Chapter

Arthroscopic Anatomy of the Knee Joint and Portals

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Abstract

Knee arthroscopy is one of the most used operative treatments in orthopedic surgery. The first knee arthroscopy was performed by Prof. K. Takagi, from Tokyo, Japan, in 1920. With further improvement, he made the first black and white photos of the inside of the knee (1932) and, soon, the first color photos (1939). Independently from Takagi, Dr. Eugen Bircher from Arau, Switzerland, in 1921 published the results of 20 "arthro-endoscopies," and that was the first time the word "arthroscopy" was mentioned in literature. In New York, USA, Dr. Michael Burman described in detail the incision points and technique of joint spreading that we use today. In 1957, Dr. Masaki Watanabe published the first Atlas of Arthroscopy. The first Arthroscopy Course in English language was held in Philadelphia, USA, in 1972. The International Arthroscopy Association, with Dr. Watanabe as president, was established in 1974. In clinical knee arthroscopy, the following division proved to be very useful: the medial compartment, the lateral compartment, the central part or central pivot, and the femoropatelar compartment. In this chapter, the normal anatomy of each of this part will be described in detail, with the descriptions of basic knee arthroscopy portals.

Keywords: knee, arthroscopy, anatomy, portals

1. Introduction

The anatomical definition of the knee is determined by the fact that the knee connects the upper and lower leg, made up of the knee joint, the patelofemoral joint, and the proximal tibiofibular joint, and the soft tissues surrounding them. In the frontal plane of the femur and tibia, an angle of 174° is made, which makes the physiological valgus of the knee. In women, valgus and recurvatum are slightly higher. The borders of the joint are on the buttock, the line that passes at 2–3 cm above the base of the patella, and on the lower leg, the circular line that passes directly below the tibial tubercle [1].

Anatomically speaking, the knee consists of bone and soft tissue structures, which built four topographic regions. In clinical knee arthroscopy, the following division proved to be very useful: the medial part consists of a medial femoral condyle, medial tibial plateau, medial meniscus, and medial part of the capsule and ligaments. The lateral part consists of a lateral femoral condyle, lateral tibial plateau, lateral meniscus, and lateral ligaments and capsules, including arch complex (lig. arcuatum). The central part or central pivot is composed of an intercondylar notch, which comprises crossed ligaments, anterior and posterior intercondylar field of the tibia (lower part of the attachment of crossed ligaments of the knee), and intercondylar eminences and tubercles. The femoropatelar part consists of a femoropatelar joint, an infrapatellar fat tissue, a patellar ligament, and a quadriceps tendon and normally presents medial and lateral patellar plicas and suprapatellar recess [2, 3].

2. Surgical anatomy of the knee

2.1 Medial compartment

2.1.1 Anterior third

Outside, superficially through the articular capsule, the horizontal part of the m. vastus medialis (m. vastus medialis obliquus) is provided. The attachment of the pes anserinus (m. sartorisu, m. gracilis, m. semitendinosus) extends from the back and down in the upper two-thirds of the tibia. The medial patellar retinaculum extends from the upper two-thirds of the medial part of the patella and is attached to the outside of the medial femoral condyle. Medial longitudinal patellar retinaculum originates from a wide base between the patella, the medial vastus, and the upper attachment of the medial collateral ligament and descends to the upper part of the tibia where it is attached behind the pes anserinus and in front and above the attachment of the medial collateral ligament. Both retinacula cover the anterior part of the joint, and their fibers come from the medial vastus and quadriceps tendon, which allows them to function as dynamic stabilizers. The individual fibers of the medial longitudinal retinaculum are drowned in the medial collateral ligament, and the other is joined to the tendon of the pes anserinus and extends to the popliteal fascia. Deep fibers extend beyond the superficial fascia to the medial collateral ligament and semimembranosus. Retinacula controls the movements of the patella toward the femur (limits the lateral deviation) and equalizes the pressure of the lateral and medial joint surface of the patella and the internal rotation of the tibia (via m. vastus medialis obliquus and patellar ligament). The pes anserinus-conjoined tendon, by its superficial position, acts as a ligament-muscle protector of the medial side of the joint in flexion and extension. Functionally, it represents an active duplicative of the medial collateral ligament [2, 3].

2.1.2 Middle third

In the middle third, the dominant structure is the medial collateral ligament as a deep tensioner under the tendon of the pes anserinus. It extends sloping down and backward from the lateral femoral condyle to the upper tibia. It consists of two thin layers, structurally different. The deep layer consists mainly of femoro-meniscal and menisco-tibial fibers. The superficial layer is structurally separate from the medial meniscus and has nothing to do with it, except in the back part where the superficial and deep layer joins and builds a posterior oblique ligament, which is attached to the posterior horn of the medial meniscus. The fibers are further arranged to "divide" the ligament into the triangles so that they are tilted selectively toward the position of the knee. This reduces the change in force, e.g., the longest fibers are tight in flexion and the shortest in the extension. In moderate flexion of the knee, all the fibers are loose and allow rotatory knee movements.

The upper third of the ligament is attached to the femur, and the lower for the tibia. During the flexion that begins with the rolling of the femoral condyle, the front fibers move backward through the femoral and tibial surfaces. That's why the ligament must be freely movable in these places (as well as through the medial meniscus) to glide over the bones and must not have a deep-coated attachment.

