IRAQI Academic Scientific Journals

TJVS Tikrit Journal of Veterinary Sciences

Tikrit Journal of Veterinary Science

Anatomical study of stifle joint in dogs

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ARTICLE INFO.

Article history:

-Received: 1/5/2023

-Accepted: 15/ 6/2023

-Available online:

Keywords

stifle joint, dogs, hindlimb, long bones .

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ABSTRACT

The stifler is one of the hindlimb joints, described as complicated join consisting of many structures that organized in accurate way to support and stabilize body and hindlimb during the movement. The stifle joint of dogs, equivalent to the knee joint in the human, is a complex composition comprising the tibia, patella femur, menisci, caudal and cranial cruciate ligaments, lateral and medial collateral ligament, also surrounding muscles like hamstring and quadriceps muscles. The long bones (tibia and femur) form this joint, while patella sits in front of it to protect it. The two C-shaped menisci act as shock absorbers, and the supporting ligaments including collateral and cruciate provide stability to the joint. The surrounding muscles, including the quadriceps and hamstring muscles, help to extend and flex the joint, respectively. Together, these structures work in harmony to allow for the complex movement of dogs' stifle joint.

Understanding the anatomical features of the stifle joint in dogs is important for diagnosing and treating injuries or conditions that affect this complex joint

1. Introduction

In the hind limbs of quadrupedal animals like dogs, sheep, and horses, the stifle joint is an important and complicated joint. It usually represents the largest synovial joint in the body of the animal and has a similarity to the human knee. The femur, patella, and tibia, which collectively make up the stifle joint, are various bones. Additionally, other joints such as between the tibia and femur (femorotibial joint), which lies one in the middle and two others (femorotibial) on the lateral and medial sides, are the three tiny joints that together make up the stifle joint medial [1].

The stifle joint is made up of the femorotibial and femoropatellar articulations and another articulation with tibia and fibula. The joint plays an important role by stabilization through paired ligaments including cruciate and collateral and cushioned by two supported cartilages known menisci. The menisci provide cushioning and assists in joint function. The menisci separate the stifle into two functional units and contains nerve endings that assist in proprioception of different species having on to four of sesamoid bones that related with the stifle joint with the patella being the most well-known. The patella guides the tendon of quadriceps over stifle joint while other sesamoid bones assist in smooth tendon/muscle movement [2].

Research problem

1. Is the stifle joint different from the other joints in the dog?
2. Is the stifle joint of dog different from other joints in other species?

The aims of the present study

1. Providing complete scientific knowledge on the subject of dog joints.
2. Knowing what surrounds the dog's joint, organized scientific knowledge.

Anatomical function

Due to the menisci, which are intra-articular fibrocartilages, which separate the articular surfaces of the stifle, it has been categorized as a complicated synovial condyle joint. The main motions around the stifle are flexion and extension [3].

Bones of the Stifle Joint

There are many articulation regions such as lateral medial and third are situated within the trochlea of femur on the interior surface on the posterior of the quadrangular end of femur bone, which protrudes caudally. Intercondyloid fossa, which is located between external and internal femoral condyles, which have thick surfaces that seem to be convex in the planes (frontal and sagittal). There is a fossa in the caudal section where is placed more laterally than the cranial part due to the modest oblique orientation of the structure. The condyle articulation is caudally continued with the articular faces on the nearby epicondyles which interact to fabella, tiny sesamoidea bones that sit in the tendon origin of the gastrocnemius. The surface of patellar trochlea (femoral) is described as wide, grove, and soft portion of the articular surface of the cranial femur that connects to the articulation surfaces of the femoral condyles [4]. Both trochlear ridges (lateral and medial) are located in the trochlea's crests, diverge close to the center. The femoral trochlea and patella articulate [5].

