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The Surgical Anatomy of Canine Coxofemoral Joint and Innovative Educational Models as El-Nady Technique and 3D Printing

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Abstract

THE current research intends to provide an appropriate surgical approach for the Canine hip joint. It will assist veterinary surgeons in treating specific disorders in the hip joint such as Canine hip dysplasia. As well as it provides alternative resources to display the normal anatomical structure of the Canine coxofemoral joint via dissected specimens preserved by the El-Nady technique, colored dried specimens, and 3D printing. This study was conducted on eight adult male mixed-breed dogs over one year, three dogs remained alive for the surgical approach. Five dogs were euthanized for reasons unrelated to the study, three dogs were used to dissect hip joint muscles and ligaments then were preserved by the El-Nady technique, and the other two dogs were used to prepare dried specimens. The results showed that the extensor muscles were gluteal, piriform, quadratus femoris, hamstring, gracilis, and adductor muscles. The flexor muscles were tensor fascia lata, sartorius, iliopsoas, and quadriceps femoris muscles. While gracilis, pectineus, and adductor muscles were the adductor muscles. The hip abductor muscles were tensor fascia lata, superficial and deep gluteal muscles. The Canine hip joint was fixed by two ligaments, the femoral head, and the transverse acetabular ligaments. The educational models as El Nady technique, dried specimens, and 3D-printed models were used to facilitate the anatomical learning process.

Keywords: Dog, 3D models, El-Nady technique, hip joint, surgical approach.

Introduction

The canine hip joint, also known as the coxofemoral joint consists of two bones: the os coxae and femur. This joint is classified as a simple, synovial, multiaxial joint, enabling a broad spectrum of movements that allows a wide range of motions this is due to the presence of a group of muscles that help in flexion, extension, adduction, abduction, lateral and medial rotation of hip joint [1-3].

Two ligaments aid in coxofemoral (hip) joint stabilization by preventing the separation of the bones (os coxae and femur), The ligament. capitis femoris, also known as the femoral head ligament or round ligament and the transverse acetabular ligament without these ligaments dislocation can occur at the coxofemoral (hip) joint. Furthermore, the coxofemoral joint capsule extends from the neck of the femur to the acetabulum's border [1-4].

Numerous instructional models facilitate the anatomy learning process for students [5]. These educational models include plastinated specimens, bony samples, radiographs, anatomical pictures, and 3D-printed models. These models serve as a framework for self-directed learning. [6]. Through self-directed learning, students become motivated to gain knowledge in a way that will help them retain it (deep learning) [7]. In addition, El- Nady Technique is considered an affordable and uncomplicated approach that produces photorealistic models with enhanced elasticity, cleanliness, and lack of odor. These specimens stay for a long period without seeing any major damage. This method is crucial for teaching veterinary anatomy and developing clinical and surgical skills. The specimens produced are flexible, making them easier to handle, and serve as substitutes for animals that are euthanized for educational purposes, assisting in overcoming

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several issues such as the growing number of students, and the possibility of formalin exposure for students. [8-10].

Material and Methods

Animals

This study was carried out on eight adult male mixed-breed dogs over one year, the weight of the dogs ranged from 20 to 25 kilograms. The dogs were collected from the Faculty of Veterinary Medicine shelter. Three dogs remained alive for the surgical approach. Five dogs were euthanized for reasons unrelated to the study, three dogs were used to dissect hip joint muscles and ligaments then were preserved by the El-Nady technique, and the other two dogs were used to prepare dried specimens. This study protocol was approved by the Veterinary Medicine Cairo University Institutional Animal Care and Use Committee (Vet-CU-25122023844).

Surgical approach

The dogs were pre-anesthetized with xylazine 1mg/kg body weight intramuscular (xylazine HCL 300 mg/ml, NexGen Pharmaceuticals, LLC. Weatherford) and anesthesia was induced by ketamine HCL 10 mg/kg body weight intravenous (Ketaset 100 mg/ml, Zoetis Manufacturing and Research Spain, S.L. Girona, Spain). Maintenance of anesthesia using 2% isoflurane (Isospire, Dechra Veterinary Products, LLC. USA).[11]

The dogs were placed on lateral recumbency, the hair in the surgical area was shaved and the site of the greater trochanter was determined by palpation, a curvilinear skin incision about 10 cm long in the dorsocranial area of the greater trochanter was performed (Fig. 1/ A). The skin edges were retracted to dissect the underlining muscles (Fig. 1/ B) such as the biceps femoris muscle caudally, superficial gluteal muscle dorsally, and vastus lateralis muscle laterally (Fig. 1/ C).

The gluteal fascia was opened, and then the middle gluteal muscle and the tensor fascia lata muscle were retracted dorsally and cranioventrally respectively. A blunt dissection and fingertip separation occurred to clarify and visualize the triangle (Fig. 1/ D &E) whose borders are laterally vastus lateralis muscle, medially rectus femoris muscle, and dorsally middle and deep gluteal muscles, The surgical approach is located at the center of this triangle then a craniolateral incision was performed to access the craniodorsal part of the hip (coxofemoral) joint.

The pelvic limb was held and moved outward, and then the joint capsule was cut to expose the femoral head (Fig. 1/ F) [12, 13] then the muscles, subcutaneous tissue, and skin were sutured routinely.

