MICROVASCULAR SYSTEM OF ANTERIOR CRUCIATE LIGAMENT IN DOG.

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INTRODUCTION. The vascular system in the anterior cruciate ligament (ACL) has been intensively studied by a number of researchers, using several microangiographic techniques in dogs, rabbits and humans. However, most of these microangiographic studies have significant shortcomings, including the lack of three-dimensional observations. This study is to investigate the microvascular architecture by using microangiogram and scanning electron microscopy (SEM).

MATERIALS AND METHODS. Twenty-eight adult dogs, weighing 7 to 15kg, were used. Microangiography specimens were prepared by injecting India ink via the femoral artery under anesthesia in 20 limbs of 10 animals. The ACL was resected, fixed in formalin, and transparent specimens were prepared using the Spalteholz technique and were examined under a stereoscopic microscope. SEM specimens were prepared using 20 limbs from 10 adult mongrel dogs. After thoracotomy was done under Ketalar anesthesia, the tissues were fixed by perfusion with 2.5% glutaraldehyde via the thoracic aorta. Then 300 ml of acrylic resin (Mercox, plasticizer mixed with 0.5 g of a hardener) was injected. After the resin had hardened, the ACL was resected, prefixed in the same fixative, and frozen in dry ice. Sections were then cut with a cryostat, postfixed with 2.0% osmic acid, and dehydrated. After critical point drying and gold deposition, the sections were examined by SEM. In some sections, the soft tissues were dissolved with 30% KOH, and cast specimens were prepared for examination by SEM.

RESULTS. Examination of transparent specimens after injection of India ink showed that the synovial membrane covering the ACL was infiltrated by an abundance of vessels from the synovial fold behind the intercondylar notch of the femur and from the infrapatellar fat pad in front of the tibia (Fig.1A). In transverse sections of the ACL, vessels infiltrating the ligament from the surrounding synovial membrane were seen running transversely and longitudinally (Fig.1B). Specimens obtained after Micropaque injection showed that the arteries in the ligament passed between the fasciculi. Transverse sections of the ACL showed that a thin synovial membrane covered the ligament circumferentially under SEM. There were vessels approximately 50-80 µm in diameter within this membrane, and vessels approximately 30 µm in diameter infiltrated the ligament along with the epitenon (Fig.2A). The ligament was made up of many oval fasciculi approximately 10-30 µm in diameter, and capillaries approximately 10 µm in diameter were also observed in the epitenon that infiltrated between the fasciculi from the ligament margin (Fig.2B). The synovial membrane covering the surface of the ACL revealed many small holes approximately 5 µm in diameter, which would allow easy infiltration of the ACL by synovial fluid. Cast specimens from the same site also showed a network of vessels running within the synovial membrane, and vessels approximately 50-80 µm in diameter were seen in the layer below this (Fig.3A,B). The ACL cast specimens also revealed a network of many vessels that originated from the tibial attachment and passed through the surface of the synovial membrane at the periphery of the ACL. Under high magnification, when side-arm branches left the main vessels, a constriction was regularly present at the bifurcation or anastomoses of capillaries took place at an approximately right angle in a T-shaped pattern. Capillaries showed a ring-like compression and this ring-like compression in the cast may represent a vascular sphincter in the microvessel (Fig.3D).

DISCUSSION. The ACL of the knee is located within the joint cavity and is immersed in synovial fluid. Therefore, the ACL is thought to receive nutrients via two routes, i.e., the vascular system and the synovial fluid. In a detailed study of the vasculature of the ACL performed in 1979, Arnoczky et al. used microangiography to demonstrate that most vessels entering the ACL originate from the infrapatellar fat pad and the synovial membrane covering the ligament, and that there is no direct communication between the vessels of the ligament and those of the adjacent bone. In the present study using microangiography and SEM, we also observed many vessels originating from the synovial fold behind the intercondylar notch of the femur and from the infrapatellar fat pad in front of the tibial attachment (paraligamentous vessels). These vessels infiltrated the synovial membrane covering the ligament and passed through the surface layer of the ligament. However, there were fewer vessels infiltrating the ligament (endoligamentous vessels) compared with those covering the surface of the synovial membrane (synovial lining vessels). Most of the vessels in the ligament infiltrated along with the epitenon and passed between the fasciculi. In isotope studies, Whiteside and Renzoni et al. demonstrated that the ACL is supplied with nutrients from the synovial fluid as well by the vascular system. In our study, SEM revealed many small holes in the synovial membrane covering the ligament, and there were communications between the joint cavity and the gaps between the fasciculi in the ligament. The fact that capillaries also passed through the gaps between these fasciculi suggests that the ACL is supplied with nutrients via two routes, both the capillaries and the synovial fluid, and that the gaps between the fasciculi play an important role in allowing the spread of substances required for metabolism to the individual fibers in the ligament.

CONCLUSION. The intention of this study was to obtain precise information of the microvascular supply of ACL in order to allow interpretation of operations.

REFERENCES