The upper end of the tibial exhibits a triangular section with a frontal apex and is partially convex in the plane of sagittal extension. The middle and lateral condyles on the proximal articulating face have almost exactly the same amount of level area, but the lateral condyle was found circular and medial condyle was oval in shape **[6]**. These two articular regions are separated by a sagittal, non-articular region called the intercondylar eminence. On their abaxial surfaces, the medial and lateral intercondylar tubercles connect to the femur. They are triangular projections on top of the intercondylar eminence [7]. There are joining between cranial ligaments including cruciate and meniscal one another in the oval depression known as the cranial intercondyloid region, which is cranial to the intercondylar eminence (Figure 1). The caudal meniscal ligaments have an attachment point in the intercondylar surface, behind the intercondylar eminence where there is a small depression. The cruciate ligament (caudal part) is attached to the notch in the popliteal region, which divides tibial condyles at its most caudal side. The lateral tibial condyle's cranial edge has a tiny notch called the extensor (muscular) groove that continues to the edge of the condyle's articular surface. This groove is traversed by the lengthy digital extensor tendon. The large quadrangular tibial tuberosity, which is located in the cranial proximal process of the tibia, is where the patellar ligament and a part of the sartorius muscles and biceps femoris are joined. The tuberosity of tibia extends from the cranial margin of tibial bone, historically known as the tibial crest. The facies articularis fibularis, an obliquely positioned aspect at articulation of forehead fibula, is situated over the tibial condyle at the lateral aspect. At this facet, a small bump upper part of fibula, where their sit of articulation [8].

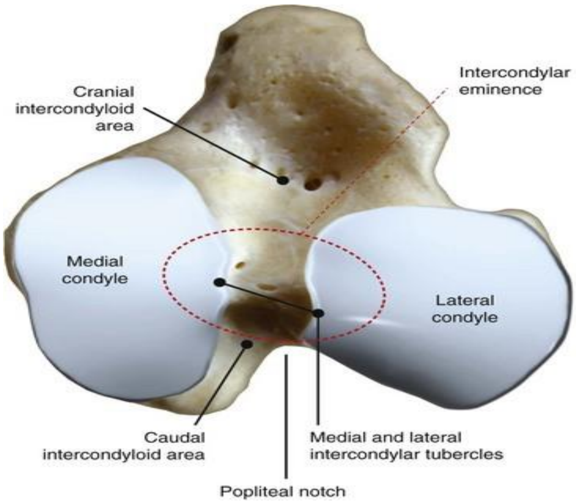

Figure 1: Anatomical description of articular surface of tibia [8]

Sesamoid Bones Associated to Stifle

The Patella has been described as the biggest sesamoid bone in the body, it has insertion in many directions of quadriceps muscles. To articulate with femoral trochlea, it has an oval form and a little curvature. The base and apex of the structure are the somewhat pointed distal surface and the blunt, proximal part, respectively. The articulation surfaces are smooth and convex in all directions. The ligament of patella sometimes works as the quadriceps tendon that passes the tibial tuberosity and patella. The quadriceps femoris tendon passes along the femoral trochlea (pulley), and the direction of patellar sesamoid bone change of it is pulled to increase the bearing of tendon surface. Two or three parapatellar fibrocartilages enhance the articulation surface of the stifle at a greater distance. This cartilage grooved extends on the ridge of the femoral trochlear and is implanted inside the medial and lateral femoral fasciae, helping to avoid patellar luxation. These two cartilages are in close proximity to one another and bend inward to connect, or there may be a third cartilage in between them [9].

Three more tiny sesamoid bones, sometimes named (fabellae), which are situated within the stifle area. This fabellae has been found in the head of gastrocnemius muscle on both sides (lateral and medial). With the exception of an amputated distal end and a horizontal articular surface that has articulation with the nearby femoral condyle of the caudal aspect, the lateral fabella is described as big and nearly ball- shaped. On the other hand, the fabella in the medial side than those in lateral side and has angular shape. These fabella has articulation with small fasces of caudal femoral condyle, but its articulation was described as erratic. In addition to this, there are small sesamoid bons known popliteus which lies on the tendon of popliteal muscle to articulate with the tibia on its lateral condyle [10].

