Clinical Anatomy of the Knee

An Atlas

Murat Bozkurt
Halil İbrahim Açar
Editors

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ISBN 978-3-030-57577-9 ISBN 978-3-030-57578-6 (eBook)
https://doi.org/10.1007/978-3-030-57578-6

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Preface

Anatomical treatment methods for the knee joint have recently become more preferred. Our primary goal in editing *Clinical Anatomy of the Knee* is to create a valuable resource that includes a rich visual content for those physicians, residents, fellows, or students practicing or interested in knee problems. With this book, we have combined the detailed anatomy of the knee joint with the biomechanics and radiology of the knee joint, and we have correlated all of this basic information together with some of the treatment methods that we have applied. In particular, we think that this transfer of basic knowledge to clinical applications will be used effectively in both diagnosis and appropriate treatment practices.

We would like to express our sincere gratitude to all of the authors who contributed to this book.

Ankara, Turkey

Murat Bozkurt, MD, PhD
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Halil İbrahim Açar, Yiğit Güngör,
and Murat Bozkurt

1.1 Introduction

The knee joint is the largest joint of the body. It includes many important structures, specific to the knee such as the menisci and cruciate ligaments. Another important feature is the joint surfaces that are not highly compatible to bring together bones. To increase compatibility and provide stability, there are several certain structures in the joint.

The knee joint is basically formed between the tibia and the femur. The patellofemoral joint, which is made of the femur and patella, is a part of the knee joint with very important properties. Although the fibula is not a direct part of the knee joint, it constitutes a significant area holding important ligaments and muscles related to the joint [1, 2].

In this section, different aspects of the knee are considered. First, the properties of the bony structures in the knee joint are defined. Then, the anatomic structures are evaluated layer by layer from the perspective of the dissector, and the relationships between them are emphasized in integrity.

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1.2 Bones

1.2.1 Distal End of the Femur

Femur is the longest and largest bone of the body. It extends from superior to inferior, from lateral to medial, slightly oblique. The anatomical axis of femur passes between the shaft of femur and intercondylar notch. It extends slightly medially, to 9° angle between the vertical axis. The mechanical axis passes between the center of the head of femur and the intercondylar notch. There is a 3° angle between the mechanical axis and the vertical axis (Fig. 1.1) [1–4].

Femur articulates with the tibia via its condyles and with the patella via the patellar surface.

The lateral and medial femoral condyles are the most significant structures observed in the distal femur. Compared to the lateral condyle, the medial condyle extends further distally. However, in anatomical position, as the femur shaft lies obliquely from lateral to medial, both the condyles end at the same horizontal level (Fig. 1.1) [1]. The femoral condyles are not symmetrical. The sagittal axis of the lateral condyle is longer than the medial. The lateral condyle axis is located in the sagittal plane. However, there is an angle of approximately 22° between the medial condyle axis and the sagittal plane (Fig. 1.2).

The most prominent point on the outer surface of the lateral condyle is the lateral epicondyle

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M. Bozkurt, H. İ. Açar (eds.), *Clinical Anatomy of the Knee*,
https://doi.org/10.1007/978-3-030-57578-6_1

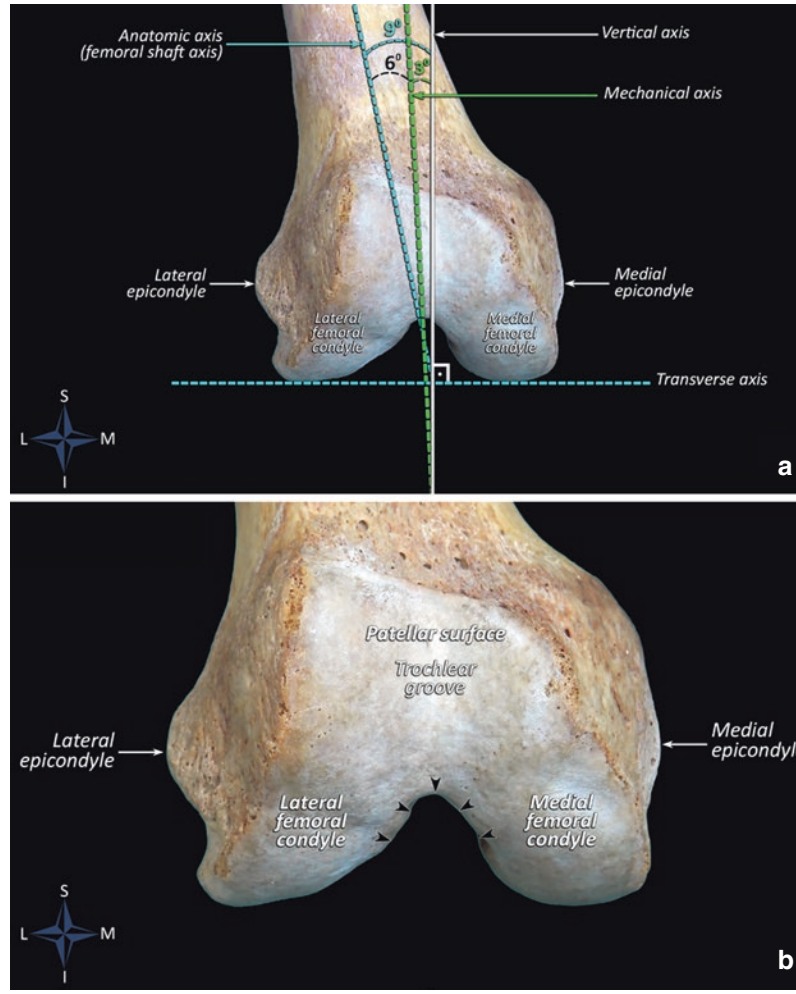

Fig. 1.1 Anterior view of the right distal femur. (**a**) The axes of the femur. (**b**) Close-up view of the distal femur. Black arrowheads indicate anterior border of the intercondylar notch. *S* superior, *I* inferior, *L* lateral, *M* medial, on the star showing directions

(Fig. 1.2). The lateral collateral ligament (LCL) attaches to just proximal and posterior to the lateral epicondyle of the femur (Fig. 1.3) [2, 5, 6]. Immediately below the lateral epicondyle, a shallow groove is observed, in which the tendon of popliteus passes. The popliteus tendon inserts to the outer surface of the lateral condyle on the portion immediately anterior-inferior to the lateral epicondyle (Fig. 1.3) [2, 6, 7]. Another important structure attached to the outer surface of the lateral femoral condyle is the lateral head of the gastrocnemius muscle [6]. This tendon originates posterior and superior to the attachment site of the lateral collateral ligament (Fig. 1.3). The medial surface of the lateral femoral condyle forms the lateral wall of the intercondylar notch.

The medial epicondyle, which is the attachment area of the medial collateral ligament, is located on the medial surface of the medial femoral condyle (Fig. 1.4) [2, 8, 9]. The adductor tubercle where the adductor magnus tendon inserts is located superior and posterior to the medial epicondyle (Fig. 1.4). As on the lateral side, the origin of the medial head of the gastrocnemius muscle is in the posterior-superior part of the medial condyle (Fig. 1.4) [2, 8, 9]. The lateral surface of the medial condyle forms the medial wall of the intercondylar notch.

Intercondylar notch is located between the condyles (Fig. 1.5). This notch contains the attachment areas of the anterior and posterior cruciate ligaments [1, 2]. The cartilage covering the trochlear groove forms the anterior border of

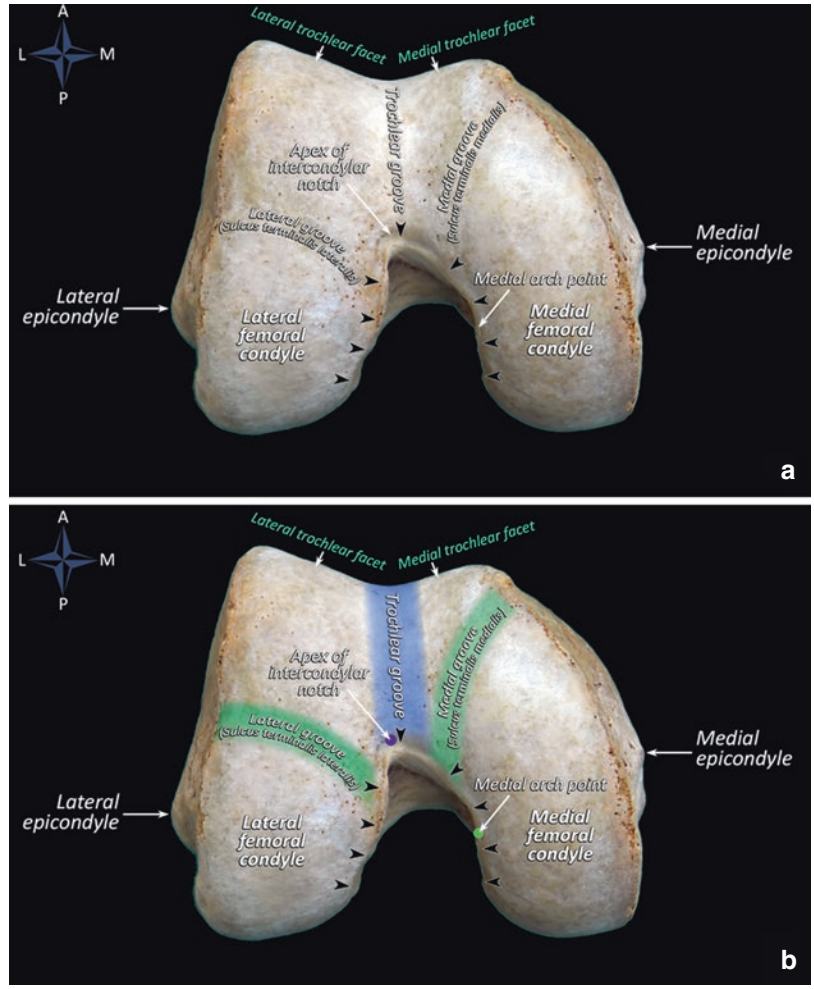

Fig. 1.2 Inferior view of the right distal femur. (**a**) Native view. (**b**) Colored view. *A* anterior, *P* posterior, *L* lateral, *M* medial, on the star showing directions

the intercondylar notch. The notch is separated from the popliteal surface by the intercondylar line posteriorly. The attachment area of the anterior cruciate ligament (ACL) is on the lateral wall of the notch, in other words, the posterior and superior parts of the medial surface of the lateral femoral condyle. This area can be observed as a slight depression (Fig. 1.5). Similarly, the attachment area of the posterior cruciate ligament (PCL) places on the medial wall of the notch, in other words, the anterior and superior parts of the lateral surface of the medial femoral condyle (Fig. 1.5).

The condyles join anteriorly to form a joint surface for the patella (Fig. 1.1). This surface, known as the patellar surface, extends further proximally on the anterior aspect of the lateral condyle (Figs. 1.1 and 1.2). The lateral facet of the patellar surface is separated from the outer surface of the lateral condyle with a more vertical and more prominent edge (Fig. 1.2). The medial facet of the patellar surface is flatter (Fig. 1.2) [2]. The trochlear groove is a significant structure for the stability of the patella. The decrease in the slope of the groove, especially the lateral side, may lead to dislocations of the patella.