Post-operatively, the dogs were administrated with cefpodoxime proxetil tablets 10 mg/kg body weight (Simplicef, Sandoz, Kundl, Austria) orally for one week, analgesic (non-steroidal anti-inflammatory agent) administrated orally such as carprofen (vetprofen caplets, Belcher Pharmaceuticals, Inc. Florida) 4 mg/kg body weight and limit exercise.

Dissection of the muscles

After the euthanasia of dogs with Sodium Pentobarbitone solution intravenous (IV) 150:200 mg/kg in dogs (PENBITAL EUTHA 400 mg/ ml, joint-stock company Bioveta, Czech) [14, 15]. The common carotid artery was opened and washed with normal saline (0.9%) then injected with a 10 % formalin solution and left for three days [16]. The dogs were placed on their sides and the pelvis was separated from the rest of the body to dissect the hip (coxofemoral) joint muscles and ligaments. the skin was removed from all sides and subcutaneous tissues, then the muscles acting on the hip joint were dissected (flexors, extensors, adductors, abductors, and rotators) [17].

To clarify and expose the coxofemoral joint ligaments, the animal pelvis was positioned on its back and a ventromedial access was used then all muscles and hip joint capsule were dissected and the sample was soaked in a 10% hydrogen peroxide solution for 2 days for bleaching [2, 18].

El-Nady Technique

El-Nady Technique consisted of five steps. First, the fixation of the dog was applied by injection of the common carotid artery with 10% formalin via a hand–operated syringe according to the dog's size and left for three days until complete saturation with the formalin solution. After three days, some changes will appear on the dog's body, such as bloated tissues, erect ears, and stiff tongue.

Secondly, the dissection process of muscles acting on the Canine coxofemoral (hip) joint was performed, and they were separated from each other. This step assists the penetration of the acetone and glycerine into all the tissues.

In the third step, the specimen was washed with water and then placed in 100% acetone twice for two weeks.

In the fourth step, the specimen was removed from acetone and immersed completely for a week in glycerin.

In the fifth and final step, the specimen was wiped out from glycerin, and wrapped in a cloth and the ends were tied well then buried in a box filled with cornstarch for one week. During this step, massage occurred in the specimen and intermittently changed the cornstarch that absorb glycerin forming clusters which must be replaced with new cornstarch powder. After one week the specimen was taken from the box and the cloth containing the specimen was unwrapped. Finally, the specimen was placed in a hygienic area such as a museum (Figs.2 & 3) [8, 10].

Dried specimens

After the dog's euthanasia and fixation with formalin 10 % solution [16], the muscles acting on the hip joint were dissected and left in air to dry for 24 hours then painted with solvent-free transparent epoxy (kemopoxy 150, CMB, CHEMICALS FOR MODERN BUILDING INTERNATIONAL, Egypt) the harder solution (B) to the base solution (A) in a ratio of 1 to 2 respectively that mixed well for few minutes. After painting muscles with epoxy then kept in the correct position of muscle and left at room temperature for two days [19, 20]. The specimens were colored with acrylic and dried for two days. (Fig.4)

3D printing

We downloaded 3D models of inner pelvic muscles of canine hip joint free {Surface Tessellation Language (STL) file format} from Sketchfab online source (free 3d model website) then adjusted the parameters of our model and printing process by a software program called Prusa Slicer 2.5.2 (PRUSA RESEARCH by JOSEF PRUSA, Czech) which converted the STL into G code that understood by printer machine, parameters such as the material used for the 3D model production was polylactic acid (PLA), fifteen % infill [21-23]. Support everywhere, the printing nozzle size on the software was 0.15 mm to increase the precision of the model, the printer nozzle size was 0.4 mm, the printing temperature was 215 ^{0} C and the printing time for receiving a 3D model was 9 hours. The printing machine used was an Original Prusa i3 MK3S+3D printer (PRUSA RESEARCH by JOSEF PRUSA, Czech) after the printing of the 3d model the support was removed and the muscles were colored with acrylic colors (red and white) [24, 25].

Results

Muscles

There are several muscles support the wide movement of the Canine hip joint; the extensor muscles consist of three gluteal muscles {superficial, middle and deep}, piriform, quadratus femoris, hamstring muscles {biceps femoris m, adductor cruris caudalis m, semitendinosus m, and semimembranosus m}, gracilis m, and adductor m, and the flexor muscles, included tensor fascia lata muscle (two parts), sartorius muscle (two parts), iliopsoas m, and quadriceps femoris m {rectus femoris m, vastus lateralis m, vastus medialis m and vastus intermedius m}.

The hip adductor muscles consisted of gracilis, pectineus, and adductor muscles. while the hip abductor muscles consisted of tensor fascia lata m, superficial and deep gluteal muscles. The hip lateral rotators consisted of {quadratus femoris m, external obturator m, internal obturator m, and gemelli m (two parts)}, while the hip medial rotators consisted of middle and deep gluteal muscles.

The lateral pelvic muscles (the tensor fascia lata, three gluteal muscles, and the piriformis. (Rump muscles). The m. tensor fascia lata (Figs. 2, 4, 5/ 2 &2') was wedge-shaped and attached to the ilium proximally from the coxal tuberersity. It had two parts; cranial (superficial) part that was inserted on the lateral femoral fascia, and caudal (deeper) part which ended in layer of lateral femoral fascia. The m. gluteus superficialis (Figs. 2, 4, 5/ 6) was a quadrangular muscle that arose from the gluteal fascia, a deep fascia, and thus from the sacral tuber of the ilium and inserted on the small trochanter tertius.