The superficial fibers are connected in the posterior part with the deep fibers (and built posterior oblique ligament) and with fibers of m. semimembranosus, and therefore the superficial fibers of the ligaments are dynamized by this muscle, especially in the position of flexion. The attachment of the remainder of the fiber to the fascia and tendon of the adductor magnus contributes to the further dynamization of the ligament. The relationship of the m. vastus medialis to the medial patellar retinaculum has already been described. A passive, firm bone attachment is present in the deeper parts of the ligament. Superficial fibers are largely dynamically bound to muscles, so passive instability can be compensated by a good muscular function, and the fibers can adequately adapt to great demands and work [2–4].

2.1.3 Posterior third

The posterior medial third of the knee—the "semimembranosus angle"—represents a functionally important part. It is separated from the medial collateral ligament in spite of the topographical close relationship. The structurally and functionally key element of this angle is the lig. posterior obliquus, which extends between the tendons of adductor magnus and semimembranosus. The main active rear stabilizer is semimembranosus muscle, which stabilizes the knee posteriorly. Semimembranosus muscle is attached to the posteromedial angle by five separate finger extensions. The first two, which go directly to the lig. obliquus posterior and climb straight through the posterior capsule as lig. popliteus obliquus, make semimembranosus an active stabilizer of the posteromedial angle. The attachments are arranged so that at least one is taut in every position of the flexion and directs the traction in the appropriate direction to give the angle of flexion. The finer are the backward fibers that flow from the m. vastus medialis. At maximal extension, the angle of semimembranosus is below the maximum tension due to the associated posteromedial sliding of the medial femoral condyle. In extension, semimembranosus helps in stabilization of the entire medial side. In 90° flexion, it has an additional role in the transmission of tension to the free capsule-ligament fibers and stabilizes the knee to prevent external rotation [2, 4].

2.1.4 Medial meniscus

The structural element of the medial compartment, from the anterior to the posterior third, is medial meniscus. It has a crescent shape, it is narrower in the front, and it extends to the rear. The free edge is facing the knee joint, and the rim is attached to the articular capsule. In the anterior third, it is relatively narrow, it is attached to the tibial plateau with a fibrous bundle that extends the meniscus anteriorly, and there is also a medial part that secures the anterolateral part of the meniscus to the anterior intercondylar area. The anterior horns of the medial and lateral meniscus are connected by the fibrous bridge that makes the transversal knee ligament. The medial patello-meniscal ligament extends from the anterior edge of the medial meniscus to the patella. In the middle third, the meniscus is still narrow. At the outer edge, there are femoral-meniscal and tibial-meniscal fibers (coronary ligament) but without an attachment to the medial collateral ligament. In the posterior third, the meniscus is spreading to the posterior horn. The femoromeniscal fibers and the coronary ligament join to the posterior oblique ligament and fix the last horn of the meniscus for the ligament. The fibers at the lower part of the posterior horn link the meniscus for the posterior intercondylar area. The horn must be firmly attached to the coronary and anteromedial collateral ligament in order to participate in anteroposterior stabilization and perform the essential role of a stress-transfer gearbox ("brakes" that limit the frontal movement of the tibia and the last displacement of the femur). This function is only possible if the femoro-meniscal part of the posterior oblique ligament and the posterior horn of the medial meniscus are intact (femoral condyle can "settle down"), and the semimembranosus attachment is not damaged (to maintain rotatory stability). ACL works synergistically with the posterior oblique ligament, by both of them tightening during the front translation of the tibia. Approximately 80% of ACL ruptures are associated with lesions of medial ligaments (the posterior oblique ligament, medial collateral ligament) [5–9].

2.2 Lateral compartment

The outer compartment has relatively weak passive stabilizers. Active stabilizers are dominant and those are: iliotibial tract (m. tensor fasciae latae and m. gluteus maximus), m. biceps femoris, and m. popliteus. The relative dominance of dynamic structures is in correlation with a higher degree of displacement during flexion (m. biceps femoris, m. popliteus, and m. tensor fasciae latae). In the lateral part, three subregions are described.

2.2.1 Anterior third

Similar to the medial part, characteristic are lateral superficial and longitudinal patellar retinacula. The attachment of the lateral longitudinal retinaculum is somewhat different from the medial, due to the more limited extension of m. vastus lateralis, as well as due to the presence of an iliotibial band outside the retinaculum. A part of the fibers of the iliotibial band ends at the lateral femoral condyle, the part extends to the patella, and the main part goes to Gerdy's tubercle. Lateral patellar retinaculum is attached to the iliotibial band with multiple fibers, and from there it extends to the patella. The lateral longitudinal retinaculum fibers originate from three different sites, patella, m. vastus lateralis, and iliotibial band, and some extend (to the lateral femoral epicondyle or tibia—Gerdy's tubercle) from the lateral iliotibial band. The lateral longitudinal patellar retinaculum is attached to the medial portion of Gerdy's tubercle and adjacent proximal to tibia parts.

Both lateral retinacula are dynamically linked to m. vastus lateralis, tensor fasciae latae (iliotibial tract), and gluteus maximus muscle (iliotibial tract). The main role of lateral retinaculum is to maintain the femoro-patellar sliding (by preventing the medial deviation of the patella) and the equalization of the pressure between the lateral and the medial half of the patella.