1.2.2 Proximal End of the Tibia

Just as at the distal end of the femur, the most significant structures at the proximal end of the tibia are the lateral and medial condyles (Fig. 1.6). The lateral and medial joint facets covered with

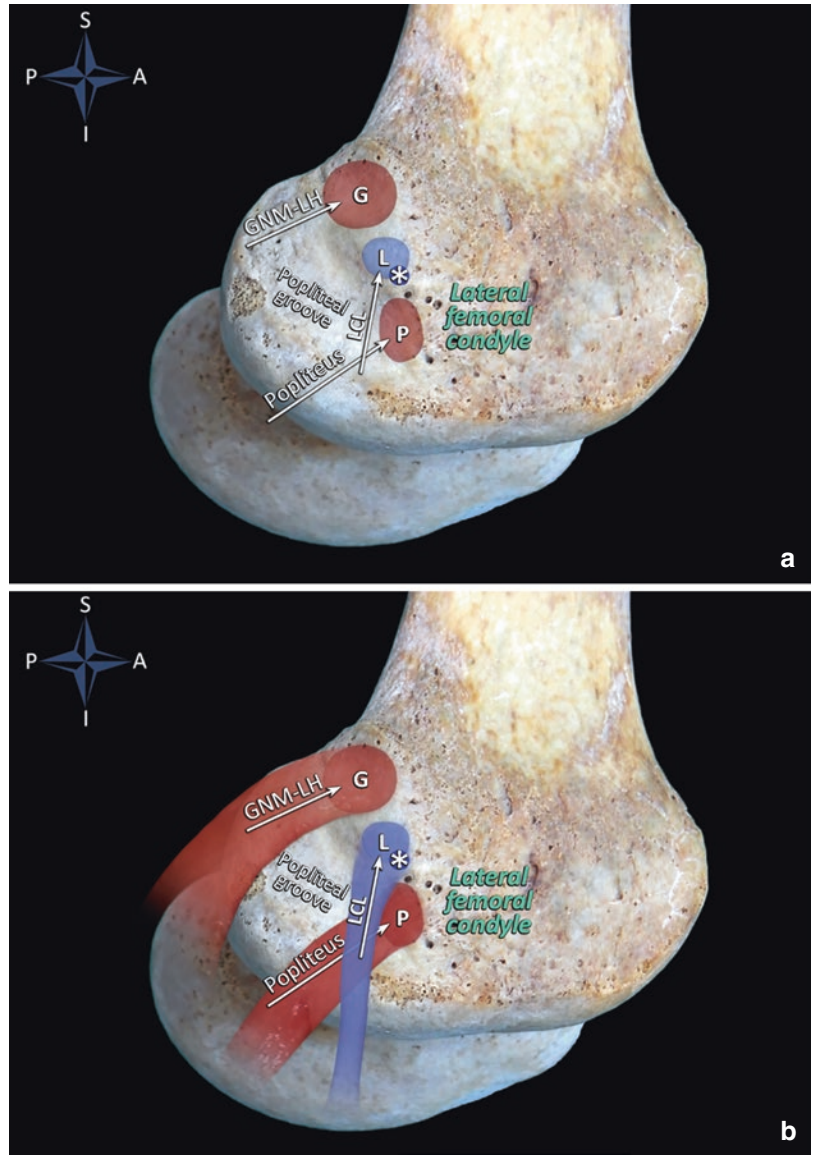

Fig. 1.3 Lateral view of the right distal femur. Structures that attach to the lateral side of the lateral femoral condyle. (**a**) Placement of footprints. (**b**) Extension of the attached structures. Asterisk is on the lateral epicondyle. *G* lateral head of the gastrocnemius (GNM-LH), *L* lateral collateral ligament (LCL), *P* popliteus. *S* superior, *I* inferior, *P* posterior, *A* anterior, on the star showing directions

cartilage are located on the superior articular surface, known clinically as the tibial plateau (Fig. 1.7). The menisci are located on the condyles. The central parts of the medial and lateral facets are in contact with the femur and the peripheral parts with the menisci. The joint surfaces are not completely in the horizontal plane. They are slightly inclined posteriorly and inferiorly according to tibia shaft (Fig. 1.8). Moreover, this inclination differs between the lateral and medial condyles. The intercondylar area is located between the condyles (Fig. 1.6). The cruciate ligaments are attached to this area with the anterior and posterior roots of the menisci (Fig. 1.7). The proximal tibia slopes posteriorly in the sagittal plane (Fig. 1.8). Because of this slope, the centers of the condyles (centers of the joint surfaces) come over the posterior part of the tibia shaft [2].

The joint surface of the medial condyle (*medial articular facet*) is oval shaped with its long axis in the anteroposterior direction

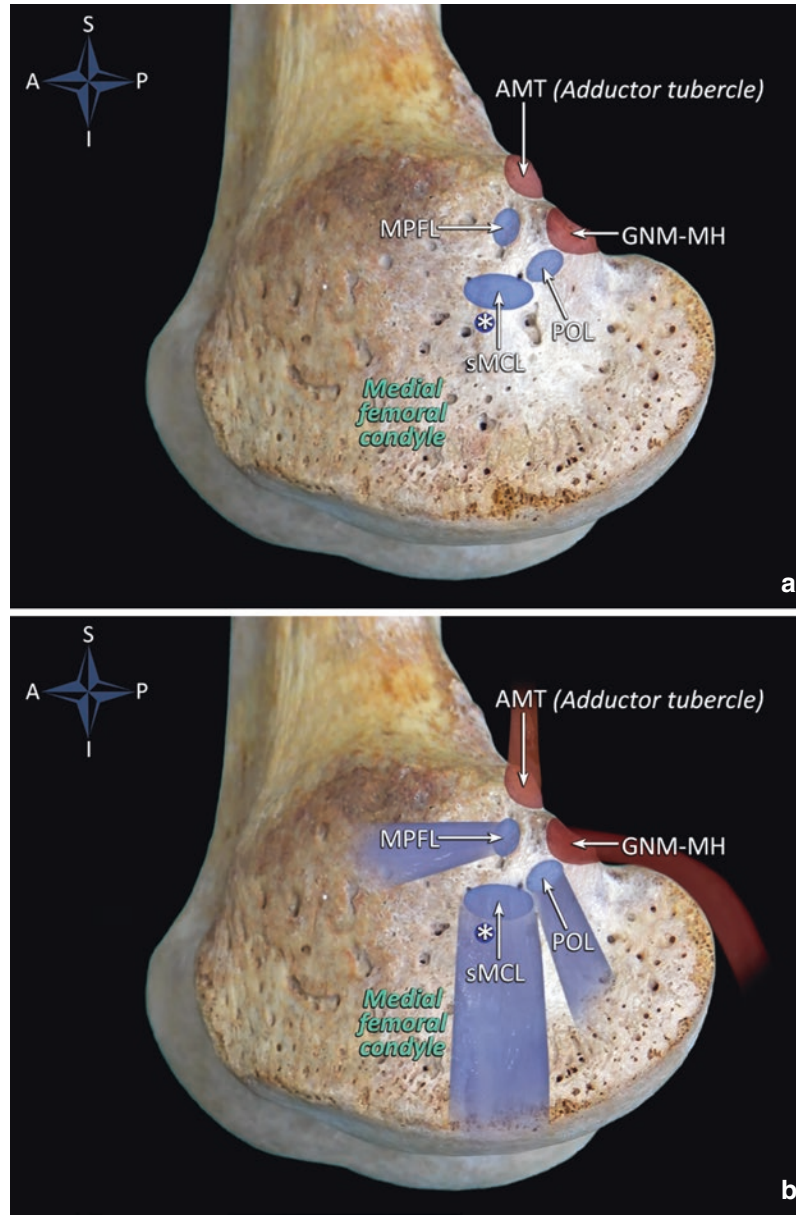

Fig. 1.4 Medial view of the right distal femur. Structures that attach to the medial side of the medial femoral condyle. (**a**) Placement of footprints. (**b**) Extension of the attached structures. Asterisk is on the medial epicondyle. *AMT* adductor magnus tendon, *MPFL* medial patellofemoral ligament, *sMCL* superficial medial collateral ligament, *POL* posterior oblique ligament, *GNM-MH* medial head of the gastrocnemius. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

(Fig. 1.7). The trace of the medial meniscus is narrower at the anterior and wider at the posterior direction (Fig. 1.7). The meniscus covers more space at the posterior part of the facet, and the anterior part has a mild slope (approximately 10°) to superior for providing a concavity. The joint surface of the lateral condyle (*lateral articular facet*) is smaller and rounder than the medial (Fig. 1.7). It is slightly concave in the transverse axis and slightly convex in the sagittal axis. Medial and lateral intercondylar tubercles are observed on the close sides of both the facets (Fig. 1.6).

An intercondylar area with an irregular surface is seen between the medial and lateral facets (Fig. 1.6). The middle region of the intercondylar area formed by the medial and lateral intercondylar tubercles is named as the intercondylar emi-

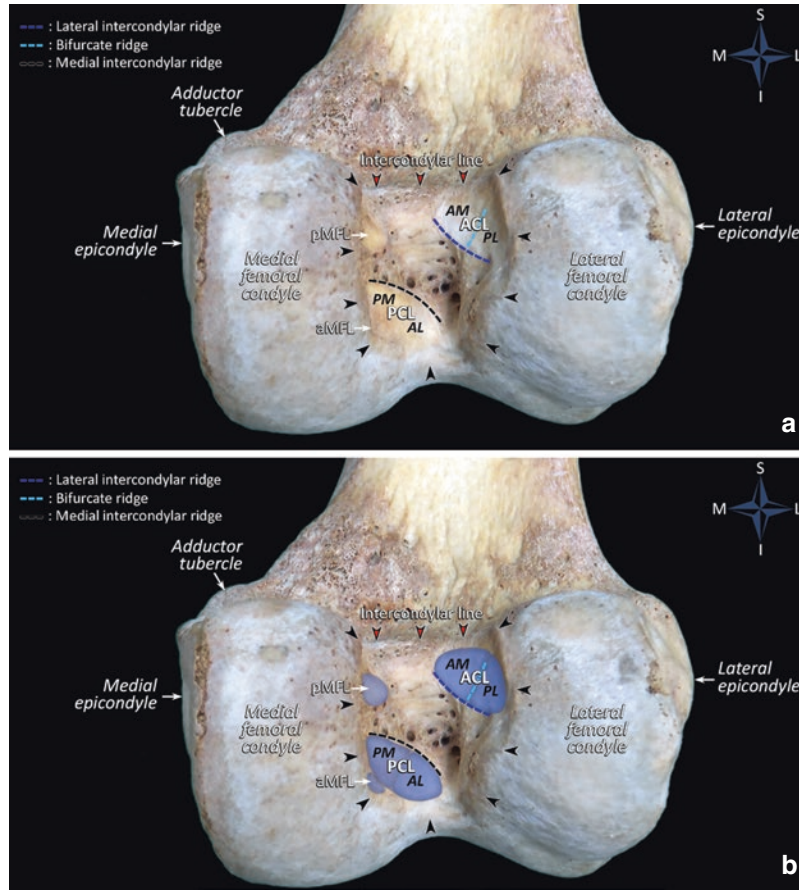

Fig. 1.5 Posterior view of the right distal femur. Structures that attach to the intercondylar notch. (**a**) Native view. (**b**) Colored view. Black arrowheads indicate border of the intercondylar notch. *ACL* anterior cruciate ligament, *AM* anteromedial bundle of ACL, *PL* posterolateral bundle of ACL, *PCL* posterior cruciate ligament, *AL* anterolateral bundle of PCL, *PM* posteromedial bundle of PCL, *aMFL* anterior meniscofemoral ligament, *pMFL* posterior meniscofemoral ligament. *S* superior, *I* inferior, *M* medial, *L* lateral, on the star showing directions

nence. The eminence is more prominent and narrower region of the intercondylar area. The ACL and the anterior roots of the menisci attach to the anterior intercondylar area in front of the intercondylar eminence (Fig. 1.7) [10, 11]. The footprint of the anterior root of the medial meniscus is seen in the anteromedial of the anterior intercondylar area [12]. The footprint of the ACL is in front of the intercondylar eminence, and the footprint of the anterior root of the lateral meniscus is immediately posterolateral to it (Fig. 1.7) [13]. The PCL and the posterior roots of the menisci are attached to the posterior intercondylar area which is posterior to the intercondylar eminence (Fig. 1.7) [14–16]. In the posterior intercondylar area, the posterior root of the lateral meniscus is attached to the flat area posterior to the lateral intercondylar tubercle. The posterior root of the medial meniscus is attached to the depressed area posterior to the medial intercondylar tubercle just anterior to PCL (Fig. 1.7) [12]. The footprint of the PCL extends more posteriorly and slightly inferiorly from the tibial plateau (Fig. 1.7) [14].

