tibial part), L5, S1
Flexion and medial rotation of the knee and extension of the hip

Semimembranosus
From the lateral facet of the ischial tuberosity
To the groove on the back of the medial condyle of the tibia, with expansions forming the oblique popliteal ligament and the fascia over popliteus
Sciatic nerve (tibial part), L5, S1
Flexion and medial rotation of the knee and extension of the hip

Gluteus maximus
Iliotibial tract

Biceps femoris
Semimembranosus
Semitendinosus
Gastrocnemius
Soleus
Tendo calcaneus (Achilles’ tendon)

Fig. 3 Muscles: From the back. Superficial muscles on the left side of the body; deep muscles on the right side.
MUSCLES OF THE FRONT OF THE LEG

Tibialis anterior
From the upper two-thirds of the lateral surface of the tibia and adjoining part of the interosseous membrane
To the medial surfaces of the medial cuneiform and base of the first metatarsal
Deep fibular (peroneal) nerve, L4, L5
Dorsiflexion and inversion of the foot

Extensor hallucis longus
From the middle third of the medial surface of the fibula
To the base of the distal phalanx of the great toe
Deep fibular (peroneal) nerve, L4, L5
Extension of the second to fifth toes and dorsiflexion of the foot

Extensor digitorum longus
From the upper two-thirds of the medial surface of the fibula
To the four lateral toes by the dorsal digital expansions, attached to the middle and distal phalanges
Deep fibular (peroneal) nerve, L5, S1
Extension of the second to fifth toes and dorsiflexion of the foot

Fibularis (peroneus) tertius
From the lower third of the medial surface of the fibula, continuous with extensor digitorum longus
To the shaft of the fifth metatarsal
Deep fibular (peroneal) nerve, L5, S1
Dorsiflexion and eversion of the foot

MUSCLE OF THE DORSUM OF THE FOOT

Extensor digitorum brevis
From the upper surface of the calcaneus
To the base of the proximal phalanx of the great toe (as extensor hallucis brevis) and the dorsal digital expansions of the second to fourth toes
Deep fibular (peroneal) nerve, L5, S1
Extension of the first to fourth toes

MUSCLES OF THE LATERAL SIDE OF THE LEG

Fibularis (peroneus) longus
From the upper two-thirds of the lateral surface of the fibula
To the lateral sides of the medial cuneiform and base of the first metatarsal
Superficial fibular (peroneal) nerve, L5, S1, S2
Plantar flexion and eversion of the foot

Fibularis (peroneus) brevis
From the lower two-thirds of the lateral surface of the fibula
To the tuberosity of the base of the fifth metatarsal
Superficial fibular (peroneal) nerve, L5, S1, S2
Plantar flexion and eversion of the foot

MUSCLES OF THE BACK OF THE LEG

Gastrocnemius
Medial head from the upper posterior part of the medial condyle of the femur; lateral head from the lateral surface of the lateral condyle of the femur
To the middle of the posterior surface of the calcaneus by the tendo calcaneus (in association with soleus)
Tibial nerve, S1, S2
Plantar flexion of the foot and flexion of the knee

Soleus
From the soleal line and upper part of the medial border of the tibia, a tendinous arch over the popliteal vessels and tibial nerve and the upper part of the posterior surface of the fibula
To the tendo calcaneus with gastrocnemius (see above)
Tibial nerve, S1, S2
Plantar flexion of the foot

Plantaris
From the lateral supracondylar line of the femur
To the calcaneus on the medial side of the tendo calcaneus
Tibial nerve, S1, S2
Plantar flexion of the foot and weak flexion of the knee

Popliteus
From the back of the tibia above the soleal line
To the outer surface of the lateral epicondyle of the femur
Tibial nerve, L4, L5, S1
Lateral rotation of the femur on the fixed tibia (or medial rotation of the tibia on the fixed femur); pulls lateral meniscus backward during flexion of the knee

Tibialis posterior
From the posterior surface of the interosseous membrane and adjacent posterior surfaces of the tibia and fibula
To the tuberosity of the navicular, with slips to other tarsal bones (except the talus) and the middle three metatarsals
Tibial nerve, L4, L5
Plantar flexion and inversion of the foot

Flexor hallucis longus
From the lower two-thirds of the posterior surface of the fibula
To the plantar surface of the base of the distal phalanx of the great toe
Tibial nerve, S2, S3
Plantar flexion of the great toe and foot

Flexor digitorum longus
From the medial part of the posterior surface of the tibia below the soleal line
To the four lateral toes by a tendon to each, reaching the plantar surface of the base of the distal phalanx
Tibial nerve, S2, S3
Plantar flexion of the four lateral toes and foot
MUSCLES OF THE SOLE OF THE FOOT

FIRST LAYER (Fig. 4)

