Gross Morphological Features of the Femoropatellar Articulation in Dogs

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Abstract:

The current manuscript had been achieved to be an essential resource for veterinary students and practitioners who deal with the anatomy of the Femoropatellar articulation in the dog. Twelve healthy adult dogs of both sexes were used in our study.

Radiography and fine anatomical dissection were performed to document the detailed gross morphology of the various components of the dog Femoropatellar articulation, including its articular capsule, bony articular surfaces and ligaments.

Results of the present study revealed that the dog Femoropatellar articulation was formed between the femoral trochlea and the articular (posterior) surface of the patella with its medial and lateral parapatellar fibrocartilages.

The bony articular surfaces, various ligaments of the studied articulation were fully described.

Key words: Dog, Femoropatellar articulation, Gross anatomy, Radiography.

Introduction:

The femoropatellar articulation is considered as a main component of the entire knee joint in equines and canines ***(Skerritt and Mc Lelland, 1984),*** in foxes ***(El Mahdy, 1992)*** and in dogs ***(Robins, 1990; Evans, 1993 and Dyce et al., 2010).***

The joint is very important from both morphological and functional aspects ***(De Rooster et al., 2006; Gupte et al., 2007 and Sabanci and Ocal, 2014)*** as well as from the clinical view point ***(Hifny et al., 2017).***

The bony architecture of the femur, patella and tibia contributed to the stability of the knee joint as a whole, along with static and dynamic restraints of the ligaments, capsule and muscles crossing the joint ***(Goldblatt and Richmond,2003).***

The canine knee joint is frequently subjected to many injuries including fractures, synovitis, cruciate ligaments injury and tearing of the menisci ***(Carpenter and Cooper, 2000)*** and it is a common location for

lameness in dogs ***(Marino and Loughin, 2010).***

Knowledge of the normal anatomy of the studied joint will allow selection of the best treatment options, providing a return to the normal joint motion and minimizing further degeneration and dysfunction of the joint ***(Carpenter and Cooper, 2000).***

An understanding of the normal anatomy of the femoropatellar articulation in dogs is essential in the proper treatment of any injury that might occur.

Therefore, the objective of this manuscript was to reveal and characterize the structural organization of the femoropatellar articulation both grossly and radiographically in the healthy adult dogs, as representatives of the family" canidae" and one of the most frequently used models of joint degeneration related to osteoarthritis.

The study also aimed to provide essential knowledge for the students and anatomists and to help veterinary surgeons and clinicians in the proper diagnosis and treatment of the joint injuries.

Materials and Methods

The present work was carried out on twelve clinically healthy adult dogs of both sexes, with an average body weights ranged from 10-15 kg. The animals showed no evidence of marked bony or joint abnormalities and were euthanized using intravenous injection of thiopental sodium, then, the pelvic limbs of these animals were separated after authentication.

1) Radiographic examination:

With regards to the x-ray investigation, four fresh pelvic limbs were examined using digital radiology equipment. Postero-anterior and medio-lateral radiographic images of the studied joint were taken in order to document the normal morphology of its osseous constituents. The technique used exposure factors were 66 KVP, 3mAs and focal film distance (FFD) about 70 cm, with the joint placed directly on the cassette or detector.

2) Gross anatomic description:

Fine careful gross dissection of twenty freshly separated pelvic limbs was done to describe the normal gross anatomical structure of the femoropatellar articulation including the muscles related to the joint, the articular capsule, the various ligaments as well as the bony articular surfaces of the joint under investigation. The dissected joint was photographed using digital camera (Nikon, COOLPIX L100, Japan).

The nomenclatures used in this study was adopted according to the ***Nomina Anatomica Veterinaria (NAV) (2017)*** whenever needed.

Results:

A) Gross anatomic characteristics

The femoropatellar articulation (Articulatio femoropatellaris) in dogs was constructed between the trochlea of the femur and the articular (posterior) surface of the patella with its medial and lateral parapatellar fibrocartilages. It was contained together with the femorotibial and proximal tibiofibular articulations within a common articular capsule.

Trochlea ossis femoris:

The femoral trochlea was present anteriorly on the distal extremity of the femur.

It appeared in the form of two parallel almost identical ridges (medial and lateral) with nearly equal heights and sagittally directed (Figs.1,3& 9). A smooth groove-like articular surface (Facies patellae ossis femoris) which measured 5-6 mm in width was present between the two ridges and adapted for the articular (posterior) surface of the patella.

