SOME ANATOMICAL DETAILS OF THE KNEE JOINT

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In current texts, descriptions of the knee joint lack precision in certain details, and it is believed that revision of the anatomy of this important joint might be of value. It is proposed to give an account of the true capsule of the joint, the accessory ligaments, and the attachment of certain muscles.

CAPSULE AND ACCESSORY LIGAMENTS

In order to appreciate the arrangement of the capsule and ligaments of the knee joint it is advisable to consider the joint in the foetus, and trace the changes which occur during development of the adult structure. In the foetus the joint is a simple diarthrodial structure, the capsule being attached around the articular surfaces including that of the patella. The upper end of the fibula articulates with the femur; and the conjoined horizontal surfaces of the tibial plateau and upper end of the fibula are surrounded by a simple tubular capsule which is attached at its upper circumference round the articular surface of the femur. The capsule is interrupted anteriorly by a gap, to the margins of which the articular surface of the patella is attached. At this stage the joint already contains the two menisci.

Lateral ligament of the knee joint—
As a result of the different rate of growth of tibia and fibula, the fibula is excluded from the knee joint; its upper end sinks below the tibial plateau and articulates with the tibia at the superior tibio-fibular synovial joint. The head and styloid process of the fibula pull down with them a prolongation of the original capsule. The margin of the tibia from which capsule is lacking (having been "stolen" from it by the fibula) is that part over which the tendon of popliteus passes. This part of the capsule is the short external lateral ligament of old terminology; in current British terminology it has no name. It might be described as the deep part of the lateral ligament of the knee joint. It represents part of the true joint capsule. It is attached above to the lateral epicondyle of the femur and below to the styloid process and medial (tibial) border of the upper surface of the head of the fibula. Its free posterior border, lying over the popliteus fascia and firmly adherent thereto, constitutes the arcuate ligament (Fig. 1). The arcuate ligament is attached firmly towards its upper end to the posterior arch of the lateral meniscus. Morphologically, the long external lateral ligament of old terminology (or the lateral ligament of the knee joint of current terminology) may be the degenerated tendon of peroneus longus (Bland Sutton 1884, Wheeler Haines 1941). It arises from the lateral epicondyle of the femur, in continuity with the upper part of the short external lateral ligament already described. It is inserted into the upper surface of the head of the fibula, lateral to the deep part (Fig. 1). Between them the deep part of the tendon of biceps femoris is inserted, thus separating them at the head of the fibula. The long external lateral ligament (lateral ligament of current terminology) divides the tendon of biceps into superficial and deep parts.
Medial ligament of the knee joint—Like the lateral ligament, the medial ligament possibly consists of two, morphologically distinct, parts. The deep part, named in old terminology the short internal lateral ligament, has no name in current British terminology. It is part of the capsule of the joint. It is attached to the articular margins of the femur and tibia on their medial aspects and is continuous with the capsule of the knee joint in front and behind. It is attached intimately to the medial meniscus. The superficial part, which is by far the larger and the more important, arises below the adductor tubercle from the medial epicondyle of the femur and is inserted into the medial condyle of the tibia, and into the posterior part of its subcutaneous surface for a distance of one handsbreadth below the level of the knee joint. It is a broad, flat, triangular structure, and is very strong. Its anterior border is vertical, but its posterior border is oblique in opposite directions above and below the joint, so that the widest part is over the medial meniscus (Fig. 2). Posteriorly it overlaps the deep part (short internal lateral ligament described on page 683), and in this situation its fibres are attached firmly to the medial meniscus; its anterior border is free of attachment to the meniscus. According to Bland Sutton (1884) the anterior vertical part is, morphologically, the degenerated tendon of adductor magnus. The hamstring part of adductor magnus (the presemimembranosus muscle of Comparative Anatomy), which is innervated by the sciatic nerve, is inserted into the adductor tubercle. From this point downwards it is represented by the vertical part of the medial ligament of the knee joint. The deep or capsular, and the superficial or tendinous, parts of the medial ligament of the knee joint are fused into a single structure above, but they are separated below by an expansion from the semimembranosus tendon which passes forwards between them (Fig. 3). This is the expansion which is often described as being inserted into the medial meniscus; in our experience it is inserted only into the tibia. Still lower, the medial ligament is separated from the tibia by the passage beneath it of the medial inferior genicular vessels and nerve. Strong retinacular fibres from the medial border of the patella curve towards the anterior border of the upper part of the medial ligament (Fig. 2). In flexion of the joint the anterior edge of the medial ligament passes backwards, thus exposing a greater extent of the medial meniscus.