Articulation of stifle joint

The femorotibial is a joint connecting flattening condyles of tibia with the femoral condyle which is thick and cylinder in shape. This joint is responsible for major body weight-bearing and articulate mainly with stifle. The interposition of the menisci (lateral and medial) improves the positioning of the articular edges of the condyles of both the tibial and femoral ends. The patellar ligament, which appears to be tightly connected to the tibia, allows the patellofemoral joint to easily engage with the tibiofemoral articulating resulting in the two joints being interrelated. Thus, the femur and patella move together whenever the tibia and femur move at all [11]. By lengthening the quadriceps muscles' moment arm, the femoropatellar joint enhances the effectiveness of the extensor mechanism. The last part of the stifle joint is the proximal tibiofibular joint [11].

Three freely connecting sacs are formed by the stifle joint capsule: two of them the articulation of lateral and medial femorotibial joints, and another one between the femur and patellar bones. Those menisci separate femoromeniscal and tibiomeniscal portions by the femorotibial sacs. The infrapatellar fat pad (body), which separates the layers (synovial and fibrous) from the joint capsule distal to the patella, is extra synovial. The lateral capsule of femorotibial joint has three more sub pouches, between the tibial condyle (lateral one) and the upper end of tibia, a brief extension runs. A third partly encircles the tendon of the popliteal muscle over femoral condyle (laterally) and creating the synovial bursa to decrease the friction, while the fourth extends distally along the extensor groove, near the attachment point of tibial tuberosity and patellar ligament, a tiny synovial bursa is typically present. [12].

Ligaments of Stifle Joint

A group of linked ligaments join menisci to the tibia. The meniscotibial ligament (medial part) attaches to the intercondylar segment of the tibia at the cranial side, and this is also where both the cruciate and meniscotibial ligaments are inserted (Figure 2). The caudal median meniscus joins to tibia through caudal inter condyle region from its caudal boundaries (Figure 1). The popliteal notch, which is immediately caudal to the caudal inter condyloid region, is where attachment between the ligament of the caudal meniscotibial and lateral meniscus (Figure 2). The tibial ligaments including cranial and caudal corresponding menisci were mentioned as other names of these ligaments. In the same way, femoral ligament attaches the femoral condyle at the medial side and runs on the lateral surface of meniscus of stifle join [12]. The inter meniscal ligament is described as a band of transverse fibrous that joins the ligament of cranial tibial to meniscus from its lateral side (Figure 2).

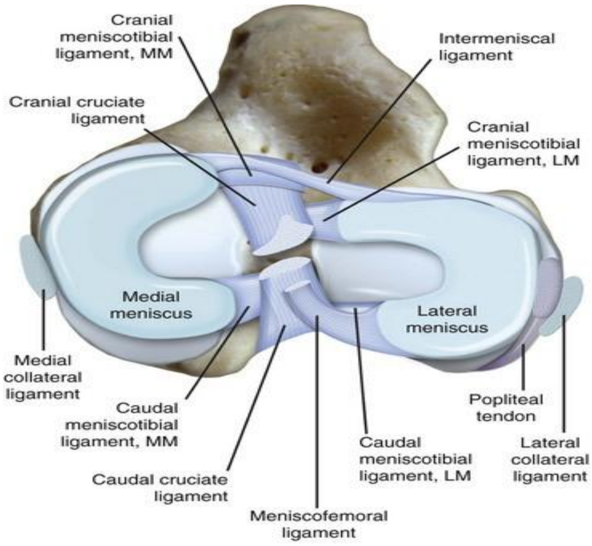

Figure 2:Inner surface of stifle joint showing ligaments and meniscus [12].

Primary ligamentous support is provided by those group of ligaments such as cruciate and collateral femorotibial in the stifle joint. Both cruciate ligaments can be divided into intra-articular, or inside the stifle joint, but because the synovium covers them, they are regarded as extra synovial. Based on where they join the tibia, these ligaments are referred to as cranial and caudal. They also decussate, or cross, one another. The cranial or lateral cruciate ligaments connect to the inner fossa of famous condyles, and also to lateral femoral condyle at the medio caudal side. It then travels diagonally across the inter condyloid fossa in different directions (distal, medial, cranial) to bend the inter condyle tibia at cranial area. A greater caudolateral portion of this ligament connects to the tibia at laterocaudally site, whereas a small band ligament attaches to tibia on the medial side cranially. Due to the movement of ligament from upper to lower direction, the ligament fibers spiral craniomedially by around 90 degrees axially.

