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SPECIES-SPECIFIC FEATURES OF INTRAORGANIC VASCULARIZATION OF THE TARSAL JOINT CAPSULE IN CATTLE AND CANINES

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ABSTRACT

The comparative studies of the tarsal joint capsule of cattle (*Bos taurus*) and canines (*Canis lupus*) have clarified general patterns of the structural organization of a joint capsule and the species-specific features of its angioarchitectonics. The differences in the formation of the fibroelastic layer and the location of vascular fields in the cases of animals with different stances were established. The zones of intensive intraorganic vascularization of the joint capsule were revealed; that being—the plantar and dorsal surface in the case of cattle, the lateral and medial surfaces—in case of the canine.

Key words: angioarchitectonics; hock joint; joint capsule; tarsal joint; vascular fields

INTRODUCTION

The tarsal joint is one of the important links in the musculoskeletal system which takes direct part in animal locomotion. At the same time, the tarsal joint capsule is one of the structures that ensures its proper functioning.

It is known that the tarsal joint is a complex joint that includes four simple ones. The differences in how the simple joints are connected and how they move show the differences in the functions they perform. Animals with different types of limb support have different patterns of motion, and consequently differences in the structure of various joint parts as well as in the nature of the joint capsule vascularization. The joint capsule, as its structural unit, participates in all the metabolic processes [20]. And such structural units of the capsule as the synovial membrane synoviocytes, vascular elements which nourish it, and the location in the joint capsule nerve endings—they all play an important role in the metabolic processes.

Synoviocytes of the joint capsule synovial membrane are responsible for the synthesis of synovial fluid structural components: glucopolysaccharides, mucopolysaccharides, hyaluronic acid, etc. [16]. The synovial fluid is the very component which ensures metabolism and catabolism of the joint cartilage, as well as performs the function of joint shock absorption.

The functioning of synoviocytes directly depends on the vascularization and innervation of the joint capsule [8]. It has been demonstrated [15, 19] that in the case of obstruction of the blood supply (natural or experimental) in the joint capsule there are degenerative changes in the nerve endings, changes in the structure of the synovial fluid, and as a result, disorders of the joint function in general [13].

Some animal species have a natural tendency to develop various pathological processes in the area of the tarsal joint. Thus, high-yield cattle [2, 18] often have arthrosis or arthritis of different aetiologies [21]; in the case of a canine [11], especially large breeds [6], mechanical joint injuries often occur, ankylosis or arthrosis develops [1, 7]. Such feline breed as Scottish fold have a genetic predisposition for the occurrence of osteochondrodisplasticity of the tarsus and metatarsus [3, 10]. In the case of treatment and in order to prevent the above-mentioned and other hock joint pathologies, it is important and necessary to know the topography of the vascular fields in the joint capsule area; as well as the intensity of vascularization of any surface of the capsule.

The purpose of our study was to determine the topography of the vascular fields in the tarsal joint capsule in cases of animals with different stances and different types of movement, per se cattle (*Bos taurus*), as an unguligrade animal, and a canine (*Canis lupus*) as a digitigrade animal. Another task was to establish common and distinctive features through analysis.

MATERIALS AND METHODS

Joint capsules were used for this study, they were separated from other anatomical structures of the joint according to the surfaces (dorsal, medial, plantar, lateral) and fixed in a 10 % aqueous solution of neutral formalin. The capsules were taken from the pelvic limbs of deceased or slaughtered animals. Namely, 4 bulls (*Bos taurus*) of the black-and-white breed, 2 to 3 years old, and from the pelvic limbs of 5 canines, 3 to 7 years old. Altogether 6 tarsal joint capsules of the cattle and 7 tarsal joint capsules of canines were used for the research. We compared the haemomicrocirculatory circulation in the tarsal joint capsule in cases of animals with different stances, for instance, of a bull and a canine. Within this work, the comparison of the structure and vascularization of the tarsal joint capsule of a left limb as opposed to a right limb was not carried out.

