TISSUE TRANSPLANTS FOR REPAIR OF CANINE ANTERIOR CRUCIATE LIGAMENT

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Sohan Singh Rathor

1959

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by

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AN ABSTRACT

Submitted to the College of Veterinary Medicine
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Surgery and Medicine

1959

Approved William V. Lumb

SOHAN SINGH RATHOR ABSTRACT

An experimental replacement of the ruptured anterior cruciate ligament with various materials was performed in 19 dogs. In this study, tendon of the peroneus longus muscle, skin and a strip of fascia lata were inserted as substitutes. After operation, the leg was fixed in a Thomas splint for three weeks.

On clinical examination before euthanasia, most of the dogs, after eight to nine weeks, showed no lameness when walking and running. Each dog was examined for anterior drawer movement before euthanasia. Every dog showed a moderate degree of movement.

On post mortem examination, the transplanted tissue appeared viable. In all dogs, the transplanted tissue was not so taut as the original anterior cruciate ligament. In some dogs, arthritic changes were seen, and in some the articular cartilage underwent aseptic necrosis.

On histological examination, significant tissue reaction was seen in all the transplanted tissues.

Transplantation of tendon in the knee joint exhibited superiority over fascia and skin.

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ACKNOWLEDGMENTS

The author expresses his sincere feelings of gratitude to Dr. W. O. Brinker, Professor and Head of the Department of Surgery and Medicine, under whose guidance and constant encouragement it was possible to carry out this project. A sense of gratitude is expressed to Dr. Wm. V. Lumb, Associate Professor, Department of Surgery and Medicine, for his invaluable guidance and aid in preparing this manuscript.

He is also thankful to Dr. M. Lois Calhoun, Professor and Head of the Department of Anatomy, for providing facilities for histological work and for the preparation of microphotographs. Thanks are expressed to Dr. N. R. Cholvin for his help in taking photographs.

Acknowledgments are made to all the members of the teaching staff, Department of Surgery and Medicine, for their help in this project. Appreciation is due to Dr. M. Bharadwaj for preparing the drawings.

Appreciation is due to the fellow graduate students and the senior class of 1959.

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CHAPTER I

INTRODUCTION

In recent years with the advancements in canine surgery, knee joint surgery, particularly anterior cruciate ligament repair, has become a major problem.

A strip of fascia lata is the most common tissue used as a transplant to replace the ruptured anterior cruciate ligament in present day practice. However, since this material is not entirely satisfactory as a substitute, the problem of replacing the ligament with some tissue which resembled it more closely histologically was suggested as a research problem.

The tendon of the peroneus longus muscle appeared to be the tendon which could be most logically substituted and was used as the transplant for the anterior cruciate ligament. A comparative study of tendon, fascia, and skin transplant to replace the anterior cruciate ligament was done. Histological study of tendon, fascia, and skin was also carried out in order to evaluate the clinical use of these tissues.

CHAPTER II

REVIEW OF THE LITERATURE

Materials, technic and results of conservative and operative repair of the cruciate ligaments have been reported by various authors.

A. Medical Literature

In 1900, Battle[3] reported a case of rupture of the cruciate ligament along with rupture of the medial collateral ligament and patellar dislocation to the lateral side. He opened the joint by cutting across the patellar ligament and sutured the cut ends of the anterior cruciate ligament with silk. As regards the ligaments, good results were obtained. The patient could walk and flex the joint.

Ruptured cruciate ligaments were reported by Robson[35] (1903). He opened the joint by an oblique incision and found excessive synovial fluid and a congested membrane. Both the cruciates were ruptured from their proximal attachments. The anterior cruciate ligament was stitched with catgut to the synovial membrane and tissues on the medial side of the lateral condyle. The posterior, which was too short, was split in order to lengthen it and was fixed to the synovial membrane and cartilage on the medial surface of the medial condyle. A plaster of Paris cast was applied for one month. The operation resulted in good functional use of the knee joint.

According to Jones and Smith[29] (1913), rupture of the cruciate ligaments may be with or without fracture of the tibial spine. They reported rupture of an anterior cruciate ligament along with avulsion of the tibial spine or its internal tubercle, rupture of the internal ligament and dislocation of the internal semilunar cartilage. They were of the opinion that recent cases of rupture of the cruciates should not be operated. Rest and fixation of the joint were the principle factors in producing good results. For old rupture of the cruciate ligaments, they split the patella and its ligament in two halves and "plaited chromicized gut to link the ends". Six weeks rest was given to the patient and good functional movements resulted after eight months. Good function was confidently expected, in the absence of a bone block.

Hey Groves[25] (1917) reported rupture of the cruciate ligaments along with fracture of the tibial spine. He regarded it impossible to suture the ligaments, either with soft suture or wire. A rigid plaster or leather case was worn for a year, followed by a hinged apparatus. In forming a new anterior cruciate ligament, he used an ilio-tibial band of fascia lata and the tendon of the semi-tendinosus for the posterior cruciate ligament. In each case the new ligament retained its proximal attachment in the thigh, was threaded through canals bored in the femur and tibia and was sewn to the outer surface of the latter bone.

Smith[45] (1918) was of the opinion that the immediate treatment of injuries to the cruciate ligaments should be conservative rather than operative. The knee was immobilized at an angle of 20 degrees for three months. Faradism to the quadriceps and general massage with movements of the patella were practiced daily. Eight plies of silk were pulled through the drilled hole in the femur and sutured with the ligament. The joint was immobilized for eight weeks. Arthritis resulted due to the silk acting as a foreign body. A fascial strip was also used to replace the ruptured anterior cruciate ligament. A hole was drilled in the tibia from the medial side and in the femur from the joint surface to the lateral condyle.

Again in 1919, Hey Groves[26] opened the knee joint by a "U" shaped incision and the patella was reflected upwards along with the tibial tubercle. The medial limb of incision was along the line of medial extensors of the hock, while the outer limb was lateral to the patella. The ilio-tibial band was defined and an eight inch strip was separated with intact attachment to the tibial head. This strip was obliquely passed through femoral and tibial holes to replace the anterior cruciate ligament. The free end of the strip was fixed by an ivory nail and sutured on the prominent point of the medial condyle of the femur, this reinforcing the internal lateral ligament. Semitendinosus and gracilis tendons were used to form the posterior cruciate ligament. The leg was kept in a cast for three weeks with daily massage and Faradism to the quadriceps muscles.

A strip of fascia lata three-quarters of an inch wide was used by Eikenbary[14] (1927) to replace the anterior cruciate ligament. Both free ends of the strip were sutured firmly to the underlying tissues.

Forrester[17] (1928) described conservative and operative treatments for repair of the cruciate ligaments. Conservative treatment consisted in application of a plaster cast with the knee angled at 20 degrees. The cast was kept in place for two months. A knee cage was used for six to eight weeks after removal of the cast. For operative repair, the knee was opened by cutting the patella in two halves longitudinally. A strip of fascia, which was sutured to the periosteum, was used to replace the anterior cruciate ligament. A plaster cast was applied from toe to groin with the leg at an angle of 20 degrees for six to eight weeks.

Wagner[51] (1930) reported several cases of fracture of lateral condyle of the femur along with tear of the anterior cruciate ligament. No attempts were made to repair the anterior cruciate ligament. The knee was immobilized for the repair of fractures.

A case of congenital absence of cruciate ligaments was reported by Fairhank[15] (1930). In 1924, he examined a case with congenital anterior subluxation, hyperextension, dislocation of peroneal tendons, valgus of foot, absence of outer part of the foot and two toes and anterior-posterior curve in lower third of the tibia. The knee was treated by fixation in flexion for two years without good results. He operated the same case in 1927 and used a fascial strip to form the anterior cruciate ligament and reinforced the medial collateral ligament by the same. After the knee was fixed in moderate flexion for four months, stability of the joint was obtained.

A strip of fascia from the vastus lateralis was used by Cubbins et al.[10] (1932) for repair of the anterior cruciate ligament. Tendon and aponeurosis of the biceps were used for replacement of the posterior cruciate ligament. In their cases they were unable to see any remnants of the injured cruciate ligaments or any injury to the menisci. The knee joint was flexed at an angle of 25 degrees and the new ligaments were drawn taut and sutured to the osteo-periosteal beds. These ligaments were slightly twisted. They reported that synovial membrane regenerated on these new ligaments. In case of rupture of both the cruciate ligaments, they were of the opinion that the anterior cruciate ligament should be constructed first and the posterior cruciate ligament 10 weeks later. The leg was held at an angle of 25 degrees in a plaster cast for four weeks. Drainage of the joint was provided.

A strip of fascia lata criss-crossed on the medial side of the femoral condyle and tibia was used by Bosworth and Boardman[5] (1936) to stabilize the knee. The anterior strand of fascia lata limited the forward slipping of the tibia and the posterior strand limited the posterior displacement. The leg was immobilized in a plaster cast for three weeks.

Rupture of a ligament or undue relaxation following partial rupture was always associated with displacement or fracture of one of the cartilages. Campbell[6] stated that impairment of the anterior cruciate ligament and medial collateral ligament was associated with injuries of the medial cartilage. Impairment of posterior cruciate ligament and lateral collateral ligament was associated with injuries of external semilunar cartilage. He concluded that the use of a fascial strip often resulted in severe local reactions. He used a long pedicle strip which was dissected out from the femoral attachment to the attachment of the capsule to the tibia. This strip contained very strong tendinous tissue from the medial border of the quadriceps and patellar tendon. The free end of the strip was stitched to the periosteum and the fascia lata. The leg was immobilized for three weeks. Excellent results were obtained.

Avulsion fracture of the tibial attachment of the anterior cruciate ligament was repaired by Lee[32] (1937). He drilled two parallel holes in the tibia and repaired the tibial tubercle by the use of double sutures. A compression bandage was applied along with a plaster cast.

A strip of fascia lata was used by Cubbins _et al._[11] (1937) for repair of the anterior cruciate ligament. The new ligament twisted slightly and was drawn tight. The new tendons were sutured to the osteoperiosteal bed. No attempts were made to close the fascia. Skin was sutured with clips. Excellent results were reported even in the presence of fibrous arthritis.

According to Key and Conwell[31] (1937) the importance of cruciate ligaments in stability and function of the knee joint is so great that injuries of these ligaments may be followed by grave permanent disability. In some cases, they were impossible to repair, consequently, injuries of the cruciate ligaments were regarded as serious. Injuries to the anterior cruciate ligament were more frequent than those of the posterior one. The authors immobilized the joint for three months at an angle of 20 to 30 degrees, as both cruciate ligaments and both collateral ligaments were relaxed in this position.

A fascial strip, eight inches long and two inches wide from the lateral side of the thigh, was passed by Carrel[7] (1937) through the lateral condyle of the femur and the tibia to repair the ruptured anterior cruciate ligament. The knee was kept in a plaster cast angled at 170 degrees for four weeks.

The knee joint was exposed by Macey[33] (1939) through a lateral patellar incision, which exposed the lateral femoral condyle for reception of the reconstructed ligament. The tendon of the semitendinosus was identified and severed at its muscular attachment. The belly of the muscle was then sutured with the semimembranosus muscle, the tendon was pulled through the joint and sutured to the periosteum. The knee was held in full extension while the tendon was being sutured.

Injuries of the lateral collateral ligament in association with capsular and cruciate ligament injuries were recorded by Valls[50] (1939). The proximal end of the medial collateral ligament was most often affected, along with rupture of the anterior cruciate ligament. Valls prepared a new ligament with four to six threads of thick twisted silk, which was sterilized by boiling in cyanure oxide. These threads were used for successful repair of the cruciate ligaments and collateral ligaments, and simplified the technic.

In 1939, Cubbins *et al.*[12] once again reported on several cases of rupture of the cruciate ligaments. They repaired these cases with a strip of fascia lata. They concluded that early operation for repair of ligaments in a completely dislocated knee joint should be contraindicated. Simple immobilization for 120 days was recommended. Early operation for a single ligament was always indicated. Avulsion of the femoral attachment of the collateral ligaments was very common. These cases recovered completely upon immobilization of the knee for 90 days. They reported the failure of cruciate ligaments to regenerate.

A study of tendon transplantation into bone was performed by Kernvecin[30] in 1942. The tendon of the extensor carpi radialis was transplanted into the radius of dogs. He concluded that the anchorage is due to the ossification and gradual incorporation of the tendon in the bone. Prolonged immobilization retarded the tensile strength of the union. He pointed out that the bone sand, due to drilling holes, underwent aseptic necrosis and the relative size of the tendon to the holes had little effect on the rate of union of the tendon to the bone. In his experiments, disuse atrophy resulted and retarded the rate of fixation.

Ossification of the transplant was most marked in the cortical area.

In 1942, Blair[4] used four strips of fascia for replacement of the anterior cruciate ligament. These fascial strips were placed tightly in the femur and tibia in crisscross fashion on the medial and lateral sides. He found abnormal mobility of the knee for four to five weeks, after which it disappeared.

Conservative treatment was suggested for repair of the anterior cruciate ligament by Hauser[22] (1947). He applied a cast from groin to the tibia with the knee joint slightly flexed for two to three months. According to Hauser, the results of intra-articular operation had not been entirely satisfactory. He also cited the report of Watson-Jones that lameness recurred after some time. Considering the above statement, Hauser repaired the ruptured cruciate and collateral ligaments extra-articularly. A strip of the tendon of the quadriceps femoris was separated from the medial side. The proximal end was divided and reflected distal and was fixed with a nail and number one chromic gut to the medial and posterior side of the tibia. A strong fibrous band was formed obliquely from the anterior part of the condyle to the posterior part of the tibia. The band was in the same direction and had the same effects as the anterior cruciate ligament, except that it was outside the joint. The leg was immobilized in a plaster cast for three months.

Helfet[23] (1948) was of the opinion that operative replacement of the ligament should be done. At the same time, he reported that extra-articular tendon transposition replaced the functions of the ligaments without replacing them anatomically. The tibial tubercle with patellar ligament was grafted medially, and the tendon of the gracilis was put on the tibia in order to check the rotation.

According to Soevr[46] (1949) the changes in the synovial membrane started after one month and reached their peak during the second and third months after injury. There was a temporary fibrosis of the synovial membrane and the fat pad. Effusion of blood in the joint produced immediate and intense proliferative reactions in the synovial membrane. These regressed rapidly.