Due to its position and attachment, the iliotibial tract acts as a "lateral femoro-tibial collateral ligament" and plays an important role in the function of the femoro-tibial joint. Its dynamic parts end up on the lateral femoral condyle (Kaplan's complex fibers at the Krakow spot) and proximal tibia (Gerdy's tubercle). The passive fibers are placed forward and deeper and establish a firm connection between the lateral condyle and Gerdy's tubercle, so they are often distinguished as an "anterolateral femoro-tibial ligament."

The iliotibial band synergistically works with two groups of muscles. In the position from 0 to 40° of flexion, it moves forward with respect to the axis of rotation and thus supports the extensor muscles. By increasing the flexion, it slides backward through the lateral epicondyle (behind the axis of flexion) and becomes synergistic to the flexor muscle group when the flexion exceeds 40° (the launch of the iliotibial band via the femoral epicondyle plays an important role in the existence of the pivot shift). The iliotibial band functionally helps in anterolateral rotatory stability by fixing the knee toward the lateral opening (stress varus). It also stabilizes the lateral tibial plateau, preventing sliding forward with rotary movements.

In the deep layer of the front and middle third, there is a joint capsule. It consists of a synovial coat, and, in the absence of reinforcement by the ligament fibers, it is very stretchable. Only the lateral patello-meniscal ligament fibers pass from the outer edge of the meniscus to the patella and are sometimes incorporated into the capsule. The ligament serves as a receptor for the reflex stabilization of femoro-patellar and femoro-tibial movements, analogously to the medial menisco-patellar ligament. The anterior part of the deep articular capsule is freely movable in relation to the iliotibial band. It is covered with fatty tissue that is absorbed into the infrapatellar fat tissue. It is firmly attached to the edge of the lateral meniscus. The fibers of the transferal ligament of the knee pass from the anterior horn of the lateral meniscus to the opposite side [2, 3].

2.2.2 Middle third

Structurally and functionally, the middle and posterior thirds are closely related. Most elements show hierarchical arrangement from the front to the rear or vice versa.

The most superficial in this area is the wide tendon of biceps femoris muscle. It extends downward and forward in the outer part of the last third and connects on the head of the fibula with two arms: the back, the greater part, and the front (middle attachment of the biceps tendon together with the fibular collateral ligament). Trauma is a common cause of bone tendon avulsion, and also high muscular strain can cause dislocation of the fibular head. The biceps femoris tendon is attached to the tibia by the extensions that pass over and below the lateral collateral ligament. Biceps femoris muscle is an important stabilizer of varus angulation in extended knee and internal rotation in flexion (more specifically, the short head of biceps femoris muscle is the main antagonist of the popliteal muscle and thus the internal rotation). In addition to being an important external rotator, biceps femoris muscle is also a flexor, due to the position behind the axis of flexion.

The lateral collateral ligament descends back and forth from the femoral condyle to the fibula's head. It is smaller than the medial collateral ligament but can be identified as a separate structure. It contributes to passive stabilization of the outside of the knee, and synergist is to the posterior cruciate ligament (PCL). Deep and completely separated from the lateral collateral ligament is the popliteal muscle tendon, which starts from the lateral femoral condyle and descends backward where it connects with the body of the popliteal muscle in the last third of the lateral section. The articular capsule is very thin and is not firmly attached to other structural collagen elements. It is noticeable that there is no anatomical connection with the lateral meniscus, whose edge is freely moving in the middle third of the outer compartment [2, 3].

2.2.3 Posterior third

In the posterior part of the lateral side dominates, structurally and functionally, the popliteal muscle. More superficial are the fibers of the oblique popliteal ligament. The fibers end up on the fabella or, if this does not exist, extend outer and upward to the attachment of the lateral head of the gastrocnemius muscle. In this way, the fabella and the oblique popliteal ligament are bound structurally and functionally to the lateral tendon of gastrocnemius muscle. In this area, the deep part of the muscle tendon strengthens the joint capsule. Distally, the fabella joint capsule and the tendon of gastrocnemius muscle are separated. On the distal part of the fabella, the arch ligament (which is a tendon extension from popliteal muscle) and a fabello-fibular ligament are attached (Vallois). These extensions emphasize the role of the fabella as the point where stress is transmitted (although it is present in only about 20% of the population).

The arch ligament extends from the posterior part of the tibia and the head of the fibula to the middle of the joint capsule. Some fibers are projecting to the fabella, but it also receives fibers from m. popliteus (the beginning of the tendon is branching) and allows the muscle to tighten the ligament to the fabella. The deep part of the ligament is attached to the posterior horn of the lateral meniscus with the tendons of the popliteal muscle, so popliteal muscle actively pulls the meniscus during flexion until the femoral condyle is rotated backward.

The popliteal muscle is originated from the posteromedial tibial surface and is initially parallel to the arch ligament. After giving extensions for the arch ligament and the posterior horn of the lateral meniscus, the muscle continues laterally forward and upward. In a deep layer, the tendon passes behind the arch ligament; enters the popliteal aperture; then goes over the outer part of the upper tibia, below the lateral collateral ligament; and is attached to the lateral femoral condyle. The tendon has the thickness of the pencil. Besides attachments to the arch ligament, the lateral meniscus, and the femur, there are also deep direct tendon attachments for the posterior joint capsule. Popliteal muscle also acts as an internal rotator of the tibia in flexion.

The posterior part of the capsule is reinforced with fibers which are sometimes referred to as the posterolateral collateral ligament. The fibers enter the capsule as a ligament, and they are almost parallel with the popliteal tendon and are attached to the posterior horn of the lateral meniscus and to the tibia. The most important active stabilizer of the posterolateral angle is the popliteal muscle with its deep attachments.