Upon fixing the joint capsules they were rinsed with running water during the day, and 10—15 μm thick sections were cut using a freezing microtome.

The staining of the sections was carried out using hematoxylin and eosin with differentiation by hydrochloric acid.

The analysis of the preparations was performed with microscopes JENAVAL and ZEISS with the zoom of 100, 125 and 200 times. The comparison of vascularization features of the tarsal joint capsule in the case of a *Bos taurus* and a canine were based on visual observation. The statistical analysis was not conducted due to insufficient number of anatomical samples. Since this work was a part of a research study, the respective statistical data will be processed and presented in the following papers.

All morphological studies were carried out keeping to bioethical norms strictly, according to the Ukrainian Law "On Protection of Animals from Cruel Treatment" of March 28, 2006.

RESULTS

As a result of the research, it was discovered that the capsule of the tarsal joint of a bull differs somewhat in histostructure, vascular topography, number of vessels, ratio of large vessels (arterioles and venules) to capillaries compared to those in the case of the canine.

The fibrous membrane of the joint capsule's dorsal surface both in the bull and the canine, was represented by disorderly connective tissue. It is customary that this connective tissue collagen fibres and their bundles were pointed in various directions; longitudinally, transversally and obliquely. Between the collagen bundles there was loose connective tissue. In the case of a canine, the layers of loose connective tissue between fibres were more significant than that of a bull.

The vascular elements laid in between layers of a loose connective tissue. Compared to a canine, a large number of haemomicrocirculatory bed structures were observed in case of a bull. They were represented by capillaries that formed anastomosis, arches, loops and gyrus, and sometimes glomeruli were formed. Along with the capillaries, a large number of arterioles and venules were observed which predominated over the heamomicrocirculatory bed structures (Fig. 1). At the same time, in the case of the canine, in loose connective tissue layers there was a small

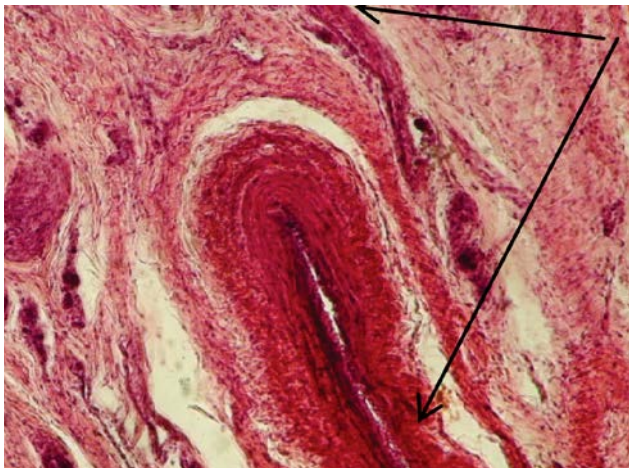

Fig. 1. Artery and vascular fields of the joint capsule of the cattle. Dorsal surface. Haematoxylin-eosin. Magn. ×125

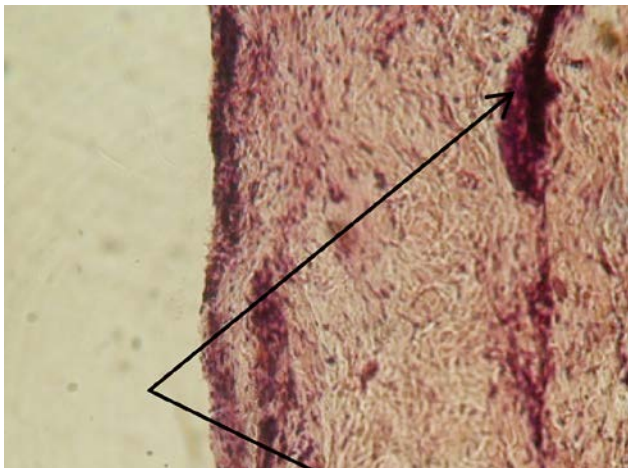

Fig. 2. Microvessels of the capsule subsynovial layer of the canine tarsal joint. Dorsal surface. Haematoxylin-eosin. Magn. ×250