The medial and lateral trochlear ridges were continuous posteriorly with the respective femoral condyles. Posteriorly, each femoral condyle at its proximo-lateral aspect possessed a small articular facet; facies articulares sesamoidea medialis et lateralis (Fig.4) for the attachment with the corresponding gastrocnemius sesamoid bones (Ossa sesamoidea m. gastrocnemii or fabellae of the gastrocnemius muscle) which were embedded in the tendon of origin of both medial and lateral heads of the M. gastrocnemius (Figs.3&4).

Patella:

The patella appeared somewhat elliptical in form with a rounded end proximally and a slightly pointed apex distally (Figs.2,3,8 &9). In adult dogs, the patella was measured about 1.68 cm in length and 0.96 cm in width and was embedded in the deep face of the insertion tendon of M. quadriceps femoris.

The opposing articulating surface of the femoral trochlea and that of the patella were not quite similar to each other, since their transverse diameters were not equal, therefore, the medial and lateral borders (Margo medialis et lateralis) of the patella were covered by two elongated fibrocartilaginous bars representing the medial and lateral parapatellar fibrocartilages *(Fibrocartilagines parapatellares*) which met together proximal to the patella and articulated with the

corresponding ridges of the femoral trochlea. The medial parapatellar fibrocartilage was much broader and thicker than the lateral one (Figs.8,9), measured approximately 3-4 mm in width and was about twice the extensive as that of the lateral parapatellar fibrocartilage.

The patellar articular surface (*Facies articularis patellae*) was smooth and convex both longitudinally and transversely.

Ligaments of the femoropatellar articulation:

he patellar ligament as well as the femoropatellar ligaments served to hold the patella in position against the ridges of the femoral trochlea.

1. Lig. patellae:

The patellar ligament (Figs.8, 10) appeared as a strong and thick white fibrous band (about 35 mm long, 7.9 mm wide and 1.4 mm thick) which extended distally from the distal end of the patella to be attached with the tibial tuberosity. The latter appeared as a relatively large bony process at the anterior aspect of the tibial proximal extremity.

A large quantity of fat separated the patellar ligament from the joint capsule was clearly observed.

2. Ligg. femoropatellare mediale et laterale:

The femoropatellar ligaments were two short fibrous bands (medial and lateral) that extended transversely between the respective borders of the patella and the corresponding gastrocnemius sesamoid bones (gastrocnemius fabellae), thus, they might be called the fabellopatellar ligaments.

The lateral fabellopatellar ligament (Fig.7) appeared much stronger and longer (about 1 cm. long), however, the medial fabellopatellar ligament was thinner than the analogous lateral one and difficult to be separated from the femoropatellar articular capsule. Both ligaments in the dissected specimens appeared clearly reinforcing the femoropatellar articular capsule on either side, therefore, considered as intracapsular ligaments.

Capsula articularis

The articular capsule of the femoropatellar articulation in the dog appeared characteristically extensive and strong, therefore, it played a very significant role in the protection and stability of the joint. In the same time, it allowed the free movement of the joint. It composed of an outer fibrous layer (or membrane) and an inner synovial one.

1. Stratum fibrosum (Membrana fibrosa):

The outer fibrous layer of the articular capsule (Figs.5,6 &7) consisted of dense, inelastic fibrous connective tissue membrane. It was thick and strong anteriorly and, on both

sides, as it was reinforced by the patellar ligament, fabellopatellar ligaments and collateral ligaments of the femorotibial articulation, respectively. It was also reinforced by the tendinous insertions of the muscles about the joint, such as the biceps femoris, quadriceps femoris and Sartorius muscles.

It was attached very close to the margins of the parapatellar fibrocartilages as well as those of the femoral articular surface.

2. Stratum synoviale (Membrana synovialis):

The synovial membrane, by the naked eye, appeared very thin, glistening and transparent. It enclosed the articular cavity entirely but was absent on the articular cartilage.

A separated from the patellar ligament by considerable amount of fat (infrapatellar fat).

