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# Species-specific features of intraorganic vascularization of the tarsal joint capsule in cases of cattle and canine

**Abstract.**

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

**Keywords:** joint capsule, tarsal joint, hock joint, angioarchitectonics, vascular fields.

**Introduction.**

Tarsal joint is one of 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 tarsal joint is a complex joint that includes four simple ones. Differences in how simple joints are connected and how they move show the differences in 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 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 synovial membrane synoviocytes, vascular elements which nourish it, and located 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 joint shock absorption.

Functioning of synoviocytes directly depends on vascularization and innervation of a joint capsule[8]. It is proved [15,19] that in case of obstruction of 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 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 to the occurrence of osteochondrodisplastic of the tarsus and metatarsus [3, 10]. In 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 stance and different type of movement nature, 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.**

A joint capsule was used for the study, it was 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 capsule was taken from the pelvic limbs of deceased or slaughtered animals. Namely, 4  bulls (Bos taurus) of black-and-white breed, 2 to 3 years old, and from pelvic limbs of 5 canines, 3 to 7 years old. Respectively, 6 tarsal joint capsules of the cattle and 7 tassal joint capsules of the canine were used for the research. We compared the hemomycrocirculatory circulation in the tarsal joint capsule in cases of animals with different stance, 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 capsule was being rinsed with running water during the day, and sections 10-15 microns thick were made using a freezing microtome.

The stainting of the produced 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 case of a bos taurus and a canine is based on visual observation, statistical analysis was not conducted due to insufficient number of anatomical samples. Since this work is 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 the Ukrainian Law “On Protection of Animals from Cruel Treatment” of 28/03/2006.

**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 vessles, ratio of large vessels (arterioles and venules) to capillaries compared to those in the case of canine.

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

Vascular elements lay in between layers of a loose connective tissue. Compared to a canine, a large number of hemomycrocirculatory bed structures are observed in case of a bull. They are represented by capillaries that form anastomosis, arches, loops and gyrus, and sometimes globs are formed. Along with the capillaries, a large number of arterioles and venules were observed, they predominate over the hemomycrocirculatory bed structures(Fig. 1). At the same time, in case of canine in loose connective tissue layers there is a small number of capillaries compared to cattle. They do not form anastomosis, some places arches are formed. There is a small number of arterioles and venules near the capillaries.

The dorsal surface synovial membrane of both cattle and canine consists of 3-5 rows of synovial cells. But in case of cattle synovial membrane has thin, filamentous, dense synovial villi. The canine's synovial membrane practically does not have any villi. The capsule subsinovial layer in case of a canine is thin and has a small number of capillaries located in different directions regarding the synoviocytes (Fig. 2). In case of cattle capillaries form a dense grid in the capsule subsinovial layer, they are located in different directions regarding synoviocytes.

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

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

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

The synovial membrane of the joint capsule's medial surface in the bull case has 5 to 6 rows of synoviocytes, synovial villi are not present. There are many capillaries in the subsinovial layer, they come close to the synoviocytes forming loops and arches. In the canine case the synovial membrane of this surface has villi resembling a fringe. There are 4 to 5 rows of synoviotic cells as part of the synovial membrane.

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

In the cattle case the synovial membrane of the joint capsule's lateral surface has from 3 to 6 rows of synoviotic cells. In the subsinovial layer capillaries shape arches and loops. In the canine case the subsinovial layer has a large number of capillaries forming arches, loops and gyrus, they are located close to the synovial membrane's synoviocytes . Synovial membrane has 3 - 4 rows of synoviotic cells.