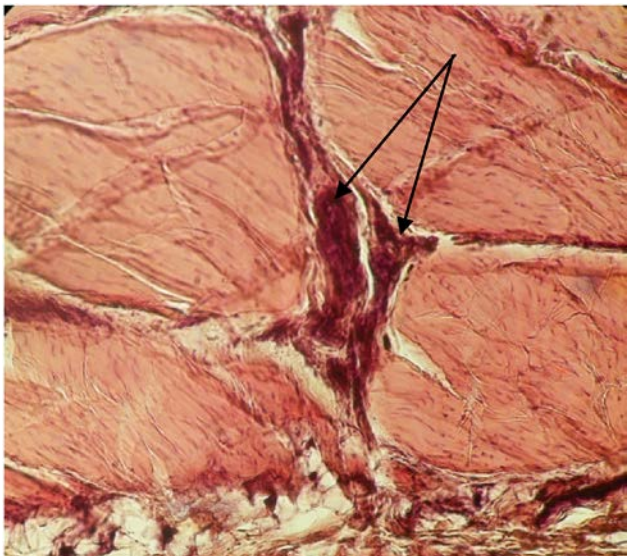

Fig. 3. Glomerulus and anastomoses of vessels in the joint capsule fibrous membrane of the canine. The plantar surface. Haematoxylin-eosin. Magn. 250

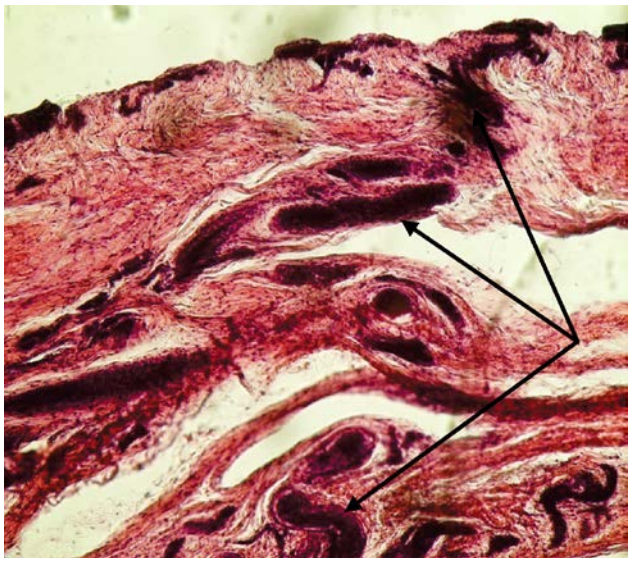

Fig. 4. Capillary network of joint capsule of the cattle. The plantar surface. Haematoxylin-eosin. Magn. ×125

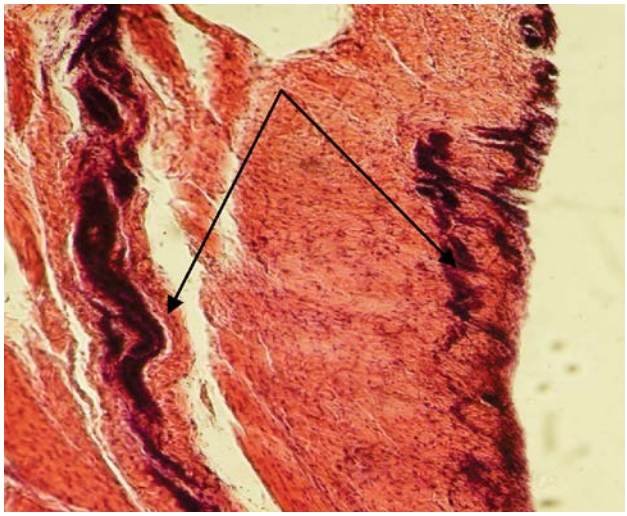

Fig. 5. Vascular network of subsynovial and synovial layers of the joint capsule in the cattle. Medial surface. Haematoxylin-eosin. Magn. ×125