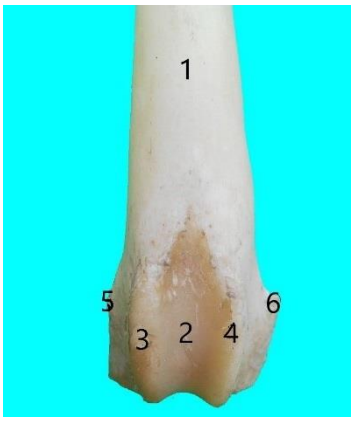

Fig. (1): A photograph of the anterior aspect of the distal extremity of the femur of an adult dog showing:

1. Corpus ossis femoris
2. Facies patellae ossis femoris
3. Trochlea ossis femoris (medial ridge)
4. Trochlea ossis femoris (lateral ridge)
5. Epicondylus medialis
6. Epicondylus lateralis

Fig. (2): A photograph of an adult dog patella showing its articular surface
1. Apex patellae
2. Basis patellae
3. Margo medialis patellae
4. Margo lateralis patellae
5. Facies articularis patellae

Fig. (3): A medio-lateral radiographic image of an adult dog knee joint:
1. Corpus ossis femoris, 2. Patella, 3. Trochlea ossis femoris (medial ridge), 4. Epicondylus medialis femoris, 5. Os sesamoideum m.gastrocnemii medialis, 6. Os sesamoideum m.gastrocnemii lateralis, 7. Condylus medialis femoris, 8. Tuberositas tibiae, 9. Crista tibiae, 10. Condylus medialis tibiae, 11. Os sesamoideum m. poplitei, 12. Caput fibulae , 13. Corpus fibulae, 14. Corpus tibiae

Fig. (4): A postero-anterior radiographic image of adult dog knee joint showing:
1. Corpus ossis femoris, 2. Condylus medialis femoris, 3. Condylus lateralis femoris, 4. Condylus medialis tibiae, 5. Condylus lateralis tibiae, 6. Incisura poplitea, * Black arrows indicate the ossasesamoidea m. gastrocnemii, 7. Fossa intercondylaris femoris, 8. Caput fibulae, 9. Corpus fibulae, 10. Corpus tibiae, 11. Eminentia intercondylaris tibiae, * Red arrow indicates the os sesamoideum m. poplitei.

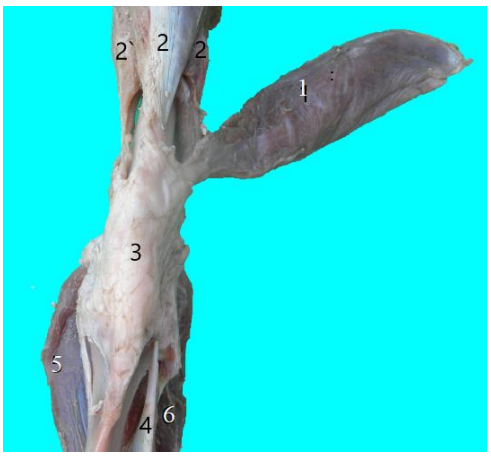

Fig. (5): A photograph of the intact knee joint (anterior aspect) of an adult dog showing:

1. M. biceps femoris, 2. M. rectus femoris, 2`. M. vastus medialis, 2``. M. vastus lateralis, 3. Capsula articularis (stratum fibrosum), 4. M. extensor digitorum longus, 5. M. gastrocnemius (caput mediale), 6. M. gastrocnemius (caput laterale)

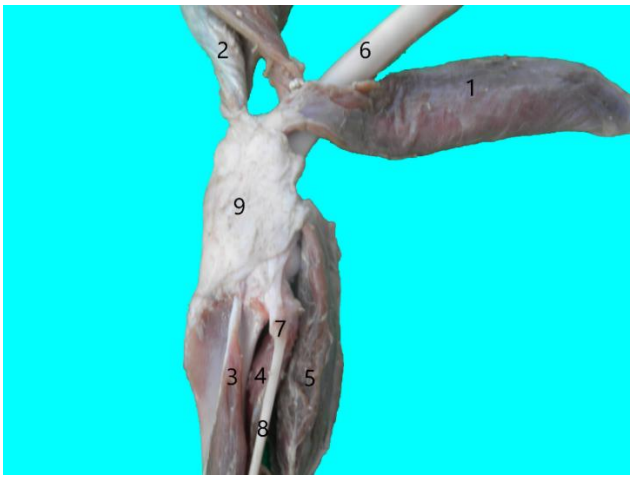

Fig. (6): A photograph of the intact dog knee joint (antero-lateral aspect) showing:
1. M. biceps femoris, 2. M. rectus femoris, 3. M. extensor digitorum longus, 4. M. gastrocnemius (caput mediale), 5. M. gastrocnemius (caput laterale), 6. Corpus ossis femoris, 7. Caput fibulae, 8. Corpus fibulae, 9. Capsula articularis (stratum fibrosum)

