UDC: 636.7 : 611.728.2
DOI: 10.31073/vet_biotech42-13

DUMITRIU A.*, e-mail: antonina.dumitriu@sasp.utm.md
Technical University of Moldova, Kishinev, Republic of Moldova

ASPECTS OF THE INNERVATION MODE OF THE ADJACENT ANATOMICAL FORMATIONS OF THE COXOFEMORAL JOINT IN DOGS

The canine coxofemoral joint is a remarkable structure, similar to that of humans. Anatomo-topographically, the canine hip region includes a bony base, articular surfaces with ligamentous structures and intra-articular as well as extra-articular joining means represented by a vast muscle mass. Orthopedic diseases, such as coxofemoral dysplasia in dogs, are common, and the relationship between body structure and joint load during locomotion, as well as topographic and morphometric research can facilitate the diagnosis of such diseases. The objective of this study was to specify the structure of the coxofemoral joint, the ligamentous and muscular component. Each muscle was dissected from the surrounding tissues and divided into groups based on their innervation. The hip joint and its components were visually examined for damage to the articular cartilage.

***Keywords**: dog, coxofemoral joint, ligaments, muscles.*

Introduction. The canine coxofemoral joint (*Articulatio coxae*) has major clinical importance, because hip dysplasia is an orthopedic disorder of complex development characterized by joint laxity and osteoarthritis, extremely common in dogs [1-3]. As a result, all the literature, conventional, anatomical sources consulted describe the anatomy of the hip joint.

Structurally, it is a typical enarthrosis, synovial, spheroidal joint [4-8]. The articular surfaces of the hip are formed by the head of the femur (*Caput ossis femoris*) which presents the acetabular fossa (*Fovea capitis*); acetabulum (*Acetabulum)* with the articular surface and acetabular fossa (*Fossa acetabuli*); the ridge of the acetabular cavity with an acetabular fibrocartilaginous spring (*Labrum acetabulare*), which jumps over the acetabular notch forming the transverse acetabular ligament (*Ligamentum transversum acetabuli*) [9].

As means of connecting the intra-articular structures are the pericapsular ligaments (described by very few authors): the iliofemoral ligament (*Lig. iliofemorale*) with fixation on the cranial side of the joint capsule; the iliofemoral ligament (*Lig. ischiofemorale*) with fixation on the caudal side of the joint capsule and the pubofemoral ligament (*Lig. pubofemorale*) with fixation on the ventral side of the joint capsule; which are some soft tissue structures, deriving from the joint

* PhD student

capsule in the form of bundles of fibers with a role in the connection between bone surfaces [9, 10].

The ligament of the femoral head, designated in the official nomenclature as *Ligamentum capitis ossis femoris* [9], is unambiguously described and reflects general knowledge. This ligament is located inside the articular capsule, which is very strong, represented by a conoid sleeve with the large insertion base on the coxal and the small base on the femur and connects the acetabular fossa (*Fossa acetabuli*) with the *Fovea capitis ossis femoris* [4, 11-14]. This ligament plays an important role, especially during the growth period, as a “bridge” for blood vessels, and later not only as a support but also as a brake in the movement process [15]. The ligament is quite elastic and can stretch with a potential for rupture [11, 14].

The hip also consists of a muscle mass, these structures are confirmed by a multitude of authors, crossing the coxo-femoral joint, represented by long, voluminous and strong muscle masses [16], adapted to squatting, propulsion and fast movement [17].

Authors such as Coțofan V., et al. (1999), describe 26 muscles acting on the coxo-femoral joint, and Shahar R., and Milgram J., (2001) demonstrate the insertions and action of 29 muscles on the movements of the pelvic limb, of which 26 muscles form directly the thigh with action on the coxo-femoral joint [6, 18].

The muscles of the coxo-femoral region are grouped in layers and systematized in the muscles of the pelvis and the thigh, which ensure both triplanar mobility and joint stability [6, 15].

Probably this relatively different systematization and grouping of the muscles of the coxo-femoral region, described by different authors, give different numerical results.

The geometry of the canine hip region is represented by three axes, offering the possibility of movement in all directions. The biodynamics of the musculature is strictly dependent on the axial orientation, which is very important in statics and locomotion [19, 20], having a greater influence on locomotor dynamics than the thoracic limbs [8, 21], and the balance is maintained by the antagonism between the abductor and adductor muscles.