Frequently the ligament was torn in an irregular fashion. O'Donoghue[38] (1950) opened the joint by incising the capsule on the medial side of the patellar tendon. Two parallel holes were drilled from the anteromedial surface of the tibia and the ligament was tied either by number three silk or number ten cotton. In this case, the rupture was from the tibial insertion. If it was torn from the femoral attachment, holes were drilled in the lateral condyle. For the medial collateral ligament, if the rupture was in the middle, a simple ligature was satisfactory. If torn at the bony attachment, the end was tied with suitable suture material and this material was passed in three or four superficial holes in the tibia. The knee was extended at an angle of 150 degrees and the leg was put in a plaster cast.

In 1950, Colonna[8] reported that rupture of the collateral ligaments seldom occurred without some injuries to the adjacent semilunar cartilage. For repair of the cruciate ligaments and collateral ligaments, he recommended simple immobilization of the joint. According to Colonna, functions of synovial fluid were to lubricate the joint and supply nutrients to the articular cartilages and the cruciate ligaments.

Autogenous and homogenous transplantation of the whole knee joint were performed in dogs by Herndon and Chase[24] (1952). The deeper layers of cartilage cells remained viable, but some degeneration of the articular cartilages of the femur and tibia resulted. Asceptic necrosis began superficially and peripherally to the weight bearing surface of the joint. These cartilages were replaced by fibrous tissue. Necrotic meniscus was replaced by fibrocartilage. They concluded that good results may be expected in non-weight bearing joints.

Rupture of both cruciate ligaments were reported by Ficarra[16] (1953). He stated that several operative procedures had been devised, but the preponderance of opinion was that none of them was any good.

Jonas[28] (1954) also described the use of a fascial strip for the replacement of the anterior cruciate ligament and use of semitendinosus and gracilis for replacement of the posterior cruciate ligament.

New tendons and articular ligaments were prepared from fascial strip by Markowitz[34] (1954). He reported that dog fascia was thinner and more difficult to manipulate than human fascia. An anterior cruciate ligament was prepared from a fascial strip and the free ends were stitched to the periosteum and bone with silk.

DePalma[13] (1954) enumerated all the above mentioned operations and stated that regardless of the methods employed redevelopment of the quadriceps muscle played a major role in the success of the operation.

Strips of fascia lata and sliced tendon were grafted by Peer[40] (1955). When fascial grafts were removed after one year, no cellular activity was noted around them. They retained their normal structures macroscopically and microscopically. He reported edema of the graft, resulting from an imperfect re-establishment of circulation, and the transplanted tendon seemed to be larger than normal. A free autogenous piece of Achilles tendon and the tendon of the flexor hallucis were implanted in the knee joints of dogs. Under tension, they maintained their own structures. He concluded that the tendon transplants in the synovial cavity without functional stress lost their specific character and behaved as if they were displaced subcutaneously.

The epidermal layer of skin, with or without the underlying layer of fat, was used to replace the cruciate ligaments by Anderson[1] (1956). The cutis was sutured to the periosteum as well as to itself after being passed through holes drilled in the bone.

Speed[47] (1956) described all the possible methods for repair of the knee ligaments. Neither the normal anatomy nor function of the original set of ligaments could be restored by surgical reconstruction. This was particularly true of the cruciate ligaments. Tissues which were utilized to replace the cruciate ligaments were likely to be inadequate in size and strength. It was surgically impossible to duplicate their rather broad, flat attachments to the condyles of the femur.

Fried and Hendel[18] (1957) used peroneus longus for replacement of the paralyzed tibialis anterior muscle. Good results were obtained by the substitute when the tibialis posterior was normal.

B. Veterinary Literature

According to Schroeder and Schnelle[43] (1936), rupture of the cruciate ligaments may not be repaired completely. They reported that fixation of the joint for three to six weeks resulted in good functional recovery. A padded bandage was passed around the anterior surface of the proximal end of the tibia and fastened to the posterior bar of a Thomas splint. The leg was fixed with forward lift of the thigh towards the anterior bar and backward pull on the proximal end of the tibia to the posterior bar. For rupture of both cruciate ligaments, the same plan was followed; in addition, the tarsal joint was also fixed in more acute flexion.

Osteoarthritis of the knee joint was reported by Schnelle[41] (1941). Injuries to the ligaments within the joint which allowed extra motion and caused increased wear of the joint surface resulted in osteoarthritis. According to Schnelle, the knee joint was the most frequent site for arthritis of any joint in the body. In some cases, there was considerable new bone formation around the injured area.

Schroeder and Schnelle[42] again in 1941 reported a case of ruptured anterior cruciate ligament. The limb was fixed in semiflexed position under moderate traction for three to six weeks.

Injuries of the menisci along with rupture of the cruciate and lateral ligaments were reported by Nilson[37] (1949).

A one centimeter wide strip of fascia lata was used by Paatsama[39] (1952), to replace the anterior cruciate ligament. The fascial strip, retaining its distal attachment, was pulled through femoral and tibial tunnels. It was slightly twisted. The free end of the strip was sutured to the insertion of the ligamentum rectum patella on the tibial tuberosity. The leg was fixed in a Thomas splint for 15 days. In studying this problem experimentally in dogs, Paatsama cut the anterior cruciate ligament and observed the pathological changes which followed. Progressive osteoarthritic changes occurred in the joint and were readily observed after two to three weeks.

Full-thickness and split-thickness skin grafts were placed intraperitoneally by Armistead[2] (1956). They formed occasional microscopic cysts in the peritoneal cavity. He reported that the elements did not change their structures, but in pigs extensive necrotic changes were seen. Hair growth ceased in the grafts.

In 1957, Titkemeyer and Brinker[48] used a 3/8 inch wide fascial strip for replacement of the anterior cruciate ligament. The primary skin incision was continued medially below the joint. The distal attachment of the fascial strip remained intact and the free end of the strip was passed through drilled holes in the femur and tibia and securely sutured to the patellar (quadriceps femoris) tendon. Good results were reported after keeping the limb in a Thomas splint for three weeks.

A thin strip of skin from the parapatellar area was used by Gibbens[19] (1957), to replace the anterior cruciate ligament. The strip was placed in 1:1000 quaternary ammonia solution. It was passed through the joint and the proximal end was turned downward along the lateral collateral ligament. The joint was slightly flexed and the transplant was pulled taut and anchored with steel wire to the lateral collateral ligament and fascia above and below the joint. The incision was closed by steel wire and the leg was kept in a Thomas splint for 14 days. Satisfactory recovery was reported after six months.

Anatomy of the Stifle Joint and Peroneus Longus Muscle.

The stifle joint of the dog is the most complicated and weakest joint in the body. Primarily it consists of two joints:

1. Femoro-tibial
2. Femoro-patellar

In addition, there are the following structures:

Fabellae: These are two sesamoid bones, each lying on the posterior surface of the femoral condyles.

Joint Capsule: The inner synovial membrane, embryologically, originates from the mesenchyma. It has numerous folds in the joint cavity. The function of the synovial membrane is to secrete synovial fluid and lubricate the joint surfaces. The synovial membrane is richly supplied with blood in order to remove the heat generated in the joint, which otherwise might cause damage to the joint structures. The external fibrous tissue layer is continuous around the joint. This is tough and protects the joint cavity from trauma and infection.

Fat Pad: This is placed on the tibial tuberosity, anterior to the attachment of the anterior cruciate ligament on the tibia.

Menisci: These are two in number, medial and lateral. They are composed of hyaline cartilage and are semicircular, planoconcave discs with thinner inner and thicker outer border. Their function is to act as shock absorbers in the knee joint. Due to anatomical structure, they provide a deeper area for articulation of the femoral condyles, and stabilize the joint on medial and lateral sides by filling the space.

Cruciate Ligaments: The location and the direction of the cruciate ligaments are of great importance to their repair by substitution (Figure 1). They are named according to their attachment on the tibia. The anterior cruciate ligament runs from the anterior fossa on the

Figure 1. Cruciate ligaments.

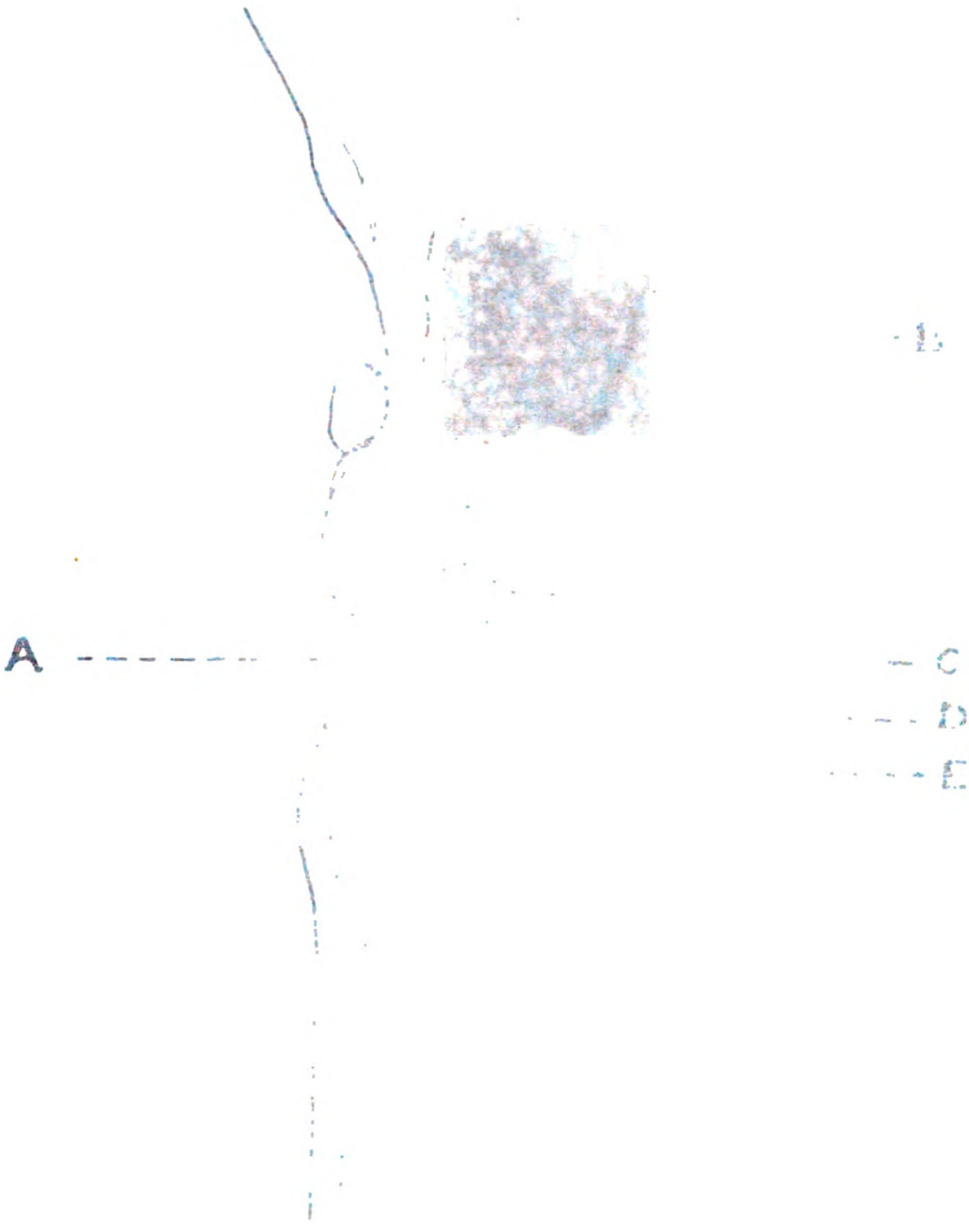
A. Lateral meniscus

B. Cut edge of medial condyle

C. Anterior cruciate ligament

D. Posterior cruciate ligament

E. Cut edge of medial meniscus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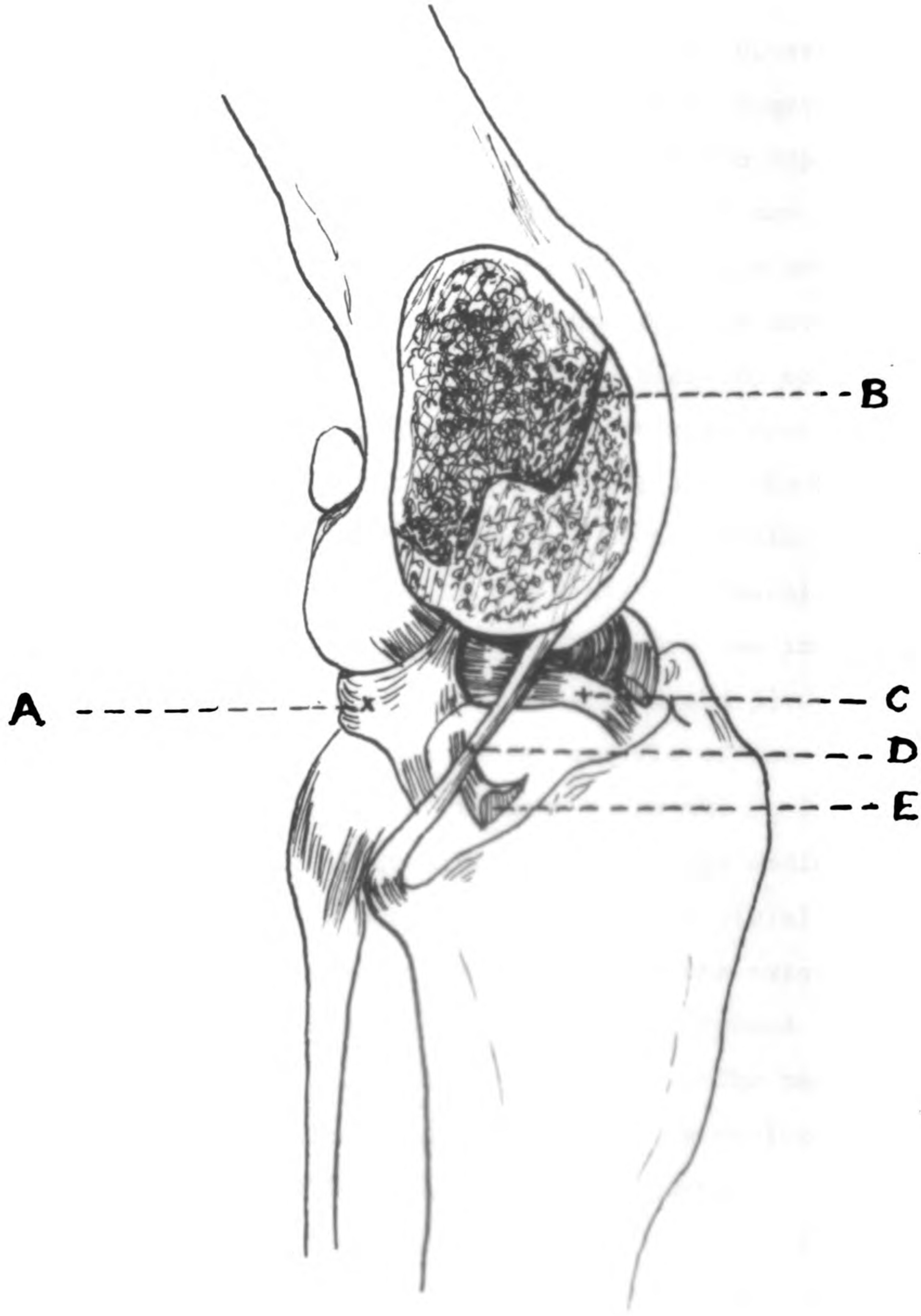
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tibial spine to the medial wall of the lateral condyle of the femur. Its direction is upward and backward in an oblique fashion. The stronger posterior cruciate ligament runs from the popliteal notch of the tibia to the medial wall of the medial condyle of the femur. The function of the anterior cruciate ligament is to check the forward movement of the tibia during flexion. The backward movement of the tibia is checked by the posterior cruciate ligament. Both these ligaments not only check the anterior and posterior movement of the tibia, but also prevent rotation of the tibia in general.