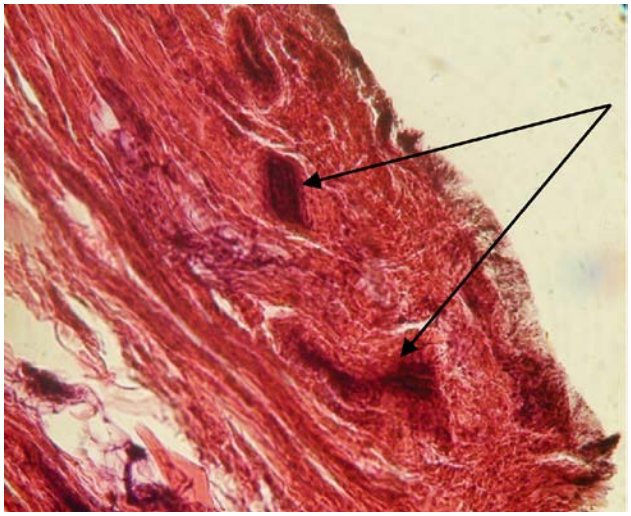

Fig. 6. Vascular network of subsynovial and synovial layers of the joint capsule in the canine. Medial surface. Haematoxylin-eosin. Magn. ×125

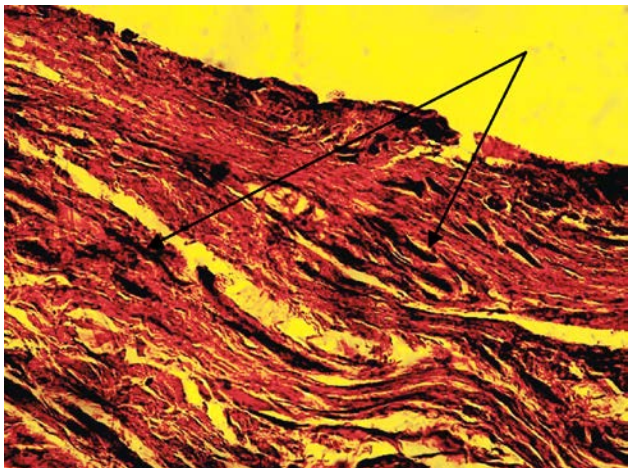

Fig. 7. Capsule vascular net of the tarsal joint of the canine. Lateral surface. Haematoxylin-eosin. Magn. ×125

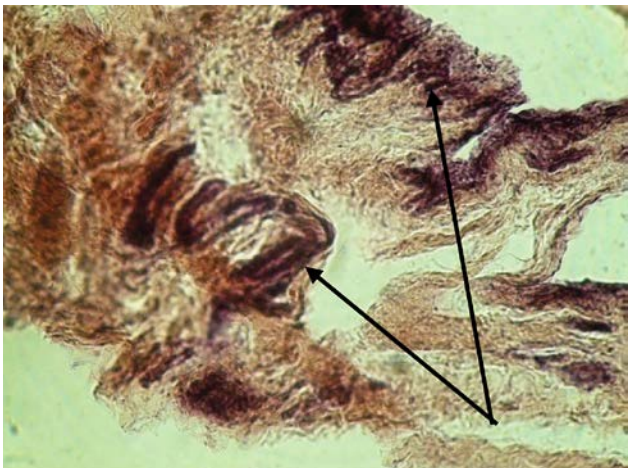

Fig. 8. Capsule synovial shell of the tarsal joint in cattle. Lateral surface. Haematoxylin-eosin. Magn. ×125

number of capillaries compared to cattle. They did not form anastomosis and in some places arches were formed. There was a small number of arterioles and venules near the capillaries.