Abductor hallucis
From the medial process of the calcaneal tuberosity and the plantar aponeurosis
To the medial side of the proximal phalanx of the great toe
Medial plantar nerve, S2, S3
Abduction and plantar flexion of the great toe

Flexor digitorum brevis
From the medial process of the calcaneal tuberosity and the deep surface of the central part of the plantar aponeurosis
To the lateral four toes by a tendon to each; the tendon divides into two slips (to allow the flexor digitorum longus tendon to pass between them), which are attached to the sides of the middle phalanx
Medial plantar nerve, S2, S3
Plantar flexion of the four lateral toes

Abductor digiti minimi
From the lateral and medial processes of the calcanean tuberosity and the plantar aponeurosis
To the lateral side of the base of the proximal phalanx of the fifth toe (with flexor digiti minimi brevis)
Lateral plantar nerve, S2, S3
Abduction and plantar flexion of the fifth toe

SECOND LAYER (Fig. 5)

Quadratus plantae (flexor accessorius)
From the (concave) medial surface of the calcaneus and from the plantar surface of the calcaneus in front of the lateral process of the tuberosity
To the lateral border of flexor digitorum longus before the division into four tendons
Lateral plantar nerve, S2, S3
Assistance with plantar flexion of the four lateral toes

Lumbricals
First lumbrical from the medial border of the first tendon of flexor digitorum longus
Second, third and fourth lumbricals from the four adjoining tendons of flexor digitorum longus
To the medial sides of the dorsal digital expansions of the tendons of extensor digitorum longus
First lumbrical—medial plantar nerve; second, third and fourth lumbricals by the lateral plantar nerve, S2, S3
Plantar flexion at the four lateral metatarsophalangeal joints and extension at interphalangeal joints
Tendons of flexor digitorum longus and flexor hallucis longus

Fig. 4 Muscles of the sole of the right foot: first layer. For dissection see p. 92.

Fig. 5 Muscles of the sole of the right foot: second layer. For dissection see p. 93.
THIRD LAYER (Fig. 6)

Flexor hallucis brevis
From the plantar surface of the cuboid and lateral cuneiform
By a tendon to each side of the base of the proximal phalanx of the great toe, the medial tendon joining with that of abductor hallucis and the lateral with adductor hallucis; there is a sesamoid bone in each tendon.
Medial plantar nerve, S2, S3
Plantar flexion of the metatarsophalangeal joint of the great toe

Adductor hallucis
Oblique head from the bases of the second, third and fourth metatarsals
Transverse head from the plantar metatarsophalangeal ligaments of the third, fourth and fifth toes
To the lateral side of the base of the proximal phalanx of the great toe, with part of flexor hallucis brevis
Lateral plantar nerve, S2, S3
Adduction of the great toe

Flexor digiti minimi brevis
From the plantar surface of the base of the fifth metatarsal
To the lateral side of the base of proximal phalanx of the fifth toe, with abductor digiti minimi
Lateral plantar nerve, S2, S3
Plantar flexion of the metatarsophalangeal joint of the fifth toe

FOURTH LAYER (Fig. 7)

Dorsal interosseous (four)
From adjacent sides of the bodies of the metatarsals
To the bases of proximal phalanges and the dorsal digital expansions; first and second to the medial and lateral sides of the second toe; third and fourth to the lateral sides of the third and fourth toes
Lateral plantar nerve, S2, S3
Plantar flexion of the metatarsophalangeal joints and extension (dorsiflexion) of the interphalangeal joints of the second, third and fourth toes; abduction of the same toes

Plantar interosseous (three)
From the bases and medial sides of the third, fourth and fifth metatarsals
To the medial sides of the bases of the proximal phalanges and dorsal digital expansions of the corresponding toes
Lateral plantar nerve, S2, S3
Plantar flexion of the metatarsophalangeal joints and extension (dorsiflexion) of the interphalangeal joints of the third, fourth and fifth toes; adduction of the same toes
Tendons of tibialis posterior and fibularis (peroneus) longus
Nerves

BRANCHES OF THE LUMBAR PLEXUS (Fig. 8)

Muscular T12, L1, L2, L3, L4 to psoas major and minor, quadratus lumborum and iliacus
Iliohypogastric and ilioinguinal L1 to parts of internal oblique and transversus abdominis in anterior abdominal wall
Genitofemoral L1, L2, giving off
  Genital branch (to cremaster muscle of spermatic cord)
  Femoral branch
Lateral cutaneous of thigh L2, L3
Femoral L2, L3, L4, giving off
  Nerve to pectineus
    Anterior division, giving off
      Intermediate femoral cutaneous
      Medial femoral cutaneous
    Nerve to sartorius
  Posterior division, giving off
    Saphenous
    Nerves to quadriceps femoris
Obturator L2, L3, L4, giving off
  Anterior branch
    Muscular to adductor longus, adductor brevis and gracilis
  Posterior branch
    Muscular to obturator externus and adductor magnus
  Accessory obturator (occasional) L3, L4 to pectineus