Collateral Ligaments: These are two in number, medial and lateral (Figure 2 and 3). The medial arises from the medial condyle of the femur and ends on the tibia one inch below the articulation. It attaches feebly on the medial meniscus. It is not inserted into the tibial condyle, over which it glides during the extension and flexion. A synovial bursa is interposed between the ligament and the condyle. The medial collateral ligament is stretched in extension. The lateral collateral ligament is poorly developed, arises from the lateral condyle of the femur and is attached on the fibular head. It does not attach to the lateral meniscus. The

Figure 2. Ligaments of stifle, lateral aspect

A. Tendon of quadriceps

B. Patella

C. Fabella

D. Lateral collateral ligament

E. Tendon of popliteus

F. Tendon of long digital extensor

G. Patellar ligament

Figure 3. Ligaments of stifle, medial aspect

A. Tendon of quadriceps

B. Medial collateral ligament

C. Patellar ligament

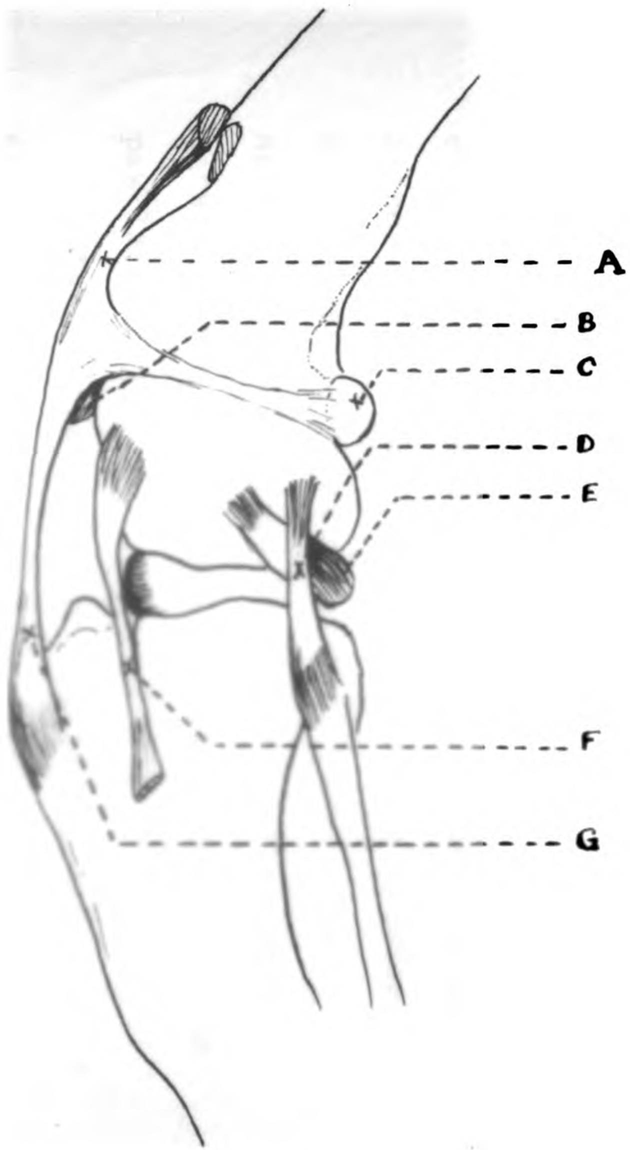


Figure 2

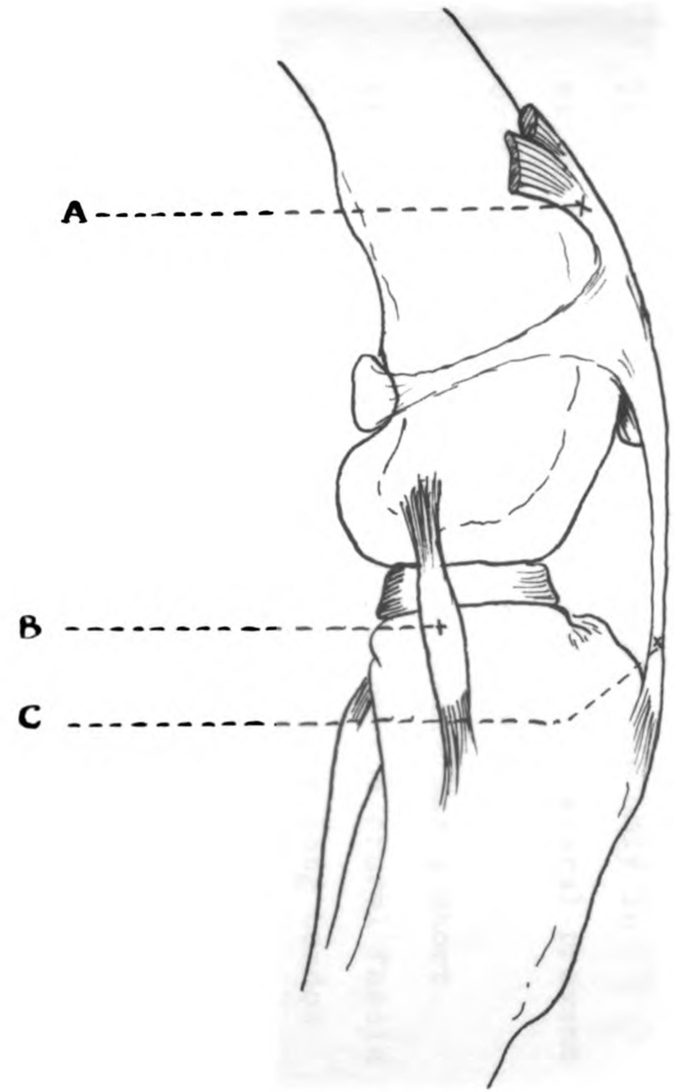


Figure 3

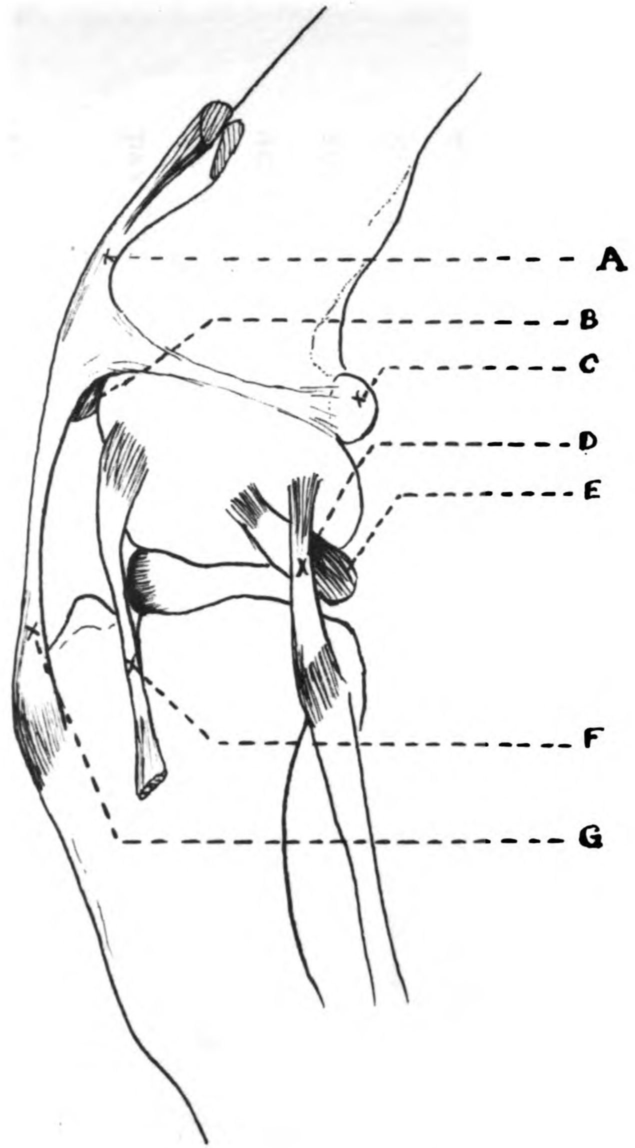


Figure 2

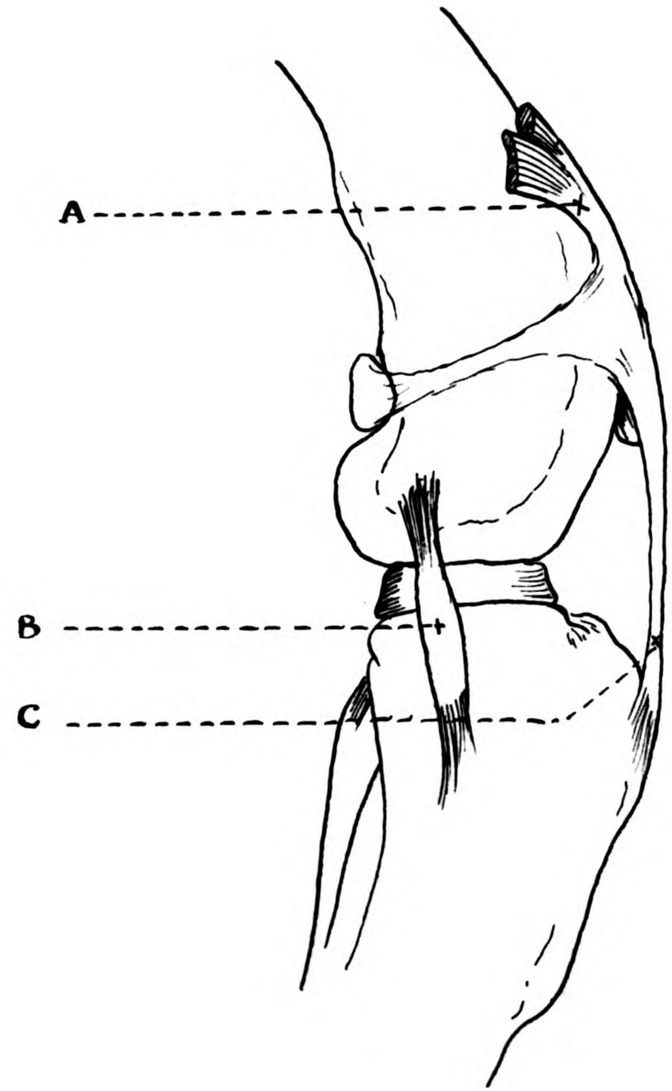


Figure 3

lateral collateral ligament is tense only in extension. Both these ligaments in general prevent over-extension of the stifle joint.

Peroneus Longus: This muscle has a short triangular belly which lies under the crural fascia and anterior to the fibula. It has a long tendon which extends from the middle third of the tibia to its insertion on the metatarsus. This tendon runs in the groove formed by the annular ligament on the lateral malleolus of the fibula. At the distal end of the tarsal joint, it makes a right angle, runs on the volar surface of all the metatarsal bones, and ends on the first metatarsal and the sesamoid bone. The muscle arises from the lateral condyle of the tibia, anterior part of the fibular head, and the distal part of the lateral ligament of the knee joint. Miller[36] described its termination on the fourth tarsal and proximal end of all the metatarsal bones. According to Sisson and Grossman[44], it ends on the plantar surface of the first metatarsal bone. The action of the peroneus longus is to flex the tarsal joint and turn the plantar surface of the paw laterally.

The stifle joint is supplied by branches of the femoral artery. The anterior cruciate ligament is poorly supplied in comparison to the menisci and the posterior cruciate ligament. The anterior cruciate ligament, therefore, has less regenerative power than the posterior cruciate ligament.

Histological Structure of Tendon, Ligament, Fascia and Skin.

Tendon, ligament and fascia are classified as regularly arranged dense connective tissues and may be broad or cord-like. The fibers are densely packed and lie parallel to each other to form structures of great tensile strength.

Tendon: According to Copenhaver and Johnson[9], tendons are composed almost entirely of white fibrous tissue (Figure 5). These fibers are so closely packed in bundles that they appear an almost homogenous mass. Between the fiber bundles are found fibroblasts which have plate-like extensions. Trautman[49] called these fibroblasts tendon cells. In longitudinal section, they appear in rows with distinct nuclei. The tissues which are composed of collagenous fibers are poor in elastic tissue. Tendons are covered superficially by loose connective tissue except where the tendon sheath occurs. The tendon fibers are richly supplied with sensory nerve fibers.

Ligaments: These are structurally similar to tendons (Figure 4). They are predominantly formed of collagenous fibers. Copenhaver and Johnson stated that few ligaments were composed almost entirely of elastic fibers. Greep[20] believed that ligaments were composed of parallel bundles of collagenous fibers which formed broad sheets.

Fascia: According to Copenhaver and Johnson, fascia has the same composition as tendon, but is broad (Figure 7). The fibers may be arranged in several superimposed layers. The fiber bundles are not so tightly packed as in tendons.

Skin: It has been divided into two layers, epidermis and dermis (Figure 6).

Epidermis:

Developed from ectcderma.

1. Stratum Germinativum: Basophilic cells.
    a. Stratum Cylindricum: Columnar cells.
    b. Stratum Spinosum: Stratified cells.
2. Superficial Horny Layer:
    a. Stratum Granulosum: Consists of one to five layers of

Figure 4. Cross section of the anterior cruciate ligament.