The posterior part of the lateral meniscus is directly linked to the posterior capsule, the popliteal tendon, and the arch popliteal ligament (most common site of avulsions and ruptures). Popliteal muscle actively pulls and puts the lateral meniscus under the lateral femoral condyle during flexion and prevents the meniscus from incarceration under the condyle. The popliteal aperture gives more space that is necessary for the lateral meniscus for its high mobility (thus reducing the incidence of rupture in this area). In the popliteal aperture, the tendon is completely separated from the meniscus. The posterior horn of the meniscus is tied to the central part of the joint. The posterior menisco-femoral ligament (Wrisberg) attaches the meniscus to the posterior intercondylar area of the tibia, while the anterior menisco-femoral ligament (Humphry) attaches the front part of the posterior horn to the posterior part of an anterior intercondylar area.

There is a symmetrical, functionally connected triad of elements of the posteromedial and posterolateral parts of the joint. On the medial side, there are the posterior horn of the medial meniscus, the posterior oblique ligament, and the semimembranosus muscle and on the lateral side posterior horn of the lateral meniscus, arch complex, and popliteal muscle. Further symmetry is observed in relation to the synergistic function. The internal posteromedial elements are in functional correlation with ACL (combined lesion in 80% of cases) and posterolateral angle with PCL (again, combined lesions in 80% of cases) [2, 3].

2.3 Central part (central pivot)

The dominant structures of the central pivot are cruciate ligaments, anterior (ACL) and posterior (PCL). Both ligaments together form a line of femoral condyles and kinematic laws of joint movements. The anterior third of the central pivot, bounded by the intercondylar area of the tibia and the intercondylar groove of the femur, is the site of the attachment of the anterior horns of medial and lateral meniscus and the transverse ligament of the knee. Between them, the relatively wide space of the intercondylar area is occupied by a tibial attachment of the ACL. With the extended knee, the ACL extends vertically over the intercondylar groove to the attachment back on the lateral femoral condyle. In hyperextension it retracts under the vault of the groove in the intercondylar notch called "Grant's groove." At this point the ligament can be twisted or even ruptured if it is too tight on the groove. Grant's groove is a measure of the width of the ACL. In the knee flexion, the ACL comes in a horizontal position and is closely related to the PCL at the point where they cross, directly above the vascular pedicle.

ACL stabilizes the tibia toward the frontal translation relative to the femur. The elements of the posteromedial angle of semimembranosus and anterolateral femoro-tibial ligament also act synergistically. Approximately one-third of the capacity of the anterior stabilization is due to ACL, and the remaining are of two structural elements (the isolated rupture of the ACL leaves two-thirds of the capacity intact). The structure of the ligament is such that it almost never transmits load through the entire surface; individual fibers are loaded selectively during a particular movement or in a particular position of the joint. Anteromedial fibers are most affected when the knee is almost extended, posterolateral fibers when the knee is flexed in a higher degree, and intermediate fibers stabilize the internal rotation, during which the fibers of the ligaments rotate.

ACL vascularization comes from the branches of the middle geniculate artery. This blood vessel connects the ACL and PCL at the crossing point. The artery enters the ACL from the subcortical web, but does not feed the whole ligament but only the sites of attachment.

Both cruciate ligaments have a common frontal synovial sheath. In spite of the intra-articular position, both ligaments are extrasynovial. The common synovia originates from the crossed "central pivot," and it is vascularized by the branches of the middle geniculate artery.

PCL is better vascularized; it receives four branches of the middle geniculate artery that are arranged throughout the entire length of the ligament. Its origin from a wide area on the medial part of the medial femoral condyle passes downward and backward and is attached to the posterior intercondylar area of the tibia on a small surface. During knee extension it is relatively flat and rises during knee flexion, but it does not have the risk of collapsing under the front edge of the intercondylar groove. After achieving vertical position during flexion, the PCL becomes the central point of the knee rotation and has a significant stabilization effect. The only synergistic effect in the flexion has a quadriceps femoris muscle. In the knee extension, because of PCL-like orientation, the posterior oblique ligament and posteromedial capsule are acting synergistically, and they rupture together in the trauma. Like the ACL, the PCL consists of three strands of fibers that are loaded depending on the position of the joint. Posteromedial fibers tighten in the extension and limit hyperextension (their attachment is furthest on the intercondylar area). The central and anterolateral bundles are tense at medium and full flexion (their attachment is on the outside of the posterior intercondylar area, near the lateral meniscus). In addition to other functions, the PCL is the posterior translation stopper, although in the case of internal rotation, this role can be partly taken by the Humphry and Wrisberg menisco-femoral ligaments that are tightened in that position (and therefore may mask the posterior instability in the position of the internal rotation of the knee). On the medial side, PCL is connected by fibers with the posterior horn of the medial meniscus.

Intercondylar eminence of the tibia is the basic axis of rotation of the knees in small and middle flexion. It is covered with a thick, strong layer of cartilage and is located between the medial surfaces of the femoral condyles, which are also covered with cartilage. The posterior part of the meniscal cartilage, which differs in hardness, thickness, and resistance, can act as a duplication of intercondylar eminence. The axial role of eminence in moderate flexion is important for guiding an articular surface in varus, valgus, or rotatory loads and for the absorption of compressive forces, especially since the peripheral joint structures in this position is loosened.