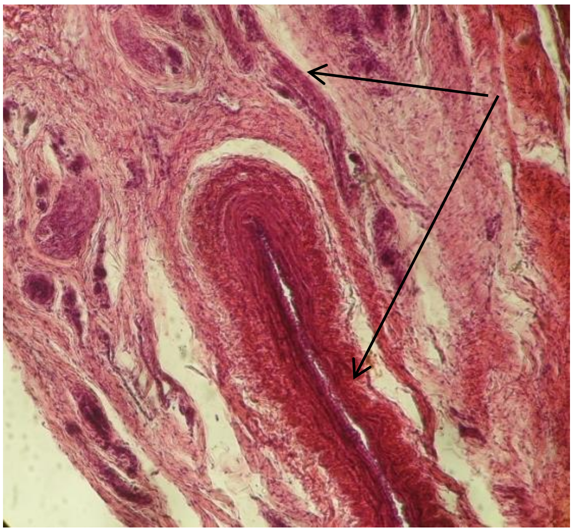

Fig. 1. Artery and vascular fields of the joint capsule of the cattle. Dorsal surface. Hematoxylin-Eosin. In. x 125

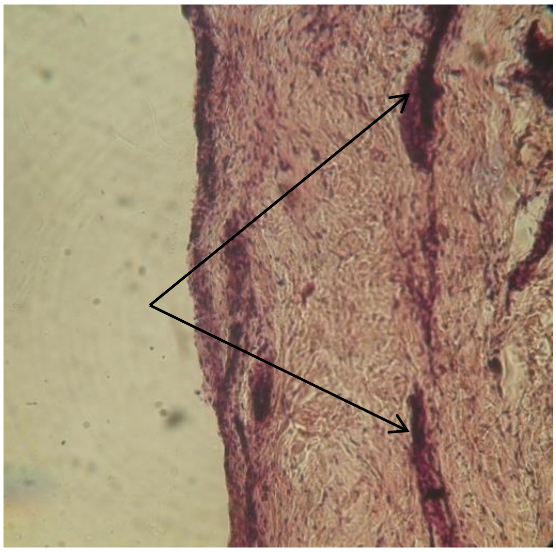

Fig. 2. Microvessels of the capsule subsinovial layer of the canines tarsal joint. Dorsal surface. Hematoxylin-Eosin. In. x 250

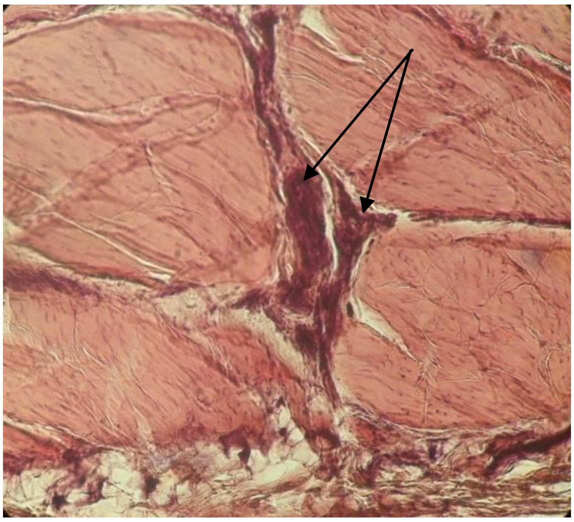

Fig. 3 Globs and anastomoses of vessels in the joint capsule fibrous membrane of canine. The plantar surface. Hematoxylin - Eosin. In x 250

Fig. 4. Capillary network of joint capsule of the cattle. The plantar surface. Hematoxylin-Eosin. In. x 125

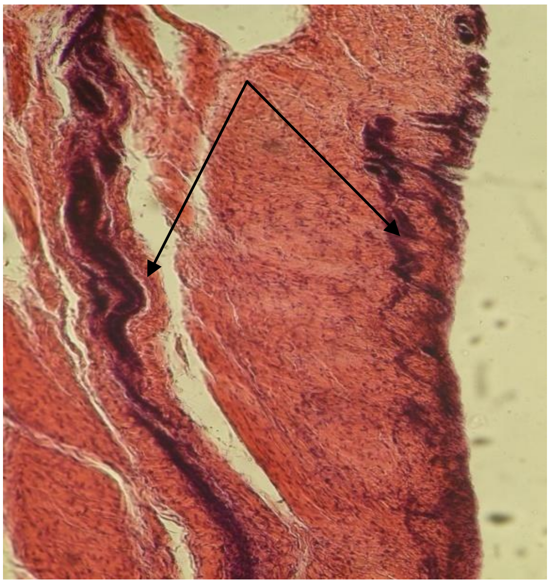

Fig. 5. Vascular network of subsinovial and synovial layers of the joint capsule, the cattle case. Medial surface. Hematoxylin-Eosin. In. x 125