A. Fibroblast

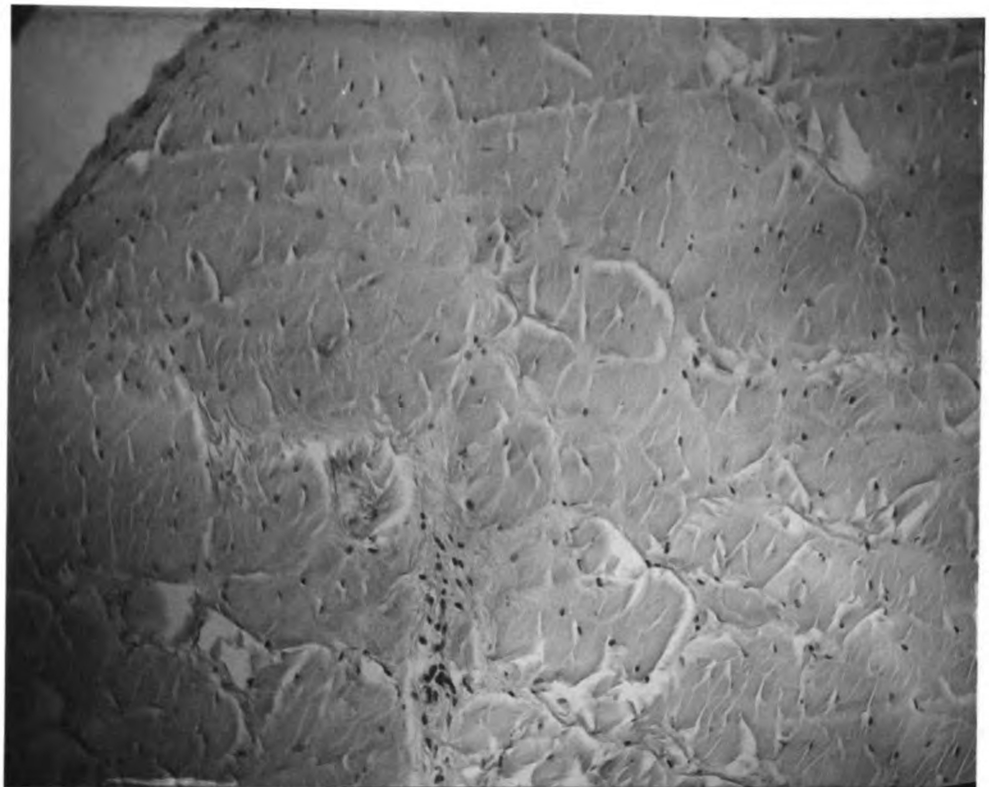
B. Fiber bundles (X75 H&E)

Figure 5. Cross section of the tendon of the peroneus longus.

A. Fibroblast

B. Fiber bundles (X75 H&E)

Figure 4



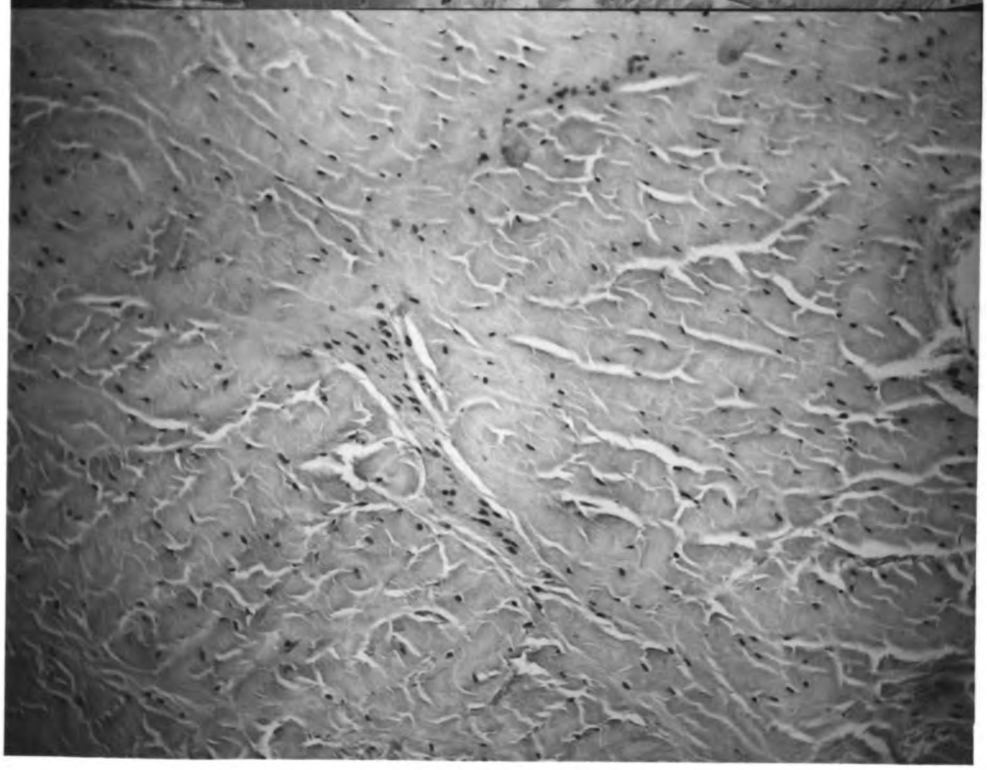


Figure 5

Figure 6. Section of the normal skin from the stifle region.

A. Stratified squamous epithelium

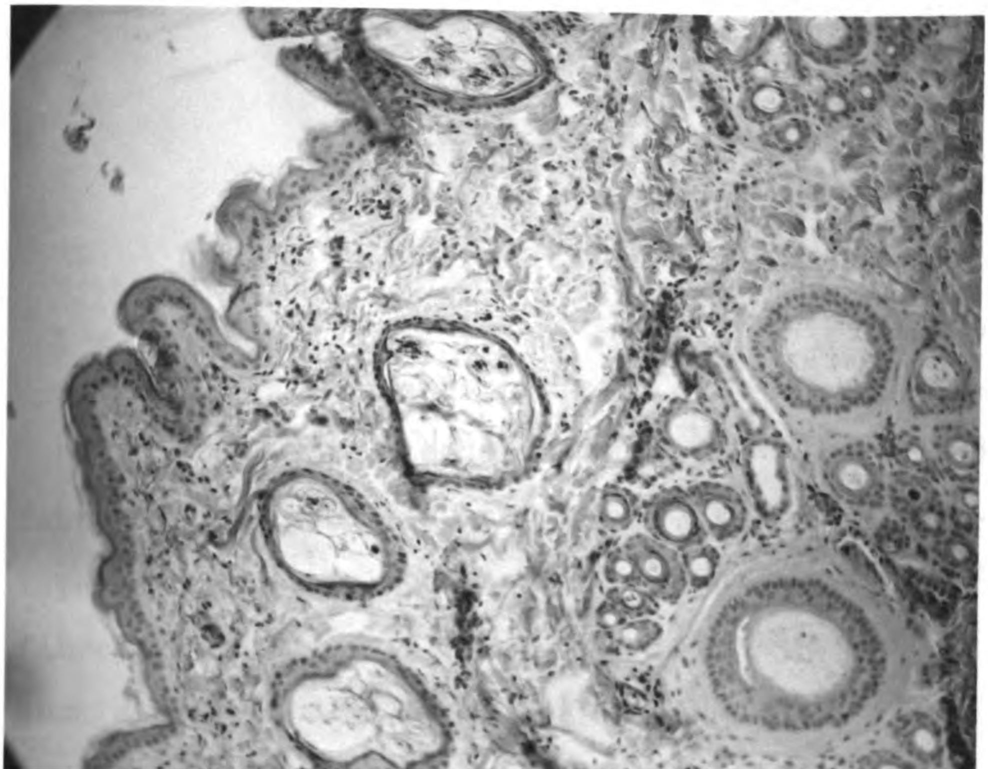
B. Sebaceous glands (X75 H&E)

Figure 7. Longitudinal section of the fascia lata.

A. Fibroblast

B. Fiber bundles (X75 H&E)

Figure 6



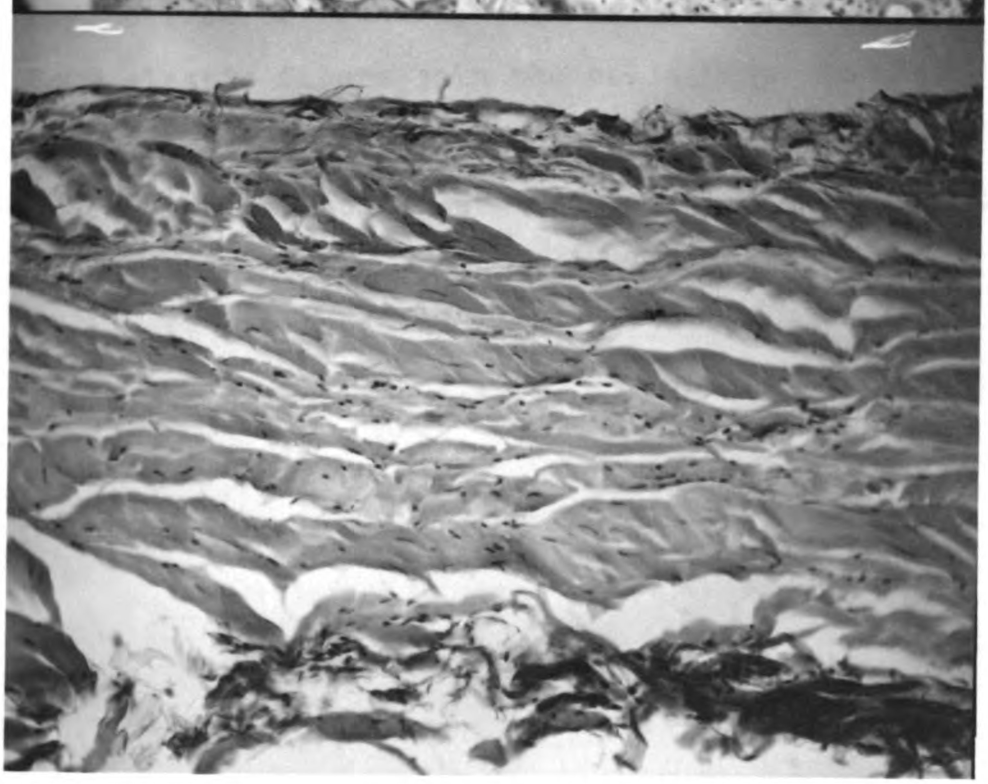


Figure 7

basophilic serrated cells. They show first sign of cornification.

b. Stratum Lucidum: Acidophilic layer of homogenous appearance.

c. Stratum Cornium: Flat cells containing true horny substance.

Epidermis of all domestic animals contains pigment.

Dermis: It extends from the epidermis to the fatty areolar subcutaneous tissue. The superficial layer of dermis is condensed with an admixture of fibroblastic elements. The remainder of corium consists of bundles of collagenous fibers. They may be flat or rounded, and follow a wavy course. Some elastic fibers join the collagenous bundles. The line of demarcation between the derma and the underlying subcutaneous tissue is rarely clear cut. Derma contains blood vessels, nerves, and lymphatics. It encloses the hair follicles and sebaceous glands and some times the sweat glands.

CHAPTER III

MATERIALS AND METHODS

Normal healthy dogs of different breeds were used. No definite age was determined, but all dogs were mature. Commercial dry dog food was fed and two dogs were kept in each cage. Four series of operations were performed.

The tendon of the peroneus longus muscle was obtained from the lateral side of the leg. First, an incision was made between the lateral malleolus and the fifth metatarsal bone and the tendon was cut. Second, an incision was made on the middle third of the fibula, and the tendon was pulled out. In the first series, the tendon was cut from its muscular junction and in the second series it remained intact. A strip of fascia lata was obtained from the lateral side of the thigh which retained its distal attachment. A full thickness skin strip was obtained from the anterior surface of the knee joint. All dogs were destroyed and the transplanted tissue was taken for histological examination.

The anterior cruciate ligament was cut

before the transplantation of new tissue. The operated leg was immobilized in a Thomas splint for three weeks. The Thomas splint was prepared according to the size of the dog.

The following instruments were needed for operation on each dog.

One Kirschner pin chuck and key

Two Steinman stainless steel pins with trochar point

One piece of tantalum wire, seven to eight inches long

One Ferguson needle #4, 1/2 circle, taper point

Twenty-four inches of 0.3 mm. vetafil*

Four Halstead mosquito forceps

One Mayo-Hegar needle holder

One thumb forceps

One Bard-Parker handle #3 with #10 blade

One Mayo scissors

Two Allis tissue forceps

Four Backhaus towel forceps

One suturator containing size "A" nylon

Each dog was anesthetized with pentobarbital sodium and laid in lateral recumbency on the

*Bengen and Co., G.M.B.H., 8-12 Dreyerstrasse, Hannover, West Germany.

operating table. The leg was clipped with Oster clippers (size 40 blade) from the sacrum to the metatarsal bones. The leg was held and scrubbed with germicidal detergent* for at least four times or more. In male dogs, the scrotum was protected from the detergent to prevent irritation to the scrotum. All aseptic precautions were taken and caps, masks, gowns and surgeon's gloves were worn. The paw was covered with a sterile towel which was secured with a towel clamp. The whole leg was passed through the hole in a shroud which maintained the sterile field.

Tendon Transplantation

First method: On the lateral side, between the lateral malleolus and the fifth metatarsal bone, the tendon of the peroneus longus was identified. A half inch incision was made transversely in the skin over the tendon (Figure 8). Keeping anteriorly, the tendon was lifted with a curved hemostat and was cut above its attachment on the first metatarsal bone. Two stitches of nylon were applied in the skin to close the incision.

A second incision two inches long was made on the lateral side of the middle third of the

---

*Parke, Davis and Co., Detroit, Michigan.