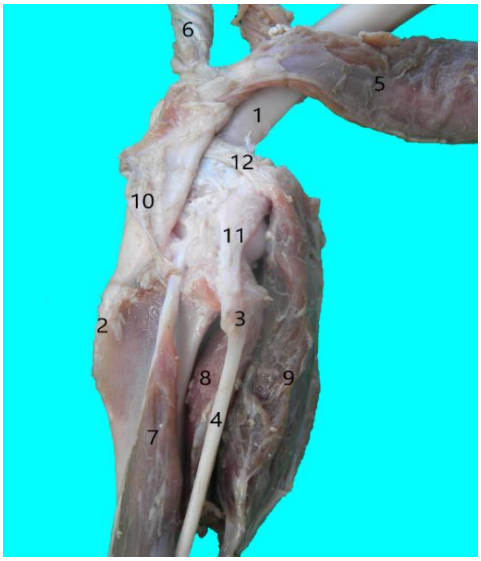

Fig. (7): A photograph of the dissected knee joint (lateral aspect) of an adult dog:

1. Corpus ossis femoris, 2. Tuberositas tibiae, 3. Caput fibulae, 4. Corpus fibulae, 5. M. biceps femoris, 6. M. rectus femoris, 7. M. extensor digitorum longus, 8. M. gastrocnemius (caput mediale), 9. M. gastrocnemius (caput laterale), 10. Capsula articularis (reflected), 11. Lig. collaterale laterale (fibulare), 12. Lig. fabellopatellare laterale

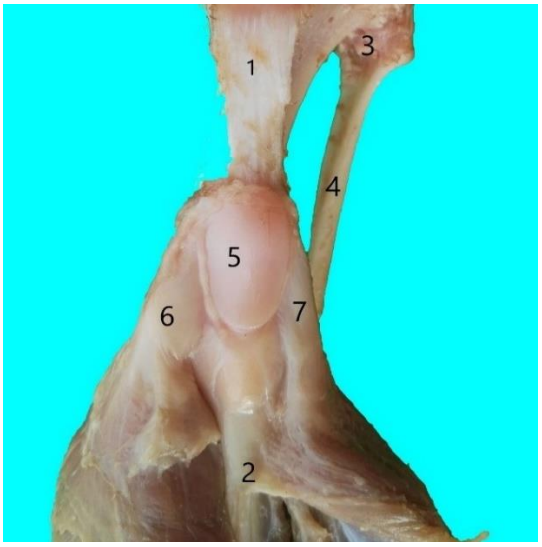

Fig. (8): A photograph of the anterior view of an adult dog knee joint showing:

1. Lig. Patellae
2. M. quadriceps femoris (reflected downwards)
3. Caput fibulae
4. Corpus fibulae
5. Facies articularis patellae
6. Fibrocartilagineus parapatellaris medialis
7. Fibrocartilagineus parapatellaris lateralis

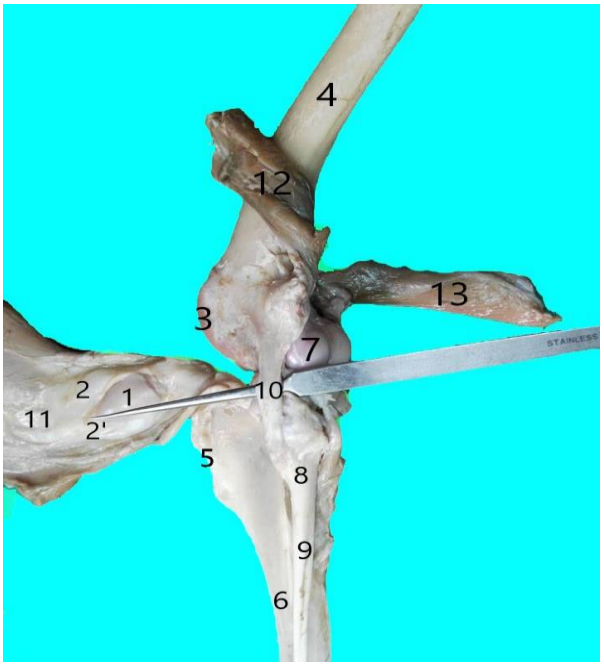

Fig. (9): A photograph of the knee joint (lateral aspect) of adult dog showing:

1- Facies articularis patellae
2- Fibrocartilaginous parapatellaris medilais
2`. Fibrocartilaginous parapatellaris lateralis
3- Trochlea ossis femoris (lateral ridge)
4- Corpus ossis femoris
5- Tuberositas tibiae
6- Corpus tibiae
7- Condylus lateralis femoris
8- Caput fibulae
9- Corpus fibulae
10- Lig. collaterale laterale (fibulare)
11. M. quadriceps femoris (tendinous insertion)
12- M. gastrocnemius (caput laterale)
13- M. gastrocnemius (caput mediale)

Fig. (10): A photograph of the anterior aspect of the proximal extremity of the dog tibia:

1. Lig.cruciatum anterius tibiae
2. Lig.meniscofemorale medialis (peripheral border)
3. Lig.transversum genus lateralis (peripheral border)
4. Lig . tibiale anterius ad meniscus medialis
5. Lig. patellae (reflected downwards)

6- Tuberositas
7- Meniscus
8- Meniscus
9- Corpus fibulae

Discussion

A) Gross anatomic characteristics:

Results of the current study regarding gross morphology of the femoropatellar articulation in healthy adult dogs revealed its general conformation and the specific morphologic organization, which were conditioned by the social environmental conditions of their habitat, biomechanical characteristics of their movement behavior and the character of the joint motion.

The construction of the femoropatellar articulation in dogs between the trochlea of the femur and the articular surface of the patella with its medial and lateral parapatellar fibrocartilages was in conformity with that stated in

canines by ***Nickel et al. (1986); Shievely (1987); Smith (1999) and Dyce et al. (2010)***.

This articulation protects the quadriceps femoris muscle by providing a wider bearing surface for its tendon, thus distributing pressure over a wider area and reducing wear ***(Smith, 1999)***.

Our study described the femoral trochlea as two sagittal and equal ridges, with a groove –like articular surface; measured about 5-6 mm wide, between the trochlear ridges and served for articulation with the posterior (articular) surface of the patella. The patella in the dog appeared elliptical in form, and was measured approximately 1.68 cm long and 0.96 cm wide and was incorporated in the insertion tendon of the quadriceps femoris muscle.

However, the patella was triangular in goat ***(Fathi et al., 2016)***, quadrangular in horse ***(Dyce et al., 2010)*** and oval in fox ***(El Mahdy, 1992 and El Bably and Noor, 2017)*** and its length reached up to one cm in the adult fox ***(EL Mahdy,1992)***. The medial and lateral borders of the patella in the dog were covered by the medial and lateral parapatellar fibrocartilages which met together proximal to the patella. These winged or alar cartilages of the patella helped to prevent luxation of the patella ***(Evans, 1993 and Carpenter and Cooper, 2000).***

The medial parapatellar fibrocartilage in the dog, as revealed in the present study was much broader and thicker than the lateral one confirming what stated by ***Dyce et al. (2010)*** who found that the medial parapatellar fibrocartilage is especially well developed in the large dogs.

Baum and Zietzschmann (1936) added a suprapatellar fibrocartilage being present in older dogs in the tendon of the rectus femoris muscle. Such cartilage was also present in the rabbit ***(El Nady, 2004)*** and fox ***(El Bably and Noor, 2017)***.

However, the site of union between the medial and lateral parapatellar fibrocartilages in the present study might represent the suprapatellar fibrocartilage discovered in rabbit and fox by the previous authors.

The single patellar ligament that extended between the patella and the tibial tuberosity in the dog confirmed the same result obtained by ***Evans (1993) and Carpenter and Cooper (2000)*** in the same animal. Such patellar ligament was also present in the fox ***(El Mahdy, 1992; El Bably and Noor, 2017);*** in the goat ***(Ibrahim et al.,1987 and Fathi et al., 2016);*** in the sheep ***(May, 1970);*** in the Bengal tiger ***(Arencibial et al., 2015);*** in the rabbit ***(El Nady, 2004);*** in the

cat ***(Policu, 1984)*** as well as in human ***(Williams and Warwick, 1980).***

The patellar ligament in adult dogs, as recorded in the present study was measured about 35 mm long and 7.90 mm wide, while these measurements in the adult foxes were 31.40 mm and 7.73 mm, respectively, as recorded by ***El Mahdy (1992).***

The current work declared the presence of a large quantity of infrapatellar fat between the patellar ligament and the articular capsule and this fat was also present in other domestic animals as mentioned by ***Sisson (1975); Nickel et al. (1986); Shievely (1987) and Dyce et al. (2010)***.