BRANCHES OF THE SACRAL PLEXUS

Superior gluteal L4, L5, S1, to gluteus medius, gluteus minimus and tensor fasciae latae
Inferior gluteal L5, S1, S2, to gluteus maximus
Nerve to piriformis S1, S2
Nerve to quadratus femoris and gemellus inferior L4, L5, S1
Nerve to obturator internus and gemellus superior L5, S1, S2
Posterior femoral cutaneous S2, S3
Sciatic nerve L4, L5, S1, S2, S3 giving off
  Muscular branches to biceps, semimembranosus, semitendinosus and part of adductor magnus
  Tibial nerve—see below
  Common fibular (peroneal) nerve—see below
  Perforating cutaneous, pudendal and other pelvic and perineal branches

BRANCHES OF THE TIBIAL NERVE
L4, L5, S1, S2, S3 (Fig. 9)

Muscular to gastrocnemius, plantaris, soleus, popliteus, tibialis posterior, flexor digitorum longus and flexor hallucis longus

Fig. 8 Diagram of cutaneous nerves of the front and back of the right lower limb.

Sural (ending as lateral dorsal cutaneous and then dorsal digital to lateral side of fifth toe)
Medial calcanean
Medial plantar—see below
Lateral plantar—see below

BRANCHES OF THE COMMON FIBULAR (PERONEAL) NERVE L4, L5, S1, S2

Recurrent
Lateral cutaneous of calf
Fibular (peroneal) communicating
Nerves

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Superficial fibular (peroneal), giving off
Muscular to fibularis (peroneus) longus and fibularis (peroneus) brevis
Medial branch (medial dorsal cutaneous), giving off Dorsal digital
Lateral branch (intermediate dorsal cutaneous), giving off Dorsal digital

Deep fibular (peroneal), giving off
Muscular to tibialis anterior, extensor hallucis longus, extensor digitorum longus and fibularis (peroneus) tertius
Lateral terminal, to extensor digitorum brevis
Medial terminal, giving off Dorsal digital (to first cleft)

BRANCHES OF THE MEDIAL PLANTAR NERVE L4, L5, S1

Trunk giving off
Nerve to abductor hallucis
Nerve to flexor digitorum brevis
Proper plantar digital nerve of great toe, giving off
Nerve to flexor hallucis brevis
First common plantar digital nerve, giving off
Nerve to first lumbrical
Proper plantar digital nerves of first cleft
Second common plantar digital nerve, giving off
Proper plantar digital nerves of second cleft
Third common plantar digital nerve, giving off
Proper plantar digital nerves of third cleft

BRANCHES OF THE LATERAL PLANTAR NERVE S1, S2

Trunk, giving off
Nerve to quadratus plantae
Nerve to abductor digiti minimi
Superficial branch, giving off
Fourth common plantar digital nerve, giving off
Proper plantar digital nerves of fourth cleft
Proper plantar digital nerve of fifth toe, giving off
Nerve to flexor digit minimi brevis
Nerve to third plantar interosseous
Nerve to fourth dorsal interosseous
Deep branch, giving off
Nerve to adductor hallucis
Nerves to second, third and fourth lumbricals
Nerves to first, second and third dorsal interossei
Nerves to first and second plantar interossei

Fig. 9 Diagram of dermatomes of the front and back of the right lower limb. (A dermatome is the area of skin supplied by any one spinal nerve.) Note that both the dorsum and sole of the foot are supplied by L5 and S1 dermatomes.
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Regional anaesthesia
for foot and ankle

- Popliteal Block
- Ankle Block
- Midfoot Field Block
- Common Digital Block

**Advantages**
- Most foot and ankle surgery can be performed in the day care setting.
- A combination of regional or field block with or without general anaesthesia allows faster patient recovery and better postoperative analgesia.
POPLITEAL BLOCK
A popliteal block essentially blocks two terminal branches of the sciatic nerve but has to be combined with a saphenous nerve block to ensure complete effectiveness of block technique. The nerves can be identified using the nerve stimulator (1) or, more easily, using the ultrasound (2) technique as described below.

Indications
For surgery on the ankle or foot, this block can be used as the sole anaesthetic or in conjunction with general or spinal anaesthesia for postoperative analgesia. If a tourniquet is required, a calf tourniquet should be used.

Contraindications
1. Patient refusal
2. Infection of the site of block
3. Coagulopathy

Precautions
As surgery on the forefoot can be easily performed under an ankle block; a popliteal block in these cases is not necessary. It will cause foot drop, which may delay patient mobilization or discharge.

