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GROSS ANATOMICAL STUDY OF THE ARTICULATIO GENUS (STIFLE JOINT) OF THE RABBIT

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SUMMARY

The aim of the present study was to grossly dissect the stifle joint and to compare its anatomical structures with that of other small domesticated animals. Dissection of twelve stifles joints from six Baladi and New Zealand rabbits of different ages and sexes was conducted. Conventional radiography and cast preparations of the joints was performed. Digital images were shot using Sony cyber-shot DSC F 717 digital camera. The study revealed a great similarity between bony and ligamentous structures of the stifle joint in the dog and rabbit. However structural variations of the stifle joint among domesticated animals are discussed.

INTRODUCTION

As a prey, Rabbits are fast moving to escape from their predators such as carnivores. This behavior requires powerful hind limbs. The stifle joint being one of the major and complicated components of the hind limb was the aim of the present study. Rabbits have been used as an important laboratory animal, yet the detailed anatomical literatures available are quite few. I hope this study be helpful for students, scientists, veterinarians and orthopedic researchers.

MATERIALS AND METHODS

Dissection of twelve stifles of six cadaver specimens of clinically healthy male and female Baladi and New Zealand rabbits, young and adult, was performed.

The animals were slaughtered and hind limbs were separated and immersed in formalin 5 % solution for three days. A Macroscopic dissection of the stifle joint was then performed. The distal extremity of the femur and the proximal extremity of the tibia and fibula were separated, and the gross appearance of the joint capsule, articular surfaces, the periarticular soft tissues, and ligaments were examined. Joint capsule of some specimens was injected with gum-milk latex colored with blue ink, and diluted with ammonium hydroxide solution. About the middle of the lateral border of the patellar ligament, the needle was inserted, and then directed caudomedially into the cavity of femoropatellar capsule. From the latter, the latex passes to the communicated medial and lateral femorotibial capsules.

The relative position of the articulating bones in the normal standing posture of the animal, was explored through a conventional radiographic X-ray examinations were performed on young and adult rabbits at the department of surgery, faculty of veterinary medicine, Cairo University. Radiographs were obtained in lateral, oblique, craniocaudal and skyline projections, at 42 KV, 300 MA, .30 mas, using Toshiba KXO-15E system.

Digital images were shot using Sony DSC F717, cyber-shot digital camera; labels are added in Adobe Photoshop 7.0 program. The nomenclature applied in this study was according to the Nomina Anatomica Veterinaria (1994) and illustrated veterinary anatomical nomenclature (1992)

RESULTS

Articulatio genus

The rabbit stifle joint is composed of femoropatellar, femorotibial articulations.

Articulatio femoropatellaris Plate 1 Figs. A, B, C & D, plate 2 figs. A & F and plate 3 fig. A

The femoropatellar articulation is between the patella, a sesamoid bone in the deep surface of the tendon of vastus intermedius muscle, and the trochlea of femur.

Articulatio femorotibialis Plate 1 figs.B & D, plate 2 and plate 3

The articulating bones are the femoral and tibial condyles in addition to two fabellae; medial and lateral present in the origin of the medial and lateral heads of gastrocnemius muscle.

Capsula articularis

The synovial joint capsule is ample and and could be divided into three communicable synovial sacs; a femoropatellar sac and two femorotibial sacs. The femoropatellar sac (Plate 1 fig. C/6) extends proximally between the shaft of the femur and the quadriceps femoris muscle for about 1.5 cm. The femoropatellar sac is continuous with the medial and lateral femorotibial synovial sacs at the distal end of the trochlea (plate 1 fig. C/7 & plate 2 fig. B/3, 4). The two femorotibial sacs are separated by incomplete septum and they communicate together transversly across the intercondyloid space. The two fabellae of the gastrocnemius muscle are included within the femorotibial sacs (Plate 2 fig. C/3, 4). The lateral femorotibial sac extends to surround the tendon of origin of popliteus muscle. It also sends a tendon sheath recess distally through the extensor sulcus of the tibia to surround the tendon of origin of the long digital extensor muscle (Plate 1 fig. C/7).