The dorsal surface of the synovial membrane of both cattle and canines consisted of 3—5 rows of synovial cells. But in the case of cattle the synovial membrane had thin, filamentous, dense synovial villi. The canine's synovial membrane practically did not have any villi. The capsule of the subsynovial layer in the case of a canine was thin and had a small number of capillaries located in different directions regarding the synoviocytes (Fig. 2). The cattle capillaries formed a dense grid in the capsule subsynovial layer and they were located in different directions regarding the synoviocytes.

There was a large number of thick collagen fibres bundles with thin layers of loose connective tissue in between them on the plantar surface in the fibrous membrane structure of the tarsal joint capsule in the case of the canine. In the case of cattle, these bundles were somewhat thinner, and the layers of loose connective tissue were larger. Between collagen fibres in the canine case there were capillaries that formed glomeruli, as well as anastomoses with visible thickening at he site of the fusion (Fig. 3). Sometimes, small arterioles and venules were found in layers of loose connective tissue. In the case of the bull a significantly greater number of the haemomicrocirculatory bed structures were observed in the tarsal joint capsule's fibrous membrane when compared to those in the canine. The vascular architectonics is as well more diverse. Thus, there are capillaries, which form loops, gyrus and arches, and in places—anastomoses in the layers of loose connective tissue in a capsule of the bull. Along with the small capillaries, a significant number of larger vessels were found; arterioles and venules, but they did not predominate over the haemomicrocirculatory bed structures (Fig. 4).

In the case of the bull, the joint capsule's synovial membrane had 4 to 6 rows of synoviocytes on the plantar surface and the subsynovial layer had a well-developed capillary network. Capillaries from the subsynovial layer penetrated the synovial membrane and created tight vascular-cellular contacts. At the same time, in the canine, the tarsal joint's capsule synovial membrane had only 3 rows of synovial cells on this surface and the subsynovial layer contained a small number of haemomicrocirculatory bed structures.

In the bull, it is typical for the fibrous membrane of the joint capsule's medial surface to have a large number of unidirectional collagen fibre bundles with a small amount of loose connective tissue between them. Small arterioles and venules (with capillaries branching out from the latter) passed in layers of loose connective tissue. The capillaries form anastomosis, as well as gyrus and arches in places. In he canine, the capsule fibrous membrane from this surface was very similar to the capsule fibrous membrane of the bull. The layers of the loose connective tissue between the collagen bundles were slightly larger, and there was a greater number of small arterioles and venules.

The synovial membrane of the joint capsule's medial surface in the bull and had 5 to 6 rows of synoviocytes (synovial villi were not present). There were many capillaries

in the subsinovial layer where they came close to the synoviocytes forming loops and arches. In the canine the synovial membrane of this surface had villi resembling a fringe. There were 4 to 5 rows of synoviotic cells as part of the synovial membrane.

The lateral surface of the tarsal joint capsule in the cattle had the smallest amount of haemomicrocirculatory bed structures compared with other surfaces. The fibrous membrane was represented by disorderly connective tissue with single collagen bundles. In the canine, the same fibrous membrane had a significant amount of vascular structures and also a small number of multi-directional collagen fibre bundles.

In the cattle, the synovial membrane of the joint capsule's lateral surface had from 3 to 6 rows of synoviotic cells. In the subsynovial layer the capillaries shaped arches and loops. In the canine, the subsynovial layer had a large number of capillaries forming arches, loops and gyrus; they were located close to the synovial membrane's synoviocytes. Synovial membrane had 3—4 rows of synoviotic cells.