A triangular area is seen on the anterior surface of the proximal end of the tibia. The base of this triangle is above, and it is formed by the line joining the anterior edges of the condyles. The top of the triangle is marked by the tibial tuberosity (Fig. 1.9) [1]. The tibial tuberosity is formed of two areas which are flatter at the superior and rougher at the inferior. The patellar tendon is attached to the inferior part and the infrapatellar bursa is located beneath this tendon in the superior part [2]. The lateral edge of this triangle is more evident than the medial.

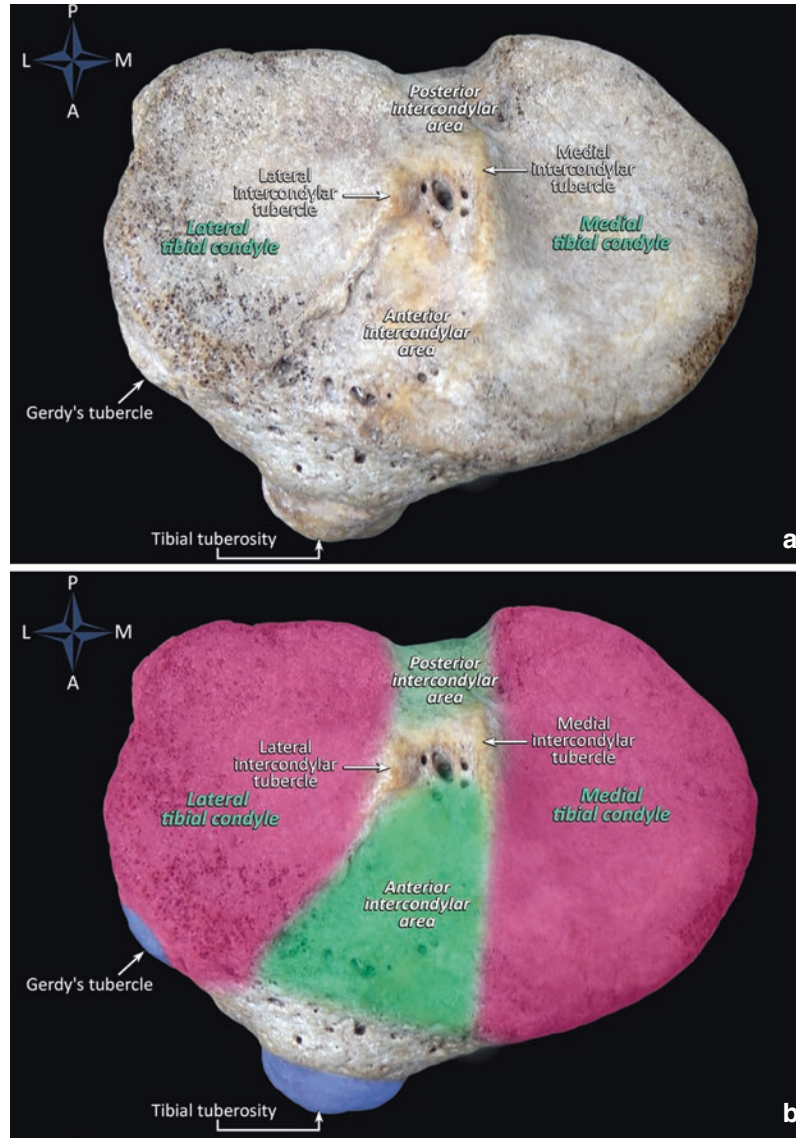

Fig. 1.6 Superior view of the right proximal tibia. (**a**) Native view. (**b**) Colored view. *P* posterior, *A* anterior, *L* lateral, *M* medial, on the star showing directions

Majority of the iliotibial tract fibers are attached to the most prominent point on this edge. This protuberance is known as Gerdy's tubercle (Fig. 1.9) [6].

The posterior and inferior surfaces of the lateral condyle of tibia make a joint with the fibula head. The fibular articular facet is smooth and oval shaped. The slope of the facet varies considerably between individuals (Fig. 1.10). A shallow groove where the popliteus tendon is located is observed at the medial side of the facet. Semimembranosus inserts are on the posterior side of the medial condyle. A groove is observed for semimembranosus tendon, above the insertion of this muscle. The upper part of this groove appears vertical, and semimembranosus tendon is located on it. The lower part of this groove appears transverse, and the anterior arm of semimembranosus tendon is attached to it. The attachment area of the posterior oblique ligament (POL) is observed medial to semimembranosus. This area is between the attachments of semi-

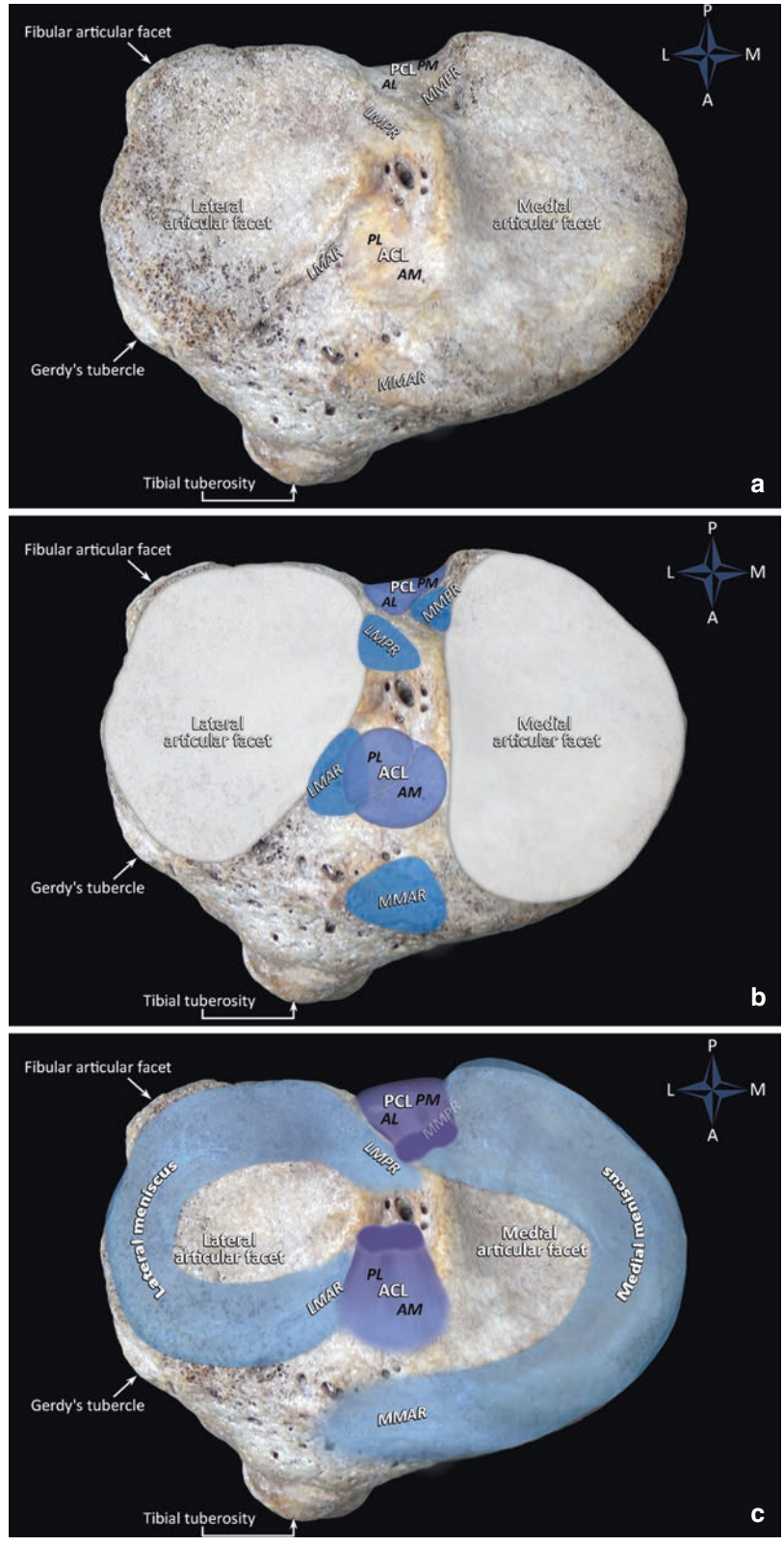

Fig. 1.7 Superior view of the right proximal tibia. Structures that attach to the intercondylar areas. (**a**) Native view. (**b**) Colored view. (**c**) Extension of the attached structures. *ACL* anterior cruciate ligament, *AM* anteromedial bundle of ACL, *PL* posterolateral bundle of ACL, *PCL* posterior cruciate ligament, *AL* anterolateral bundle of PCL, *PM* posteromedial bundle of PCL, *LMAR* lateral meniscus anterior root, *LMPR* lateral meniscus posterior root, *MMAR* medial meniscus anterior root, *MMPR* medial meniscus posterior root. *P* posterior, *A* anterior, *L* lateral, *M* medial, on the star showing directions

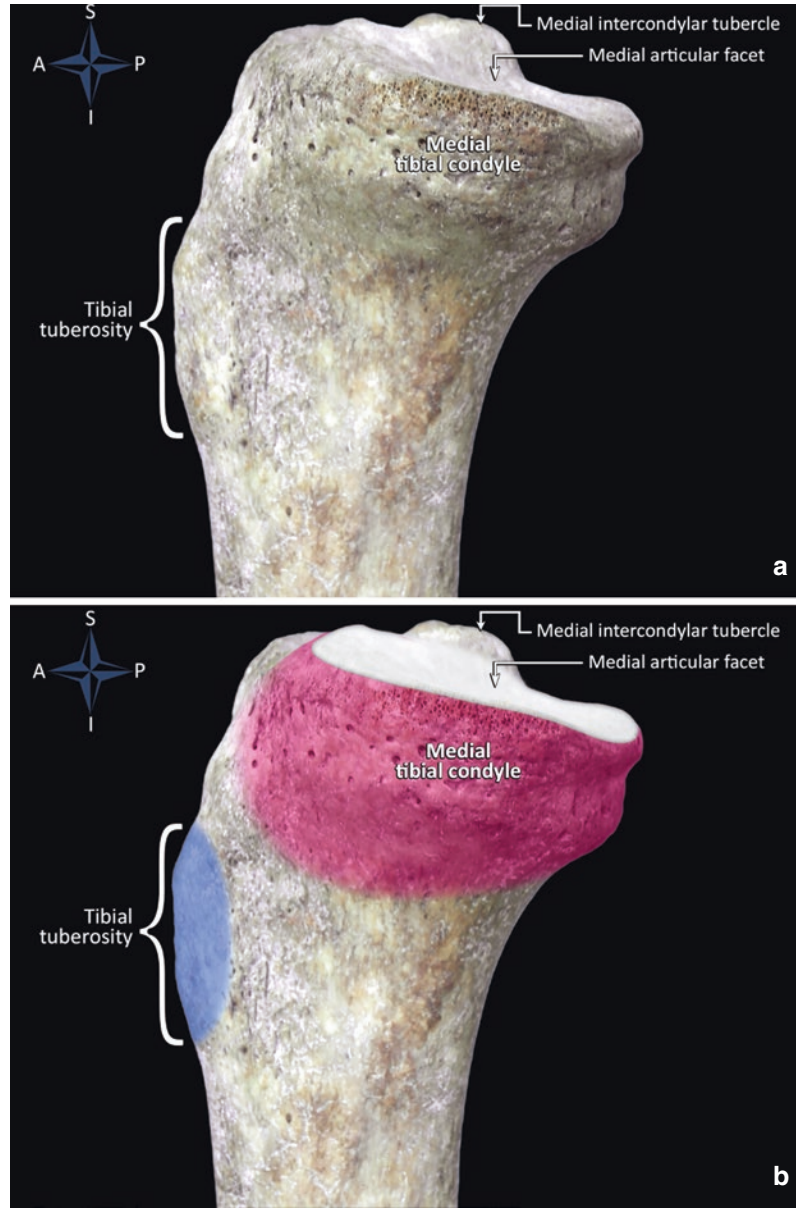

Fig. 1.8 Medial view of the right proximal tibia. (**a**) Native view. (**b**) Colored view. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

membranosus and PCL. The posterior intercondylar area extends a few centimeters distal to the tibial plateau level between the two condyles in the form of a groove (Fig. 1.10).