Meniscus lateralis and ***meniscus medialis*** (plate 2 fig. E/4, 5 and plate 3 fig. D/1, 2) are semilunar (C-shaped) fibrocartilages interposed between the two condyles of femur and tibia. Each meniscus is thick at its peripheral margin and thin concave centrally to correct the incongruence that exists between the articulating surfaces of the femur and tibial condyles. Menisci are very important to absorb shocks during jumps of rabbits and to prevent or minimize friction between articular surfaces.

The fibrous joint capsule surrounds the femorpatellar and femorotibial joints. It adheres to the medial and lateral collateral ligaments of the stifle joint. Laterally it contacts tendon of insertion of the biceps femoris muscle, while, cranially it is in contact with the patellar ligament (plate 1 fig. A/ 6, 7, 8 & 9).

Ligaments of the Articulatio femoropatellare

Lig. patellae. Plate 1 fig. C/3 and plate 3 figs. A/ 8, B/12, C/9 & D/8. The patellar ligament extends from apex of the patella to tibial tuberosity. A suprapatellar fibrocartilage is interposed between the quadriceps femoris muscle and the patellar ligament. The patellar ligament is separated from the joint capsule by a large quantity of fat; infrapatellar fat body which increases at the site where the patellar ligament inserts on the tibial tuberosity. The patellar ligament is in contact with the cranial aspect of the fibrous capsule.

Lig. femoropatellare mediale and lig. Femoropatellare laterale are thickenings in the fibrous joint capsule extending from the corresponding border of the patella medially and laterally by indistinct fibers to be inserted on the corresponding fabella in heads of gastrocnemius, so they are called fabellopatellar ligaments; medial and lateral.

Ligaments of the Articulatio femorotibialis

1- Lig. collaterale laterale. Plate 3 fig. C/5, and plate 3 fig. D/10. The lateral collateral (fibular) ligament extends from lateral epicondyle of femur to head of fibula and adjacent part of the lateral condyle of the tibia. Along its short course it crosses the tendon of origin of the popliteus muscle.

2- Lig. collaterale mediale. Plate 3 fig. B/11 & D/ 11. The medial collateral (tibial) ligament extends from the medial epicondyle of the femur to the medial condyle of the tibia. During its course it adheres to the fibrous layer of the joint capsule and to the outer margin of medial meniscus.

3-Ligg.cruciata genus. Plate 2 and 3.

Cruciate ligaments of stifle joint, according to their nomenclature they cross each other forming X shape. The cranial and caudal cruciate ligaments located intracapsular forming an incomplete septum between the two femorotibial synovial sacs.

a) Lig. cruciatum craniale. Plate 3 fig. B/9 & fig. D/5

The cranial cruciate ligament originates from the cranial intercondyloid area of the tibial plateau passes through the intercondyloid fossa of the femur in a diagonal direction to be inserted onto the caudal part of the medial surface of the lateral femoral condyle.

b) Lig. Cruciatum caudale. Plate 2 fig. D/8 & fig. E/9 and plate 3 figs. B/10, D/6

The caudal cruciate ligament is longer than the cranial one and originates from the caudal part of the intercondyloid area of the tibial plateau near the popliteal notch. It passes craniomedially and dorsally through the intercondyloid fossa of femur in a spirally twisted manner to be inserted on the caudomedial part of the medial femoral condyle.

4- Lig. Transversum genus. Plate 3 figs. A/4 & D/3

Transverse ligament of stifle joint or intermeniscal ligament, it is stretched between the cranial ends of medial and lateral menisci. It lies caudal to the cranial tibial ligament of medial meniscus and cranial to the cranial tibial ligament of lateral meniscus.

5) Cranial tibial ligament of the medial meniscus. Plate 3 figs. A/3 & D/4

It extends from cranial end of the medial meniscus in a diagonal manner to the cranial intercondyloid area of the tibia, being cranial to both the transverse ligament of the stifle joint and the cranial tibial ligament of the lateral meniscus and the cranial cruciate ligament.