Anatomy
The predominant nerve innervating the lower limb below the knee is the sciatic nerve and its branches. The saphenous nerve is the only sensory contribution below the knee.

The sciatic nerve divides at a variable distance proximal to the popliteal crease into the tibial and common fibular (peroneal) nerve branches.

The saphenous nerve is a branch of the femoral nerve from its posterior division. It leaves the femoral triangle at its lower angle and passes across the front of the femoral artery in the subsartorial canal to reach the medial side of the vessel. It leaves the canal by passing beneath the posterior border of sartorius and becomes superficial posterior and lateral to the knee joint, then travels the leg distally along with the great saphenous vein as far as the medial side of the foot).

(1) NERVE STIMULATOR-GUIDED TECHNIQUE
Although various approaches to the nerves situated in the popliteal fossa have been described, the preferable one is the posterior approach. This approach is less painful to the patient as the needle passes only through skin and adipose tissue on its way to the nerves.

Equipment and drugs
1. Nerve stimulator (e.g. B Braun Stimuplex)
2. Insulated 50 mm needle
3. Local anaesthetic: Use 0.5% levobupivacaine for anaesthesia and 0.25% if the block is done only for postoperative analgesia.

Procedure (Fig. 10)
After intravenous access is established and appropriate monitoring applied, the patient lies in a prone position with a pillow placed underneath the leg so that the knee becomes slightly flexed.

A line is drawn on the skin along the popliteal crease and along this line the tendon of biceps is felt on the lateral side of the fossa and marked. Similarly, the tendon of semitendinosus is felt and marked on the medial side.

The line marking the popliteal crease between these tendons is divided and a perpendicular line drawn cephalad from this point.

A point on the perpendicular line is marked 7 cm from the popliteal crease line and the needle insertion point is 1 cm lateral to this point.

An intradermal wheal of local anaesthetic is injected at this point.

A 5 cm stimulating needle is then inserted perpendicular to the skin and initial stimulating current set at 1 mA, frequency 2 Hz.

Nerve stimulation should be elicited within 1.5–2.5 cm.

With this approach, the common fibular (peroneal) nerve is often first identified, causing dorsiflexion of the foot.

Once the needle is adjusted so that a twitch may be found at 0.3–0.5 mA, 10 ml of local anaesthetic is injected after excluding intravascular needle placement by careful aspiration, the twitch should disappear immediately.

The needle should then be redirected to stimulate the second nerve, by either moving it medially to locate the tibial nerve (if the common fibular (peroneal) nerve was found first) or laterally to locate the common fibular (peroneal) nerve (if the tibial nerve was found first).

When the other nerve is located, another 10 ml of local anaesthetic is injected.

Complications
1. Nerve damage
2. Intravascular injection leading to local anaesthetic toxicity

Fig. 10 Nerve stimulator-guided technique for popliteal block.
Regional anaesthesia for foot and ankle

(2) ULTRASOUND TECHNIQUE
A popliteal block can be safely and easily done using ultrasound. Indications, contraindications and complications are similar to the nerve stimulator-guided technique.

Equipment and drugs
1. Ultrasound machine with high frequency linear probe
2. Probe cover and jelly
3. Nerve stimulator (e.g. B Braun Stimuplex)
4. Insulated 100 mm needle
5. Local anaesthetic. Use 0.5% levobupivacaine for anaesthesia and 0.25% if the block is done only for postoperative analgesia.

Procedure (Figs 11 and 12)
After intravenous access is established and appropriate monitoring applied, the patient lies supine with leg elevated and resting on a support.

The ultrasound probe is placed behind the knee just above the popliteal crease so that a transverse (cross-sectional) image of the popliteal artery and vein superior to it may be observed.

Nerves lay superficially to the blood vessels and the tibial nerve (largest) is identified first; then the common fibular (peroneal) nerve, which is seen to converge with the tibial nerve when the probe is moved cephalad, is identified.

Once the nerves have been clearly identified, a needle is inserted in the scanning plane so that the entire needle can be observed on the screen live, as it approaches the nerves; then, 20 ml of local anaesthetic is injected to surround the nerves.

Complications of this procedure are similar to nerve stimulator-guided procedure.
ANKLE BLOCK
The ankle block is a simple block to perform that targets the terminal branches of the sciatic and femoral nerves. Complete ankle block requires five injections; mild sedation, therefore, may improve patient comfort during block performance.

Indications
This block can be used as an anaesthetic technique for surgery on the forefoot. It can also be used for postoperative analgesia for surgery on the midfoot done under general anaesthesia, since most of these types of surgery need a thigh tourniquet.