The coxo-femoral joint produces movements of flexion - extension, abduction - adduction, circumduction and internal rotation - external rotation. The amplitude of movement of the joint in flexion is 100°-110°, and in extension 130°-135°, the abduction angle is approximately 50°-60° and the adduction angle is slightly smaller, the rotation around the diaphyseal axis of the femur, from the inside to the outside reaches 100° [22].

The goal of the work. Elucidation of the morphofunctional organization of the components of the coxo-femoral joint region in the dog, of the ligamentous, muscular structures and their fixed, mobile insertions.

Materials and methods. The scientific research was carried out in the specialized laboratory of the Faculty of Veterinary Medicine of the Technical University of Moldova. In order to specify the anatomical structure of the canine pelvic limb, especially of the coxofemoral joint, 5 half-breed dog cadavers, respectively ten coxo-femoral joints, were subjected to an anatomo-topographical study. The bodies of the dogs were taken from different veterinary clinics of Chisinau.

The hindquarters, pelvis, and hindlimbs were dissected using various morphological exploration techniques to highlight the regional topography. The anatomical components were previously fixed in 10% formalin solution for several days. In order to avoid inhalation of dangerous formalin vapors, a few days before preparation, the preservation solution was changed according to the method proposed by B. Berne. In the scientific examination process, the following were used: anatomical instruments (scalpel, dissecting needles, anatomical forceps, etc.), AFMA anatomical magnifier.

Anatomical-morphological methods have a significant value for assessing age changes, as well as structural components and dysfunctions.

Results of research and discussion. Upon receipt of the cadaver, the coxo-femoral joints were examined to determine joint laxity, crepitation and range of motion. The skin and subcutaneous tissues were meticulously removed. All the muscles surrounding the coxo-femoral joint were identified and the source of innervation determined. They were categorized into 5 groups, depending on the sources of innervation (Tab. 1), as follows: group no. 1 includes the muscles innervated by the cranial and caudal gluteal nerves, group no. 2 with innervation from the sciatic nerve, group no. 3 with innervation from the femoral nerve, group no. 4 with innervation from the obturator nerve and group no. 5 with innervation from the caudal femoral cutaneous nerve.

Thus, the component muscle masses of the pelvis and thigh are: superficial gluteal muscle (*M. glutaeus superficialis*), middle gluteal muscle (*M. glutaeus medius*), piriform muscle (*M. piriformis*), gluteal muscle deep (*M. glutaeus profundus*), tensor muscle of the fascia lata (*M. tensor fasciae latae*), m. sartorius (*M. sartorius*) with the two portions, vastus lateralis (*M. vastus lateralis*), vastus intermedius (*M. vastus intermedius*) and vast medial muscle (*M. vastus medialis*), straight femoral muscle (*M. rectus femoris*), femoral biceps muscle (*M. biceps femoris*), caudal abductor muscle of the calf (*M. abductor cruris caudalis*), semimembranosus muscle (*M. semimembranosus*), semitendinosus muscle (*M. semimembrano*), gracilis muscle (*M. gracilis*), long adductor muscle (*M. adductor longus*), large adductor muscle (*M. adductor magnus*) and adductor muscle short (*M. adductor brevis*), pectineus muscle (*M. pectineus*), internal obturator muscle (*M. obturatorius internus*), external obturator muscle (*M. obturatorius externus*), twin muscle (*Mm. gemelli*), m. femoral quadriceps (*M. quadratus femoris*), articular m. (*M. articularis coxae*), m. iliopsoas (*M. iliopsoas*) and the caudal crural abductor muscle (M. a*bductor cruris caudalis*) (fig. 1).

Table 1

Muscle groups of the pelvis and thigh and sources of innervation

No.	Muscle	Sources of innervation
1	Superficial gluteal	N. gluteus cranialis, N. gluteus caudalis
	Middle gluteal	
	Deep gluteal	
	Piriformis	
	Tensor fascia lata	
2	Biceps femoris	N. ischiaticus
	Semimembranosus	
	Semitendinosus	
	Internal obturator	
	Gemelli	
	Quadratus femoris	
3	Vastus lateralis and intermedius	N. femorales
	Vastus medius	
	Rectus femoris	
	Iliopsoas	
	Cranial sartorius	
	Caudal sartorius	
4	Gracillis	N. obturatorius
	Adductor longus	
	Pectineus	
	External obturator	
	Adductor magnus et brevis	
5	Abductor cruris caudalis	N. cutaneus femoris caudali

Researching the ligamentous structures of the coxofemoral joint, we would find that the femoral head ligament (*Ligamentum capitis ossis femoris*) is not the only structure that adheres to the acetabular fossa (*fossa acetabuli*), as is generally accepted, but also adheres to the transverse acetabular ligament (*ligamentum transversum acetabuli*) and is completed by a strong accessory ligament that runs in the caudal direction to attach to the acetabular ridge through the notch and that extends on the cranio-ventral surface of the body of the ischium (fig. 2).