In comparison, the cruciate ligament of its two parts including cranial one is shorter and smaller. The epi ligamentous zone of the cruciate ligaments is made up of loose connective tissue under synovial layer, also it covers the core surface of fascicles which contain collagen fibrils and fibroblast. The epi ligamentous region cannot be found anywhere else than where the caudal cruciate ligament coils over the cruciate ligament (cranially)

The medial ligament contains a large number of mechanoreceptors and proprioceptors, while afferent axons from the synovium that surrounds the ligament provide innervation. The popliteus muscle's tendon of origin is located over the collateral ligament that is situated on the lateral aspect before joining the lateral femoral epicondyle at an oval spot. There are few ligament fibers connecting to the tibial condyle on the lateral side, however, the top of the fibula provides the distal attachment [13]. The medial epicondyle of the femur has an oval region where the medial tibial collateral ligament connects. It integrates with the joint capsule as it moves distally and is firmly attached to the medial meniscus [14].

Meniscus

The fibrocartilage disc is located against the distal condyle of femur and proximal condyle of tibia is named the meniscus according to attachment, function, and disc shape that tends to be (C in shape). In general, the body of the meniscus usually has a crescent form, a triangular section to adapt to articulation bones surfaces for both the tibia and femur [15].

The proximal sections of the menisci are described as spherical and rest on both condyles of the tibia, whilst the proximal sides are mentioned to be concave and rest on condyles of the femur. The meniscus is considered a perfect example of a specific functional structure due to it having the wedge form, and soft faces, joint compressive stresses generate radial flexible forces. When the joint becomes loaded with weight, the tensile strain formed in the tissue is produced from the organization of collagen fibers against the radial force, consequently, the hoop stress is prominent at this tensile tension. The ligaments mentioned in the preceding section (cranial and caudal menis cotibial ligaments of the menisci) function as a tight link between the bones and horns of the meniscus (cranial and caudal). These ligaments are vital for the distribution of loading within the meniscus due to counteract the hoop forces that appear in the meniscus under axial stress.

Understanding the procedure of meniscal damage and doing surgical processes on the menisci requires an understanding of normal meniscal attachment patterns. The medial meniscus has a strong attachment to the tibia by the tibial meniscus ligaments (cranial and caudal) (Figure 2). The inter meniscal ligament separates the medial and lateral menisci cranial horns. While the function of this ligament is undetermined, it probably assists in the stabilization of cranial horn and the loop tension. To avoid problems while doing surgery near the inter meniscal ligament, it is critical to understand where the ligament is situated [16].

The medial meniscus's caudal tibial ligament is a flat, fan-shaped tissue that wraps around the medial tibial plateau's most caudal portion; thus, it is hard to see its caudal part during arthrotomy or arthroscopy. its caudal placement should be taken into account when meniscal treatments like caudal meniscal release and caudal hemimeniscectomy are done. Through the coronary ligament, which runs along the majority of the meniscus, the medial part of meniscus and collateral ligaments joined the capsule of stifle joint indirectly to the femur and tibia. Another powerful connection to the tibia is made possible by the medial meniscus' abaxial edge, which merges with the medial collateral ligament. In comparison to the meniscus medial one, the meniscus in the lateral side has a small joining to the tibia. lateral meniscus has a few linking to the tibia, but it attaches the meniscus horn from the cranial portion at the inter condyle region, which is located behind the tibial attachment of the cruciate ligament (cranial portion) and cranial to the intercondylar eminence [17].

The tibial ligament (caudal) associated with the lateral menisci is sometimes absent in the dogs, which can be connected the tibial either cranially or caudally for the cruciate ligament (caudal) that embedded of the popliteal notch on the lateral surface. These ligaments might represent a fine, non-fibrous linking between the tibia bone and the menisci [18].