Contraindications
1. Patient refusal
2. Infection at the site of block
3. Coagulopathy

Anatomy
The five nerves to block are:
- The saphenous nerve, which arises from the femoral nerve.
- The tibial, superficial and deep fibular (peroneal), and sural nerves, which are branches of the sciatic nerve.
- The saphenous nerve lies close to the great saphenous vein in the subcutaneous tissue just in front of the medial malleolus.
- The tibial nerve lies behind the posterior tibial artery, posterior to the posterior tibial artery under the sustentaculum tali.
- The sural nerve—four-finger breadths above the lateral malleolus in the subcutaneous plane toward the tendo calcaneus.
- The superficial fibular (peroneal) nerve (Fig. 16)—subcutaneous infiltration between the two malleoli. Start in the midline and inject on either side.
- The deep fibular (peroneal) nerve (Fig. 17)—on the anterior aspect of the ankle, inject either side of the dorsalis pedis artery.

Complications
1. Intravascular injection
2. May effect mobilization if proprioception is affected

Fig. 13 Saphenous nerve block.

Fig. 14 Tibial nerve block.
Fig. 15 Sural nerve block.

Fig. 16 Superficial fibular (peroneal) nerve block.

Fig. 17 Deep fibular (peroneal) nerve block.
MIDFOOT FIELD BLOCK

The midfoot field block is a simple block to perform. There is no requirement for a nerve stimulator or ultrasound guidance. This technique has proven to be very reliable for surgery on up to three rays of the forefoot. Limbers and associates reported a 100% success rate in 42 patients in a day care environment undergoing forefoot surgery. There were no conversions to a general anaesthetic, and the patients were sedated at the time of block insertion. The surgery was undertaken under an ankle tourniquet. Previous studies have shown similar results with 98% to 100% success rates.

Other midfoot blocks have been described and are known eponymously as the Sharrock and Mayo blocks. The midtarsal block described by Sharrock involves a block of the deep fibular (peroneal) nerve and posterior tibial nerve.

The deep fibular (peroneal) nerve lies lateral to the dorsalis pedis artery that is located by palpation.

The posterior tibial nerve is anaesthetised by palpating the posterior tibial artery and injecting posterior to it.

These two nerve blocks are supplemented by a subcutaneous field block, anaesthetising the superficial fibular (peroneal) and saphenous nerves.

The Mayo block involves infiltration of a local anaesthetic ring block in the tissues proximal to the surgical site. A wheal is raised proximal to the first digital interspace after which the needle is advanced in a plantar direction and additional anaesthetic injected. The needle is then withdrawn and directed medially from the dorsal surface to raise a wheal.

These blocks are intermediate procedures between anatomical nerve blocks at the ankle, as previously described, and local infiltration. The block described here, is a modification of the midfoot block as described by Ptaszek and associates, it is easy to perform and can be combined with controlled intravenous sedation if required.

Indications

1. Bunion surgery
2. First metatarsophalangeal joint fusion
3. Forefoot surgery (maximum three toes)

Contraindications

1. Patient refusal
2. Infection at the site of block
3. Coagulopathy
4. Allergy to anaesthetic agents

Anatomy

The Great Toe of the foot is supplied by branches of four main nerves, three dorsal and one plantar: dorsally—the superficial fibular (peroneal) nerve, saphenous nerve and deep fibular (peroneal) nerve; plantar—the medial plantar nerve.

The superficial fibular (peroneal) nerve divides at the level of the ankle into medial and lateral branches. The medial branch divides into two dorsal digital nerves: one branch supplies the medial side of the great toe and the other the adjacent sides of the second and third toes. It communicates with the saphenous nerve and deep fibular (peroneal) nerve, the terminal branch of which supplies sensation to the dorsum of the first web space (p.163, Fig. 22, A, B).

The medial plantar nerve is a branch of the tibial nerve and supplies the medial–plantar aspect of the great toe (p.163, Fig. 23 A, B). The common plantar digital nerves, which divide to supply the remaining plantar aspect of the medial three and a half toes, are also branches of the medial plantar nerve.

Equipment and drugs

1. 23G hypodermic needle
2. 2% chlorhexidine
3. 5–20 ml of 2% lignocaine without adrenaline (maximum dose of 4.5 mg/kg)

Procedure

Prior to block insertion, the patient may be sedated with monitored intravenous sedation.

The first injection site (Fig. 18) is at the level of the tarsometatarsal joint medially.

The needle is advanced in the subcutaneous plane from dorsal to plantar until the plantar skin is tented. Anaesthetic is injected as the needle is withdrawn.

The saphenous and medial plantar nerves are blocked at this point.

A small amount of anaesthetic is also injected subperiosteally into the first metatarsal.

The second injection site (Fig. 19) is into the first web space to block the medial terminal branch of the deep fibular (peroneal) nerve.