6) Cranial tibial ligament of lateral meniscus. Plate 3 fig. B/8

It extends from the cranial end of the lateral meniscus in a diagonal way to be inserted on the cranial intercondyloid area of the tibia forming an acute angle with the origin of the cranial tibial ligament of medial meniscus.

7) Caudal tibial ligament of the medial meniscus. Plate 2 fig. E/8

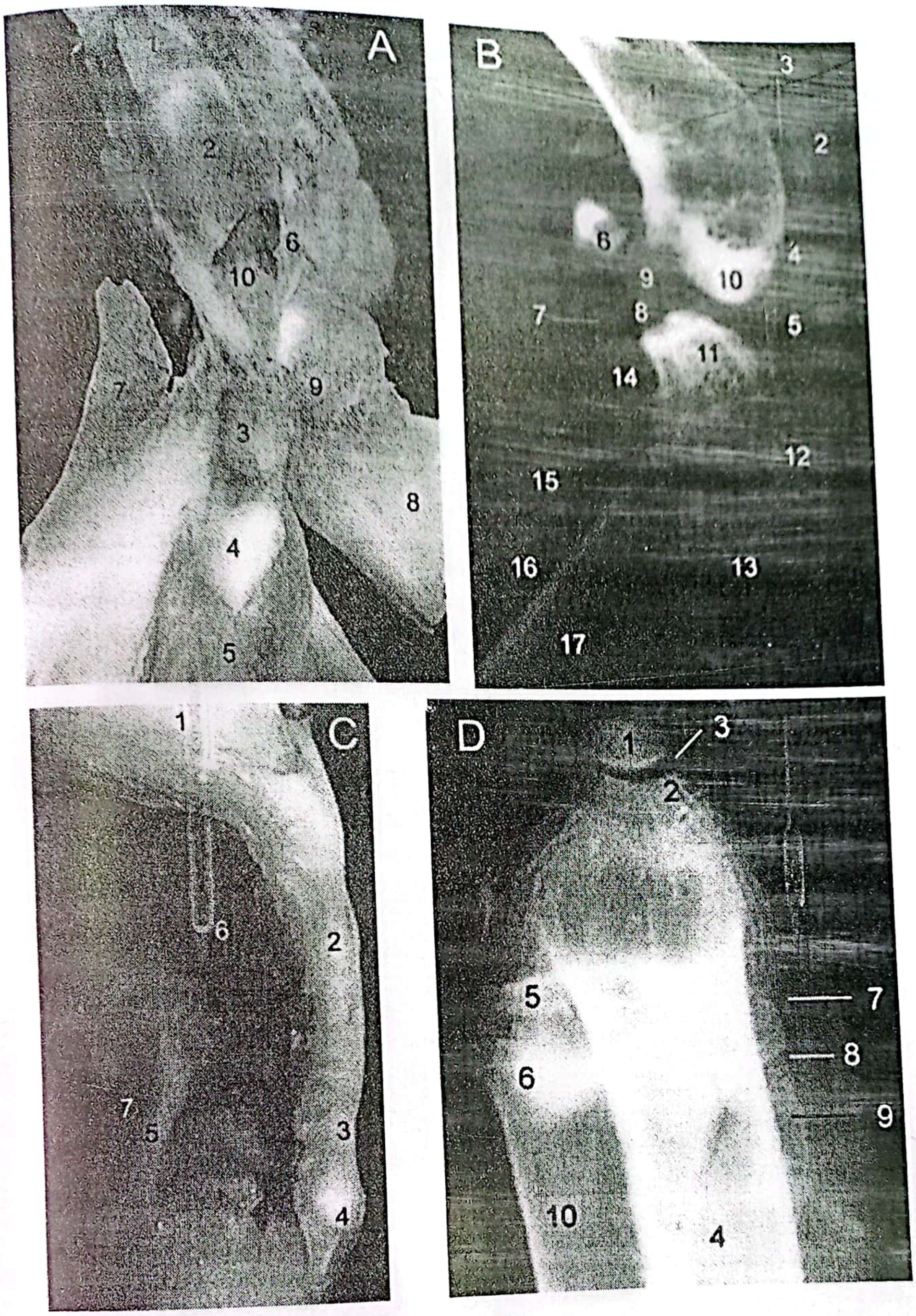
It extends from the caudal axial end of the medial meniscus to the caudal intercondyloid area of the tibia, being cranial to the tibial attachment of caudal cruciate ligament.