Because of its attachment to the femur and near proximity to the popliteal tendon, the lateral meniscus can rotate with the condyles of femur. Consequently, it can be seen less vulnerable to damage than the those can be occurred in the static meniscus on the medial side.

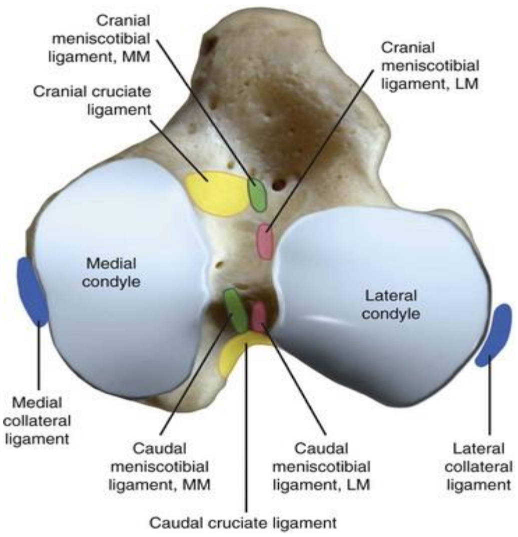

Figure 3 Showing anatomical sites connected the stifle ligaments to tibia. [18].

Menisci are fibrocartilaginous complexes composed mostly of cells, an extracellular proteoglycan and glycoprotein framework, and a weaving network of collagen fibers (primarily type I collagen). Because this matrix has three highly structured layers of collagen fibrils, compressive loads may be dispersed both superficially and tangentially into rim stresses [19]. This distribution establishes a very efficient method for the meniscus (body and horns) to share load. The collagen on the outer layer is randomly arranged and has a structure that is comparable to articular hyaline cartilage. Collagen fibers have orientations differently in two functionally separate sections of the meniscal tissue of deeper layers (Figure 4): in the innermost third, where they are primarily radial, and the remaining two-thirds, where they are circumferentially directed [20].

This means that the exterior two-thirds may be acting in tension, while the inner third can act in compression. Radially oriented collagen fibers are less common in the majority of meniscal tissue and are thought to perform as bind fibers, limiting horizontal slicing of round collagen strands.

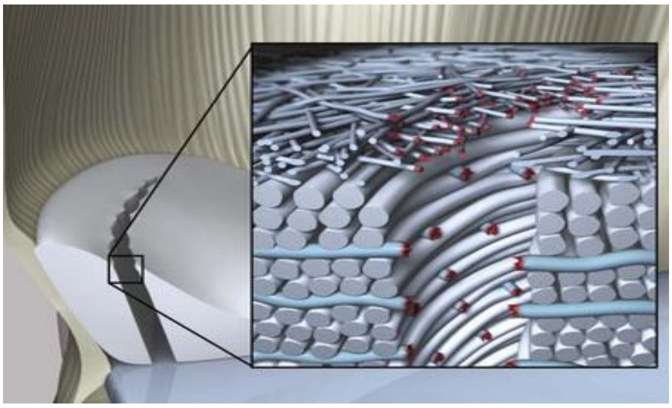

Figure 4 The diagram represents the direction of collagen fibers within the layers of the meniscus [21]

Proteo-glycans, which has been described as large positively charged molecules that are hydrophilic could keep 50 times the amount they weigh in water in a free solution, are also important components of the meniscus' extracellular framework. The capacity of the proteoglycan form aggregates aids in their immobilization within the collagen fibrillar meshwork. Proteoglycans play a crucial function in establishing the meniscus's material qualities by giving the tissue a high ability to withstand heavy compressive stresses. According to a previous hypothesis, the meniscus is a substance that alternates between a hard-core state and an intricate interstitial fluid phase [22]. As a consequence, when a force is placed on meniscal tissue, the solid phase responds elastically since it is mainly made up of collagen bundles arranged circumferentially. But at the same time, the fluid is carrying the compressive force as it slowly extrudes at a rate determined by the fluid's viscosity and the tissue's permeability. The menisci behave like an elastic rubbery material under dynamic compression at high loading frequencies, but at lower frequencies, there is substantial viscous dissipation. This behavior is also time dependent [20]. The extracellular matrix composition largely determines the size of static and dynamic compressive moduli, because they rise with carbohydrates content and reduce with water content [23]. Given the strong relationship between function and structure in the meniscus, pathological imperfections in the meniscal pathway that cause metabolic changes appear to impact biomechanical aspects.