The large m. gluteus medius (Fig. 2, 4, 5/ 7) located between superficial gluteal and tensor fascia lata arose from the iliac crest and most of the sacral tuber. Some fibers also arose from the sacroiliac ligament and the deep surface of the gluteal fascia. This muscle ended with a thick tendon on the greater trochanter. The m. piriformis (Fig. 2, 5/ 9) arose on the lateral surface of the third sacral and first caudal vertebrae. Its insertion linked that of the m. gluteus medius on the major trochanter. Muscle. gluteus profundus (Fig. 2, 4, 5/ 8) was fan-shaped, originating from the lateral surface of the body of the ilium. Its tendon ended on the trochanter major distal to the m.gluteus medius.

Inner pelvic muscles were (mm. obturator internus, the Gemelli, the obturator externus, and the quadratus femoris). The m. obturator internus (Fig. 2, 5/ 12) was fan-shaped and covered the obturator foramen internally originating from the pelvic symphysis and the dorsal part of the ischium and pubis. The mm. gemelli (Fig. 2, 5/ 11 &11') consisted of two parts originating from the lateral surface of the ischium, caudal to the acetabulum, and ventral to the lesser ischiatic notch. The m. obturator externus (Fig. 3, 5/ 22) was fan-shaped and covered the obturator foramen externally originating from the ventral surface of the pubis and ischium. Muscle. quadratus femoris (Fig. 3, 5/ 21) arose from ventrocaudal part of the ischium. All these muscles were inserted in the trochanteric fossa of the femur.

The hamstring muscles (caudal thigh muscles) including the m. biceps femoris, The m. semitendinosus, m. abductor cruris caudalis and the m. semimembranosus. The m. biceps femoris (Fig. 2, 3, 4, 5/ 3) was a long muscle made from two unequal heads, a cranial, superficial one, and a caudal, deep head. It was derived from the sacrotuberous ligament and the ischiatic tuberosity and inserted in the tibial crest, stifle fascia, and tuber calcanei. Muscle. abductor cruris caudalis (Fig. 2, 3, 4, 5/ 10) was a straplike muscle deep to the m. biceps femoris. Its origin was from the sacrotuberous ligament, its insertion into the crural fascia toward the caudal part of the biceps.

The m. semitendinosus (Fig. 2, 3, 4, 5/ 4) situated in the caudal part of the thigh, originated from the ischiatic tuberosity inserted in the proximal tibia and the tuber calcanei. The m. semimembranosus (Fig. 2, 3, 4, 5/ 5 & 5') was three-sided in cross-section ascended from the ischiatic tuberosity and consisted of two equally sized bellies, the cranial belly of the m. semimembranosus inserted on the medial condyle of the femur. The caudal one partially covers the cranial belly from the lateral aspect and terminates in the medial condyle of the tibia under the femorotibial joint.

The large m. quadriceps femoris (cranial thigh muscles) involved four heads the rectus femoris (cranial), vastus lateralis (lateral), vastus medialis (medial), and a fourth head the vastus intermedius. The m. rectus femoris (Fig. 3, 5/ 19) was circular in cross-section that arose from the ilium cranially to the acetabulum, located between the vastus lateralis and the vastus medialis. The m. vastus medialis (Fig. 3, 5/ 18) originated from the medial side of the proximal end of the femur, covered by the cranial part of the m.sartorius and m. tensor fascia lata. The larger m. vastus lateralis (Fig. 2, 4, 5/ 13) started from the caudal surface of the femur at the lateral lip in the proximal part. The m. vastus intermedius was the smallest part of the quadriceps and ascended from the proximal end of the femur, it lied on the femur. All quadriceps femoris muscle heads were inserted on the tibial tuberosity.

The iliopsoas (Figs. 3, 5/ 20) was one of the sublumbar muscles, it consisted of a union of the iliacus and psoas major muscles, originating from ventrocranial border of the ilium and lumbar vertebrae respectively, and inserted in the lesser trochanter of the femur.

The medial muscles of the thigh the m. sartorius (Figs. 2, 3, 4, 5/ 1& 1') were composed of two straplike parts; the cranial part that originated from thoracolumbar fascia and ended on the patella and the other caudal part originated from the iliac spine and ventral border of the ilium then inserted in the cranial border of the tibia. The m. gracilis (Fig. 3, 4, 5/16) was a sheet-like muscle that originated from the pelvic symphysis by the symphysial flat tendon and was inserted into the tuber calcanei and the cranial border of the tibia. The m. pectineus (Fig. 3, 4, 5/17) was a small, spindle muscle that extended from the iliopubic eminence and prepubic tendon and terminated on the caudomedial part of the femoral distal end. The mm. adductors (Fig. 3, 4, 5/14) was a large pyramidical muscle that originated from the ischium ventral surface and was inserted into the facies aspera of the femur.

The comparison between the soft plastination technique and the hard model is summarized in (Table 1).

Ligaments

The Canine coxofemoral joint was stabilized by two ligaments; the transverse acetabular ligament (Fig. 6/2) was a thin band that crossed the acetabular notch and closed the acetabulum's margin, located at the ventrocaudal zone of the acetabulum, and the other ligament was the (femoral head) round ligament (Fig. 6/1) a dense cord of collagenic material that extended from the fovea capitis in the femoral head to the acetabular fossa within the joint capsule.