8) Caudal tibial ligament of the lateral meniscus. Plate 2 fig. E/7

It extends from the caudal axial end of the lateral meniscus to the popliteal notch of tibia, being caudal to the tibial attachment of caudal cruciate ligament.

9) Lig. meniscofemorale. Plate 2 figs. D/7 & E/6 and plate 3 fig. D/9

It extends from the caudal axial end of the lateral meniscus passes dorsomedially in a diagonal manner, crossing the intercondyloid fossa of femur to be inserted on the medial aspect of medial femoral condyle.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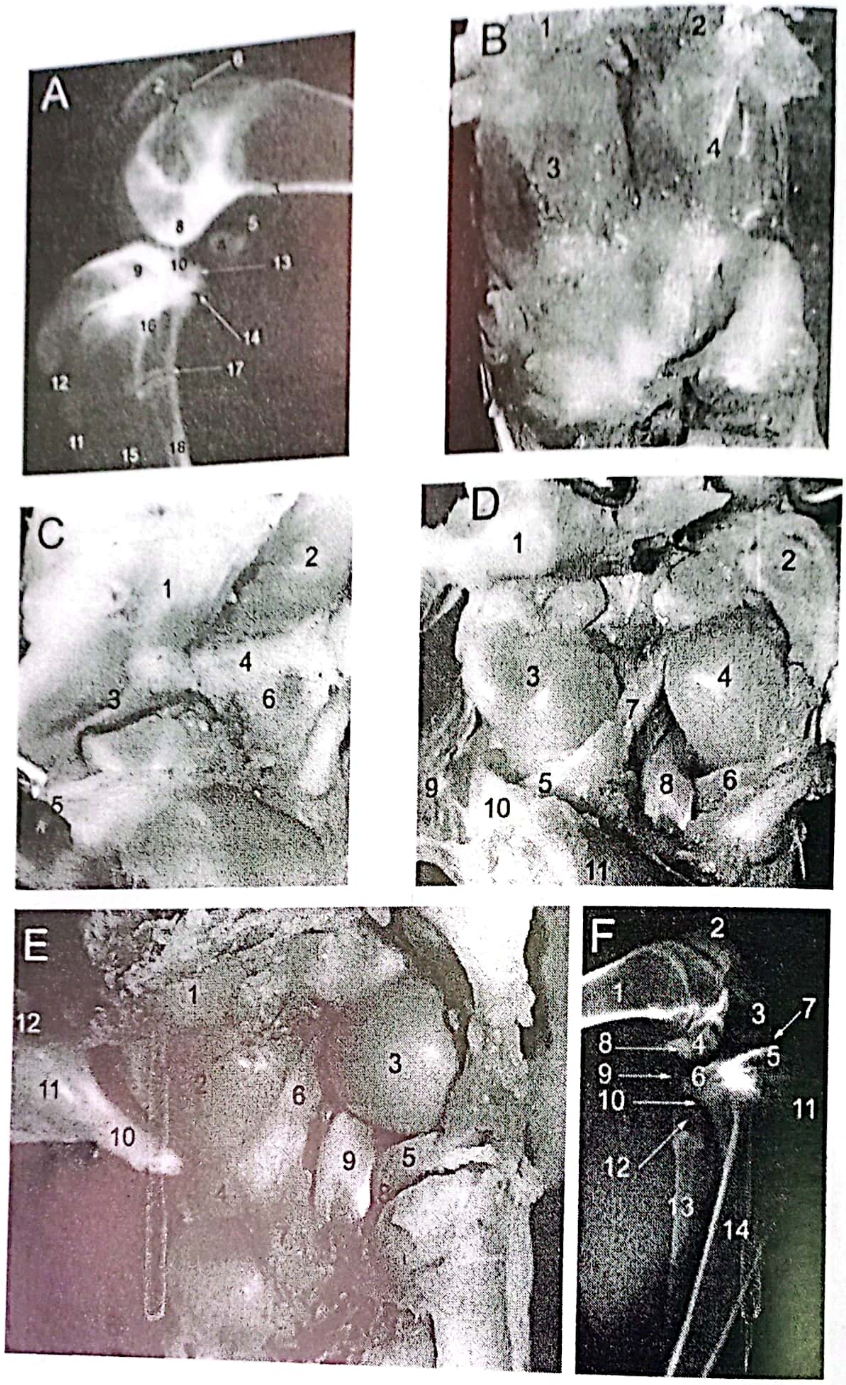
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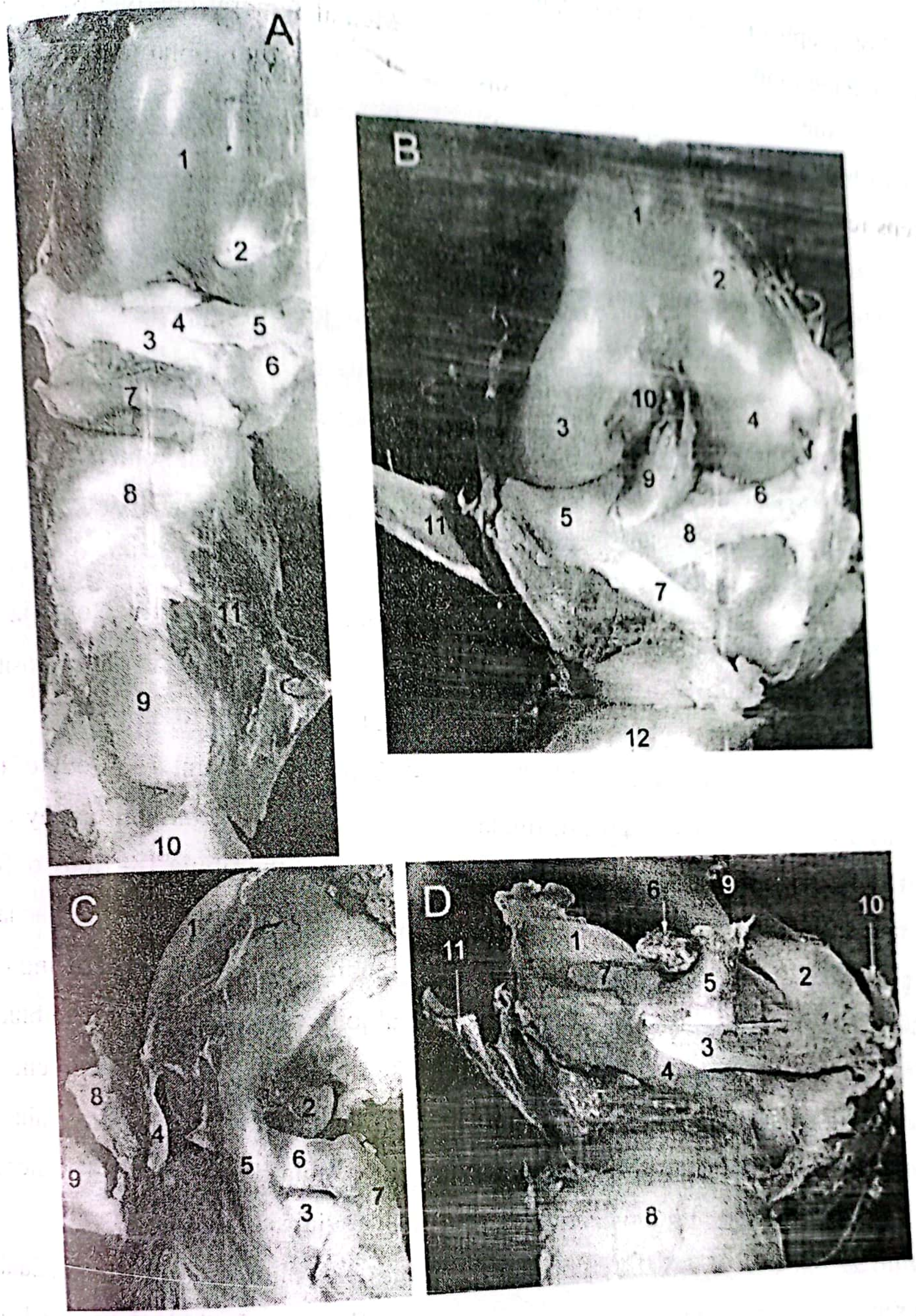
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Plate: (3)