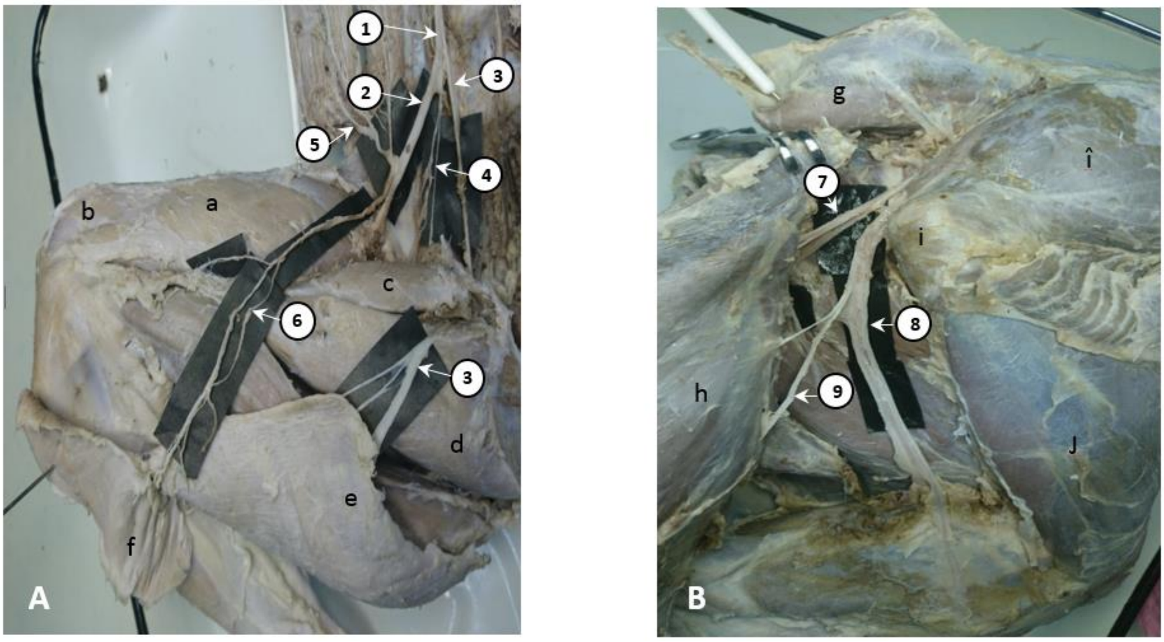

Fig. 1 (A, B): 1 – *Plexus lumbalis caudalis,* 2 – *N. femorales,* 3 – *N. obturatorius,* 4 – nerve branches in depth *mm. iliopsoas,* 5 – nerve branches for *m.sartorius,* 6 – branches of *n. femorales,* 7 – *N. gluteus cranialis,* 8 – *N. ischiaticus,* 9 – nerve branches for *m. tensor fasciae latae,* a – *m. rectus femoris,* b – articulatio genus, c – *m*. pectineus, d – m. adductor, e – m. gracilis, f – m. sartorius, g – m. gluteus superficialis, h – m. tensor fasciae latae, i – trochanter major, î – m. gluteus medius, j – m. vastus medialis.

Fig. 2. 1 – caput ossis femoris, 2 – Ligamentum capitis ossis femoris with extracapsular insertion, cranio-ventral on the body of the ischium.

Conclusions and prospects for further research. From a clinical point of view, the canine hip joint (*Articulatio coxae*) with all adjacent structures is of major importance, since coxo-femoral dysplasia is a common orthopedic disorder in dogs. The detailed knowledge of the anatomy of the ligaments associated with the joint is paramount in the study of the functionality of the joint, and the analysis of the anatomical structures needs to be done according to the spatial orientation in relation to the axes of rotation at the level of the canine articular hip and the fixed insertion sites and mobile of the muscles.

The results of the research confirm that the muscles of the coxo-femoral region are grouped in layers and systematized in the muscles of the pelvis and thigh, being 25 in number. The structures adjacent to the coxofemoral joint are innervated by the following nerves: femoral nerve, obturator nerve, cranial gluteal nerve, caudal gluteal nerve, caudal femoral cutaneous nerve and sciatic nerve.