DISCUSSION

Summing up, it can be said that the lateral surface of the joint capsule in the canine is the most vascularized. It has the most extensive vascular network, shaped by capillaries of different architectonics. The medial surface of the capsule was slightly less vascularized, but it had many capillaries in the synovial and subsynovial layers, similar to the medial surface of the joint capsule of the cattle. Unlike the canine, the most vascularized surface of the joint capsule of the cattle was its plantar and dorsal surfaces. The joint capsule's dorsal surface in cattle had in its composition more large vessels which prevailed over the haemomicrocirculatory bed structures, but the capillary network in this part of the capsule was also quite powerful. In the canine, the plantar part of the tarsal joint capsule had a small number of microvessels in the subsynovial layer compared with other surfaces and with a similar surface to such in the case of cattle. Nevertheless, there were capillaries observed in the fibrous membrane of the plantar surface; these capillaries formed large anastomosis with a visible ampoule-like expansion, in which some part of the blood may be deposited. In some places capillaries formed glomeruli. In the dorsal part of the tarsal joint capsule in the canine there were a small number of blood vessels in the haemomicrocirculatory bed, as well as small arterioles and venules in some other places. A similar structure was observed on the lateral surfaces of the joint capsule in the cattle, the least vascularized area in this animal's body.

While comparing the intra- and extraorganic vascularization of the tarsal joint capsule it is possible to follow the correspondence between the intensity of intraorganic vascularization and the presence of major vessels that give branches from the corresponding surface of the joint capsule. Hence, the capsule of the tarsal joint of cattle is vascularized by the branches of the saphenous artery (*a. saphena*), lateral and medial plantar arteries (*a. lateralis plantaris* et *a. medialis plantaris*), the branches of the cranial tibial artery (*a. tibialis cranialis*), as well as a perforating artery (*a. perforans*). The canine's tarsal joint capsule was vascularized by the caudal tibial artery (*a. tibialis caudalis*), the superficial branch of the cranial tibial artery (*a. cranialis tibialis*), the branches of the cranial saphenous artery and the lateral and medial tarsal arteries (*a. lateralis* et *medialis carpi*) [17]. The microscopic examination indicated that the capsule surfaces which included the branches of the major vessels had larger vascular fields.

Various intraarticular techniques are used to treat and prevent osteoarthritis of the canine joints [14]. The drugs used in this treatment have some effect on all structures of the joint including the capsule. It is logical to assume that the most vascularized areas of the joint capsule will respond more actively to the drugs. It has also been proven that lameness and other functional disorders of the pelvic limb's distal parts in cattle are often accompanied by vascularization disorders [4, 13].

With age, the structural components of the joints wear out and the nature of the limbs' movement changes [11]. The studying of the joints parts helps to understand the causes and nature of age-related changes. The joint capsule surfaces, which have various vascular elements, are more metabolically active. With age when metabolism decreases, structures that are less saturated with capillaries can undergo more destructive changes. And changes in the limbs' movements can begin from these very areas.

The movement in the tarsal joint occurs mainly in one area: flexion—extension. Nevertheless, our studies have shown that there are other types of motion in the joint as well. [5, 9]. The load in this case is divided into different surfaces of the joint cartilage and joint capsule uneavenly

[12]. The most loaded areas of the joint capsule will obviously have more haemomicrocirculatory bed structures, which will provide a higher level of metabolic activity in this area.

The problem of histostructure and intraorganic vascularization of the tarsal joint capsule in cases of animals with different stance and movement are still poorly researched. In the available bibliography, we did not find any information to compare with the results of our research.

CONCLUSIONS

Significant differences in the structure of the tarsal joint capsule have been observed in the case of a canine, as a representative of digitigrade animals, and cattle, as a representative of unguligrade animals. The difference in the structure of the fibro-elastic layer and in the localization of the vascular fields, apparently, has to do with the nature of a stance, a movement speed and the weight of an animal.

When using medical treatment for various pathologies in the area of the tarsal joint in a canine, it is better to carry it out in the area of the lateral or medial surface of the limb as it is more saturated with vascular elements. In a case of cattle, such procedures should rather be executed in the area of planter or dorsal surfaces.

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