Along with infiltration of the web space, subperiosteal infiltration of the lateral first metatarsal is also undertaken.

The third injection site (Fig. 20) is on the plantar surface, just proximal to the metatarsophalangeal joint and blocks the plantar digital nerves.

If surgery to other toes is planned, the lesser rays are blocked with supplementary common digital blocks. Practically however, it is difficult to extend this block beyond three-toe surgery since the volume of anaesthetic required exceeds the toxic dose.

Complications

1. Intravascular injection
2. Failure of the block
3. Neuropraxia
Fig. 18 First injection site for midfoot field block.

Fig. 19 Second injection site for midfoot field block.

Fig. 20 Third injection site for midfoot field block.
THE COMMON DIGITAL BLOCK

The nerve supply to the lesser toes, 2, 3, 4, 5, is identical to that of the fingers. In the foot, four nerves supply each digit, two dorsal (dorsal digital nerves) and two plantar (proper plantar digital nerves). The dorsal nerves are branches of the superficial fibular (peroneal) nerve and the plantar nerves are from divisions of the medial and lateral plantar nerves (p.163, Figs A,B).

The common digital block is preferred to using a ring block because it causes less soft tissue swelling and tension, and it does not compromise surgical dissection. An ankle or toe tourniquet can be used with this block.

Indications
1. Nail surgery
2. Interphalangeal joint fusion
3. Flexor tenotomy

Contraindications
1. Infection at site of block
2. Coagulopathy
3. Patient refusal
4. Allergy to anaesthetic

Equipment and drugs
1. 23G hypodermic needle
2. 2% chlorhexidine
3. 2.5 ml of 1% lignocaine without adrenaline at each injection site (maximum dose of 4.5 ml /kg)

Procedure (Fig. 21)
The needle is inserted in the web space at the level of the metatarsophalangeal joint and advanced vertically until it tents the plantar skin.

The needle is then slowly withdrawn and approximately 2.5 ml of local anaesthetic injected.

This procedure is then repeated on the opposite side of the same toe.

As with digital block in the fingers, co-administration of epinephrine must be avoided since this can cause spasm of the end arteries that supply the digits, resulting in ischaemia and even necrosis.

Complications
1. Intravascular injection
2. Failure to block

Fig. 21 Common digital block.

Bibliography
Sensory innervation of the ankle

Fig. 22 A B

Fig. 23 A B
The lymphatic system

GENERAL KEY POINTS

The lymphatic system has four major functions:
1. Produce, store and recirculate lymphocytes, cells mainly responsible for immune response in the body.
2. Store macrophages (phagocytes).
3. Drain surplus tissue fluid to the bloodstream.
4. Transport absorbed fat from the intestine to the bloodstream.

The combined fluid product is known as lymph.

- Lymph is drained from areas of tissue via very fine threadlike lymphatic vessels (lymphatics), that are thin walled, similar to veins, and have valves to ensure one-way flow.
- Lymph flow is chiefly maintained by external pressure on the delicate-walled lymphatic vessels by surrounding tissue structures.
- Lymphatics connect to main trunks and are interrupted en route by lymphoid organs and nodes, which act as filters.
- Afferent lymphatic vessels carry unfiltered lymph into a node.
- Efferent lymphatic vessels carry filtered lymph out of a node.
- Several main lymphatic trunks converge towards their venous junction (cervical lymphovenous portals), returning lymph to the venous bloodstream.

There are normally three trunks on the right side of the body and four on the left.

<table>
<thead>
<tr>
<th>Right-sided trunks</th>
<th>Left-sided trunks</th>
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<tbody>
<tr>
<td>Right jugular trunk</td>
<td>Left jugular trunk</td>
</tr>
<tr>
<td>Right subclavian trunk</td>
<td>Left subclavian trunk</td>
</tr>
<tr>
<td>Right bronchomediastinal trunk</td>
<td>Left bronchomediastinal trunk</td>
</tr>
<tr>
<td></td>
<td>Thoracic duct</td>
</tr>
</tbody>
</table>

- The main lymphoid organs of the body are the tonsils, spleen, thymus and lymph nodes, of which some 400–450 are present in the normal adult.
- Lymph nodes are sited regionally and may be found as singleton, pairs or in distinct multiple cluster groups (Fig. 24).
- Nodes are usually small, ovoid or kidney (reniform) in shape and vary between 0.1 and 2.5 cm in length.
- Some nodes, but not all, may be palpable in their normal state, but particularly so when diseased.