3D printed model

The 3D printed acrylic colored model showed the dogs' inner pelvic muscular layer (caudal hip muscles) and articular coxae muscle of the hip joint (Fig. 7) composed of several muscles: the articular coxae muscle (Fig. 7/1), internal obturator m (Fig. 7/2), the first part of Gemellus m (Fig. 7/3), the second part of Gemellus m (Fig. 7/4), external obturator m (Fig. 7/5), and quadratus femoris m (Fig. 7/6).

Discussion

The performed studies on dogs revealed that during the hip (coxofemoral) joint dissection, the tensor fascia lata, semimembranosus, and sartorius muscles were divided into two parts; cranial and caudal parts these results were similar to those of [1, 26] this was in contrast to what some authors [27] mentioned, that there was a third part of the sartorius muscle in dogs named the accessory part which placed between the cranial and caudal parts of the sartorius muscle. While in feline, equine, and bovine [28-30] reported that the tensor fascia lata and sartorius muscles were not divided, unlike those in a dog.

The current study found that m. abductor cruris caudalis also known as m. tenuissimus in cats was present deep to the m. biceps femoris medially, the same results reported by many investigators [1, 28, 31]. Some researchers[29, 30] stated that the m. abductor cruris caudalis was absent in both equine and bovine.

Our study revealed that gluteofemoralis or caudofemoralis was absent in dogs, in agreement with [1], while [28, 31] reported that the gluteofemoralis or caudofemoralis muscle was present in felines and considered a part of the m. biceps femoris.

The present study revealed that the obturator foramen in dogs was covered internally by the m. obturator internus, the same results were mentioned by some researchers[1]. This muscle was found in felines [28, 31], while it was absent in ox [30].

During this study, we noticed that the adductor in dogs was composed of two muscles (adductor magnus et brevis and adductor longus) that were regularly not visibly divided the same was recorded by [1], while in felines the adductor magnus and adductor longus were more distinct [28, 31].

According to the present work, the approach to the craniodorsal aspect of the hip (coxofemoral) joint through a craniolateral incision in the dog was the best choice and preferable approach to the Canine coxofemoral (hip) joint since this method was less invasive to the muscles. These results were similar to the recent findings [12], while veterinary surgeons stated that there were four surgical approaches for the hip joint; the first approach was at the dorsal aspect of the joint through an intergluteal incision [32], the second approach was via the craniodorsal and caudodorsal aspects by osteotomy of the greater trochanter [33] or by tenotomy of the gluteal muscles [34], the third approach applied to the caudal aspect of the joint, and body of the ischium regarding a previous study [35], and the fourth approach was at the ventral aspect of the joint or the ramus of the pubis resembling revealant studies [33].

The present work revealed that the specimens of the El Nady technique (a modified form of plastination) were durable, nontoxic to the environment, flexible, and without offensive odor unlike the traditional anatomical specimens (formalin odor) to decrease health risks. These results were similar to previous studies [10, 36] in addition to other studies [5, 6] stated that numerous alternative educational models such as plastinated specimens, radiographs, and 3D printing models had replaced traditional anatomy learning, which involved complete body dissections and lectures on topographical structural anatomy.

The current study recorded that the accurate and practical use of three-dimensional printing models can help in anatomy learning as another alternative tool, particularly for bone, the printed specimen's precision was extremely near to that of the real specimen. Additionally, the ethical worries of cadaver specimens can be avoided by this technique as reported by recent literatures [37-40], while another literature [41] mentioned that understanding anatomical structures through dissection is deeper than any other learning tool.

Conclusion

The specimens preserved by the El-Nady technique were long-lasting, flexible, and resistant to major deterioration, these specimens can also serve as a substitute for animals subjected to death for academic purposes. Three-dimensional models, which closely mimic the real specimens, are considered an advanced teaching tool that will facilitate the comprehension of the specimen's anatomical structures, in addition to their features such as being light in weight and needing low cost and effort compared to real cadaveric specimens. The craniolateral surgical incision of the hip joint used in this study will assist veterinary surgeons in performing surgical operations such as femoral head osteotomy and open reduction of hip joint luxation.

Acknowledgments

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Funding statement

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Conflict of interest

There are no conflicts of interest to declare.

Ethical Approval

This study follows the ethics guidelines of the Faculty of Veterinary Medicine, Cairo University Institutional Animal Care and Use Committee (Vet-CU- IACUC) with an approval number 25122023844. The shelter of the faculty of veterinary medicine was informed about the study protocol and they approved to join the dogs in the study.

TABLE 1. The comparison between the soft plastination technique and the hard model.

Soft plastination technique	Hard model
Flexible sample production.	Non-flexible (solid) sample production.
Produce easily handled samples.	It is less easily handled compared to samples of the soft plastination technique.
The steps are more than those of the hard model.	The steps of this process are less.
It is expensive compared to the hard model due to the several chemicals used (acetone, glycerin, cornstarch).	It is less costly than the soft plastination technique (Epoxy only).
This process takes more time than the hard model (weeks and months).	This process takes less time (days).
Compared to the hard model, labeling is less easy.	The specimens can be easily labeled, and the labels remain in place when specimens are re-coated with epoxy.
(Fig. 2&3) [8, 10]	(Fig. 4) [18, 19, 42]