Plate 1

Fig. A) A photograph of opened femoropatellar articulation in the rabbit showing:

1- Femur 2- Trochlea of femur 3- Patella 4- Suprapatellar fibrocartilage

5- Quadriceps femoris muscle. 6- Synovial membrane of the femoropatellar joint

7- Fibrous capsule of the stifle joint 8- Biceps femoris muscle 9- Tendon of insertion of biceps femoris muscle. 10- Infrapatellar fat body.

Fig. B) Oblique mediolateral radiographic image of the rabbit left stifle joint showing:

1- Femur, 2- Patella, 3- Femoropatellar joint 4- Trochlea 5- Infrapatellar fat

6- Proximal sesamoids (fabellae) 7- Distal sesamoid 8- Femorotibial joint

9- Lateral condyle of femur 10- Medial condyle of femur 11- Medial condyle of tibia 12- Tibial tuberosity 13- Tibial crest 14- Head of fibula 15- Shaft of fibula 16- Interosseous space 17- Shaft of tibia

Fig. C) A photograph showing a lateral view of the joint capsule of the rabbit right stifle joint injected with blue latex.

1- Quadriceps femoris muscle 2- Patella in trochlear groove, 3- Patellar ligament, 4- Tibial tuberosity 5- Lateral collateral lig. 6- Femoropatellar synovial sac., 7- Lateral femorotibial synovial sac.

Fig. D) A radiographic image of the flexed stifle joint of a young rabbit; skyline projection showing; 1- Patella, 2- Trochlea of femur and the patellar groove 3- Femoropatellar joint 4- Shaft of femur superimpose tibia and fibula 5- Medial femoral condyle 6- Medial tibial condyle 7- Femorotibial joint 8- Tibiofibular joint 9- Head of fibula 10- Shaft of tibia

Plate 2

Fig. A) A lateromedial radiographic image of the stifle joint of the rabbit showing:

1- Body of femur 2- Patella 3- Lateral supracondylar crest 4- Lateral fabella 5- Medial fabella 6- Femoropatellar joint 7- Lateral ridge of the trochlea

8-Lateral condyle of femur 9- Lateral condyle of tibia 10- Medial condyle of tibia

11- Tibial crest 12- Tibial tuberosity 13- Fabella in the tendon of M. popliteus

14- Tibiofibular joint 15- Body of tibia 16- Head of fibula 17- Proximal epiphyseal ossification center of the fibula 18- Body of fibula

Fig. B) A photograph of the caudal view of the rabbit right stifle joint showing the femorotibial joint capsule injected with blue latex; 1- Origin of medial head of gastrocnemius 2- Origin of lateral head of gastrocnemius 3- Medial femorotibial synovial sac 4- Lateral femorotibial synovial sac.