TABLE I

OPERATIVE DATA

Dog Number	Date of Operation	Transplanted Tissue
1*	2-4-59	Tendon of the peroneus longus muscle
2*	2-9-59	Tendon of the peroneus longus muscle
3*	2-16-59	Tendon of the peroneus longus muscle
4*	2-20-59	Tendon of the peroneus longus muscle
6	2-26-59	Tendon of the peroneus longus muscle
7	2-27-59	Tendon of the peroneus longus muscle
8	3-3-59	Tendon of the peroneus longus muscle
9	3-17-59	Tendon of the peroneus longus muscle
10	4-6-59	Tendon of the peroneus longus muscle
11	4-10-59	Tendon of the peroneus longus muscle
12	4-10-59	Tendon of the peroneus longus muscle
14	4-17-59	Tendon of the peroneus longus muscle
15	4-17-59	Tendon of the peroneus longus muscle
2	4-22-59	Skin
18	5-15-59	Fascia
19	5-18-59	Skin
20	6-8-59	Tendon of the peroneus longus muscle
22	6-18-59	Fascia
23	6-18-59	Tendon of the peroneus longus muscle

*Both ends of the tendon were cut.

fibula (Figure 8). The incision was in the groove formed by the extensor and flexor muscles of the hind limb. All the bleeding vessels were ligated, the crural fascia was incised, and the tendon of the peroneus longus muscle was lifted with a curved hemostat. In order to obtain a long piece, the muscular tissue was scraped off, in some cases, and the tendon was cut proximally. The subcutaneous fascia and skin were sutured with nylon leaving a small opening. The tendon was kept under the skin in order to prevent drying. The leg was then extended and turned laterally so that the anterior surface of the knee faced upward. A four to six inch skin incision was made longitudinally over the anterior surface of the patella to below the tibial tubercle. Bleeding vessels were ligated and the subcutaneous fascia was separated. With the scalpel, a cut was made in the joint capsule on the lateral side of the patellar ligament. With a pair of scissors, the incision was extended downwards and upwards keeping close to the patella. The patella was dislocated medially and the leg was flexed. The joint was blotted and the anterior cruciate ligament was cut first from the femoral attachment and then from the tibial attachment. An oblique hole was drilled in the lateral femoral condyle above the lateral collateral ligament. In the tibia, the hole was drilled from the medial side, emerging at the tibial attachment of the anterior cruciate ligament. The tendon of the peroneus longus was then pulled through the holes with the help of a wire loop. The leg was extended and the patella was brought back to the normal position. The joint capsule was sutured with vetafil. The femoral end of the tendon was anchored in the joint capsule and the tibial end was fixed in the patellar tendon. Three to four stitches of vetafil were used to secure each end. In checking, some anterior drawer movement of the tibia was observed at this stage. Interrupted stitches of nylon were used to suture the subcutaneous tissue and skin. A Thomas splint was applied and kept for three weeks.

Second method: The tendon was cut from its distal end and exteriorized at its musculo-tendinous junction as described in the first method. The cut end was grasped with a hemostat and the hemostat was pushed upward along the belly of the peroneus longus muscle until the tendon could be pulled outside at the knee joint (Figure 9). In this way, the maximum length of tendon was

Figure 8. Lateral side of leg.

A. Incision between the lateral malleolus and fifth metatarsal bone

B. Tendon of the peroneus longus muscle

Figure 9. Anterior surface of leg.

A. Incision on the knee joint

B. Tendon of the peroneus longus muscle being pushed out at the knee joint

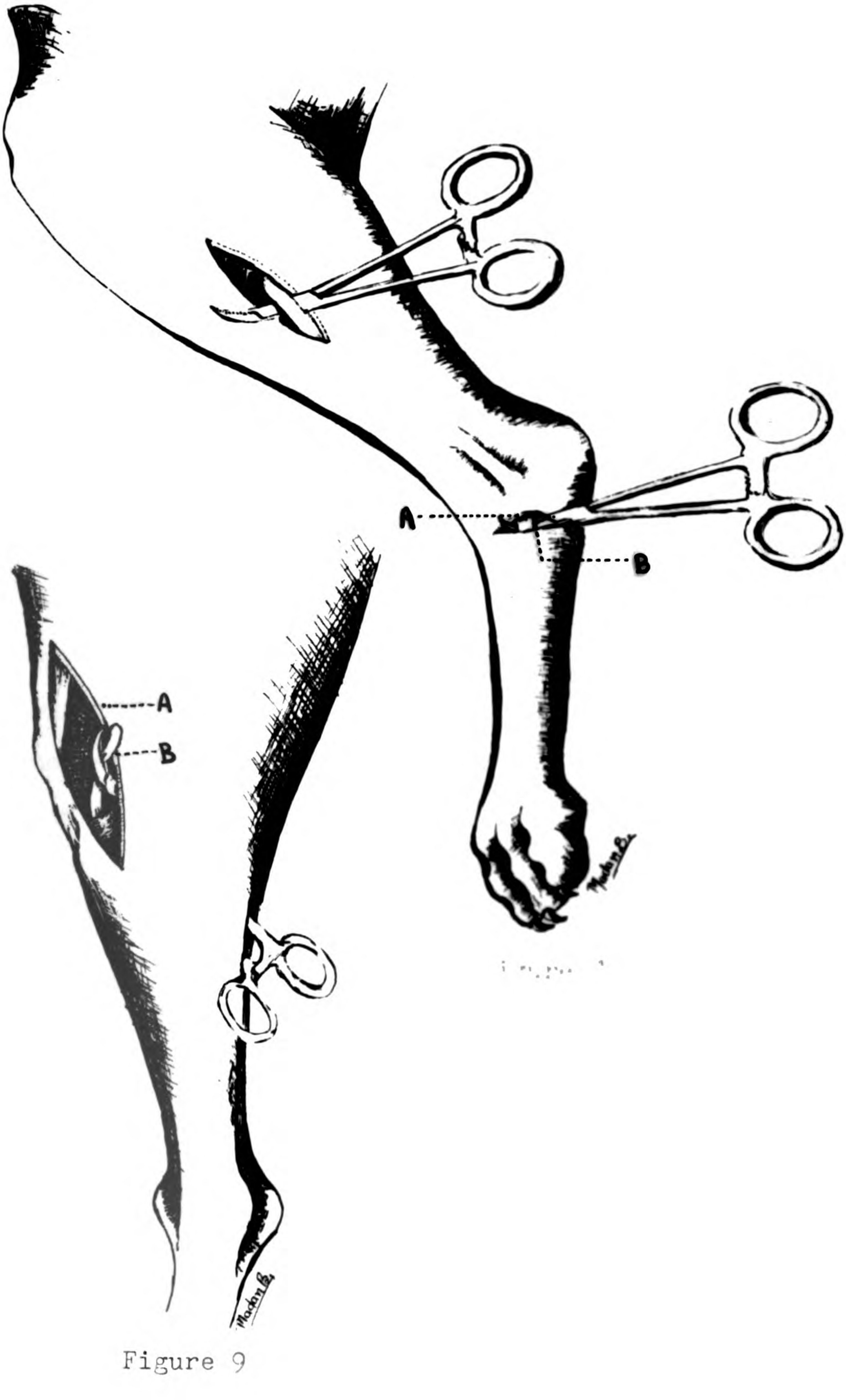


Figure 9

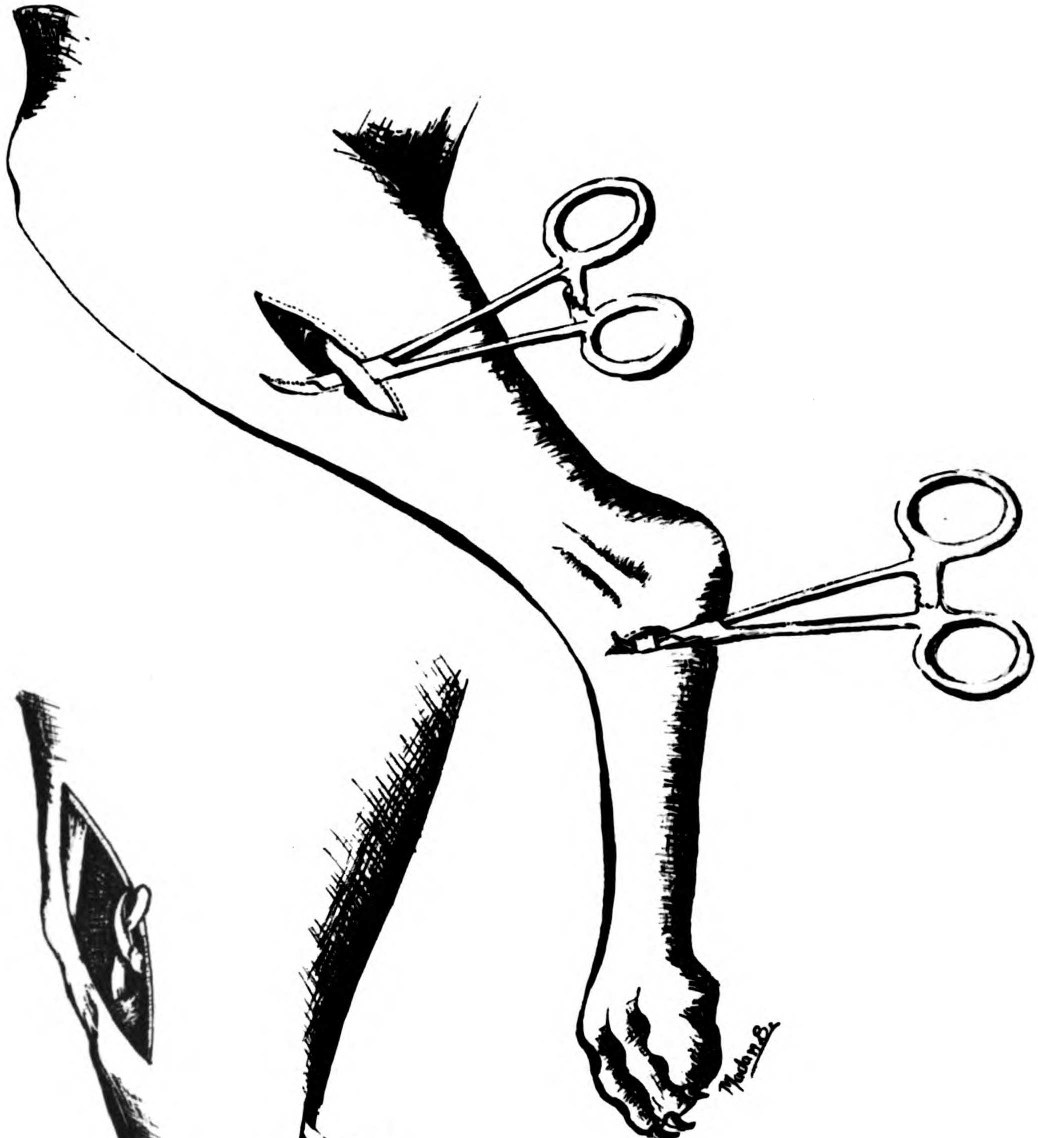


Figure 8

Figure 9

obtained. The knee joint was opened as described in the first method. An oblique hole was drilled in the tibia from the lateral side to the insertion of the anterior cruciate ligament. The tendon of the peroneus longus was pulled through the tibia with the help of a wire loop. A similar hole was drilled in the lateral femoral condyle above the lateral collateral ligament to the femoral insertion of the anterior cruciate ligament. A curved hemostat was used as a guide to determine when the pin had entered the intercondyloid space. The tendon was pulled through the femoral condyle with the help of the same wire loop (Figure 11). The leg was extended and the patella was brought back to the normal position. The tendon was pulled taut, while keeping the leg in the normal position, and was anchored to the joint capsule and the patellar tendon with vetafil (Figure 10). The joint capsule was also closed with vetafil. The subcutaneous tissue and the skin were sutured with nylon. The leg was kept in a Thomas splint for three weeks.

As a control, the attachment of the tendon of the peroneus longus muscle to the first metatarsal bone was cut surgically in one dog.

Fascial graft: The leg was prepared and

Figure 11. Tendon of the peroneus longus pulled through the knee joint.

A. Infrapatellar fat pad

B. Lateral femoral condyle

Figure 10. The tendon anchored in the patellar ligament.