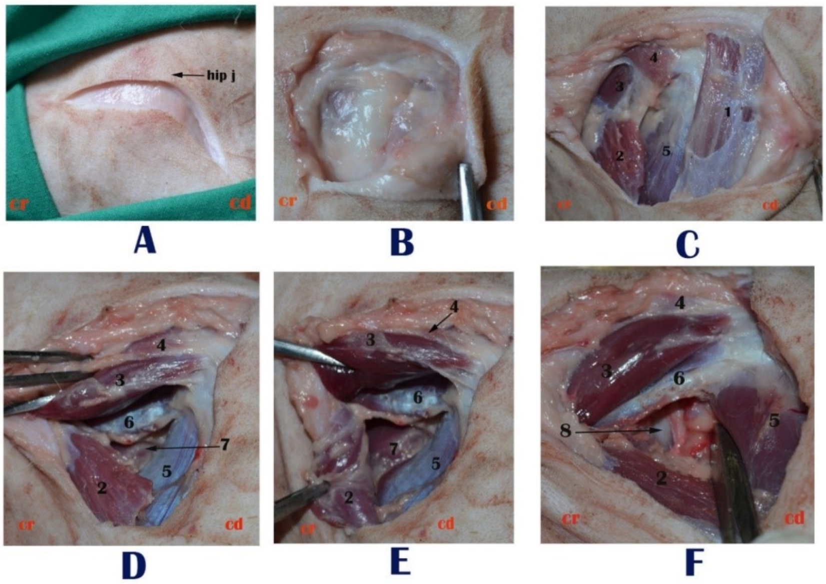

Fig. 1. shows the approach to the craniodorsal region of the hip (coxofemoral) joint through a craniolateral incision. A, the skin incision on the level of the greater trochanter; B, dissection of subcutaneous tissue; C, skin margins reflected, and the underlying muscle exposed; D &E, the boundary of the triangle, laterally: (5), medially: (7), dorsally: (3&6); F, the femoral head exposed.

1, biceps femoris muscle; 2, tensor fascia lata muscle; 3, middle gluteal muscle; 4, superficial gluteal muscle; 5, vastus lateralis muscle; 6, deep gluteal muscle; 7, rectus femoris muscle; 8, femoral head.

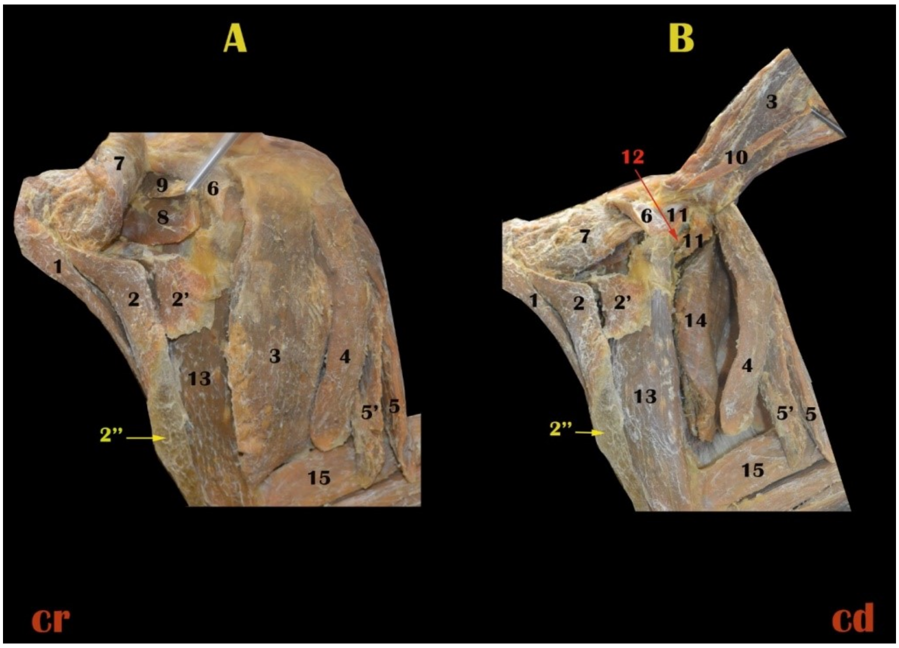

Fig. 2. shows the lateral aspect of the Canine hip (coxofemoral) joint muscles preserved by the El-Nady technique. A, superficial and middle gluteal muscles were reflected; B, the biceps femoris muscle was reflected.

1, sartorius muscle (first part); 2, tensor fascia lata muscle (first part); 2', tensor fascia lata muscle (second part); 2", fascia lata; 3, biceps femoris muscle; 4, semitendinosus muscle; 5, semimembranosus muscle (first part); 5', semimembranosus muscle (second part); 6, superficial gluteal muscle; 7, middle gluteal muscle; 8, deep gluteal muscle; 9, piriform muscle; 10, adductor cruris caudalis muscle; 11, gemellus II muscle; 11', gemellus I muscle; 12, internal obturator muscle; 13, vastus lateralis muscle; 14, adductor muscle; 15, lateral head of gastrocnemius muscle.