It was worthy to mention that the small medial and lateral gastrocnemius fabellae present in dogs were also clearly present in foxes ***(El Mahdy, 1992 and El Bably and Noor, 2017);*** in cats; and only in 7% of human had a single sesamoid bone in the tendon of the lateral head of the gastrocnemius muscle ***(policu,1984)***.

The fabellopatellar ligaments described in our study in dogs confirmed that stated by ***Smith (1999) and Dyce et al. (2010)*** in canines and ***El Mahdy (1992)*** in foxes and together with the patellar ligaments served to hold the patella in position against the ridges of the femoral trochlea. However, the medial fabellopatellar ligament in dogs was much weaker than the lateral one. This might be compensated by the broader and thicker medial parapatellar fibrocartilage described in our study in order to prevent dislocation of the patella.

The previous ligaments in other domestic animals connected the borders of the base of the patella with the femoral epicondyles due to the absence of the gastrocnemius fabellae, therefore, they were called femoropatellar ligaments ***(Nickel et al., 1986)***.

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الملخص العربى

يعتبر المفصل المفصل الفخذى الرضفى أحد المكونات الرئيسية للمفصل ا لركبى والذى يعد من أكثر مفاصل الجهاز الحركى عرضة للاصابات والالتهابات ولذلك أجريت هذه الدراسة لتوضيح التركيب التشريحى العام لهذا المفصل فى الكلاب والذى يشتمل على بعض التراكيب المعتادة فى الحيوانات الأخرى وكذا الصفات التشريحية المميزة للكلاب والتى تعتمد على الخصائص الأستاتيكية والديناميكية لهذا المفصل.

وتهدف الدراسة أيضا أن تكون مصدرا أساسيا للطلاب والأطباء والجراحين البيطريين المهتمين بتشريح الكلاب كأحد أعضاء العائلة النابية.

أجريت هذه الدراسة على أربعة وعشرون عينة من المفصل الركبى تم الحصول عليها من اثنى عشر من الكلاب البالغة السليمة من كلا الجنسين والتى تتراوح أوزانها من 10-15 كجم.

هذا وقد تم اجراء التشريح العيانى الدقيق والأشعة السينية للمفصل على عدد ثمانية عشر من المفصل الركبى وذلك لتوثيق التركيب التشريحى العام للأجزاء المختلفة للمفصل.

وقد أظهرت الدراسة أن المفصل الفخذى الرضفى يتوضع بين السطح الرضفى لعظم الفخذ الذى يشبه البكرة (الموجود بين الحيدين السهمين فى اتجاههما والمتماثلين) والسطح المفصلى الأملس لعظمة الرضفة, وقد وجد أن السطحين المتقابلين غير متطابقين مع بعضهما تماما كما أن القطر المستعرض للرضفة لا يتساوى مع قطر السطح الرضفى لعظم الفخذ ولذا وجد أن كلا من الحافة الأنسية والوحشية لعظمة الرضفة مغطاة بغضروف ليفى وهذان الغضروفان يسميان "الغضروفان الجنيبان لعظم الرضفة" وهما ينطبقان تماما على الحيدين الموجودين على السطح الرضفى لعظم الفخذ ويتقابلان أعلى عظمة الرضفة وهما مميزان للكلاب.

وقد وجد أن أربطة هذا المفصل تتكون من رباطا رضفيا واحدا يبلغ طوله فى الكلاب البالغة حوالى35 مم وعرضه حوالى7.9 مم وسمكه حوالى 1.4 مم وكذلك هناك زوج من الأربطة السمسمانية الرضفية (أنسى ووحشى) وكل هذه الأربطة بالاضافة لمحفظة المفصل تعطى قوة للمفصل.

وجدير بالذكر ان أربطة المفصل الفخذى الرضفى السابق ذكرها وكذا الغضروفين الجنيبيين لعظم الرضفة بالاضافة لمحفظة المفصل لهم دورا هاما فى تثبيت عظمة الرضفة فى مكانها.