Fig. C) A photograph of the cadual aspect of left stifle joint of rabbit showing; 1- origin of lateral head of gastrocnemius 2- origin of medial head of gastrocnemius 3- Lateral fabella 4- Medial fabella covered by synovial membrane

5- Lateral femorotibial synovial sac (opened)
6- Medial femorotibial synovial sac (intact)

Fig. D) A photograph of the cadual aspect of left stifle joint of rabbit showing;

1- Lateral fabella in origin of lateral head of gastrocnemius 2-Medial fabella in origin of medial head of gastrocnemius 3- Lateral femoral condyle 4- Medial femoral condyle 5- Lateral meniscus 6- Medial meniscus 7- Meniscofemoral ligament 8- Caudal cruciate ligament 9- Joint capsule opened and reflected

10- Tendon of origin of popliteus muscle 11- Popliteus muscle

Fig. E) A photograph of the cadual aspect of left stifle joint of rabbit showing;

1- Origin of gastrocnemius 2- Lateral femoral condyle 3- Medial femoral condyle 4- Lateral meniscus 5- Medial meniscus 6- Meniscofemoral ligament

7- Caudal tibial ligament of the lateral meniscus 8- Caudal tibial ligament of the medial meniscus 9- Caudal cruciate lig. 10- Tendon of origin of popliteus muscle (reflected) 11- Distal fabella in 10 12- Popliteus muscle reflected.

Fig. F) Oblique mediolateral radiographic image showing; 1- Femur, 2- Patella 3- Medial condyle of femur 4- Lateral condyle of femur 5- Medial tibial condyle

6- Lateral tibial condyle 7- Femorotibial joint 8- Proximal sesamoids 9- Distal sesamoids 10- Tibiofibular joint 11- Tibial crest 12- Head of fibula 13- Body of fibula 14- Shaft of tibia.

Plate 3

Fig. A) A photograph showing a cranial view of an opened left stifle joint of rabbit; 1- Trochlea, 2- Tendon of origin of long digital extensor muscle 3- Cranial tibial ligament of the medial meniscus 4- Transverse meniscal ligament 5- Lateral meniscus 6- Lateral tibial condyle 7- Infrapatellar fat body 8- Patellar ligament 9- Patella 10- Suprapatellar fibrocartilage 11- Joint capsule of stifle joint.

Fig. B) A photograph showing a cranial view of an opened left stifle joint of rabbit; 1- Trochlea 2- Extensor fossa of femur 3- Medial condyle 4- Lateral condyle 5- Medial meniscus 6- Lateral meniscus 7- Cranial tibial lig. of medial meniscus 8- Cranial tibial lig. of lateral meniscus 9- Cranial cruciateligament 10- Caudal cruciate ligament 11- Medial collateral ligament 12- Patellar ligament.

Fig. C) A photograph showing a lateral view of the rabbit stifle joint;1- Lateral ridge of trochlea 2- Lateral femoral condyle 3- Lateral tibial condyle 4- Tendon of origin of long digital extensor muscle 5- Lateral collateral ligament 6- Tendon of origin of popliteus muscle 7- Popliteus muscle 8- Infrapatellar fat body 9- Patellar ligament.

Fig. D) A photograph showing a craniodorsal view of the rabbit stifle joint; 1- Medial meniscus 2- Lateral meniscus 3- Transverse ligament 4- Cranial tibial lig. of medial meniscus 5- Cranial cruciate ligament 6- Caudal cruciate ligament 7- Medial condyle of tibia 8- Patellar ligament (reflected) 9- Meniscofemoral ligament 10- Lateral collateral ligament 11- Medial collateral ligament

DISCUSSION

Accurate data on the anatomical structure of the rabbit stifle joint is relatively rare. Jumping is a characteristic feature of some mammals, including the rabbit. The propulsive force and speed come from the ankle and knee through the long, muscular thigh and calf which are initiators of the jump (Grand and Lorenz, 1968). For maximum propulsive effectiveness, the joint motions of the limbs (hip, knee, and ankle) tend in mammals to be restricted to the sagittal plane (for flexion and extension of these joints). This is achieved by the restriction of joint motions through ligaments, bony environments, and the muscular arrangement (Grand and Lorenz, 1968). Although the femorotibial articulation of the stifle joint is a condylar joint, it acts a gingylimus (Bonnie, 1999) in the dog and (May, 1970) in sheep. Our observations on the rabbit, which is a natural jumper, were in agreement with the previous facts.