Soleus muscle is attached to the soleal line on the posterior side of the tibia at proximal. Popliteus attaches to the triangular area which is supero-medial to soleal line. The tibialis posterior attaches to the area which is inferolateral to the soleal line (Fig. 1.10).

1.2.3 Proximal End of the Fibula

The proximal end of the fibula consists mainly of the head of the fibula. The neck of the fibula is located just distal to the fibular head (Fig. 1.11). The facet of the fibular head articulates with the posteroinferior of the lateral condyle of the tibia (Figs. 1.9 and 1.11). The inclination of the articular facet varies considerably between individuals. It can be closer to the horizontal plane or have an

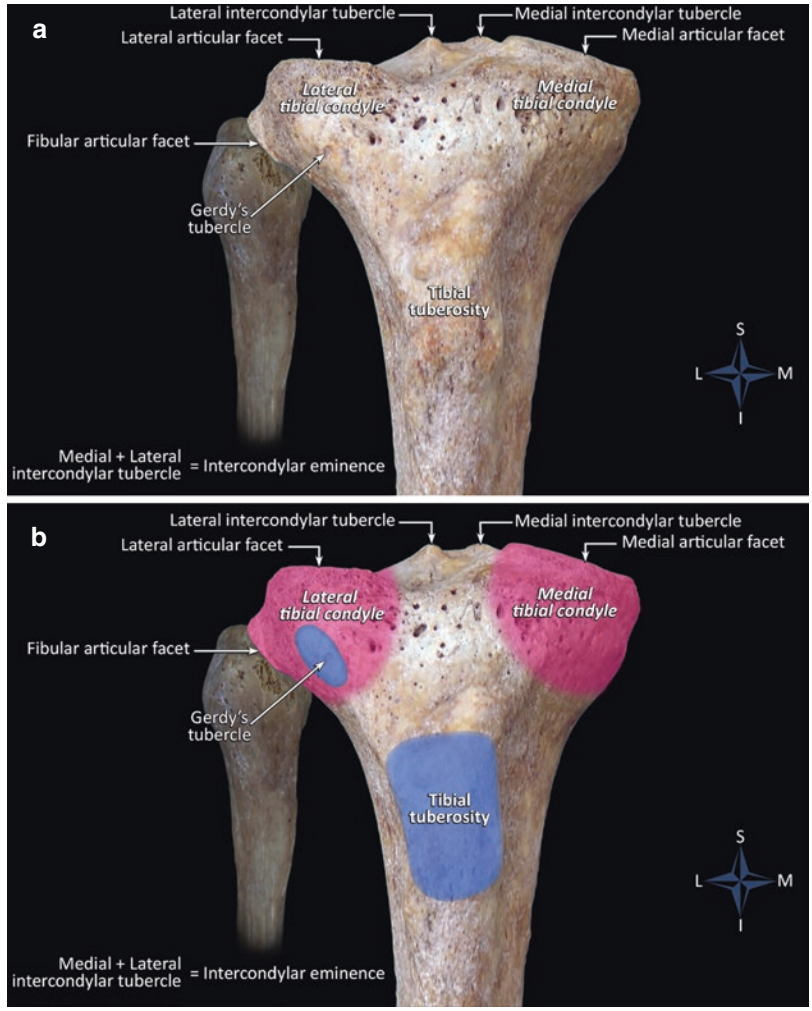

Fig. 1.9 Anterior view of the right proximal tibia. (**a**) Native view. (**b**) Colored view. *S* superior, *I* inferior, *L* lateral, *M* medial, on the star showing directions

oblique course up to 45° [2]. A prominence is observed over the head, which is named the apex of the head or styloid process. The LCL and biceps femoris are attached to the lateral of the fibular head. The popliteofibular ligament is more posteriorly attached the styloid process (Fig. 1.12).

1.2.4 Patella

The patella is the largest sesamoid bone in the body [1]. It is located inside the tendon of the quadriceps femoris. It is a triangular bone. The apex of the patella is at the inferior and base of that is at the superior (Fig. 1.13). There are two flat joint surfaces divided as lateral and medial patellar facets by a vertical ridge (Fig. 1.13) [17]. These surfaces provide fitness with the trochlear groove and facets on the joint surface facing the femur. The lateral joint surface is larger in order to fit with the longer and wider lateral trochlear facet of the patellar surface of the femur. The proximal part of anterior surface slopes slightly from superior to inferior and from posterior to anterior (Fig. 1.13). The rectus femoris is attached to the anterior and inferior of this surface, which is separated with a blunt edge from the middle part of anterior surface. The

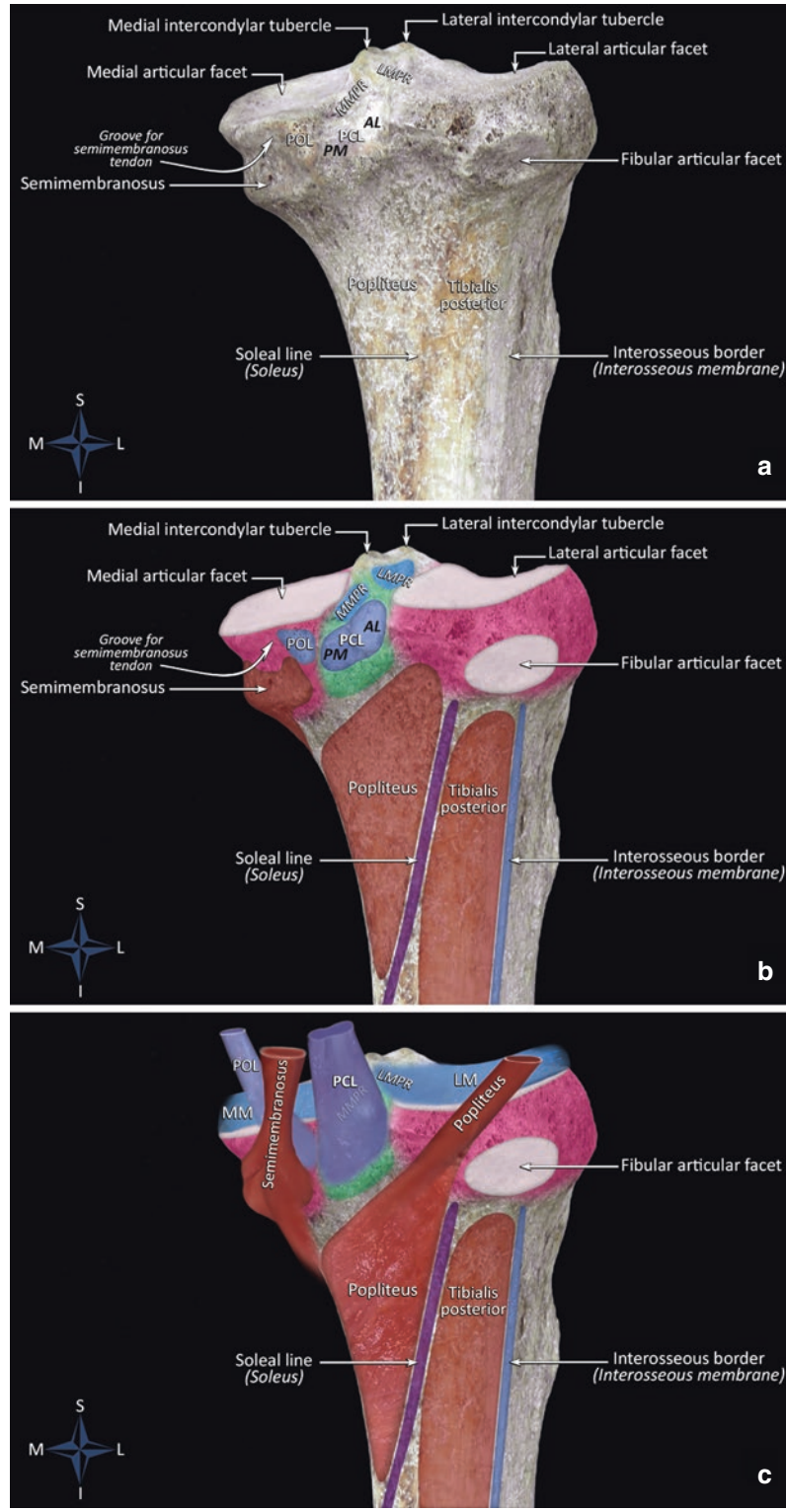

Fig. 1.10 Posterior view of the right proximal tibia. (**a**) Native view. (**b**) Colored view. (**c**) Extension of the attached structures. *PCL* posterior cruciate ligament, *AL* anterolateral bundle of PCL, *PM* posteromedial bundle of PCL, *LMPR* lateral meniscus posterior root, *MMPR* medial meniscus posterior root, *POL* posterior oblique ligament. *S* superior, *I* inferior, *L* lateral, *M* medial, on the star showing directions

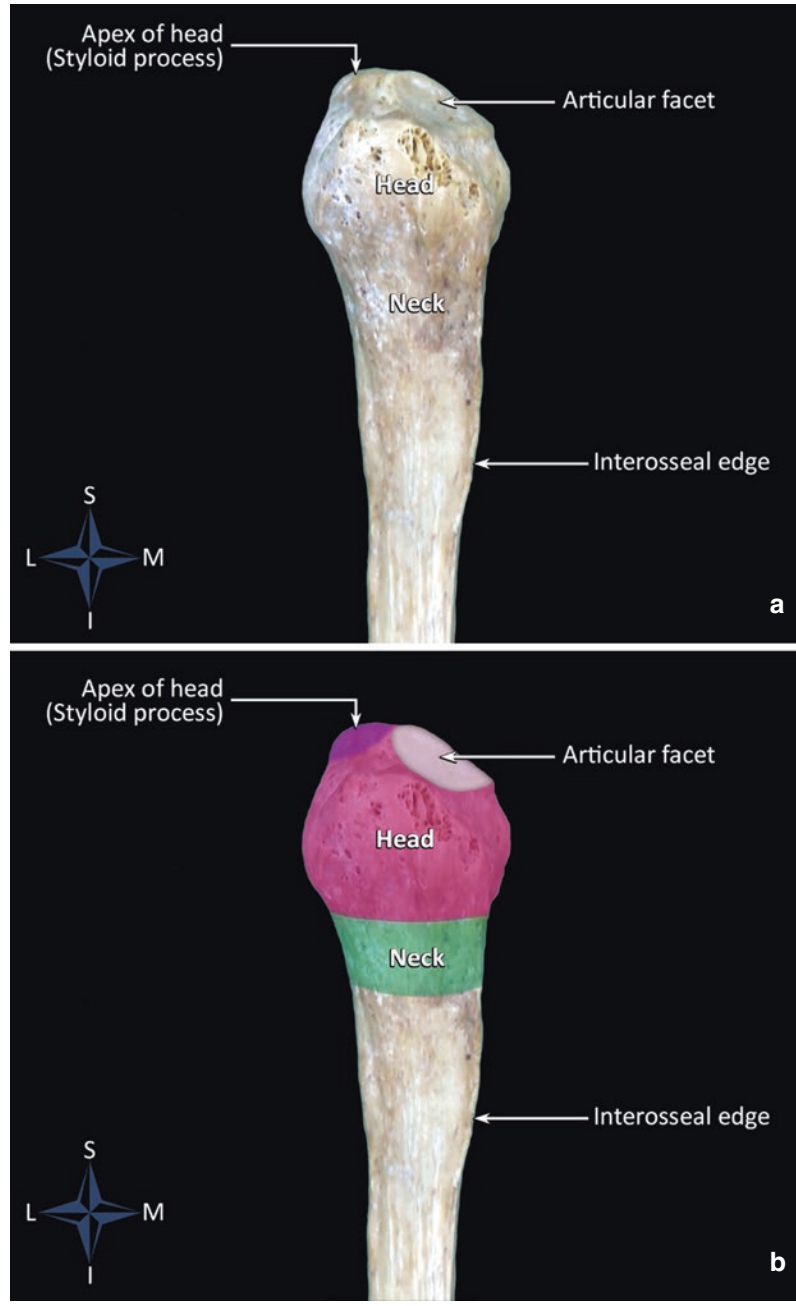

Fig. 1.11 Anterior view of the right proximal fibula. (**a**) Native view. (**b**) Colored view. *S* superior, *I* inferior, *L* lateral, *M* medial, on the star showing directions