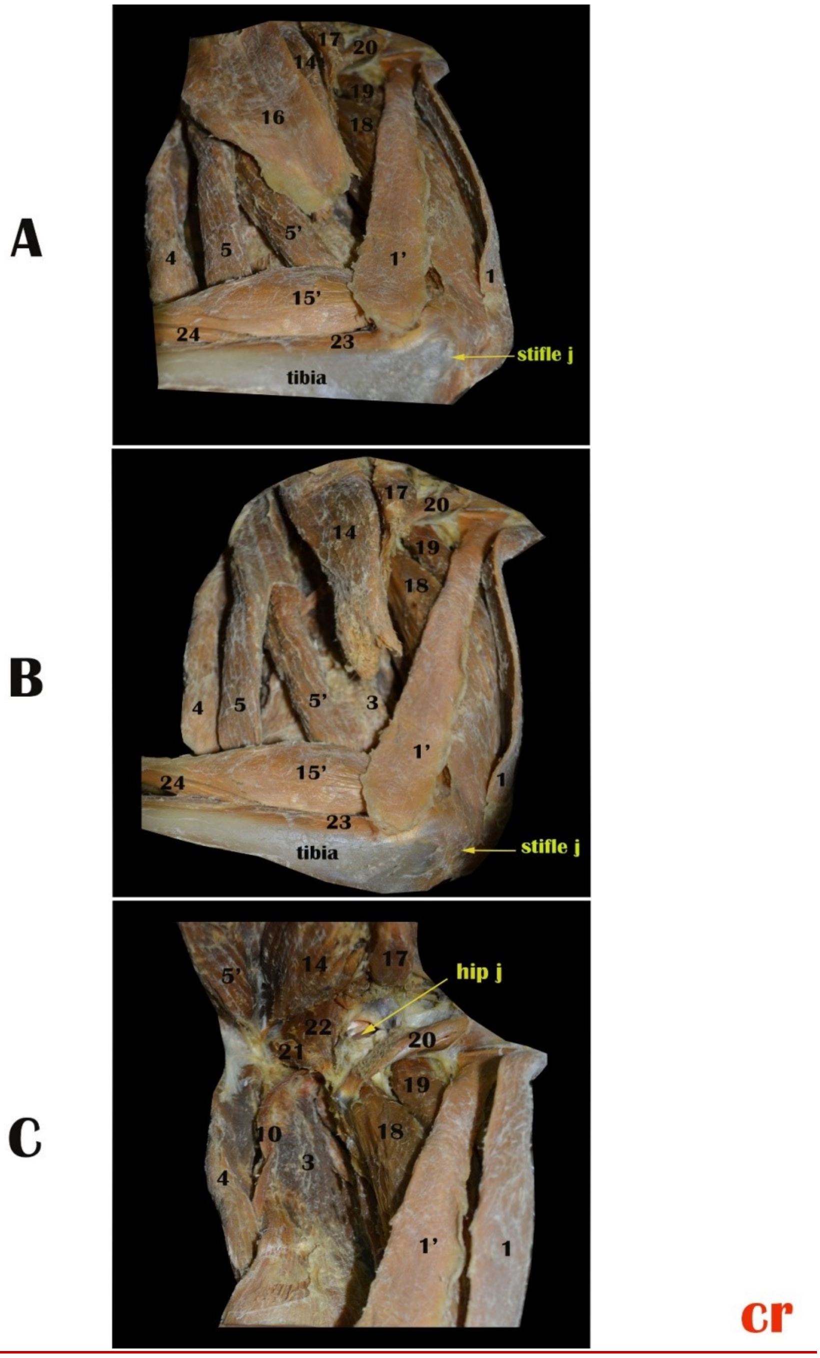

Fig. 3. shows the medial aspect of the Canine hip (coxofemoral) joint muscles preserved by the El-Nady technique. A, the 1st layer of muscles; B, the 2nd layer of muscles and the gracilis muscle is reflected; C, the third layer of muscles.

1, sartorius muscle (first part);1', sartorius muscle (second part); 3, biceps femoris muscle; 4, semitendinosus muscle; 5, semimembranosus muscle (first part); 5', semimembranosus muscle (second part); 10, adductor cruris caudalis muscle; 14, adductor muscle; 15', medial head of gastrocnemius muscle; 16, gracilis muscle;17, pectineus muscle; 18, vastus medialis muscle;19, rectus femoris muscle; 20, iliopsoas muscle; 21, quadratus femoris muscle; 22, external obturator muscle; 23, popliteus muscle; 24, superficial digital flexor muscle (plantaris).

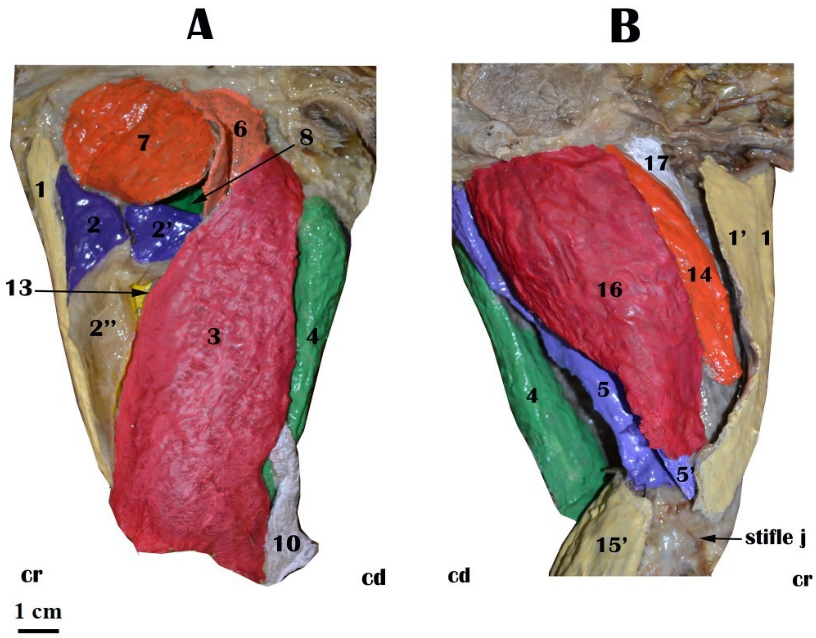

Fig. 4. shows some of the acrylic-colored dried Canine coxofemoral (hip) joint muscles. A: lateral aspect; B: medial aspect.