A. Patella

B. Patellar ligament

C. Tendon of the peroneus longus muscle pulled downward

D. Suture line of joint capsule

E. Lateral surface

F. Medial surface

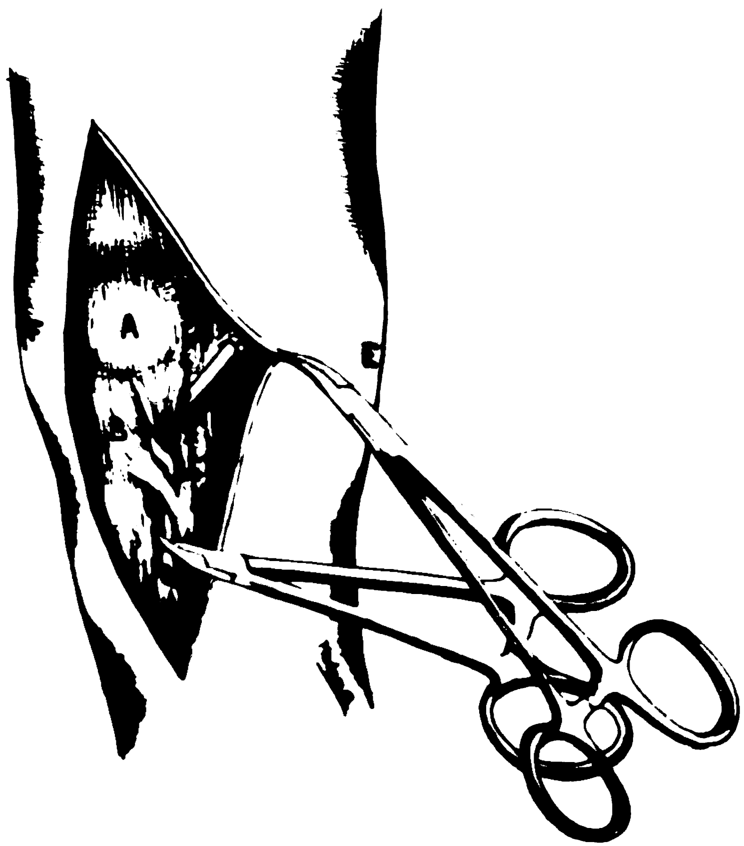


Figure 10

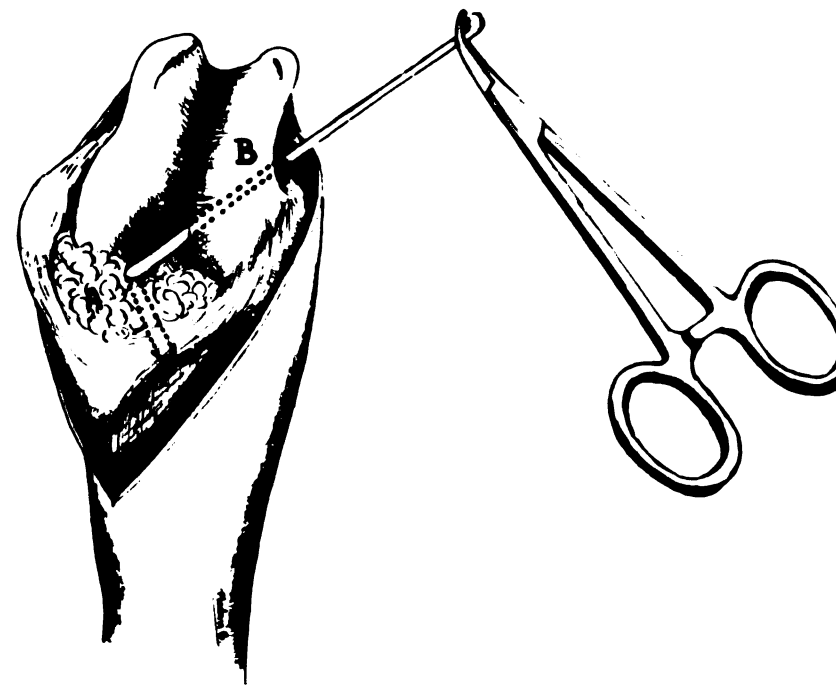


Figure 11

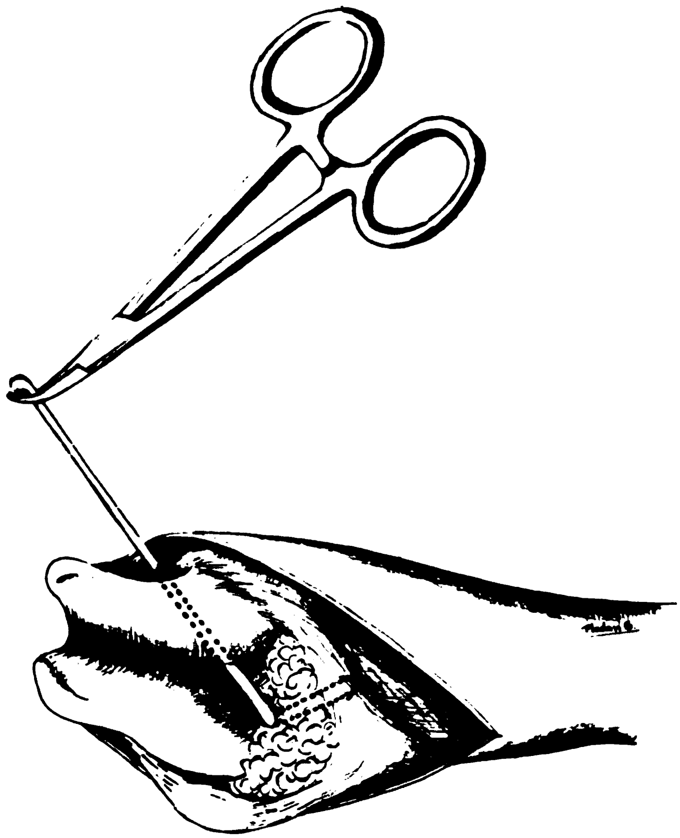


Figure 11

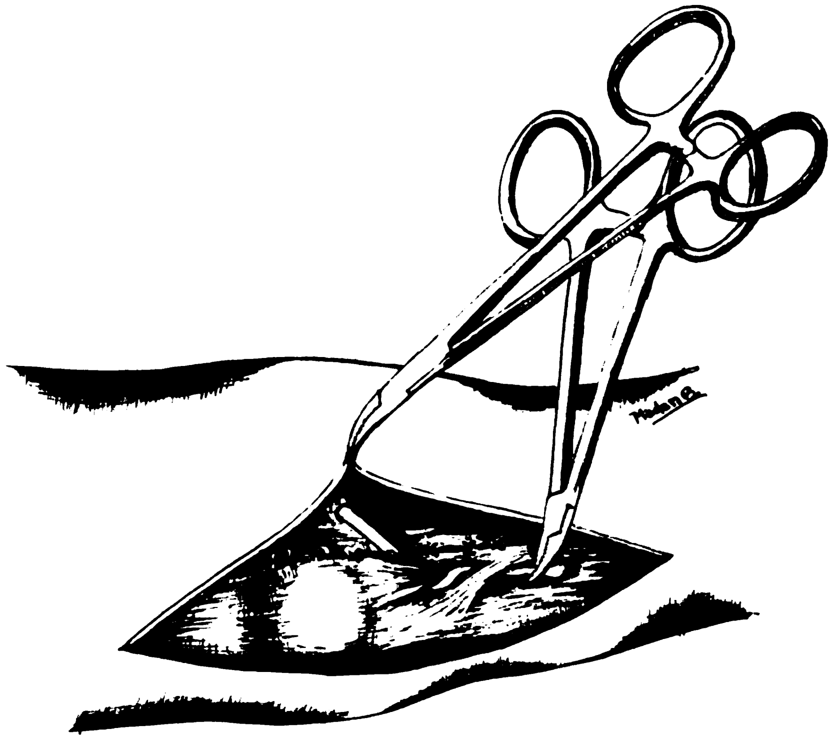


Figure 10

draped for aseptic surgery. A skin incision was made from a point about one inch distal to the greater trochanter to the patella. Subcutaneous tissue and fat were dissected revealing the biceps femoris and the tensor fascia lata. Two parallel stab incisions, about 3/8 inch apart, were made in the fascia lata, lateral and close to the patella. These incisions were continued proximal and the fascial strip was cut proximally, leaving the distal attachment (Figure 12). The remaining fascia was sutured and the proximal three-fourths of the skin incision was closed. The leg was rotated laterally and the primary skin incision was continued obliquely over the patellar tendon to the medial side below the joint. The joint capsule was opened, the patella was reflected medially and the leg was flexed exposing the femoro-tibial joint. A curved hemostat was passed under the anterior cruciate ligament. The femoral attachment was cut first, and then the tibial insertion was cut.

An oblique hole was drilled in the lateral femoral condyle above the insertion of the lateral collateral ligament. A curved hemostat was used as a guide. With a wire loop, the fascial strip was pulled through the hole. A hole in the tibia was drilled from the medial side to the tibial insertion of the anterior cruciate ligament. The fascial strip was pulled through the tibial hole with the help of the wire loop (Figure 13). The leg was extended and the patella was brought back to its normal position. With the femoro-tibial joint in the normal position, the fascial strip was drawn taut and anchored in the straight patellar ligament. It was sutured tightly with vetafil to the patellar ligament (Figure 14). Excess strip was excised and discarded. The joint capsule was sutured with vetafil. Subcutaneous tissue and skin were sutured with nylon. The limb was kept in a Thomas splint for three weeks.

Skin Graft: The leg was covered with sterile shrouds, rotated laterally and kept at full extension. A six inch longitudinal incision was made over the patella and its ligament. A similar incision was made parallel to the first one and the strip of skin, one-fourth inch wide, was cut at both ends in a conical fashion. The subcutaneous tissue was removed from the strip. The knee joint was opened by an incision lateral to the patella and patellar tendon. The patella was dislocated medially and the leg was flexed. The anterior cruciate ligament was cut from its

Figure 12. Lateral surface of the thigh.

A. Biceps femoris

B. Tensor fascia lata

C. Fascia of the tensor fascia lata

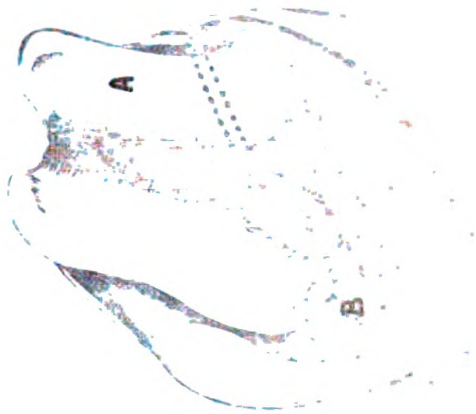
D. Patella

E. Continuation of the primary incision

Figure 13. Fascial strip pulled through the knee joint.

A. Lateral femoral condyle

B. Infrapatellar fat pad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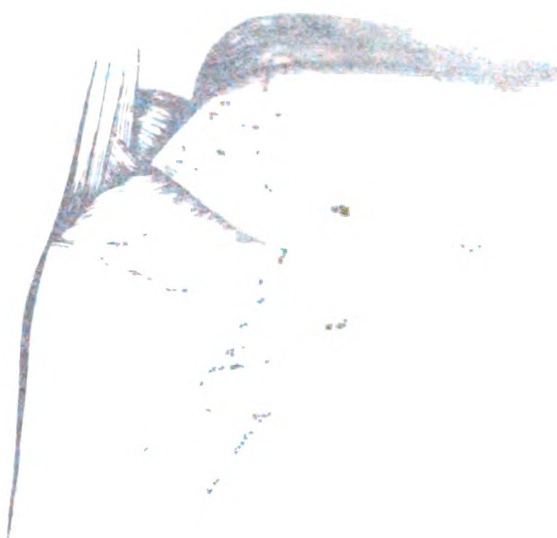
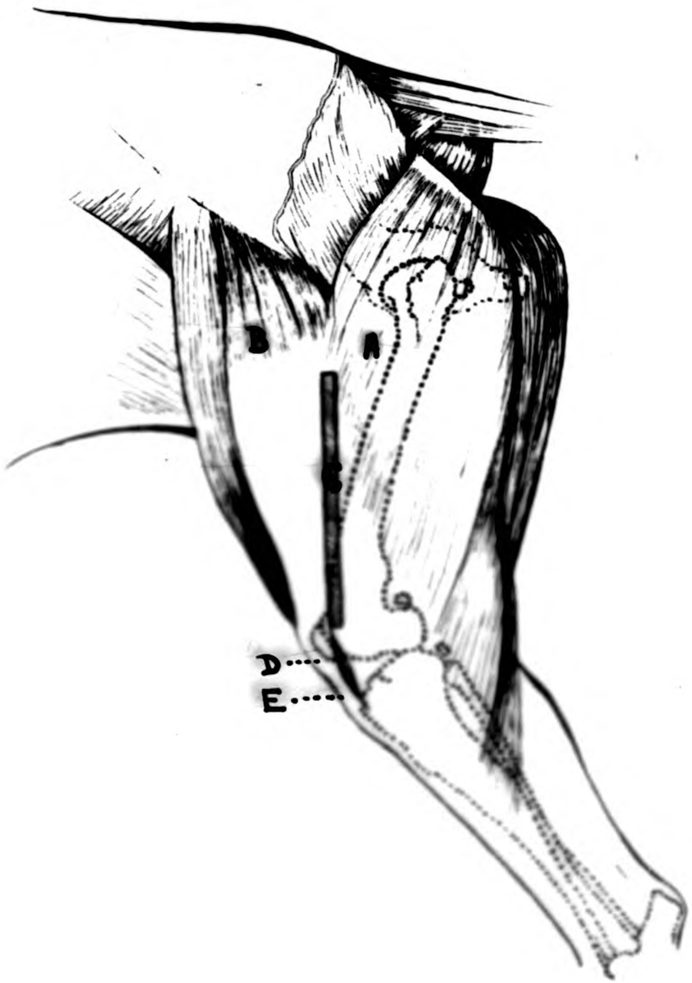




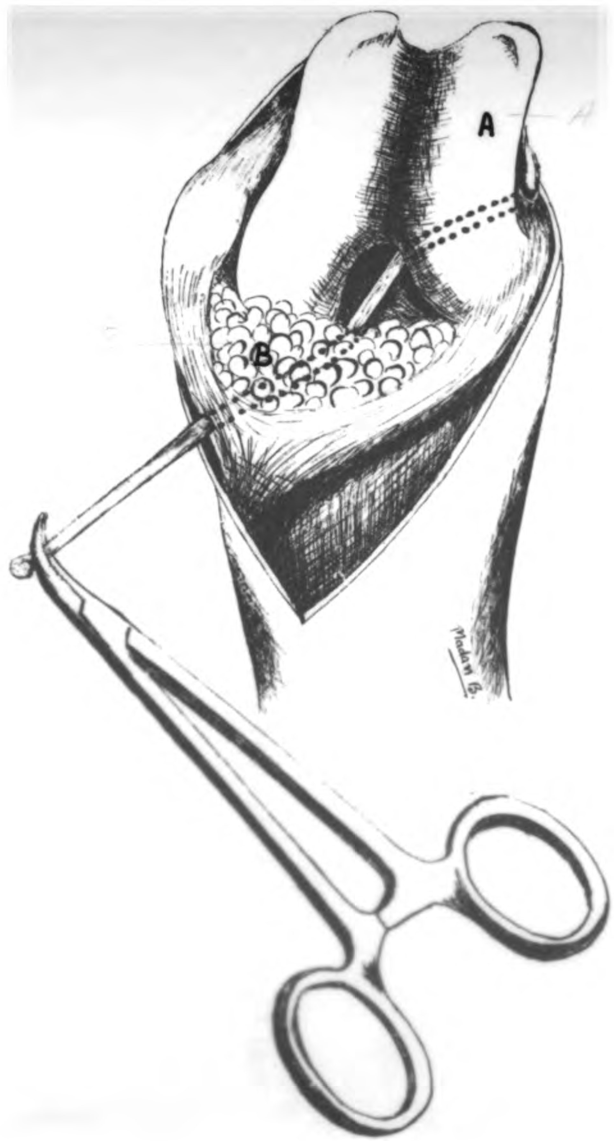


Figure 13

Figure 14. Fascial strip anchored in the patellar ligament.