Research of ligamentous structures indicates that the ligament of the femoral head is not the only structure that attaches only to the acetabular fossa, as is generally accepted, but also attaches to the transverse acetabular ligament and is supplemented by a strong accessory ligament that runs in the direction caudal to attach to the acetabular ridge, and extending on the cranio-ventral surface of the body of the ischium. Although the ligament of the femoral head is a well-known structure, its role in the etiopathogenesis of coxofemoral dysplasia in dogs remains unclear.

From this brief review of the literature we found many erroneous descriptions of ligamentous components, causing contradictions and ambiguity. Unclear data play a primary role that prevents the elucidation of the etiopathogenesis of coxo-femoral joint pathologies in dogs.

АСПЕКТИ РЕЖИМУ ІННЕРВАЦІЇ НАБЛИЖУЮЧИХ АНАТОМІЧНИХ УТВОРЕНЬ ТАЗОБЕДРЕНОГО СУСТАВА У СОБАК / Думитріу А.

Вступ. *Кульшовий суглоб собак має велике клінічне значення, оскільки дисплазія тазостегнового суглоба є складним ортопедичним порушенням розвитку, що характеризується слабкістю суглоба і остеоартритом, які надзвичайно часто зустрічається у собак. Структурно це типовий енартроз, синовіальний, кулястий суглоб.*

Мета роботи. *З'ясування морфофункціональної організації компонентів зони кульшового суглоба у собаки, зв'язкових, м'язових структур та їх нерухомих, рухомих прикріплень.*

Матеріали і методи досліджень. *Наукові дослідження проводилися на 5 трупах собак-напівкровок, відповідно, десяти кульшових суглобів. Тіла собак були взяті із різних ветеринарних клінік Кишинева.*

Результати досліджень та їх обговорення. *Після отримання трупа досліджували кульшові суглоби для визначення розбовтаності суглобів, крепітації та обсягу рухів. Шкіру та підшкірну клітковину ретельно видаляли. Були ідентифіковані всі м'язи навколо кульшового суглоба у кількості 25 та визначено джерело іннервації. Зв'язкові компоненти кульшового суглоба візуалізували і візуально досліджували щодо пошкодження суглобового хряща.*

Висновки та перспективи подальших досліджень. *Результати дослідження підтверджують, що м'язи кульшового відділу згруповані шарами та систематизовані у м'язи тазу та стегна, у кількості 25 штук. Структури, прилеглі до кульшового суглоба,*

іннервуються наступними нервами: стегновим нервом, замикаючим нервом, краніальним сідничним нервом, каудальним сідничним нервом, каудальним шкірним нервом стегна і сідничним нервом.

Дослідження зв'язкових структур показують, що зв'язування головки стегнової кістки є не єдиною структурою, яка прикріплюється тільки до вертлужної ямки, як це прийнято вважати, але також прикріплюється до поперечної зв'язки вертлужної западини і доповнюється міцною додатковою зв'язкою, що проходить каудально, щоб прикріпитися до гребеня вертлужної западини, і простягається на краніовентральній поверхні тіла сідничної кістки.

Ключові слова: *собака, тазостегновий суглоб, зв'язки, м'язи.*

REFERENCES

1. Ginja, M.M., et al. (2010). Diagnosis, genetic control and preventive management of canine hip dysplasia: a review. *Vet. J.,* 184, 269-276. doi: 10.1016/j.tvjl.2009.04.009.

2. Dumitriu, A., & Enciu V. (2021). Muscle groups that ensure the dynamics of the hip joint in dogs. Proceedings from The Biosafety, protection and welfare of animals: *Mizhnarodna naukovo-praktychna konferentsiia (27 travnia 2021 roku) – International Scientific and Practical Conference.* (pp. 80-82). Kyiv: Naukovo-metodychnyi tsentr VFPO. Retrieved from https://onedrive.live.com/?authkey=%21AC8xMoMSBHjGYvo&id=5E8999F54A87BB53%212136&cid=5E8999F54A87BB53&parId=root&parQt=sharedby&o=OneUp.

3. Dumitriu, A., & Enciu V. (2021). Screening methods of coxofemural dysplasia in dogs. Proceedings from The Rational utilization and protection of the animal world in the context of climate change: *Xth International Conference of Zoologists dedicated to the 75th anniversary of the creation of the first research subdivisions and the 60th anniversary of the founding of the Institute of Zoology*. (pp. 322-327). Chisinau. Retrieved from https://doi.org/10.53937/icz10.2021.53.