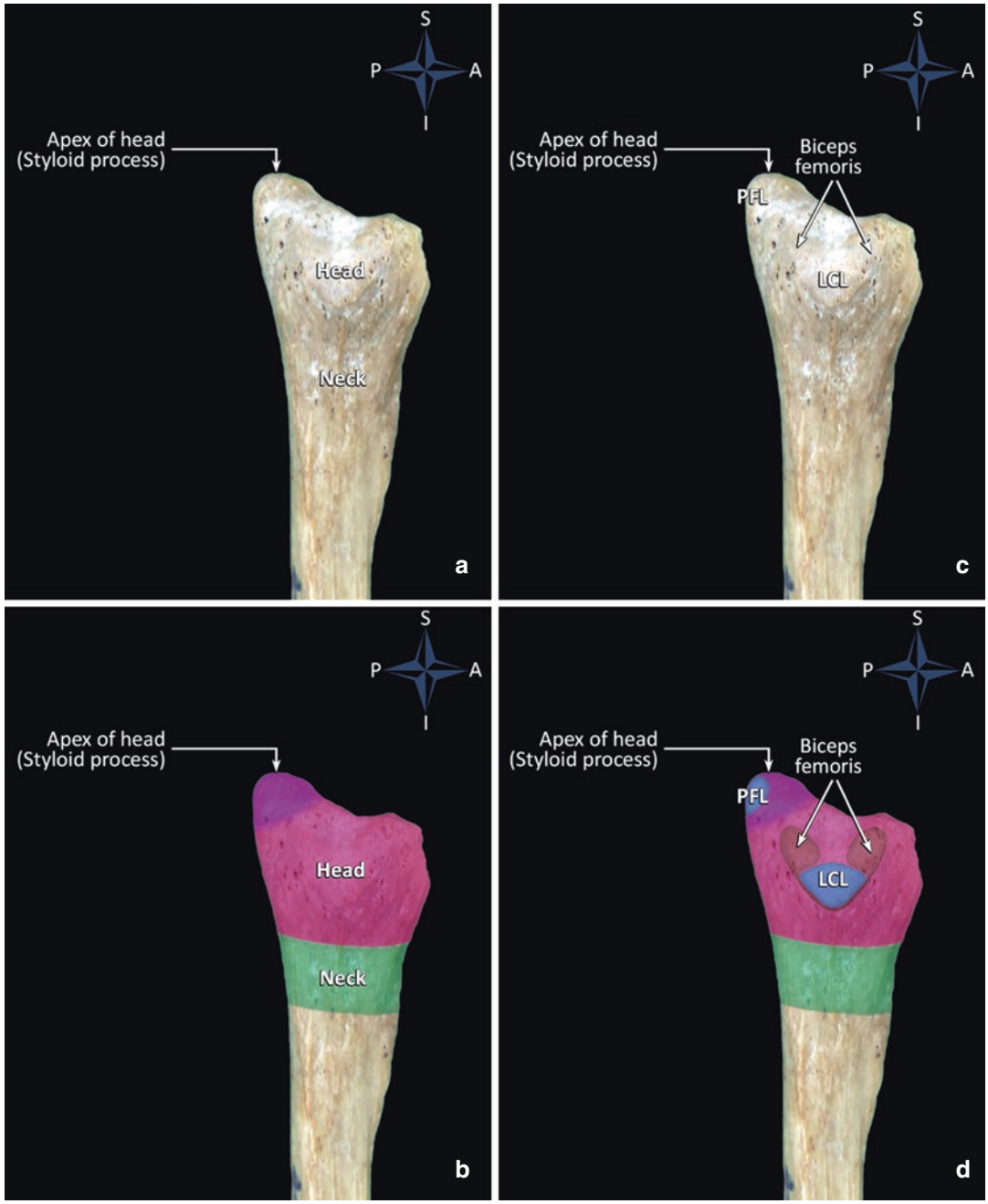

Fig. 1.12 Lateral view of the right proximal fibula. (**a**, **b**) Parts of the proximal fibula. (**c, d**) Structures that attach to the proximal fibula. (**a**, **c**) Native view. (**b**, **d**) Colored view. *LCL* lateral collateral ligament, *PFL* popliteofibular ligament. *S* superior, *I* inferior, *P* posterior, *A* anterior, on the star showing directions

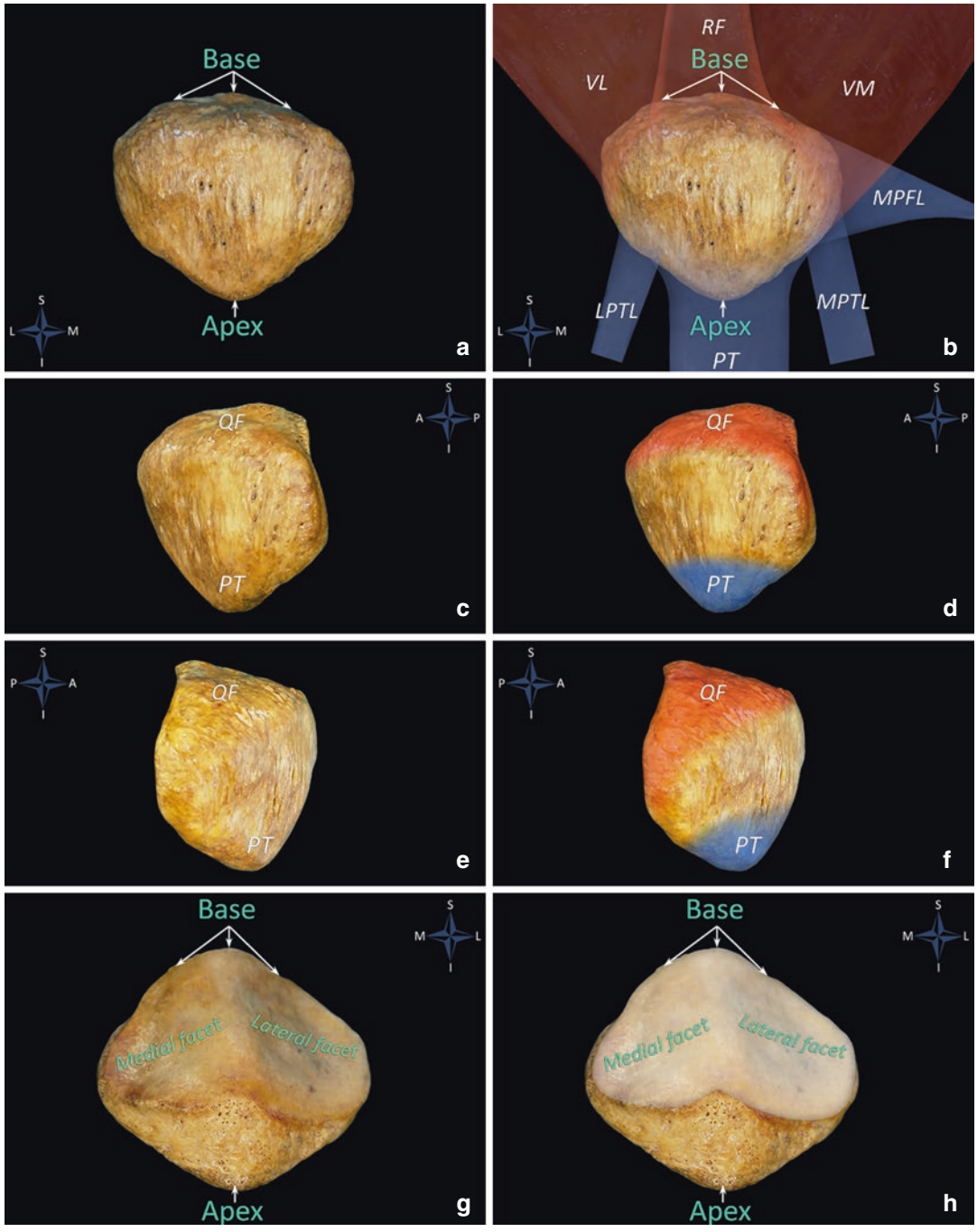

Fig. 1.13 Right patella. (**a**, **b**) Anterior views. (**c**, **d**) Anteromedial views. (**e**, **f**) Anterolateral views. (**g**, **h**) Posterior views. (**a**, **c**, **e**, **g**) Native views. (**b**, **d**, **f**, **h**) Colored views. Extension of the structures attached on patella are shown on **b**. *RF* rectus femoris, *VL* vastus lateralis, *VM* vastus medialis, *MPFL* medial patellofemoral ligament, *PT* patellar tendon, *MPTL* medial patellotibial ligament, *LPTL* lateral patellotibial ligament, *QF* quadriceps femoris. *S* superior, *I* inferior, *L* lateral, *M* medial, *P* posterior, *A* anterior, on the star showing directions

vastus intermedius is attached to the center of the remaining posterior and superior, while the vastus lateralis and medialis are attached to each side of this surface. The distal parts of the tendons of vastus lateralis and medialis are attached to the upper halves of the lateral and medial edges of the patella (Fig. 1.13) [2, 17]. In particular, the inferior part of the vastus medialis extends more distally and courses more obliquely (named *vastus medialis obliquus*) [1, 2].

1.3 Lateral and Medial Sides of the Knee

The structures on the lateral and medial sides of the knee are similarly organized in layers. The differences between references are observed in the definitions of the structures in these layers. Nevertheless, these definitions provide a great convenience for the safe operation of lateral and medial knee surgery.

1.3.1 The Medial Side of the Knee

Structures in the medial side of the knee can be examined in three layers [2, 18]. Medial support and stability of the knee is provided by these anatomic structures located from superficial to deep. The different layers have important roles and functions in the mechanics of the knee joint.

Medial subcutaneous tissue: Significant neurovascular structures are found in the subcutaneous tissue over the important medial stabilizers. The great saphenous vein and saphenous nerve must be considered in this region (Fig. 1.14).

Great saphenous vein (long saphenous vein): This vein starts from the medial of the foot and extends superiorly from immediately anterior of the medial malleolus. It extends from the medial of the leg to the posteromedial of the knee. It is located posterior to patella as far as approximately a palm-size from the medial edge of the patella (Fig. 1.15) [1, 2].