Fig. 24 A cluster (group) of adult upper limb left axillary (lateral) lymph nodes with associated vessels. They are shown actual size as presented at dissection and are typical of normal lymph node appearance in the human body.
LOWER LIMB LYMPHATICS—KEY POINTS

- Not many lymph nodes are located in the limbs.
- The leg and superficial gluteal region, infra-umbilical abdominal wall and perineum have only about 20 recognized lymph nodes. This does not include the intra-pelvic and intra-abdominal, iliac, lateral caval and aortic groups of nodes, into which the limb lymphatics drain.
- The lymphatic drainage of the lower limb is via a network of superficial and deep efferent lymphatic vessels, some of which may directly interconnect, or unite by an afferent vessel to a particular lymph node or group (cluster of nodes).
- Essentially, superficial lymphatics of the lower limb accompany superficial veins, whereas deep lymphatics accompany arteries.
- Both superficial and deep lymphatic networks of the lower limb drain in a distal (foot) to proximal (thigh/groin) limb direction.
- The intra-abdominal right-side superior lateral caval group of lymph nodes and opposite left-side superior lateral aortic group of lymph nodes are stated to be the terminal groups of nodes for the lower limbs.
- From the lateral caval and aortic groups of nodes, lymph flows through the bilateral lumbar trunks, their confluence (cisterna chyli) and then into the thoracic duct.
- Lymph finally returns to the venous bloodstream via a lymphovenous portal situated on the left-side root of neck, where the thoracic duct drains into the junction of the internal jugular and subclavian vein.
- The inguinal nodes are of key importance for lower limb. They may become enlarged due to infection of the foot (e.g. infected ingrowing toenail) or through involvement by tumour (e.g. leg melanoma).

Fig. 25 Superficial dissection of the right upper thigh femoral (triangle) region, displaying lymph nodes and associated lymphatic vessels in situ, from the front.
Lymph nodes draining the lower limbs

Abdominal lymph nodes
- Parietal lymph nodes
  - Left lumbar nodes
  - Lateral aortic nodes
- Right lumbar nodes
  - Lateral caval nodes

Pelvic lymph nodes
- Parietal lymph nodes
  - Common iliac nodes
  - External iliac nodes
  - Internal iliac nodes
  - Gluteal nodes
  - Superior nodes
  - Inferior nodes

Lower limb lymph nodes
- Inguinal lymph nodes
  - Superficial inguinal nodes
    - Superomedial nodes
    - Superolateral nodes
    - Inferior nodes
  - Deep inguinal nodes
    - (Proximal node)
    - (Intermediate node)
    - Distal node
- Popliteal nodes
  - Superficial nodes
  - Deep nodes
    - (Anterior tibial node)
    - (Posterior tibial node)
    - (Fibular [peroneal] node)

note: (( )) structures inconsistent

Fig. 26 Schematic drawing (not to scale) of the lymphatic drainage of the right lower limb.
Fig. 27 Position of the main lymph node clusters (groups) responsible for draining the right lower limb.
1  **Lateral caval nodes**
Located within the retroperitoneum on the posterior abdominal wall, the lateral caval nodes occur on the right side of the body flanking the vena cava, hence (caval). Their counterparts, the lateral aortic nodes, occur on the left side of the body flanking the aorta, hence (aortic). Both groups of nodes, anterior to the medial margins of the psoas major muscles, diaphragmatic crura and sympathetic trunks, receive efferents from the common iliac nodes. There is moderate left-to-right crossover to nodes between the inferior vena cava and the aorta.

2  **Common iliac nodes**
Located within the pelvis, a cluster of normally four to six nodes scattered around the common iliac artery. Some nodes of this group occur inferior to the bifurcation of the aorta and anterior to the fifth lumbar vertebra or promontory of the sacrum. They receive efferents from the internal iliac nodes and external iliac nodes.

3  **Internal iliac nodes**
Located deep within the pelvis level with the lumbosacral intervertebral disc and anterior to the sacroiliac joint. These nodes surround the internal iliac artery and vein scattered between the commencement of the artery, at the common iliac bifurcation, and the superior margin of the greater sciatic notch. They receive efferents from the internal iliac nodes and external iliac nodes.

4  **Gluteal nodes**
Located deep within the pelvis the gluteal nodes are a subgroup of the internal iliac nodes and form two small clusters:

4A.  **Superior node**—normally a single node that occurs close to the intrapelvic part of the superior gluteal artery near to the border of the greater sciatic notch of the hip bone.

4B.  **Inferior nodes**—normally two nodes that occur close to the inferior gluteal artery just inferior to the piriformis muscle. They drain the deep gluteal region.

5  **External iliac nodes**
Located within the pelvis posterior to the inguinal ligament midway between the anterior superior iliac spine of the hip bone and pubic symphysis. These nodes, normally 8-10 in number, form three clusters around the external iliac artery and vein in a lateral, medial and anterior* position. They receive efferents from the superficial inguinal nodes and deep inguinal nodes.