A. Patella

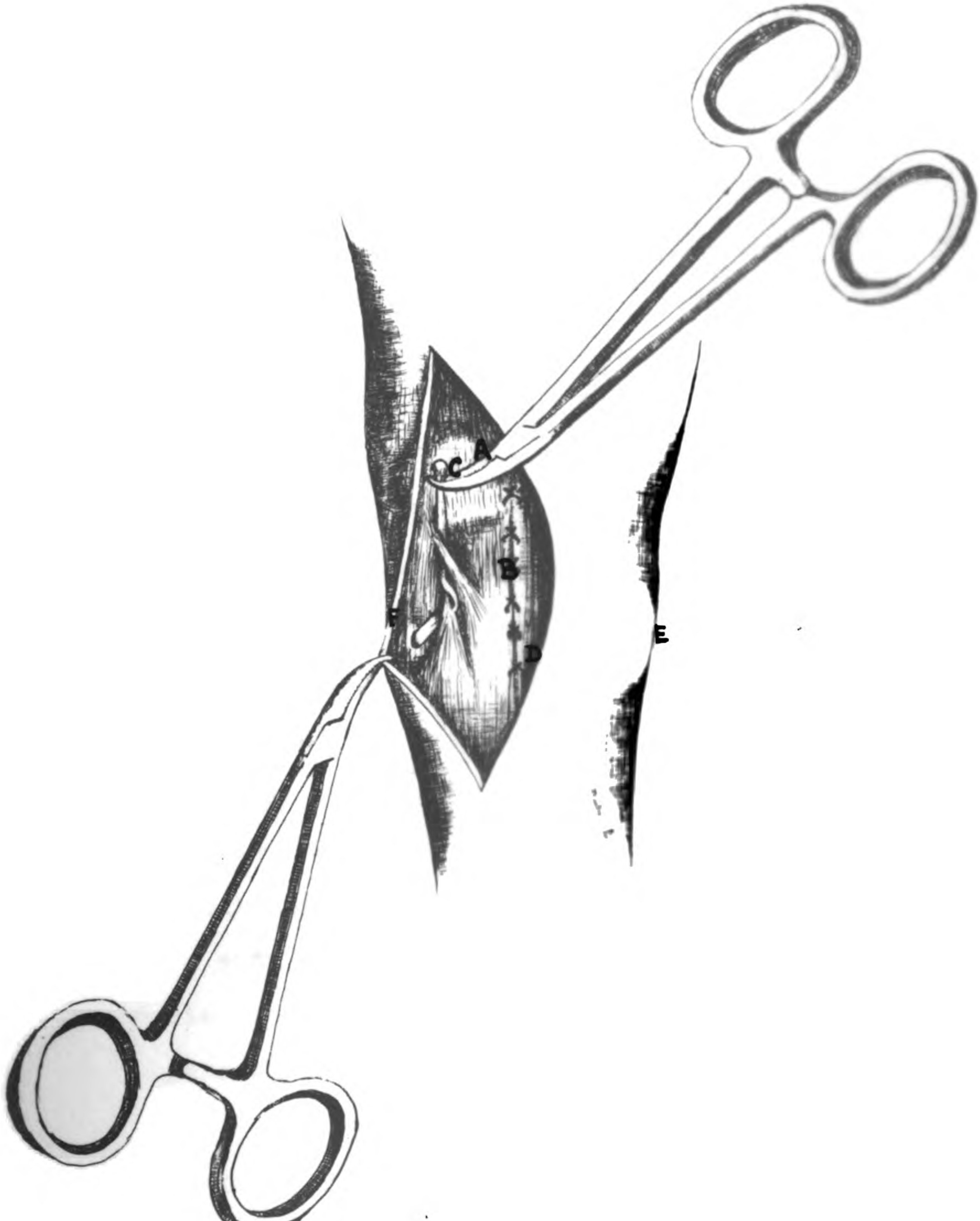
B. Patellar ligament

C. Fascial strip pulled dorsally

D. Suture line of joint capsule

E. Lateral surface

F. Medial surface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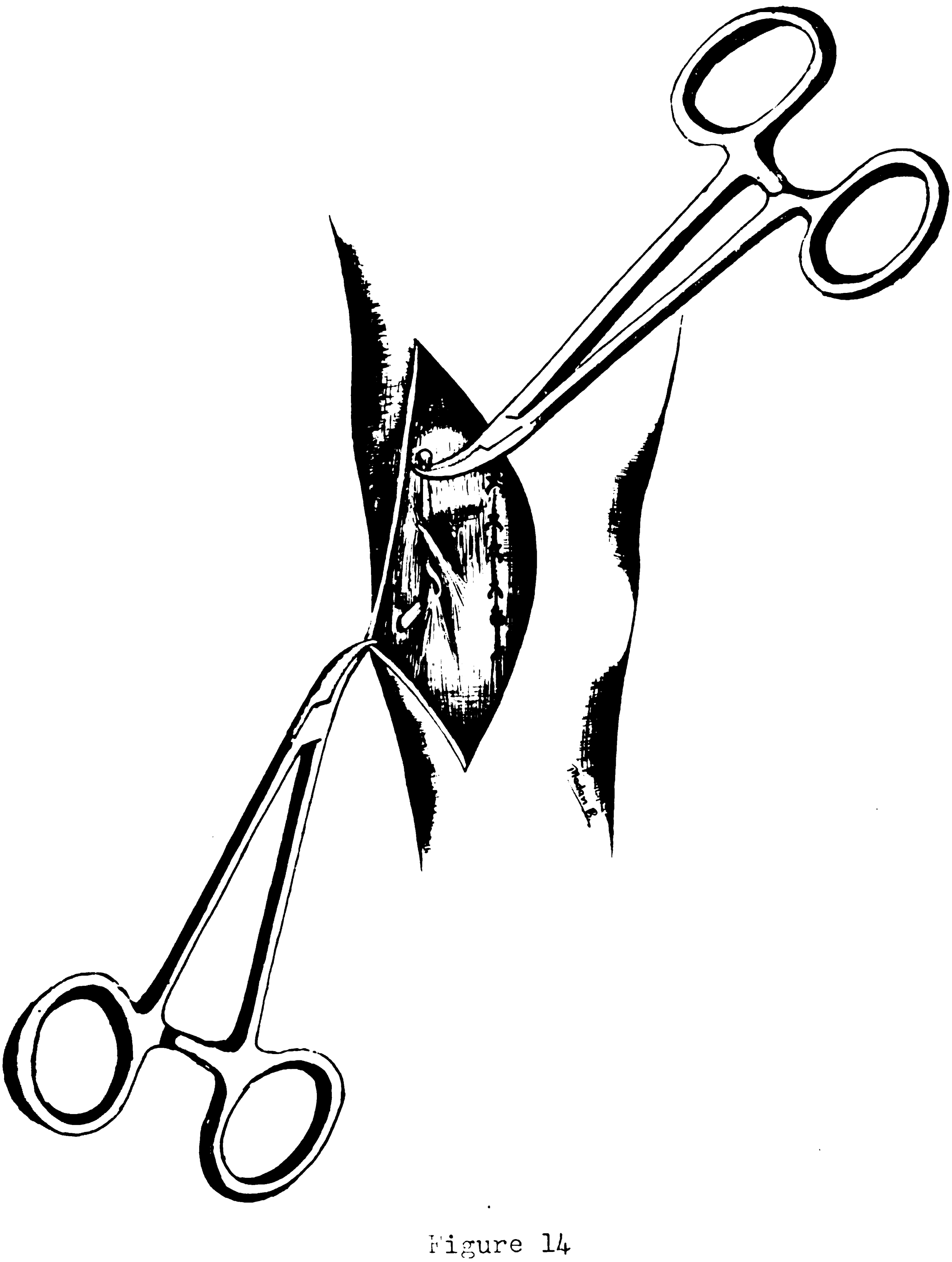


Figure 14

femoral and tibial attachments. A hole was drilled in the lateral femoral condyle and a similar hole was drilled from the medial side of the tibial tubercle. The skin strip was pulled through the knee joint with the help of a wire loop. The leg was extended and the patella was brought back to normal position. The strip was pulled tight. The proximal end of the strip was anchored to the joint capsule and the patellar tendon, while the distal end was anchored to the patellar tendon. Three to five stitches of vetafil were applied on each end. The joint capsule was sutured with vetafil. Subcutaneous tissue and skin were sutured with nylon. The leg was immobilized with a Thomas splint for three weeks.

All dogs were destroyed with pentobarbital sodium and the knee joint was examined. The patellar tendon was cut from the tibial tubercle and the patella was reflected upwards. The condition of the transplanted tissue was determined in situ. In order to get the maximum tissue for histological study, it was then cut close from its femoral and tibial attachments.

The tissue was fixed in F.A.A. (Lavdowsky's mixture, Guyer[21]). Lateral femoral condyle was obtained from two dogs and was also fixed in

F.A.A. A s/p# solution was used for decalcification, followed by a twelve hour wash in running tap water. Dehydration and infiltrating methods of Johnson *et al*.[27] were followed using tissue mat*. Sections were cut at six microns and stained with hematoxylin-eosin. Weigert's-VanGieson's stain was also used to determine the elastic tissue content of the tendon and cruciate ligament.

#Omega Chemical Company, Garden City Park, New York.

*Fisher Scientific Company, Pittsburgh, Pennsylvania.

CHAPTER IV

RESULTS

A. Clinical Data

All incisions in all dogs healed well. No evidence of infection was noticed. In six dogs, the splint became loose and was tightened on the same day. In dogs 12 and 23, the leg was caught in a door and fencing respectively, and the splint bent medially. It was straightened immediately. In dog 19, the splint was too tight and cut the semimembranosus muscle. The splint was removed, the cut ends of the muscle were sutured and healed without any infection.

A clinical examination was performed before each dog was destroyed. Dogs were observed at walk and run on the hard ground. Most of the dogs, after eight to nine weeks, showed no lameness during walking and running. Tenderness was observed after manipulating the knee joint in most of the dogs at this interval of time. On normal walking, the tenderness was insignificant. If the dog had no lameness and tenderness of the knee joint, it was considered

TABLE II

ANTIMORTEM EXAMINATION FOR LEG FUNCTION AND CREPITATION IN THE KNEE JOINT

Dog Number	Interval Between Operation and Euthanasia	Lameness	Anterior Drawer Movement	Crepitation in the Knee Joint
1	79 days	None	Moderate	None
2	174 days	None	Moderate	None
3	46 days	Slight	Moderate	None
4	45 days	Slight	Moderate	Moderate
6	57 days	None	Moderate	None
7	125 days	None	Moderate	None
8	41 days	Marked	Marked	Moderate
9	107 days	None	Moderate	None
10	71 days	None	Moderate	None
11	45 days	Marked	Moderate	Marked
12	45 days	Marked	Moderate	Marked
14	60 days	None	Moderate	None
15	60 days	None	Moderate	None
2	71 days	Slight	Moderate	Moderate
18	87 days	None	Moderate	None
19	84 days	None	Moderate	None
20	63 days	None	Moderate	None
22	110 days	None	Moderate	None
23	110 days	None	Moderate	None

to have good functional use of the leg. If the animal showed lameness and tenderness of the knee joint, it was considered to have poor function. If the animal carried the leg all the time while walking and no weight was borne by the leg, the function was considered to be nil.

The amount of anterior drawer movement of the tibia in all dogs was determined before they were sacrificed. Anterior drawer movement to a lesser degree than in clinical cases was noticed in practically all the dogs. This anterior drawer movement did not cause any lameness in dogs when walking. When the joints were examined for anterior drawer movement, crepitation was noticed in dogs 2, 4, 8, 11 and 12. The results of these examinations are tabulated in Table II.

The control dog, in which the distal end of the peroneus longus was severed, went sound on recovery from anesthesia and thereafter showed no lameness.

B. Post Mortem Data

Each dog was sacrificed with pentobarbital sodium. The knee joint was opened by cutting the patellar tendon from its tibial attachment and by reflecting patella proximal. In dogs 4 and 8, proliferative arthritic changes were noticed on the femoral condyles. In dogs 11 and 12, aseptic necrosis of the articular cartilages of the lateral femoral condyle was noticed. The synovial fluid in all dogs was of normal color except in dogs 1 and 6 which was blood tinged. The peroneus longus muscle, which looked pink and relatively smaller in size, underwent degenerative changes. In dogs 11 and 12, the patellar fat pad became fibrotic and hard. In other dogs, the changes in the fat pad were to a lesser extent. The transplanted tissue was firmly anchored in the bone, except in dog 7, in which the tendon was loose in the tibial hole.

The tendon in the knee joint appeared edematous and thickened (Figure 16). Proliferative changes from the fat pad and adjacent tissues were noticed along the transplanted tendon. In all cases, the transplanted tissue was not so taut as the original cruciate ligament. In the skin graft, a few small macroscopic cysts were seen (Figure 18). There was complete decoloration of the skin. Hair growth was checked. There was slight arthritic change in dog 2 with skin graft. The strip of fascia lata in the knee joint appeared edematous and thickened (Figure 17).

No significant tissue reaction was noticed

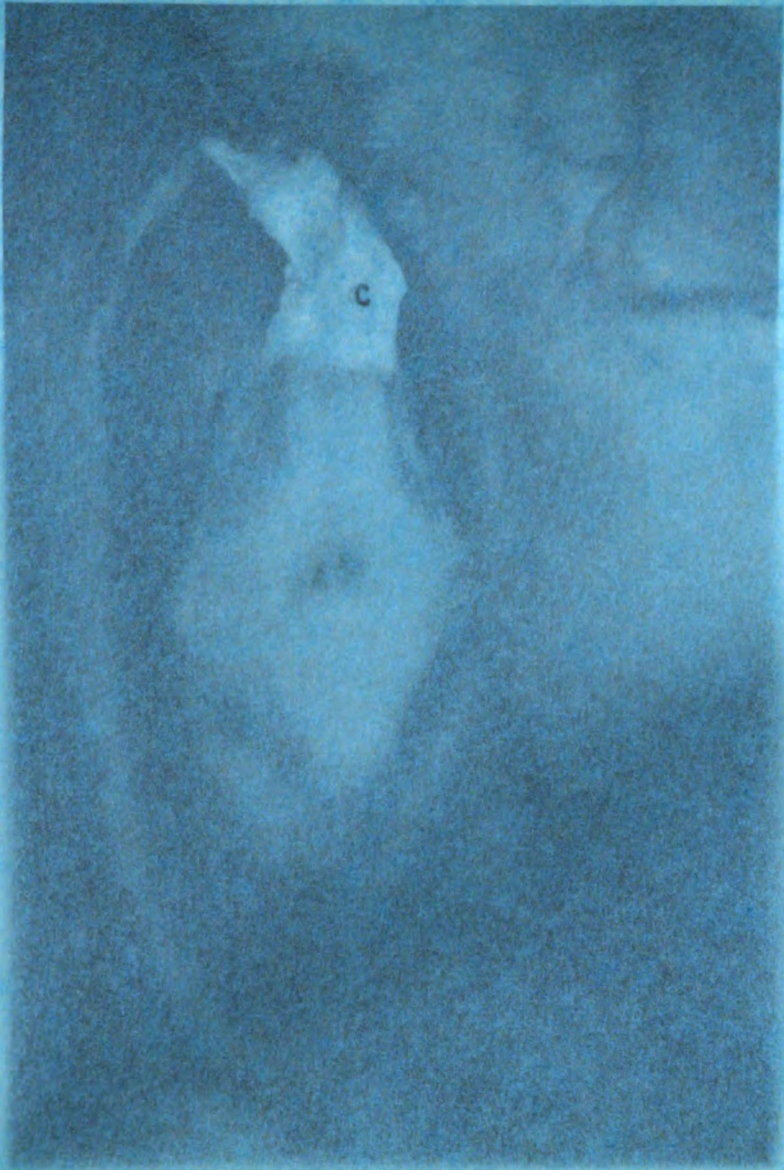
Figure 15. Normal knee joint.

A. Anterior cruciate ligament

B. Posterior cruciate ligament

C. Patella reflected proximally

Figure 16. Knee joint of dog 9 with tendon transplant.