Tension of the ligaments—Both medial and lateral ligaments of the knee joint are taut in extension, their upper attachments being placed behind the axis of rotation of the femoral condyles. They are relaxed in flexion. In flexion, moreover, a smaller surface of the femoral condyles is in contact with the tibial plateau. These two factors are responsible for the greater degree of mobility of the joint in flexion, viz., rotation and passively induced adduction and abduction. The state of the cruciate ligaments in flexion contributes to this increased mobility (vide infra).

Foetal capsule in the adult joint—Between the medial and lateral ligaments, across the front of the joint, the foetal capsule is still present with its circular gap filled by the articular surface of the patella. From the lower margin of the patella to the anterior margin of the plateau of the tibia the capsule is separated from underlying synovial membrane by a pad of fat which herniates into the joint and raises a median fold called the ligamentum mucosum,
extending into the joint as far as the anterior surfaces of the cruciate ligaments. Two alar folds extend, one on each side of the ligamentum mucosum. They have no morphological significance. The statement that they are relics of intra-articular septa is wrong. There is no evidence that primitive septa ever existed in any vertebrate knee joint (Wheeler Haines 1941). The original capsule above the patella, between it and the femur, perforates when the infant walks and thereafter communicates with a large suprapatellar bursa lying deep to the quadriceps tendon, and in the adult limb extending a handsbreadth above the joint.

Thus the foetal capsule is still present in the adult joint; it has two gaps, one allowing the popliteus tendon to emerge, and the other communicating with the suprapatellar bursa. Other gaps in the capsule for communication with bursae may occur, but they are inconstant. The added ligaments provided by the phylogenetically degenerated tendons of adductor magnus and peroneus longus, the medial and lateral ligaments respectively, greatly strengthen the joint. Posteriorly the joint is also reinforced; an expansion from the tendon of insertion of semimembranosus extends upwards and laterally across the posterior part of the true capsule. This is the oblique posterior ligament of Winslow; its upper attachment is to the lateral condyle of the femur and the intercondylar notch, rather above its margin, so that a prolongation upwards of synovial membrane encroaches a little on the popliteal surface of the femur. Loose bodies may lodge here, and elude discovery at operation. The oblique posterior ligament is a thick rounded cord of great strength (Fig. 3—The figure does not show several irregular prolongations which extend from the ligament to the popliteal surface of the femur and give rise to a fenestrated appearance above the main ligamentous band).

**INTRA-ARTICULAR STRUCTURES**

**Cruciate ligaments**—The cruciate ligaments consist of a pair of very strong bands connecting the tibia to the femur, and they lie within the capsule of the knee joint but not within the synovial membrane. It is as though they had been herniated into the synovial membrane from behind, carrying forward over themselves a fold of synovial membrane which invests their anterior and lateral surfaces, but leaves their posterior surfaces uncovered except superiorly. They are named from their tibial origins, and cross like the limbs of the letter “X.” They are essential to the stability of the knee joint. The anterior cruciate ligament is tense in extension, the posterior tense in flexion, but neither is really lax in any position of the joint. Lateral rotation of the flexed tibia unwinds them; medial rotation winds them up.