The saphenous nerve enters the adductor canal together with femoral vessels. It separates from the vessels close to the lower end of the canal. It penetrates the anteromedial intermuscular septum (subsartorial fascia), which forms the anteromedial wall of the canal, and passes beneath the sartorius. It becomes superficial by penetrating the fascia lata between the sartorius and gracilis tendon, together with the saphenous branch of the descending genicular artery (Fig. 1.16) [1, 2, 19]. From here, it subcutaneously accompanies the long saphenous vein in the medial of the leg. It gives branches to the medial of the leg (medial crural cutaneous nerve) and extends to the medial of the foot with the vein. The infrapatellar branch of the saphenous nerve often separates from saphenous nerve immediately at the posterior edge of the sartorius and then curves laterally for distributing to the infrapatellar area (Figs. 1.15 and 1.16). However, variations are frequent [20]. It can also pass in front of or through sartorius to the infrapatellar region. The nerve is observed more than one branch in approximately three fourth of the cases [20–22]. These branches may appear in different courses in the same case. The infrapatellar branch can be transected in a medial parapatellar incision or during the opening anteromedial arthroscopy portals. The course and distribution of the nerve explain the sensory loss lateral to the incision site.

Layer 1: Layer 1 is the most superficial layer underneath the subcutaneous tissue. Basically, it is formed by the insertion of the sartorius muscle which is in aponeurotic structure. The medial patellar retinaculum is observed anterior to the sartorial fascia (Figs. 1.15 and 1.16).

Sartorial fascia: Since the ending of sartorius is observed as a fascia rather than a tendon, it is called "sartorial fascia" in many references. Sartorius fascia covers the last part of the gracilis and semitendinosus tendons on the medial side of the knee (Figs. 1.15 and 1.17). Most of the fibers attach to the anterolateral side of the tibia along a

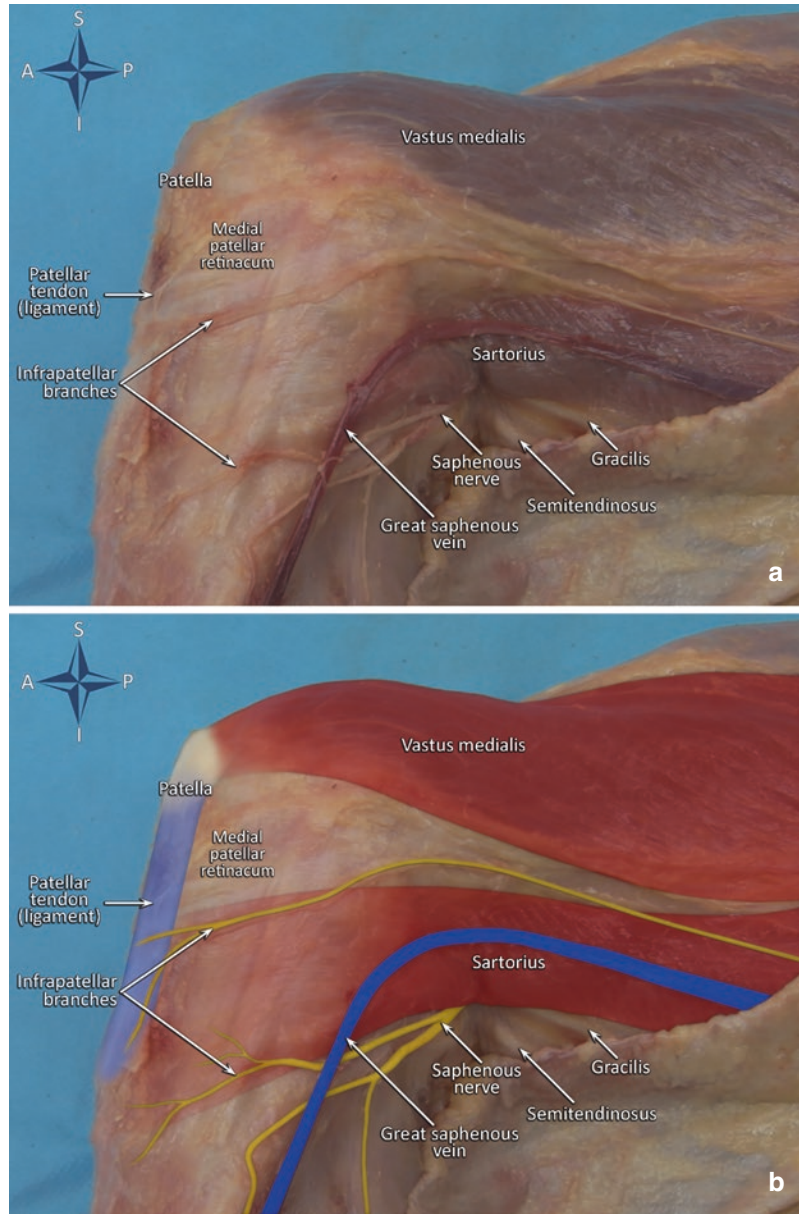

Fig. 1.14 Medial view of the right knee at 90° flexion. (**a**) Native view. (**b**) Colored view. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

thin line, just in front of the attachment of the gracilis and semitendinosus tendons, distal to the medial condyle (Fig. 1.17). The insertion on the tibia is about the level of the tibial tuberosity or approximately 5 cm from the joint line and extends 4–5 cm distally. The more distal part of the sartorial fascia combines with the fascia in the medial of the leg. There are connections with the semitendinosus and gracilis tendons close to the attachment site to the bone [23]. The tendons of the gracilis and semitendinosus with the sartorial fascia form the "pes anserinus" [19, 23]. More posteriorly, the sartorius fascia shows continuity with the popliteal fascia covering the popliteal structures.

Medial patellar retinaculum: In front of the sartorius fascia, the aponeurotic extensions of the vastus medialis in the medial of the patella form

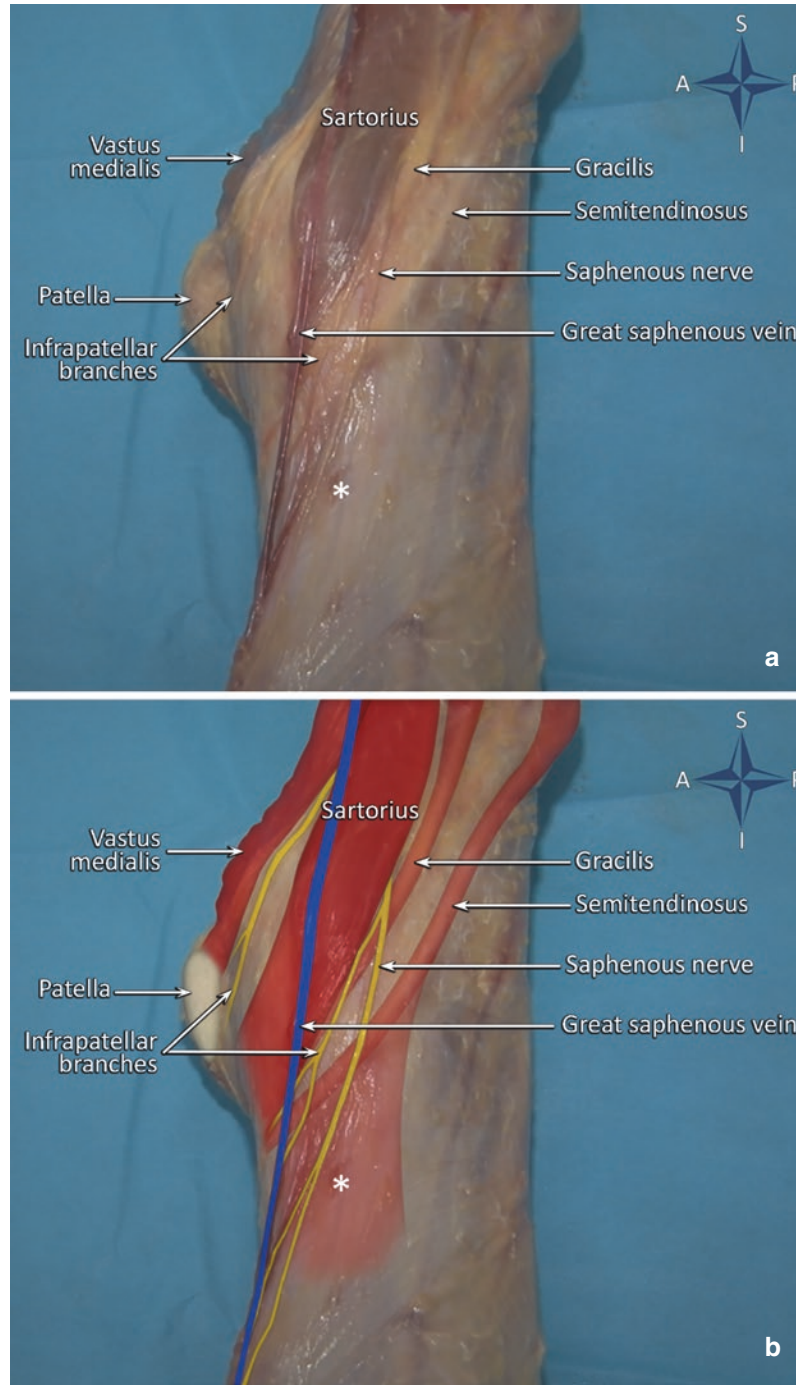

Fig. 1.15 Posteromedial view of the right knee at extension. (**a**) Native view. (**b**) Colored view. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

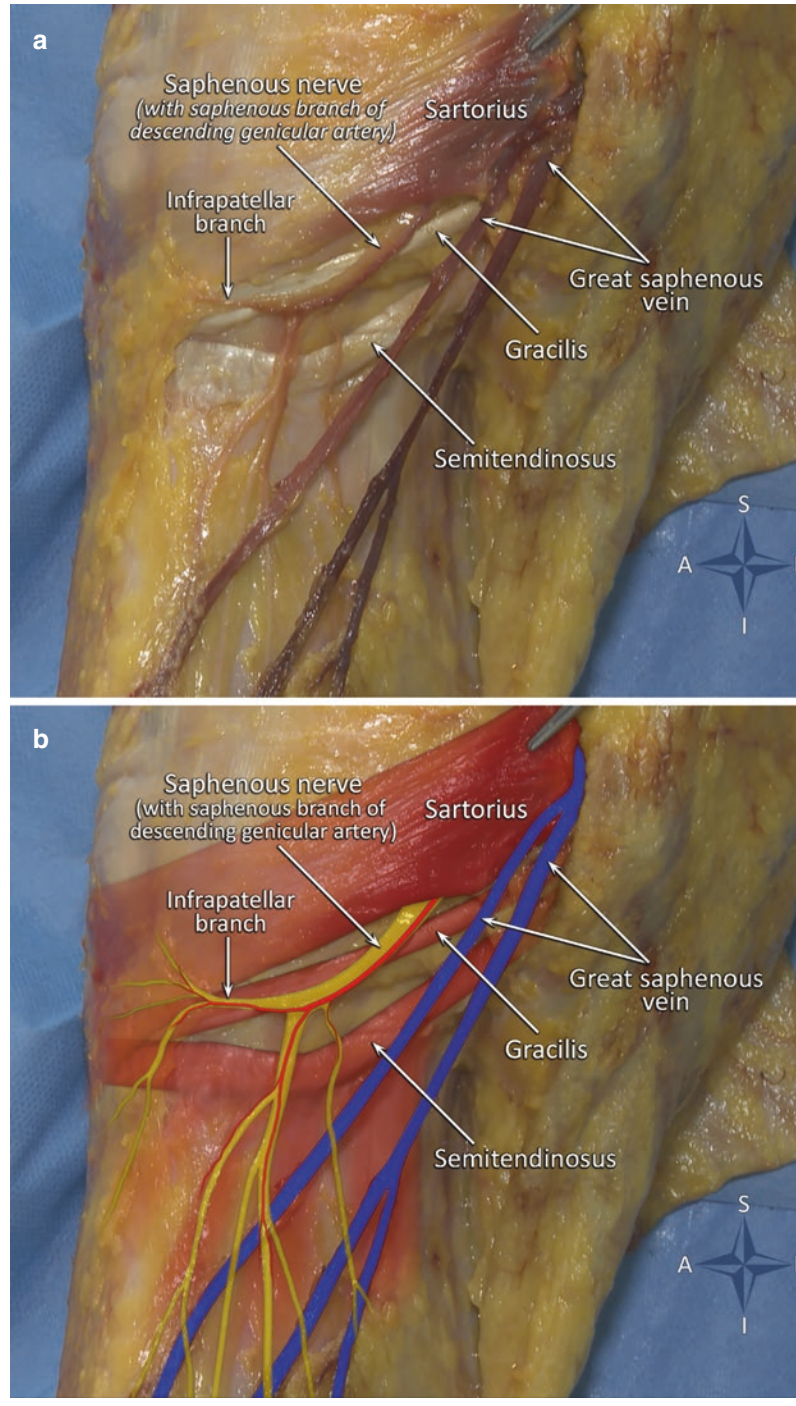

Fig. 1.16 Medial view of the right knee at 90° flexion. (**a**) Native view. (**b**) Colored view. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