However, 180° extension of the stifle joint is prevented by the medial and lateral collateral ligaments as well as the creanial cruciate ligament, on contrary the normal posture of the rabbit allows the thigh and leg to lie in contact in a flexed position this is attributed to musculoskeletal anatomy, where the femoral condyles are set caudal to the shaft of femur and also the tibial condyles being inclined caudal to the shaft of the tibia.

In the rabbit the femoropatellar joint capsule communicates distally with both medial and lateral femorotibial capsules; and the medial and lateral capsules communicate transversly across the intercondylar space, this was in agreement with what was cited in the dog by (Getty, 1975; Miller et al. 1979; Shively, 1980; Bonnie, 1999) and pig by (Sack, 1982) and sheep by (May, 1970). Thus only one injection will reach the three divisions of the joint. The joint capsule in large animals is similar to the rabbit except the horse where the femoropatellar joint capsule communicates with the medial femorotibial synovial sac only (Shively, 1980 and Dyce et al., 1996). The patellar locking mechanism is absent in the rabbit, due to the nature of the trochlea of femur. Dyce et al. (1996), reported that this locking mechanism is prominent in equine as part of the pelvic limb stay apparatus and to a lesser degree in large ruminants.

Extension of the synovial membrane to invest the tendon of origin of popliteus muscle and the recess formed distally through the sulcus muscularis of tibia as a synovial sheath around tendon of long digital extensor muscle was also in agreement to that reported in dog by (Getty, 1975; Miller et al., 1979; Shively, 1980; Bonnie, 1999 and May, 1970) in sheep

The study revealed the presence of single patellar ligament, which is similar to what was cited in carnivores, pig and small ruminants by (Getty, 1975; Miller et al. 1979; Popesko, 1979; Shively, 1980; Sack, 1982; Garrett, 1988; Pasquini 1995; Dyce et al., 1996 and Bonnie, 1999). In equine and bovine there are three patellar ligaments; medial, middle and lateral (Getty, 1975 and Dyce et al. 1996).

In the rabbit we observed a suprapatellar fibrocartilage proximal to the patella in the tendon of quadriceps femoris muscle. This cartilage was absent other domestic animals. However, Miller et Al., (1979) pointed its presence in older dogs. In equine, bovine and canine there is a parapatellar fibrocartilage (Getty, 1975; Dyce et al. 1996)

The medial and lateral femoropatellar ligaments are present in carnivores, pig and small ruminants as well as in equine and bovine (Getty, 1975; Miller et al. 1979; Shively, 1980; Sack, 1982, Pasquini 1995; Dyce et al. 1996 and Bonnie, 1999). However these ligaments are sometimes named fabellopatellar ligaments in case of carnivores Shively, (1980) and rabbits due to presence of the sesamoides in the head of gastrocnemius muscle in these species.

The fabella found in the tendon of origin of popliteus muscle in the rabbit was present in the dog (Getty, 1975; Miller et al. 1979; Shively 1980; Wesley, 1994; Boyd, 1996 and Bonnie, 1999). This sesamoid bone is absent in the other domestic animals and may be absent in small dogs, but is typically present in cats.

The cruciate ligaments and the femorotibial collateral ligaments have a common arrangement among domestic species. The meniscal ligaments have a similar arrangement but the transverse ligament connecting the two menisci which is present in the rabbit was also reported in the dog, and pig. However, it is absent in equine and bovine as reported by (Getty, 1975; Miller et al. 1979; Shively 1980; Wesley, 1994; Boyd, 1996 and Bonnie, 1999).

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