Cruciate ligaments can protect the joint from varus and valgus stress by assuming the role of "inner" collateral ligaments for a particular femoral condyle in case the collateral ligaments are ruptured. The next important role of cruciate ligaments is in the mechanism of terminal locking of the knee. This automatic terminal rotation is caused by the position of the cruciate ligaments and the unequal length of the femoral condyles. The lateral femoral condyle, due to its smaller length, is first placed on the tibial plateau and ends its rolling, while the longer medial condyle continues rolling [2, 3, 8, 10, 11].

2.4 Patello-femoral compartment

The central structure of the patellofemoral joint is patella, a sesamoid bone which, although mobile, is a fixed point for the attachment of ligaments and tendons. Analogue to the fabella in the posterolateral corner of the flexor side, the patella is a key point for forces transmitted from multiple directions: longitudinal traction forces across the quadriceps tendon and patellar ligament and transverse traction forces through the menisco-patellar ligaments and transverse retinacula. Accordingly, the function of the patella depends entirely on the action of quadriceps femoris muscle. The upper part of the patella (base) has grown in the quadriceps tendon, extra-articular, and has no joint surface. Intra-articular space extends from the tip of the patella to the quadriceps tendon, along the front side of the femur, forming a suprapatellar recess. The lower, articular surface of the patella does not fit smoothly on the trochlea all over its surface in flexion or extension. The medial part of the patella is covered with a thin layer of cartilage, and the joint surface is incorrectly curved and does not fully attach to the medial part of the trochlea; this occasionally creates a free space between the hinged surfaces in which the synovia retract, which contributes to a more uniform distribution of loads. The outer part of the patella corresponds to the outer part of the trochlea. In the extension of the knee, the patella is completely attached to the femoral joint surface. In full flexion, the lower part of the patella lies in front of the condylar part of the femorotibial joint. Sulcus terminalis separates the femoral patellar surface, with relatively high edges, especially laterally, from the area of the femorotibial joint. The distal part of the patella, as well as the upper end, grew into the ligament tissue—the patellar ligament. Posteriorly, there is a well-vascular infrapatellar fat tissue (Hoffa). It is held in place by the patellar ligaments, bilateral longitudinal retinaculum, and infrapatellar synovial plaque (odd structure centrally positioned and posteriorly up to the roof of the intercondylar groove). Movement of the patella is consistent with a fine control mechanism in which medial and lateral patello-meniscal ligaments play an important role (receptor function). This explains the identical clinical picture of medial patellar chondropathy and the lesion of the medial meniscus.

The function of the patello-femoral joint is completely dependent on the function of quadriceps. The action of the muscle causes sliding of the patella through the trochlea. This action exerts a greater pressure on the lateral part of the condyle than on the medial, since the main vector of the quadriceps force is lateral (Q angle). This causes a slight posterior movement of the lateral femoral condyle associated with the internal rotation of the tibia. Vastus medialis muscle and vastus medialis obliquus muscles are antagonists of these forces and take the patella medially.
The large contact pressure of the patella on the lateral femoral condyle occurs in

conjunction with angulation and external rotation, and vastus obliquus muscle is again an antagonist. Conversely, the patellar pressure on the medial femoral condyle increases during angulation in the internal rotation, and vastus lateralis muscle performs an antagonistic traction role. In the neutral rotation position, the lateral and medial vastus muscle acts equally as an agonist and antagonist, resulting in constant pressure changes on different contact surfaces in the medial, lateral, proximal, and distal directions. The normal mobility of the patella is based on a separate action of the different parts of quadriceps. A small disorder in this complex functional sequence leads rapidly to the decompensation of a finely balanced system. This particularly applies to the medial joint surface, where even moderate disorder rapidly leads to abnormalities in nutrition and diffusion [2, 3].

2.5 Menisci

Menisci represented a pair of the C-shaped and wedge cartilages interposed between the femur and tibia in the knee joint.

Menisci play an important role in the distribution of loads, shock absorption, joint stability, and lubrication of joint surfaces. Histologically, they are built from three different types of tissue. At the cross section, the outer part consists of a thick connective tissue that contains nerve endings and is abundantly bled. The middle part is predominantly fibrocartilaginous with fibers of different tensions. The central tissue is predominantly hyaline and contains fewer fibers and blood vessels than the more superficial fibrous tissue. The inner part of the meniscus consists of a pure hyaline cartilage that is avascular and without innervation.

Special importance is attributed to the meniscus architecture. The external parts are partially integrated into the capsuloligamentar system. Some fiber bundles are arranged in arches whose base is directed toward the inside of the joint. In the outer third, the fibers are parallel and in the inner part are more radial. The chemical structure also varies, in the fibrous connective tissue of the outer third, pre-type collagen type I and type III; there are also types V and VI. Elastin and proteoglycans are less represented but functionally relevant. Hyaline cartilage in the inner part consists of collagen type II and proteoglycan. Shorter-chain collagens (type V, IX, XI), as well as different matrix proteins (tenascin and chain proteins), are less represented.

The middle third is histologically and chemically distinct, with a defined topographic difference that causes changes from superficial to deep parts of the meniscus [7, 9, 12, 13].

2.6 Joint capsule and synovia

The structure of the articular capsule shows significant local variations. In some places it has grown into a periarticular ligament system and forms a very strong, mechanically stable layer. In other places, the capsule makes only a thin synovial membrane with surrounding fat and fibrous tissue.