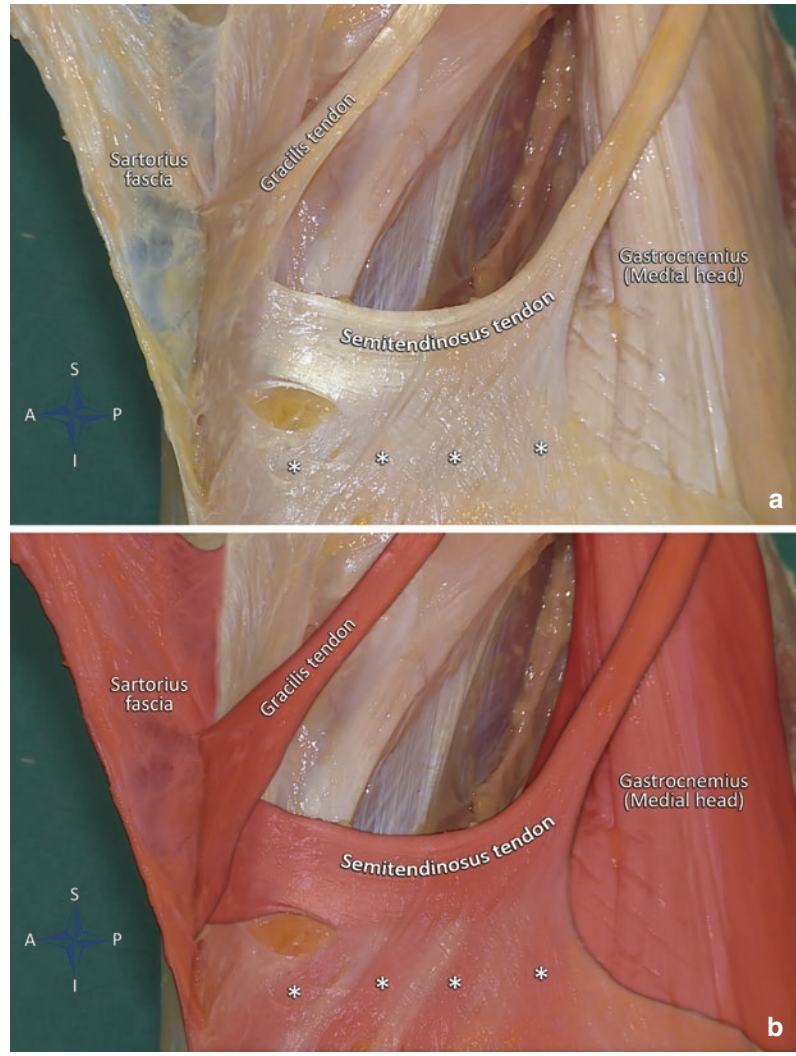

Fig. 1.17 Medial view of the right knee. (**a**) Native view. (**b**) Colored view. Pes anserinus muscles (sartorius, gracilis, and semitendinosus) are seen. Asterisks indicate accessory bands of semitendinosus blended with the fascia of medial head of gastrocnemius. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

the medial patellar retinaculum observed in the first layer. However, most of the fibers are inserted distally underneath the sartorius fascia and attach to the anterolateral of the medial condyle in front of superficial medial collateral ligament (sMCL) (Fig. 1.18) [8, 9, 18].

Tendons of gracilis and semitendinosus: These tendons extend between the first and the second layers [18]. The tendons insert on to the anteromedial of the tibia, approximately 2 cm medial and 2 cm distal from the tibial tuberosity. The gracilis tendon is anterior to the semitendinosus, and the attachment site to the bone is more proximal. Just as there are connections with overlying the sartorius fascia; particularly, the semitendinosus has wide connections with the deep fascia of the leg covering the medial head of the gastrocnemius (Figs. 1.16 and 1.17) [8, 18, 19, 23–25]. During tendon harvesting, these connections should be cut in order to isolate the tendon. There is a high risk of early rupture of the tendon which is tried to be removed without isolating. The bursa of the pes anserinus (anserine bursa) is located between the superficial MCL and the tendons of gracilis and semitendinosus [2].

Layer 2: Most of this layer is formed by the superficial medial collateral ligament (sMCL) [18]. The medial patellofemoral ligament is another important structure in this layer (Fig. 1.18).

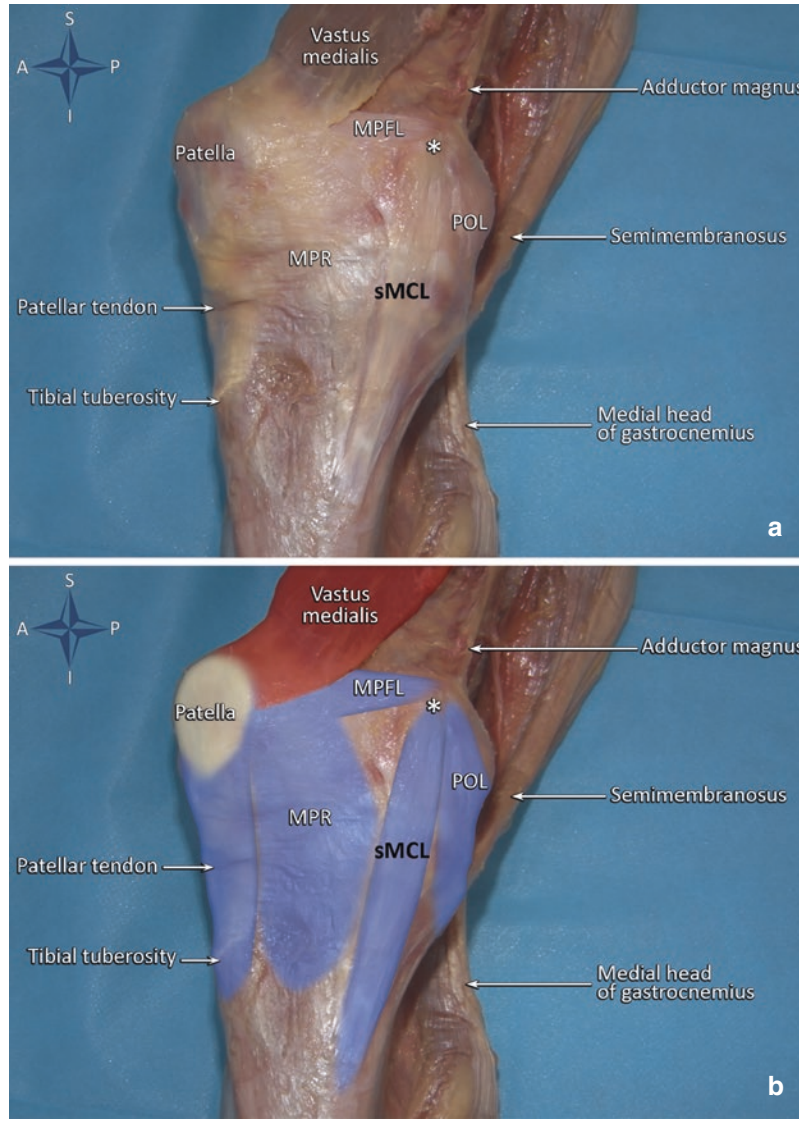

Fig. 1.18 Medial view of the right knee. (**a**) Native view. (**b**) Colored view. Pes anserinus muscles were removed. Asterisk indicates the medial epicondyle. *MPFL* medial patellofemoral ligament, *MPR* medial patellar retinaculum, *sMCL* superficial medial collateral ligament. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

Superficial medial collateral ligament (sMCL): The medial collateral ligament (MCL) is the most frequently injured ligament in the knee [26]. It consists of two parts: the superficial and deep. While sMCL is in the second layer, the deep MCL (dMCL) is in the third layer (Figs. 1.18 and 1.19). sMCL is the primary stabilizer protecting the knee from valgus at all flexion angles starting from full extension [18]. sMCL originates from just proximal and posterior to the medial epicondyle of the femur [8, 27]. Unlike the LCL, it is a smooth and wide ligament, extending vertically under the tendons of gracilis and semitendinosus. The anserine bursa is located between these tendons and the ligament. The vertical fibers of the sMCL attach to a relatively large area extending 6–7 cm distally on the just anterior to the medial edge of the tibia [28].

Medial patellofemoral ligament (MPFL): MPFL originates from immediately posterosuperior to the medial epicondyle and anteroinferior to the adductor tubercle. The ligament courses transversely to anterolateral over the capsule and extends to the inferior edge of the vastus medialis obliquus. It enters deep into the fibers of vastus medialis obliquus (VMO) and fuses with the aponeurotic lower edge of this muscle (Fig. 1.18). The MPFL together with the distal part of VMO