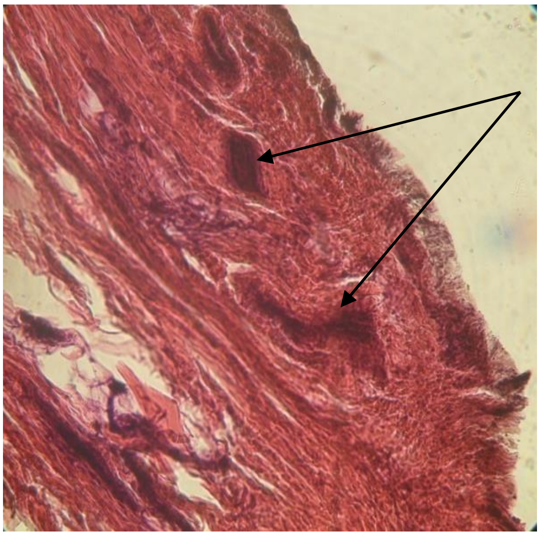

Fig. 6. Vascular network of subsinovial and synovial layers of the joint capsule, the canine. Medial surface. Hematoxylin-Eosin. In. x 125

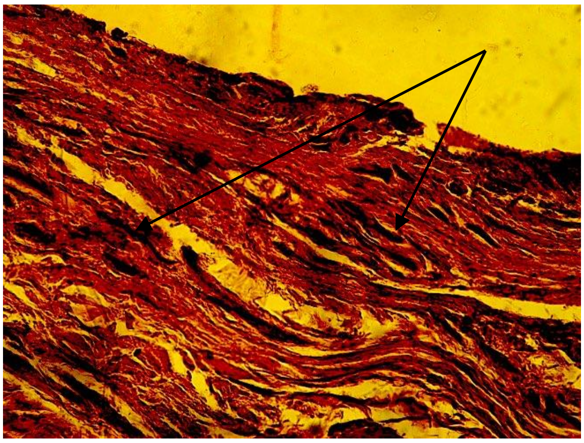

Fig. 7. Capsule vascular net of the tarsal joint, canine. Lateral surface. Hematoxylin-Eosin. In. x 125

Fig. 8. Capsule synovial shell of the tarsal joint ,cattle Lateral surface. Hematoxylin-Eosin. In. x 125

**Discussions.**

Summing up the above mentioned, it can be said that lateral surface of the joint capsule in the canine case is the most vascularized. It has the most extensive vascular network, shaped by capillaries of different architectonics. The medial surface of the capsule is slightly less vascularized, but it has 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 is its plantar and dorsal surfaces. The joint capsule's dorsal surface in the case of cattle has in its composition more of large vessels which prevail over the hemomycrocirculatory bed structures, but the capillary network in this part of the capsule is also quite powerful. In the canine case, the plantar part of the tarsal joint capsule has a small number of microvessels in the subsinovial layer compared with other surfaces and with a similar surface to such in case a cattle. Nevertheless there are capillaries observed in the fibrous membrane of the plantar surface, these capillaries form large anastomosis with a visible ampoule-like expansion, in which some part of the blood may be deposited. In some places capillaries form globs. In the dorsal part of the tarsal joint capsule in the canine case there is a small number of blood vessels in the hemomycrocirculatory bed, as well as small arterioles and venules occur some places. A similar structure was observed on lateral surfaces of the joint capsule in the cattle case, 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 a 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*). Canine's tarsal joint capsule vascularized with 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 *lateral and medial tarsal arteries (a. lateralis et medialis carpi*) [17]. The microscopic examination indicates that the capsule surfaces which include the branches of the major vessels have 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 is also proved 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]. Studying of the joints's 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 the conducted 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 hemomycrocirculatory 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 nature 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 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 case, 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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