The synovial fringe, which is found on both end sides of tibia and femur of the meniscus, is an insignificant reflection of the synovium's vascular layer and the source of the blood that supplies the canine meniscus. The blood arteries provide 25% to 25% of the menisci in the periphery. Because of the abundant blood flow, this area is known as the "red-red zone”. A few arteries may reach the intermediate red-white zone, which is located between the axial white-white zone and the rest of the menisci portion, which is largely nonvascular. The medial and lateral genicular arteries supply the peri-meniscal capillary plexus, which organizes the blood supply. In deciding how to treat the meniscus, the relative avascularity of the meniscus is crucial. The meniscus's peripheral blood supply gives a justification for mending rips in the red-red zone. When choosing whether to repair or resect a torn meniscus, one should also take into account other aspects including the existence of degeneration and the severity of the injury. [14].

Conclusion

The stifle joint is different from most other joints in the body. The stifle joint is also considered to be the most complicated joint in the body. It is composed of multiple structures, including the patella (kneecap), meniscus, femur, tibia, and ligaments. The cruciate ligaments, which cross inside the joint, are especially important for stabilizing the joint during movement. Because of its complexity and importance in weight-bearing and locomotion, the stifle joint is prone to injury and disease. Common conditions that affect this joint include ligament tears, meniscal injuries, and osteoarthritis. The stifle joint in dogs is similar to the stifle joint in other animals, including humans, in terms of its basic anatomy and function. However, there are some differences in the way that the stifle joint functions in dogs compared to other animals. For example, the stifle joint in dogs is designed to bear weight and provide stability during running and jumping activities, which are important for their natural behaviours like hunting and herding. As a result, the joint is relatively large and well-developed compared to other joints in the body. Dogs also have a unique structure in their stifle joint called the fabella, which is a small sesamoid bone located behind the knee. While some other animals also have a fabella, it is much more common in dogs and may play a role in stabilizing the joint during weight-bearing activities. Additionally, certain breeds of dogs may be predisposed to certain stifle joint conditions, such as cruciate ligament tears. This may be due to differences in anatomy or biomechanics compared to other animals. Overall, while the stifle joint in dogs is similar to other animal joints in terms of basic anatomy and function, there are some unique features and considerations related to the specific needs and behaviors of dogs

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دراسة تشريحية لمفصل الخانق في الكلاب

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الملخص

المفصل الخانق هو مفصل معقد يتكون من عدة هياكل تعمل معًا لتوفير الدعم والاستقرار للطرف الخلفي. المفصل الخانق للكلاب ، وهو ما يعادل مفصل الركبة البشرية ، هو هيكل معقد يتكون من عظم الفخذ ، والساق ، والرضفة ، والغضروف المفصلي ، والأربطة الصليبية (الجمجمة والذيلية) ، والأربطة الجانبية (الإنسي والجانبي)، والعضلات المحيطة مثل عضلات الفخذ وعضلات المأبض. يشكل عظم الفخذ والساق العظام الرئيسية للمفصل ، بينما تجلس الرضفة أمامها لحمايتها. يعمل هذان الشكلان على شكل حرف C كممتص للصدمات ، وتوفر الأربطة الصليبية والأربطة الجانبية ثباتًا للمفصل. تساعد العضلات المحيطة ، بما في ذلك عضلات الفخذ وعضلات المأبض ، على تمديد وثني المفصل ، على التوالي. تعمل هذه الهياكل معًا في وئام للسماح بالحركات المعقدة للمفصل الخانق في الكلاب. ويعد فهم تشريح المفصل الخانق للكلاب أمرًا مهمًا لتشخيص وعلاج الإصابات أو الحالات التي تؤثر على هذا المفصل المعقد.