Synovia (synovial membrane, also known as stratum synoviale) consists of two morphologically different tissues. The first (intima) is a superficial cell layer that includes an articulate cavity. By its characteristics, it is epithelial, with a thickness of three to four cells. Between the cells are frequent jaws that open in a subintimal layer of loose connective tissue, which contains abundance of lymph and blood capillaries and numerous scattered fat cells.

Cells of synovial intima do not form a continuous basal membrane that separates the epithelial from the subepithelial connective tissue. Morphologically, three types of cells are distinguished: type A (or type M for "macrophages similar") whose cytoplasm contains a developed Golgi apparatus, a lot of vacuoles, and lysosomal bubbles but a scarcely rough endoplasmic reticulum and long cell prolongation.

Type B (or F of "fibroblasts similar") contains abundant coarse endoplasmic reticulum but a little vacuum, lysosomal bubbles, and Golgi's lamellas. Cellular attachments are poorly developed. Mixed cell type (sometimes called AB) is also described. Synoviale cells are responsible for the formation of hyaluronic acid, glycosaminoglycan, and some glycoproteins of synovial fluid. Thanks to numerous vesicles, they have the ability of phagocytosis of particles from synovial fluid—this is attributed mainly to M cells. A significant portion of the synovial fluid protein passes from the subintimendous connective tissue directly through the intercellular channels into the synovial fluid. Most proteins are micromolecular plasma proteins that can diffuse through the walls of the capillary from the blood plasma into the intercellular space of the subintimal connective tissue. Free nerve endings were not found in the subintimal region, although there are fibers of the autonomic nervous system that undergo the advent of blood vessels. In deeper layers away from the intima, the number of collagen fibers (stratum fibrosum) increases, in which articular capsules give the characteristics of the ligaments and supply the capsule with numerous nerve fibers, for the transmission of pain, along with blood vessels. This layer establishes numerous structural contacts with periarticular ligaments and creates strong enhancements in some parts of the capsule [7].

3. Basic portals for knee arthroscopy

A patient scheduled for knee arthroscopy is placed on the operative table with the leg planned for arthroscopy placed on the leg holder and opposite leg on side holder (**Figures 1** and **2**). Arthroscopy could be done in general, regional, or local anesthesia, with or without tourniquet. Landmarks for arthroscopy are the patella, patellar ligament, and upper edge of the tibial plateau. The basic portals are anterolateral and anteromedial, and auxiliary portals are suprapatellar medial and lateral, central, posteromedial, and posterolateral (**Figure 3**). Knee arthroscopy starts by making anterolateral portal [2, 3]. The entry point is localized by palpation. The thumb is placed to the soft tissue groove in triangle that is formed by lateral border of patellar ligament, upper lateral part of the tibial plateau, and tip of the patella. Knee is flexed. Above the thumb and near the patellar ligament, we place a 1.2 gauge needle (**Figure 4**). With the tip of the needle, we try to reach a lateral tibial plateau. After pulling the needle out, the skin incision is made at the point that is marked by the needle. Making 0.5–1 cm horizontal incision is a good way to avoid cutting the meniscus. Incision is pointed in 45° angle to the frontal plane. After the incision is made, Kellys clamp is introduced through it in the same direction (**Figure 5**). After touching the medial condyle, the clamp is turned parallel to the condyles and pushed medially, while it can be palpated under the skin on medial side (**Figure 6**). While pulling the clamp back, soft tissue is spreading with Kelly's clamp in a manner to open and close it. The next step is introducing the 4 mm scope in the same manner. Then, slightly extend the knee and hold it in valgus (**Figure 7**). When the medial meniscus is in the field of view, the anteromedial portal is prepared. The entry point should be close to the patellar tendon on the medial border (**Figure 8**). The needle is introduced again from the medial side. We could make a pressure to the skin by the finger looking inside the joint by scope to determine the appropriate entry point. After the needle is visualized in the joint, the skin incision is made. By the visual control, the knife is then used to make the skin incision and to avoid damage of the cartilage or meniscus. Through the anteromedial portal, the probe is introduced in the joint (**Figure 9**).

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Figure 1.
Knee arthroscopy preparation: Placing the patient on the operative table – frontal view.

Figure 2.
Knee arthroscopy preparation: Placing the patient on the operative table – side view.

Figure 3.
Basic portals and auxiliary portals are marked on the knee.

Figure 4.
1.2 gauge needle is placed near the patellar ligament.

Figure 5.
Kelly's clamp introduced through the horizontal incision (45° angle to the frontal plane).

Examination begins with the suprapatellar recess, then medial compartment, intercondylar notch, and lateral compartment. For placing scope in the suprapatellar recess, the knee has to be extended, and the patella is free to be moved. The main structure in the recess is the so-called suprapatellar plication, which is a white

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Figure 6.
The clamp is turned parallel to the condyles and pushed medially.