6  **Deep inguinal nodes**
Located deep in the anterior upper thigh embedded in the fat of the femoral triangle. Normally one to three nodes in number, but may vary, lying just medial to the femoral vein. Proximal node*—situated lateral in the femoral ring. Intermediate node*—situated in the femoral canal. Distal node—situated just distal to the saphenofemoral junction. These nodes drain the glans penis, clitoris and deep thigh and receive efferents from the popliteal nodes and a few from the superficial inguinal nodes.

7  **Popliteal nodes**
Located at the back of the knee embedded in the fat of the popliteal fossa. Normally six small nodes laying close to the popliteal vessels. Some superficial nodes of the group occur near the termination of the small saphenous vein and some deep nodes lay between the popliteal artery and posterior aspect of the knee joint. This group of nodes drains the deep knee, posterolateral calf, deep leg and deep foot and receives efferents that accompany the small saphenous vein from the superficial lateral side of the leg and foot.

8  **Superficial inguinal nodes**
Located superficially in the anterior upper thigh embedded in the subcutaneous fat of the femoral triangle, these nodes form three distinct cluster groups. The superomedial and superolateral nodes, normally five to six in number situated just distal and below the medial and lateral parts of the inguinal ligament, and the inferior nodes, normally four to five in number, just lateral to and along the termination of the great saphenous vein.

8A.  **The superomedial nodes** drain superficial lymphatics from the external genitalia, inferior vagina, inferior anal canal, perianal region, adjoining abdominal wall, umbilicus and the uterine vessels that accompany the round ligament.

8B.  **The superolateral nodes** drain superficial lymphatics from the infraumbilical anterior abdominal wall and gluteal region.

8C.  **The inferior nodes** receive efferents accompanying the great saphenous vein from the superficial lateral side of the leg and foot, except for the posterolateral calf.

**Note:** * denotes inconsistent structures.
Arteries

BRANCHES OF THE FEMORAL ARTERY

Giving off the following before becoming the popliteal artery
- Superficial epigastric
- Superficial circumflex iliac
- Superficial external pudendal
- Deep external pudendal
- Profunda femoris, giving off
  - Lateral circumflex femoral
  - Medial circumflex femoral
  - Perforating
- Descending genicular

BRANCHES OF THE POPLITEAL ARTERY

- Sural
- Superior, middle and inferior genicular
- Anterior tibial, giving off the following before becoming the dorsalis pedis artery (see below)
  - Posterior and anterior tibial recurrent
  - Anterior medial and anterior lateral malleolar
- Posterior tibial, giving off
  - Circumflex fibularis
  - Fibular (peroneal), giving off
    - Nutrient to the fibula
    - Perforating
    - Communicating
    - Lateral malleolar
    - Calcanean
    - Nutrient to the tibia
    - Communicating
    - Medial malleolar
    - Calcanean
    - Medial plantar (see below)
    - Lateral plantar (see below)

BRANCHES OF THE DORSALIS PEDIS ARTERY (Fig. 28)

- Lateral dorsal
- Medial dorsal
- First dorsal metatarsal, giving off
  - Deep plantar (perforating) branch, to complete plantar arch
  - Dorsal digital branch to medial side of great toe
  - Dorsal digital branches of first cleft
- Second dorsal metatarsal, giving off
  - Perforating branches
- Dorsal digital branches to second cleft
- Third dorsal metatarsal, giving off
  - Perforating branches
- Dorsal digital branches to third cleft
- Fourth dorsal metatarsal, giving off
  - Perforating branches
- Dorsal digital branches to fourth cleft
- Dorsal digital branch to lateral side of fifth toe

Fig. 28 Diagram of branches of the right dorsalis pedis artery, excluding muscular and most anastomotic branches; note that anastomoses from the perforating branch of the fibular (peroneal) artery may link up with the arcuate artery and enlarge to replace an absent dorsalis pedis artery.
BRANCHES OF THE MEDIAL PLANTAR ARTERY

Anastomotic branch to plantar digital artery of medial side of the great toe
Superficial digital branches to anastomose with first, second and third plantar metatarsal arteries

BRANCHES OF THE LATERAL PLANTAR ARTERY (Fig. 29)

Plantar arch, giving off
First plantar metatarsal, giving off
  Plantar digital artery to medial side of great toe
  Plantar digital arteries to first cleft
Second, third and fourth plantar metatarsal arteries, each giving off
  Plantar digital arteries to second, third and fourth clefts, respectively
Perforating branches
Plantar digital artery to lateral side of fifth toe

Fig. 29 Diagram of branches of the right medial and lateral plantar arteries (excluding muscular and most anastomotic branches). The proximal parts of the medial and lateral plantar nerves are shown in green to indicate that the nerves lie on the internal sides of their corresponding arteries.
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