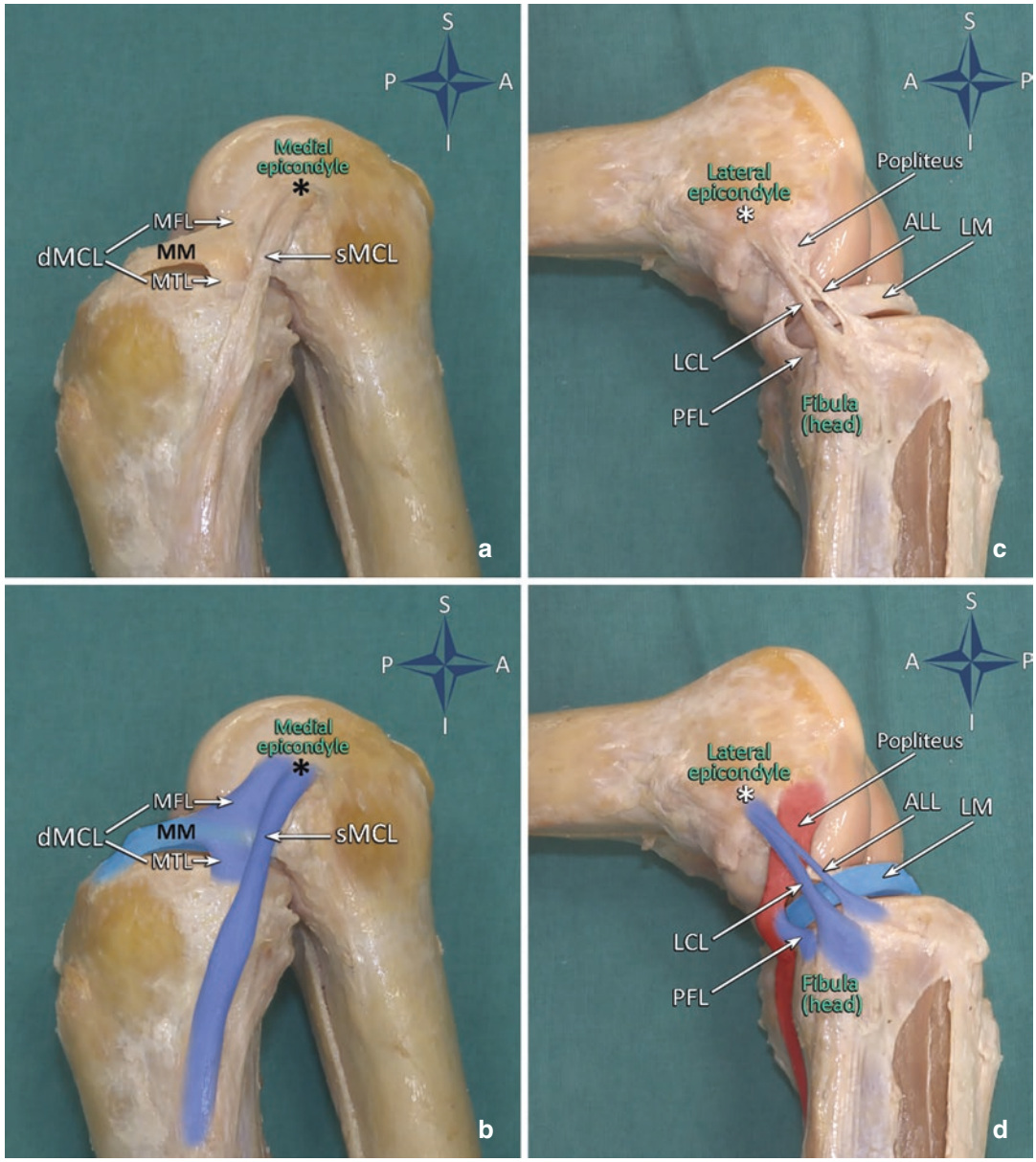

Fig. 1.19 Lateral (**a**, **b**) and medial (**c**, **d**) views of the right knee. (**a**, **c**) Native views. (**b**, **d**) Colored views. *sMCL* superficial medial collateral ligament, *dMCL* deep medial collateral ligament, *MFL* meniscofemoral ligament, *MTL* meniscotibial ligament, *MM* medial meniscus, *LCL* lateral collateral ligament, *PFL* popliteofibular ligament, *ALL* anterolateral ligament, *LM* lateral meniscus. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

attach to the upper half of the medial edge of the patella. MPFL is one of the most important static stabilizers of the patella, especially in the knee in extension [8, 18, 27].

Layer 3: Deep part of the MCL and the posterior oblique ligament are seen in this layer. These structures are secondary stabilizers protecting the knee against valgus.

Deep medial collateral ligament (dMCL): The vertically extending fibers beneath sMCL form dMCL. The upper part of this ligament extends from the femur to the medial meniscus. This part

is named as the *meniscofemoral ligament*. The inferior part of the dMCL extends from the medial meniscus to the tibia. These fibers are named the *meniscotibial or the coronary ligament* (Fig. 1.19) [8, 27, 29, 30].

Posterior oblique ligament (POL): The oblique fibers of the posteromedial joint capsule located posterior to sMCL form POL (Fig. 1.20). This ligament is a secondary stabilizer protecting the knee against valgus and, more importantly,

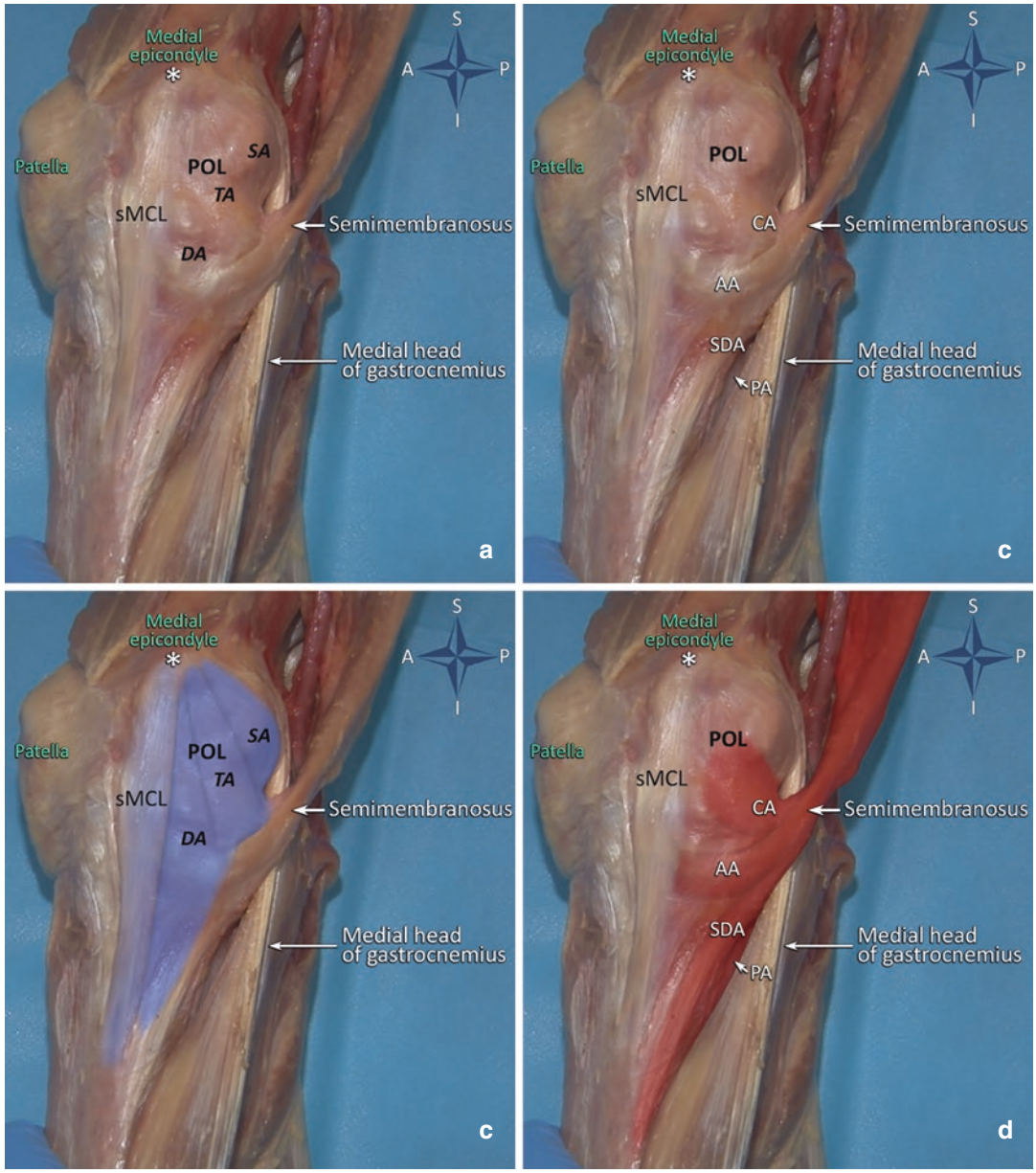

Fig. 1.20 Medial view of the right knee. (**a**, **c**) Native views. (**b**, **d**) Colored views. Pes anserinus were removed. The arms of posterior oblique ligament (POL) (**a**, **b**) and semimembranosus (**c**, **d**) in the posteromedial corner of the knee are shown. sMCL superficial medial collateral ligament. The arms of posterior oblique ligament (POL): *SA* superior (or capsular) arm, *TA* tibial (central) arm, *DA* distal (or superficial) arm. The arms of semimembranosus: *CA* capsular arm, *AA* anterior arm, *SDA* superficial direct arm, *PA* popliteal arm. *S* superior, *I* inferior, *A* anterior, *P* posterior, on the star showing directions

provides rotational stability by limiting internal rotation of the tibia in extension [8, 31, 32].

POL has three arms [8, 9, 27]. The most proximal fibers of POL extend to the posterior knee capsule. This part is called capsular or superior arm. It is weaker than other parts of the ligament. The middle and strongest part of POL is named as tibial or central arm. It inserts posterior to the medial tibial condyle, deep in the semimembranosus tendon. The most distal fibers extend immediately posterior to and parallel to the sMCL. This part, called distal or superficial arm, passes over the anterior arm of semimembranosus (Fig. 1.20).

Numerous extensions of the semimembranosus tendon that are related to POL have been described: capsular, anterior, superficial direct, popliteal, deep direct, oblique popliteal ligament arms [8, 9, 28, 33]. The most proximal capsular arm (CA) extends to the posteromedial joint capsule. Here it fuses with POL's central arm. Anterior arm (AA) enters beneath the distal arm of POL and inserts on posteromedial to the medial tibial condyle. Superficial direct arm (SDA) extends parallel to the distal arm of POL, on the medial edge of the tibia (Fig. 1.20). Popliteal arm (PA) blends with the fascia of popliteus. Deep direct arm (DDA) inserts on posterior to the medial tibial condyle, directly (Fig. 1.21).

Deep structures between sMCL and PCL is located in the posteromedial corner of the knee (Fig. 1.21) [27]. The "posteromedial corner" (PMC) structures of the knee include the posteromedial joint capsule which contains POL and the tendon of semimembranosus. In addition to limiting valgus, these structures have important functions in providing rotational stability, particularly by limiting internal rotation.

1.3.2 The Lateral Side of the Knee

Recent studies have emphasized the importance of the structures providing stability from the lateral aspect of the knee, especially "posterolateral corner (PLC)." Injuries to several structures disregarded are associated with knee instability and unsuccessful results following cruciate ligament repair [34–37].

The lateral structures of the knee limit the varus of the knee. In addition to this, posterior translation and external rotation are limited by the PLC structures. Isolated PLC damage is rarely seen. Injuries of these structures are more often (43%–80%) associated with damage to other ligamentous structures of the knee, including damage to the PCL and/or ACL [38–42].

The structures in the lateral of the knee can be identified in three layers from superficial to deep [35, 36, 38, 43, 44]. The structure described in one layer can sometimes be incorporated into the more superficial or deeper layer in different references.

Layer 1: The iliotibial tract, lateral patellar retinaculum, and biceps femoris tendon are in this layer (Fig. 1.22). The common peroneal nerve has a course between the first and the second layers.

Iliotibial tract: The lateral part of the fascia lata thickens and extends to the leg in the form of a firm band. This band is named the iliotibial tract. The tensor fasciae latae and the gluteus maximus attach to the proximal part of it anteriorly and posteriorly, respectively. A large part of the iliotibial tract extending to the leg terminates on Gerdy's tubercle on the anterolateral surface of the lateral tibial condyle. The anterior part of the iliotibial tract terminates on the lateral edge of the patella. These fibers are named the "iliopatellar band" (Figs. 1.22 and 1.23) [42, 45].

The iliotibial tract moves forward during knee extension and backward during knee flexion. It contributes to the maintenance of extension during knee extension, and also after about 30° of flexion, it passes behind the transverse axis of the knee and contributes to flexion. By preventing varus in the knee, especially in extension, it helps with stability of the knee together with the lateral ligaments and capsular structures.

Lateral patellar retinaculum: Superficially, distal aponeurotic fibers of the vastus lateralis extend at the lateral of the patella. It ends at the lateral edge of the patella together with the oblique fibers of the iliotibial tract (iliopatellar band) (Figs. 1.22 and 1.23) [45]. In the deep layer of the lateral patellar retinaculum, there are fibers