1, sartorius muscle (first part); 1', sartorius muscle (second part); 2 , tensor fascia lata muscle (first part); 2', tensor fascia lata muscle (second part); 2", fascia lata; 3, biceps femoris muscle; 4, semitendinosus muscle; 5, semimembranosus muscle (first part); 5', semimembranosus muscle (second part); 6, superficial gluteal muscle; 7, middle gluteal muscle; 8, deep gluteal muscle; 10, adductor cruris caudalis muscle; 13, vastus lateralis muscle; 14, adductor muscle; 15', medial head of gastrocnemius muscle; 16, gracilis muscle; 17, pectineus muscle.

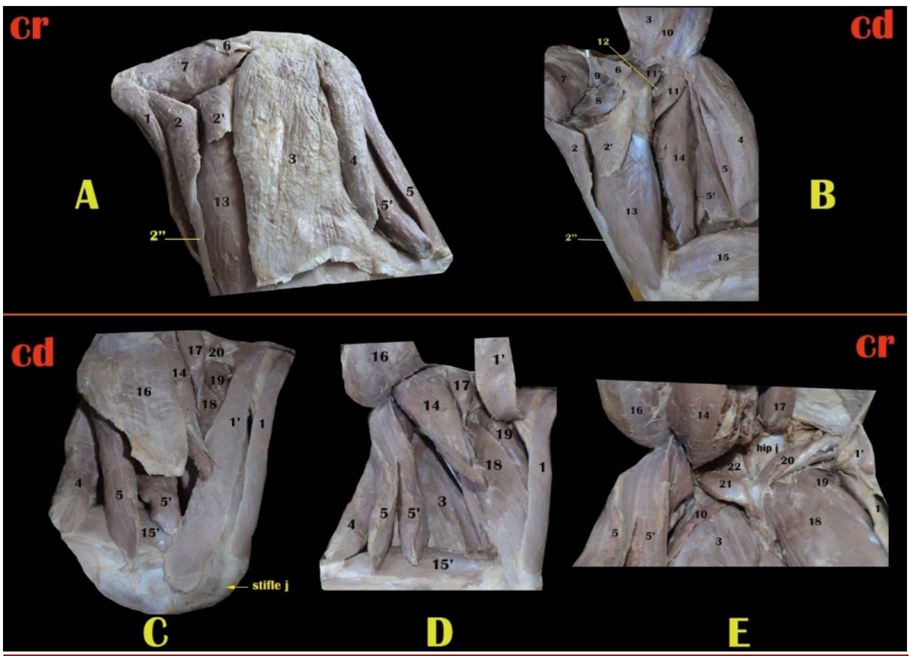

Fig. 5. shows the muscles acting on the Canine hip (coxofemoral) joint. A & B, lateral aspect; C, D & E, medial aspect.

1, sartorius muscle (first part); 1', sartorius muscle (second part); 2, tensor fascia lata muscle (first part); 2', tensor fascia lata muscle (second part); 2", fascia lata; 3, biceps femoris muscle; 4, semitendinosus muscle; 5, semimembranosus muscle (first part); 5', semimembranosus muscle (second part); 6, superficial gluteal muscle; 7, middle gluteal muscle; 8, deep gluteal muscle; 9, piriform muscle; 10, adductor cruris caudalis muscle; 11, gemellus II muscle; 11', gemellus I muscle; 12, internal obturator muscle; 13, vastus lateralis muscle; 14, adductor muscle; 15, lateral head of gastrocnemius muscle; 15', medial head of gastrocnemius muscle; 16, gracilis muscle; 17, pectineus muscle; 18, vastus medialis muscle; 19, rectus femoris muscle; 20, iliopsoas muscle; 21, quadratus femoris muscle; 22, external obturator muscle.

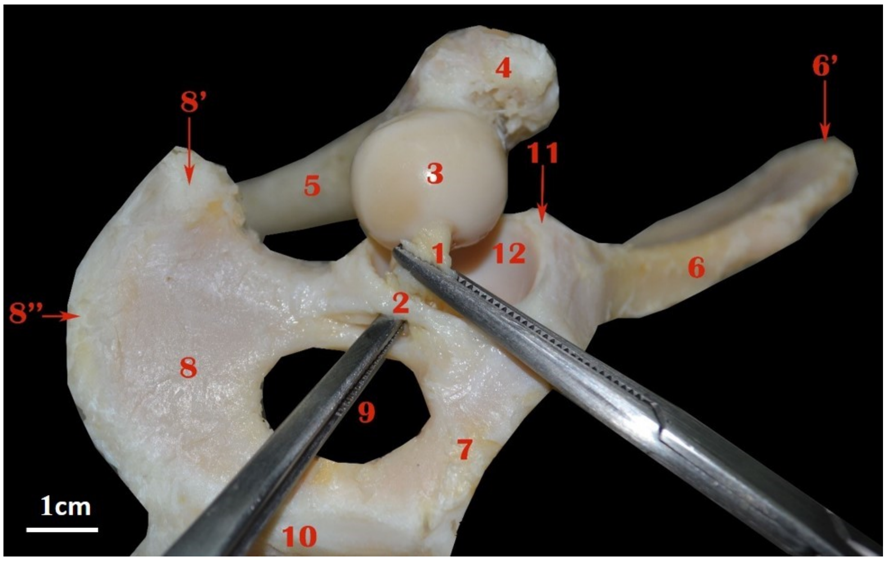

Fig. 6. shows ligaments that stabilize the Canine hip joint.
1, round (femoral head) ligament extending from the fovea capitis of the femoral head to the acetabular fossa; 2, transverse acetabular ligament closing the acetabular rim; 3, femoral head 4, greater trochanter; 5, shaft of the femur; 6, ilium; 6', iliac crest; 7, pubis; 8, ischium; 8', ischial tuberosity; 8'', ischial arch; 9, obturator foramen; 10, pelvic symphysis; 11, acetabular rim; 12, semilunar facet of the acetabulum.