**Medial and lateral menisci**—The menisci consist of fibrocartilage, curved in shape and wedge-shaped in cross section. They are avascular except for a narrow zone at their points of attachment (Davies and Edwards 1948). The medial meniscus is attached to the tibia at its anterior and posterior horns by fibrous tissue; elsewhere the circumference is attached strongly to the capsule and posterior part of the superficial medial ligament of the knee joint (Fig. 2). The lateral meniscus is likewise attached to the tibia at both horns; in addition
its posterior horn is slung by fibrous tissue “ligaments” to the femur. The slings are
attached to the medial condyle of the femur, in front and behind the attachment of the
posterior cruciate ligament, forming the ligaments of Humphry and Wrisberg respectively
(Figs. 4 and 5). These ligaments are strong structures, especially the latter, and it is
unfortunate that their names should have been dropped from current British nomenclature.
The lateral meniscus is thus fixed at its horns, but elsewhere it is freely mobile, being separated from the deep
part of the lateral ligament (capsule) of the knee joint by the tendon of popliteus (Fig. 1). Firm attachment of
the arcuate ligament to the meniscus, and attachment of the upper fibres of the popliteus muscle to the arcuate
ligament and meniscus, ensure backward drawing of the posterior arch of the meniscus in medial rotation of the
flexed tibia. It is the moving backwards of the meniscus in medial rotation of the leg which rounds off the
posterior edge of the lateral tibial condyle, and not the tendon of popliteus, as stated in most
current texts.

MOVEMENTS AT THE KNEE JOINT

Flexion of the joint is limited by the soft parts behind; extension is limited by tension
of the medial and lateral ligaments, and the anterior cruciate ligament. Full extension is
accompanied by lateral rotation of the tibia, a movement which is to some degree passive,
resulting partly from the shape of the articular surfaces (the lateral femoral condyle being shorter
than the medial, so that it is “used up” first) and partly from the pull on the tibia of the lowest
fibres of vastus lateralis. In flexing the joint from this locked position the popliteus begins
the movement by medially rotating the tibia. Popliteus, and the lowest fibres of vastus lateralis,
are thus antagonists. When the joint is flexed, medial and lateral rotation of the tibia are performed by the hamstrings. The freedom which allows this rotation of the tibia results from relaxation of the medial, lateral and anterior
cruciate ligaments; greater mobility also results from the fact that a smaller femoral surface is
in contact with the tibial plateau in flexion. In this flexed position the posterior cruciate ligament
is taut and it forms the axis around which the tibia rotates on the femur. In flexion and extension the menisci, fixed to the tibia, move
with it on the femur. In rotation of the tibia in the flexed position the menisci, especially
the lateral, move with the femur on the tibia. This is a characteristic feature of all joint
fibrocartilages in which two separate, but often simultaneous, movements take place—for
example the temporo-mandibular joint which has gliding movement in its upper compartment and true hinge movement in its lower; and the sterno-clavicular joint which permits up and down movement of the clavicle in the lateral compartment, and horizontal or rotary movement in the medial compartment. It is substantially true of the knee joint that flexion and extension take place in the upper compartment while rotation takes place in the lower. The menisci also play an important part in spreading the lubricating film of synovial fluid (MacConaill 1931).

**MUSCLE ATTACHMENTS NEAR THE KNEE JOINT**

Careful dissection shows that some accepted descriptions of muscle attachments in the region of the knee joint are inaccurate.

**Quadriceps femoris**—The four components of this muscle are inserted into a trilaminar quadriceps tendon. Anteriorly, the rounded tendon of rectus femoris flattens immediately above the patella, and forms the anterior lamina which is inserted separately at the anterior edge of the upper border of the patella. In the middle of the thigh, contiguous surfaces of the rectus femoris and vastus intermedius are each covered by a shining aponeurosis. The aponeurosis which covers the surface of vastus intermedius is continued downwards as the deepest lamina of the quadriceps tendon; it is inserted into the posterior edge of the upper border of the patella. The intermediate portion of the tendon is a lamina formed by confluence of the central edges of the vastus lateralis and vastus medialis. The lowermost fibres of vastus medialis, almost horizontal in direction, do not contribute to the quadriceps tendon. They are inserted directly into the side of the patella, and exert an indispensable influence in preventing lateral displacement of the patella during contraction of the quadriceps. It is these lowermost fibres of vastus medialis which atrophy so rapidly in affections of the knee joint such as acute synovitis. The ligamentum patellae is inserted into the tibia over the smooth, rounded part of the tubercle of the tibia—the part, that is, which is on the epiphysis. The area is limited above by an oblique groove which receives a very substantial portion of the ligamentum patellae (Hughes 1946). The infrapatellar bursa lies, not over the smooth part of the tubercle, but over the rough, pitted anterior surface of the head of the tibia immediately below the transverse ligament (Fig. 6).