Figure 7.
While pulling the clamp back, soft tissue is spread with Kelly's clamp; then, the 4 mm scope is introduced in the same manner.

band of connective tissue, sometimes separating the recess in two compartments, and can cause the symptoms like pain and snapping. The synovium is orange and red colored and we can see small blood vessels (**Figure 10**). Recess is often placed where we could find loose bodies (**Figure 11**). After examining recess, slightly pull the camera to see the femoral trochlea. The cartilage is white, shiny, and smooth. By rotating the optical for 90°, we can see articular surface of the patella, with the same characteristics (**Figure 12**). Then, slide with the scope medially. At that point we can see cartilage border of the medial femoral condyle and the soft tissue that covers the medial epicondyle. By flexing the knee, the medial collateral ligament can be identified. Sliding down in the field of vision appears the menisco-capsular junction, well vascularized, and we can clearly identify the medial meniscus as white semilunar structure with the inner edge free. Above is the visualized part of the medial femoral condyle, and beneath is the medial tibial plateau. Healthy meniscus is white, smooth, with sharp inner edge, and in full length connected to the capsule (**Figure 13**). Placing the scope beneath the femoral condyle, we should see the attachment of the posterior horn of the medial meniscus (**Figure 14**). The knee should be positioned in semiflexion and valgus. By extending and flexing the

Figure 8.
Anteromedial portal is prepared. The entry point should be close to the patellar tendon on the medial border.

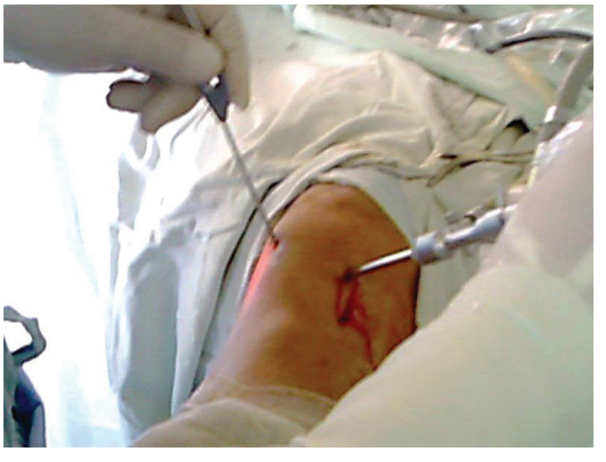

Figure 9.
Through the anteromedial portal, the probe is introduced in the joint.

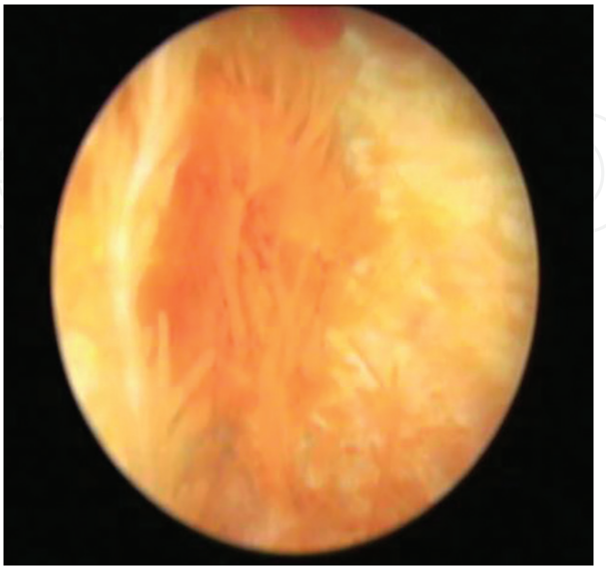

Figure 10.
The synovium is orange and red colored and we can see small blood vessels.

knee, we could examine the whole cartilage of the medial femoral condyle, and next is the intercondylar notch. The main structure is the ACL; it is represented like a white, pale band that arises from the anterior intercondylar area and goes

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Figure 11.
Recess is often placed where we could find loose bodies.

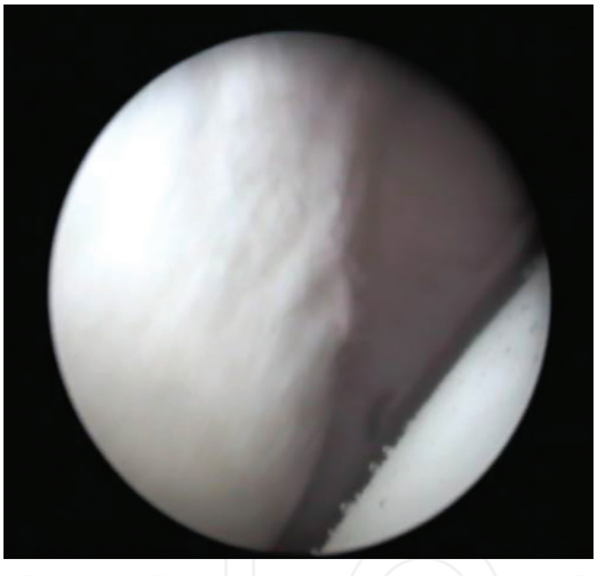

Figure 12.
The cartilage is white, shiny, and smooth. By rotating the optical for 90°, we can see articular surface of the patella, with the same characteristics.