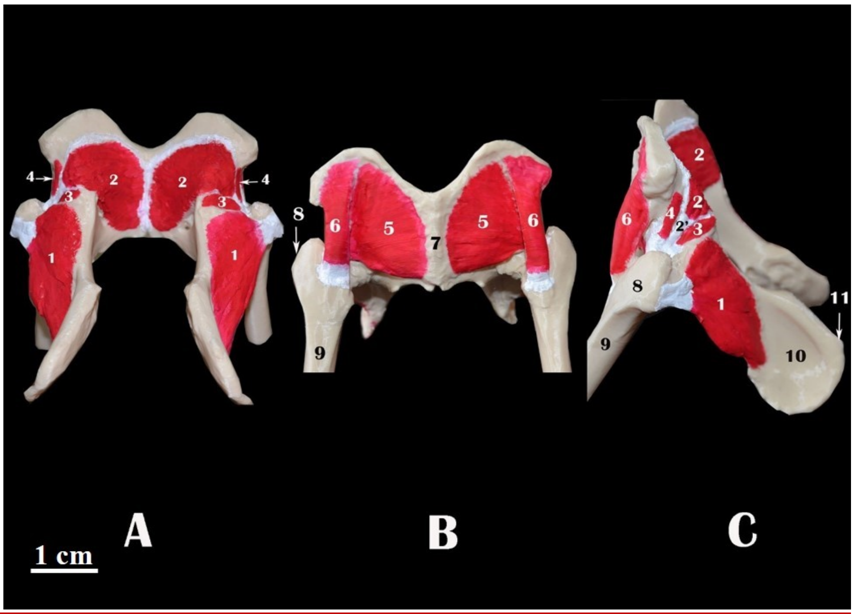

Fig. 7. shows the 3D printed acrylic colored model showing the inner pelvic muscles (caudal hip muscles) and articular coxae muscle acting on the Canine hip (coxofemoral) joint. A, caudal view; B, cranioventral view; C, lateral view.
1, Articular coxae muscle; 2, Internal obturator muscle; 2', Tendon of internal obturator muscle between two parts of Gemelli; 3, first part of Gemellus m; 4, second part of Gemellus m; 5, External obturator muscle; 6, Quadratus femoris muscle; 7, Pelvic symphysis; 8, Greater trochanter; 9, Femur (thigh bone); 10, Ilium bone; 11, Iliac crest.

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التشريح الجراحي لمفصل الفخذ عند الكلاب والنماذج التعليمية المبتكرة كتقنية النادي والطباعة ثلاثية الأبعاد

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الملخص

يهدف البحث الحالي إلى تقديم نهج جراحي مناسب لمفصل الفخذ الكلبي، والذي سيساعد الجراحين البيطريين في علاج اضطرابات معينة في مفصل الفخذ مثل خلل تنسج الفخذ الكلبي. وكذلك، لتوفير موارد بديلة لعرض البنية التشريحية الطبيعية لمفصل الفخذي الكلبي من خلال عينات مشرحة محفوظة بتقنية النادي، وعينات مجففة ملونة، وطباعة ثلاثية الأبعاد. أجريت هذه الدراسة على ثمانية كلاب ذكور بالغة من سلالات مختلطة على مدار عام واحد، بقي ثلاثة كلاب على قيد الحياة لإجراء العملية الجراحية، وتم إعدام خمسة كلاب لأسباب لا علاقة لها بالدراسة، وتم استخدام ثلاثة كلاب لتشريح عضلات وأربطة مفصل الورك ثم تم حفظها بتقنية النادي، وتم استخدام الكلبين الآخرين لإعداد العينات المجففة. أظهرت النتائج أن العضلات الباسطة هي الألوية، والكمثرية، والمربعة الفخذية، وعضلات أوتار الركبة، والعضلة النحيلة، والعضلة المقربة. كانت عضلات المثنية هي العضلة الموترة اللفافة العريضة، والعضلة الخياطية، والعضلة الحرقفية القطنية، والعضلة الرباعية الرؤوس الفخذية. بينما كانت العضلة النحيلة، والعضلة المشطية، والعضلة المقربة هي العضلات المقربة. وكانت عضلات مبعدة الورك هي العضلة الموترة اللفافة العريضة، والعضلات الألوية السطحية والعميقة. تم تثبيت مفصل الفخذ الكلبي بواسطة رباطين، رأس الفخذ، والأربطة الحُقيّة المستعرضة. تم استخدام النماذج التعليمية مثل تقنية النادي، والعينات المجففة، والنماذج المطبوعة ثلاثية الأبعاد لتسهيل عملية التعلم التشريحي.

الكلمات الدالة: كلب، نماذج ثلاثية الأبعاد، تقنية النادي، مفصل الفخذ، النهج الجراحي.