4. Sisson, S., J.D., & Rossman, G. (2002). *Anatomia de los animales domesticos*. 5 a. Edicion, Tomo II, Mason, Barcelona, Spania.

5. Barone, R. (1966). *Anatomie compare des Mamiferes domestiques*. Tome Premier Osteologie. Lyon: Ecole Nationale Veterinaire, p. 811.

6. Coţofan, V., Palicica, R., Hriţcu, V., Ganţă, C., & Enciu, V. (1999). *Anatomia animalelor domestice*, Vol. I, Ed. Timișoara: Orizonturi universitare.

7. Evans, H. E., and A. De Lahunta (2010). *Guide to the Dissection of the Dog*, 7th ed. Saunders Elsevier. p. 304.

8. Deban, S.M., Schilling, N., & Carrier, D.R. (2015). Activity of extrinsic limb muscles in dogs at walk, trot and gallop. *Journal of Experimental Biology*, 215, 287-300. Retrieved from https://doi.org/10.1242/jeb.063230.

9. Nomina Anatomica Veterinaria (6th ed.) (2017). Published by the Editorial Committee Hanover (Germany), Ghent (Belgium), Columbia, MO (U.S.A.), Rio de Janeiro (Brazil). Retrieved from https://www.wava-amav.org/wava-documents.html.

10. Schachner, E.R., & Mandi J. Lopez. (2015). Diagnosis, prevention, and management of canine hip dysplasia: a review. *Vet Med (Auckl)*, 6, 181-192. doi: 10.2147/VMRR.S53266.

11. Salomon, F.V., et al. (2008). *Anatomie fur die Tiermedizin*. Stuttgart: Enke Verlag.

12. Done, S.H., et al. (2009). *The pelvis. In: Color Atlas of Veterinary Anatomy.* (2nd ed.). (vol. 3). London: Mosby – Elsevier.

13. Liebich, H.G., et al. (2009). *Hinteroder Beckengliedmaßen (Membra pelvina).* In: Anatomie der Haussaugetiere – Lehrbuch und Farbatlas fur Studiumund Praxis. (Auflage 4). Stuttgart: Schattauer [in German].

14. Dyce, K.M., Sack, W.O. and Wensing, C.J.G. (2010). *The Hindlimb of the dog and cat*. In: Textbook of Veterinary Anatomy, (4th ed.). Saunders – Elsevier. pp. 490-500.

15. Slesarenko, N.A. (2003). *Anatomiia sobaki (Somaticheskie sistemy) – Dog Anatomy (Somatic Systems).* M.: Lan [in Russian].

16. Usherwood, J.R., & Wilson, A.M. (2005). Biomechanics: no force limit on greyhound sprint speed. *Natura,* 438, 753-754. DOI: 10.1038/438753a.

17. Williams, S.B., & Wilson, L. (2008). Functional anatomy and muscle moment arms of the pelvic limb of an elite sprinting athlete: the racing greyhound (Canis familiaris). *Journal of Anatomy*, Vol. 213, Issue 4, p. 361-372. Retrieved from https://onlinelibrary.wiley.com/doi/10.1111/j.1469-7580.2008.00961.x

18. Shahar, R., & Milgram, J. (2001). Morphometric and anatomic study of the hind limb of a dog. *AJVR,* 62, 6, 928-933. Retrieved from https://avmajournals.avma.org/view/journals/ajvr/62/6/ajvr.2001.62.928.xml?tab_body=pdf.

19. Biewener, Andrew A. (1990). Biomechanics of Mammalian Terrestrial Locomotion. *Sciense*, 250, Vol 250, No 4984, p. 1097-1103. Retrieved from https://www.researchgate.net/publication/20903571_Biomechanics_of_Mammalian_Terrestrial_Locomotion.

20. Dumitriu, A. (2021). Biodinamica musculaturii regiunii coxofemurale la câini. *Theses of the 74th student conference*, CE UASM, Chisinau, p. 55. Retrieved from https://www.uasm.md/images/stories/conf_stud/2021/Teze_conf_stud_74.pdf.

21. Martín-Serra, A., Figueirido, B., & Palmqvist, P. (2014). A three-dimensional analysis of the morphological evolution and locomotor behaviour of the carnivoran hind limb. *BMC Evolutionary Biology*, 14, 129. https://doi.org/10.1186/1471-2148-14-129.

22. Hamish, R. Denny, S.J., & Butterworth, A. (2008). The Hip. *Guide to Canine and Feline Orthopaedic Surgery.* Blackwell Science Ltd. DOI:10.1002/9780470699027.ch39.