**Biceps femoris**—The tendon of biceps is not "split" by the lateral ligament of the knee joint. It wraps around the posterior part of the lateral ligament; the deep part of the tendon lies between the lateral ligament and the true capsule of the joint (between the long and short external lateral ligaments of old terminology). The superficial part of the tendon of biceps wraps around the superficial part of the cord-like long external lateral ligament, and it is attached to the lateral margin of the head of the fibula and sends an expansion across the superior tibio-fibular joint to the tibia.

**Popliteus**—From the rounded tendon of origin the fan-shaped muscle emerges beneath the arcuate ligament and diverges towards its insertion on the popliteal surface of the tibia. Although seldom described, it is true that a very substantial portion of this muscle arises not from the tendon of popliteus but from the arcuate ligament itself. Some of the uppermost fibres actually arise from the lateral meniscus, a fact which has been noted in very few texts.
Moreover, the muscle fibres which truly leave the tendon and pass beneath the lower part of the arcuate ligament are firmly adherent thereto (Figs. 1 and 3); their attachment to the arcuate ligament draws the muscle up in a sinuous manner which disappears when the arcuate ligament is itself dissected away. Consequently the true attachment of popliteus cannot be made out when the muscle is "cleaned" for a museum specimen.

Protection of the lateral meniscus from injury—It is suggested that the attachment of popliteus to the lateral meniscus (both directly, and indirectly by way of the arcuate ligament) is the primary factor in protecting the meniscus from injury. It is not the mobility _per se_ of the lateral meniscus which makes it relatively immune from injury, but rather the _controlled_ mobility gained by the ligaments of Humphry and Wrisberg and, especially, the popliteus muscle. In flexion of the knee joint a smaller surface of the femoral condyle articulates with the tibial plateau; consequently the menisci are not likely to be nipped between the articular surfaces during uncomplicated flexion. But in the flexed position, when lateral rotation of the femur on the tibia takes place (around the axis of the posterior cruciate ligament) the lateral femoral condyle glides posteriorly along the lateral articular surface of the tibia. It does not push the posterior arch of the lateral meniscus out of the way; the meniscus is actively pulled away by the popliteus muscle and by the pull of the ligaments of Humphry and Wrisberg. It is not the tendon of popliteus but the lateral meniscus which bevels the posterior margin of the lateral tibial condyle. The synovial membrane is prolonged from the joint as the popliteus bursa, which lies deep to the muscle, between it and the tibia. It often communicates with the superior tibio-fibular joint. Fixation of the posterior surface of the popliteus muscle to the arcuate ligament precludes the formation of any bursa on the superficial aspect of the muscle. It is possible that the primary origin of the muscle was from the fibula and that its ascent to the femur in man is a secondary event (Taylor and Bonney 1905).

Soleus—The tibial origin of soleus is usually stated to be the soleal line and the middle third of the medial border of the tibia. Actually the muscle has a much more generous origin. Only the strong aponeurosis on the deep surface of soleus arises from the soleal line. It will be seen that this line has two ridges—one above and one below. To the upper ridge is attached the popliteus fascia, derived from the semimembranosus tendon; to the lower ridge the aponeurosis on the deep surface of soleus is attached. The fleshy fibres of soleus arise from an area above the soleal line on the popliteus fascia (Fig. 3).

Illo-tibial band—As is well known the fascia lata attaches around the tibial condyles. Less generally appreciated is the fact that the ribbon-like condensation which constitutes the illo-tibial band is received into a smooth non-pitted facet which stands out prominently on the front of the lateral tibial condyle. This facet marks the insertion, therefore, of three-quarters of the gluteus maximus muscle in addition to the tensor fasciae latae (Fig. 6).

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REFERENCES