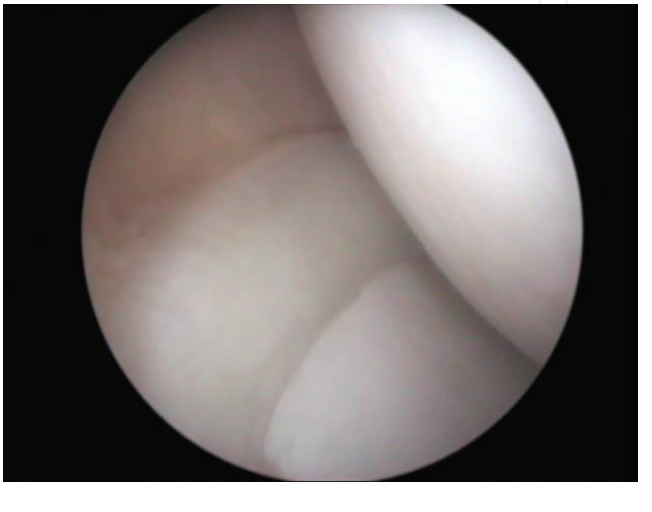

Figure 13.
Healthy meniscus (white, smooth, with sharp inner edge).

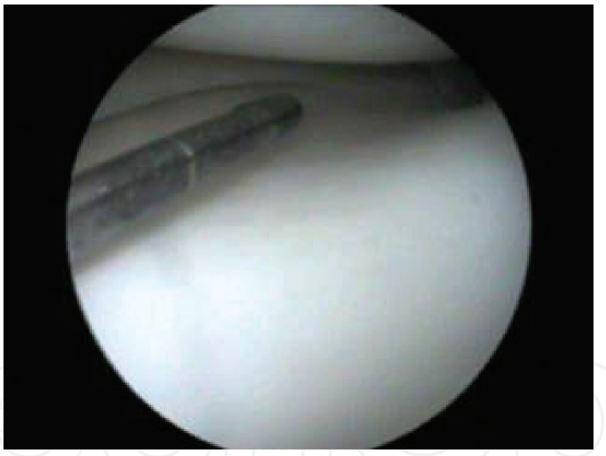

Figure 14.
The attachment of the posterior horn of the medial meniscus.

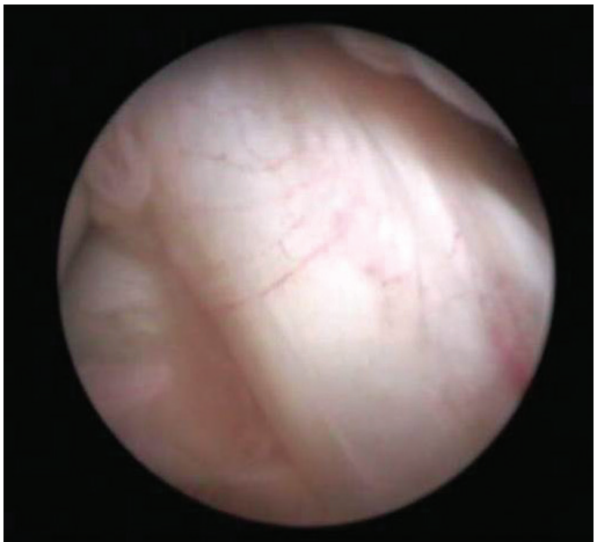

Figure 15.
Course of the ligament (best viewed by flexing the knee).

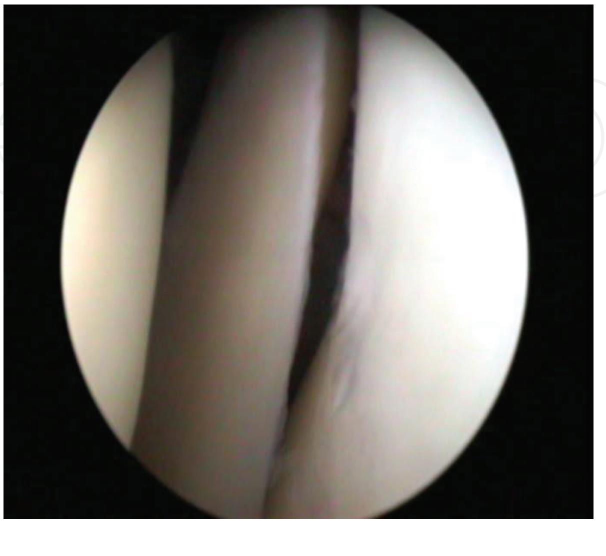

Figure 16.
Lifting up the meniscus, the popliteal tendon is visible in the popliteal aperture.

upward and backward to the attachment on the posterior part of the lateral femoral condyle. The course of the ligament is best viewed by flexing the knee (**Figure 15**). Moving the scope near the central position and pushing it slightly, we can identify the femoral site insertion. PCL is covered by synovial sheet and is not routinely visible until the synovium is removed by a power shaver. Placing the scope beneath ACL and medial femoral condyle and pushing the scope slightly posteriorly, we can identify posterior horn of the medial meniscus and posterior joint capsule. For better visualization the posteromedial portal is used. In the front part, we can see the anterior attachments of both menisci and transvers knee ligament. For examination of the lateral compartment, we must place the knee in the "figure of four" position. Attachments of anterior and posterior horns of the lateral meniscus are near each other. The inner edge is similar to the medial meniscus. In the central third, there is no menisco-capsular junction, and when we lift up the meniscus, the popliteal tendon is visible in the popliteal aperture (**Figure 16**). Ligaments of Wrisberg and Humphry are sometimes visible.

4. Conclusion

Knee arthroscopy is one of the most performed procedures in orthopedic surgery. Nowadays, it is mostly a therapeutic procedure, only in rare cases is diagnostic. Knowing arthroscopic anatomy is essential. The ability to recognize normal shape and appearance of the knee joint structures is the first step in long learning curve for further arthroscopy surgeon.

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