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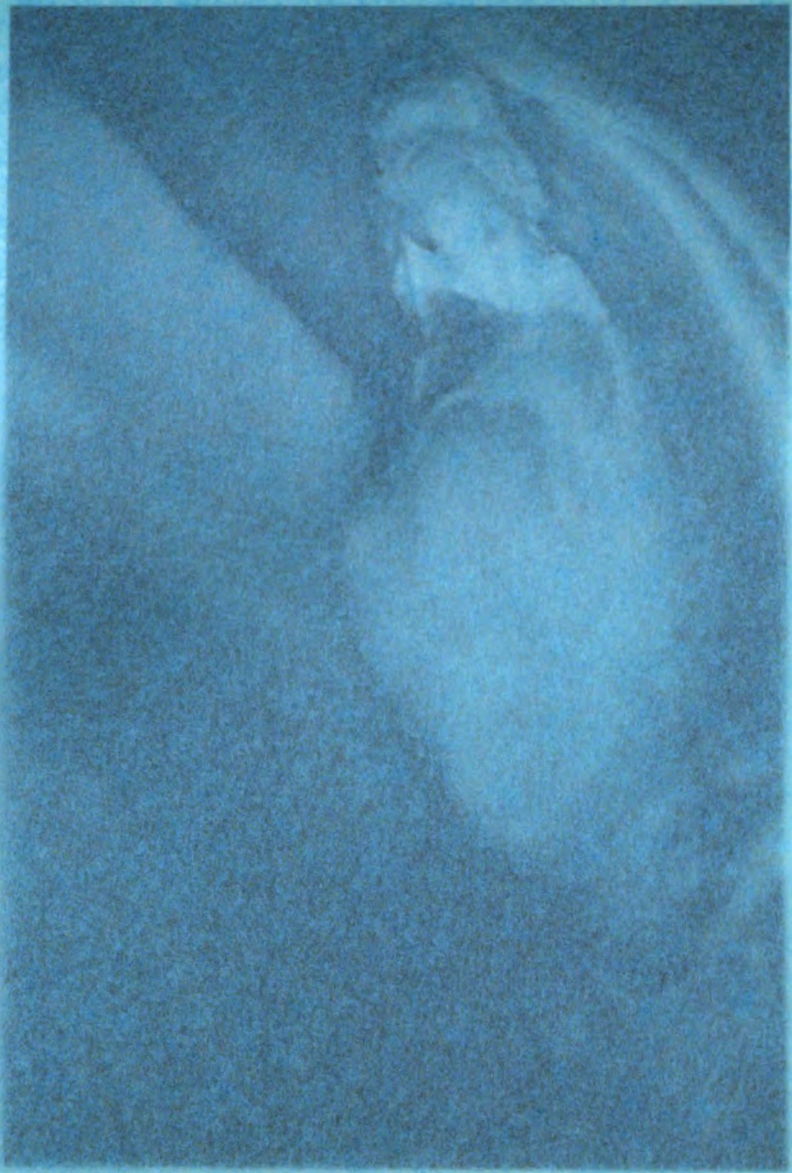


Figure 15

Figure 16

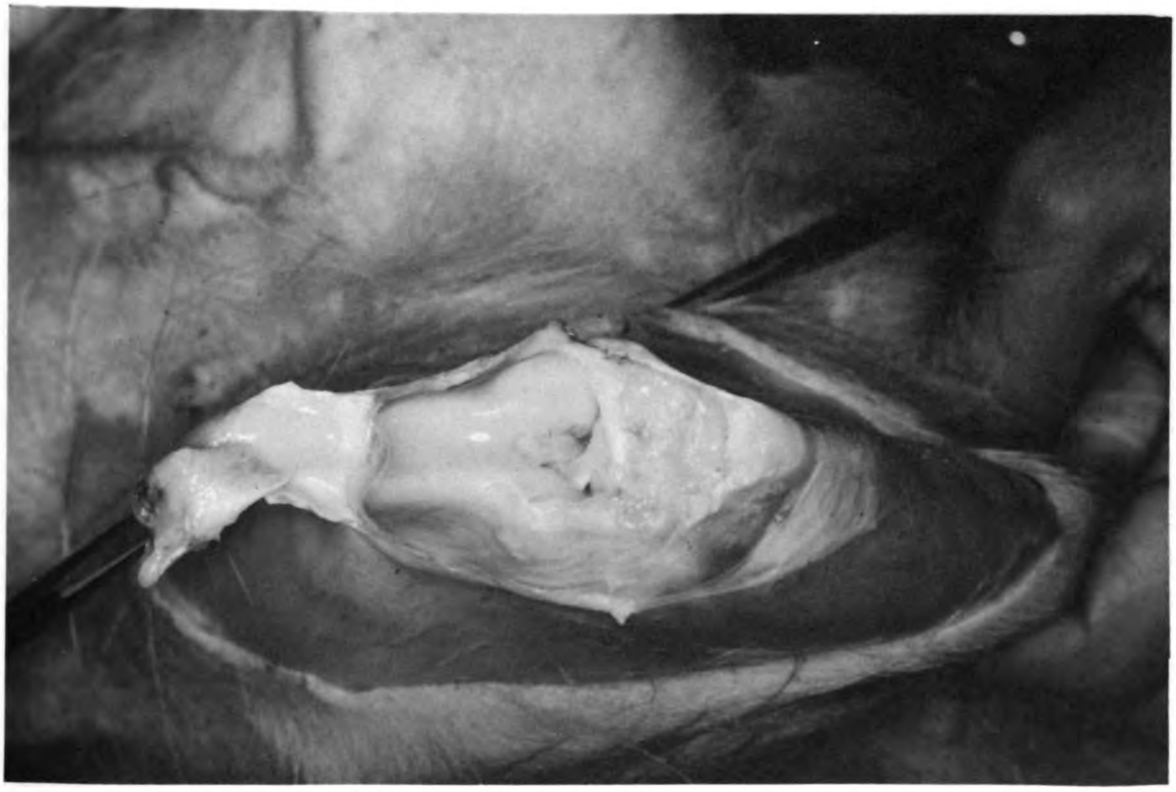


Figure 15

Figure 17. Knee joint of dog 18 with fascia transplant

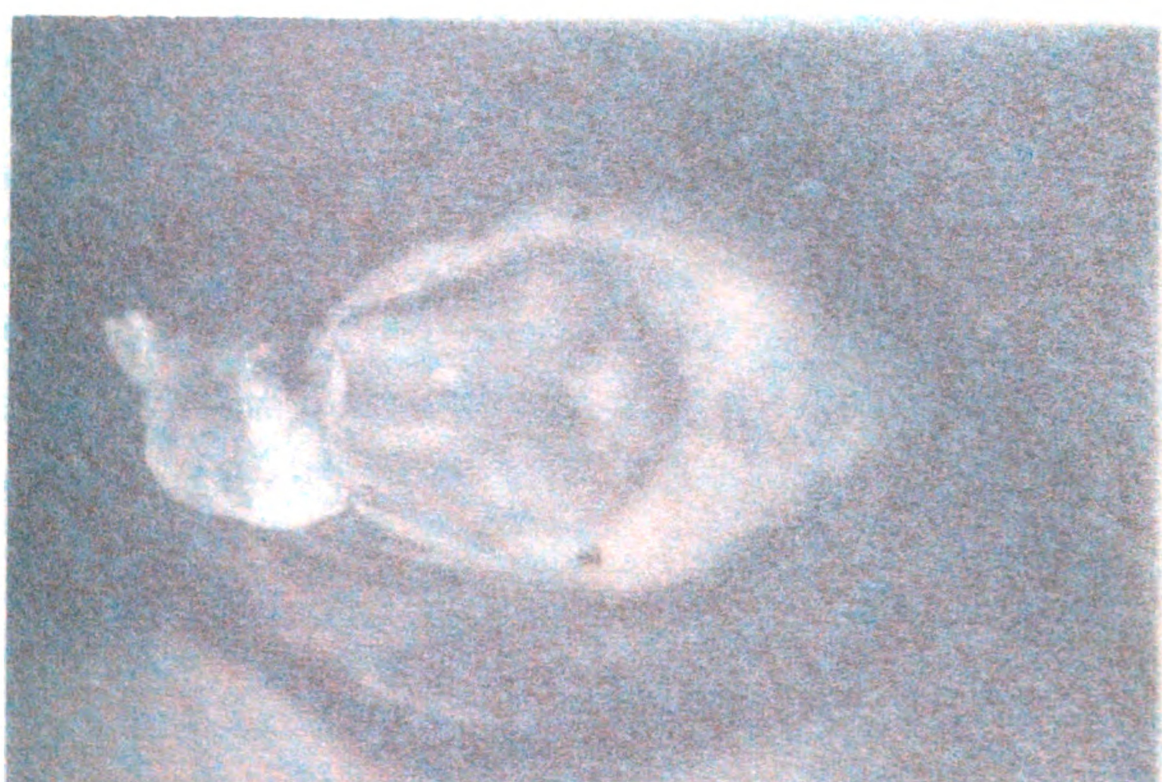
A. Lateral surface

B. Medial surface

Figure 18. Knee joint of dog 19 with skin transplant.

A. Lateral surface

B. Medial surface



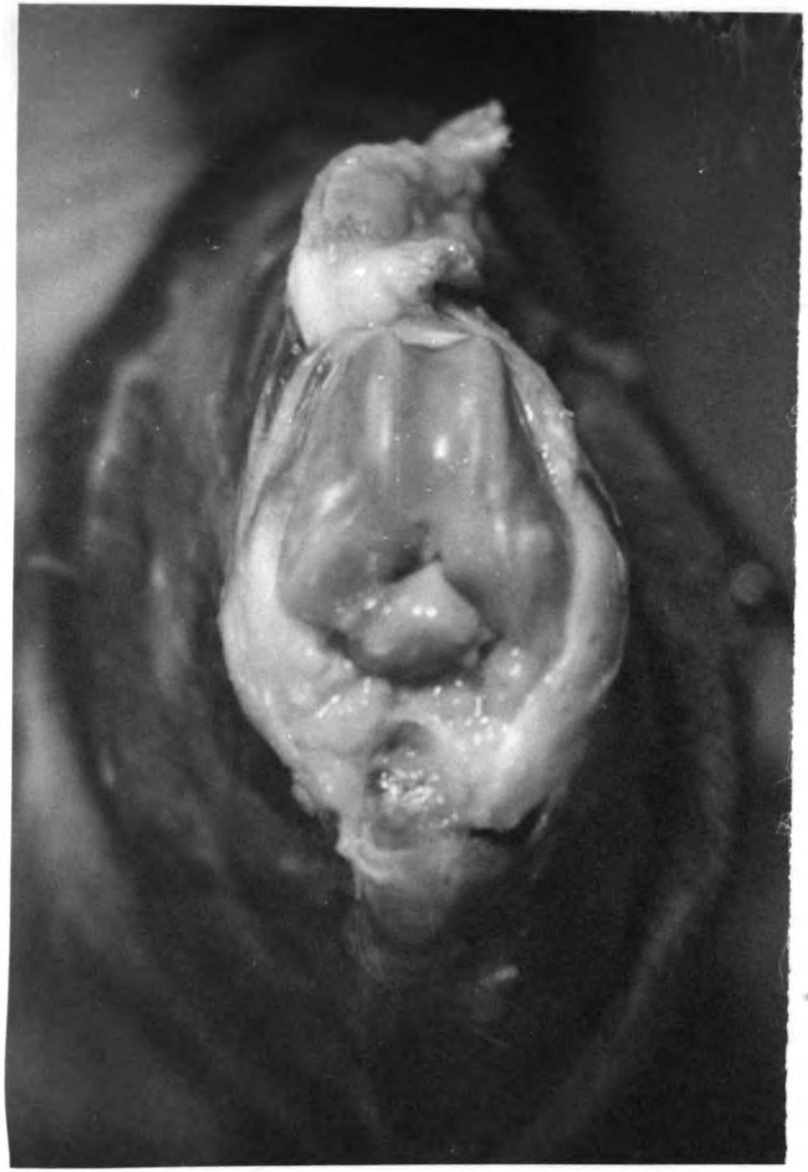


Figure 17

Figure 18

around the vetafil used to suture the joint capsule.

C. Microscopic Study

There was very little difference in the individual slides of the same tissue. General and common changes in the tissue have been described and the differences compared.

Tendon: Tissue reactions were mild in some cases and marked in a few. The older tissue was more organized and had less reaction than the tissue which remained in the joint for lesser time. The tissues in which reaction was marked had loosely packed young fibroblasts which could be easily seen adding bulk to the tissue. Various stages of immature fibroblasts and fibers were seen in the slides. The fibers were in the process of organization (Figure 20). Mature fibroblasts were seen in the organized area of the tissue. Transplanted tendon was vascularized. Arteries and veins were scattered throughout the section.

No degenerative changes were noticed, and no sign of infection was seen. Fat in and around the transplanted tissue was apparently completely lacking. In dog 12, cuboidal epithelial lining was seen around the tissue. In dog 8, the transplanted tendon exhibited cartilagenous cells.

Sections of the lateral femoral condyle of dogs 11 and 12 showed aseptic necrosis of the articular cartilage (Figure 21). No significant changes were seen in the bony tissue under the cartilage. The bone was vascularized, and did not show degenerative changes. The tendon, passing through the bone, showed impregnation of bony tissue into it from the surrounding bone. This bony growth into the tendon anchored the tendon firmly. The tissue reaction in the tendon inside the bone was insignificant. It contained less fibroblasts than the tendon in the joint space.

Skin: Absence of glands and hair follicles was noticed in the transplanted strip of skin (Figure 23). Proliferative changes and denudation of the superficial epithelial cells were seen. Cysts of different sizes were seen throughout the slide. No trace of infection was seen within the cysts. Blood vessels were seen which signified that the tissue remained viable. Tissue reaction as compared to the tendon was mild.

Fascia: The transplanted strip of fascia lata showed marked tissue reactions (Figure 22). Fibroblasts infiltrated the transplanted strip. Collagenous fibers were compressed and the inter-fiberillar space was greatly reduced. Blood vessels were seen throughout the area. In dog 18, few immature cartilagenous cells were noticed. No adipose tissue was seen in and around the transplanted strip.

Figure 19. Transplanted tendon in a drilled hole in the lateral femoral condyle from dog 12.

A. Tendon

B. Bony cells

C. Osteoblasts invading the tendon (X75 H&E)

Figure 20. Transverse section of transplanted tendon from dog 7.

A. Fibroblast

B. Fiber bundles (X75 H&E)

Figure 1

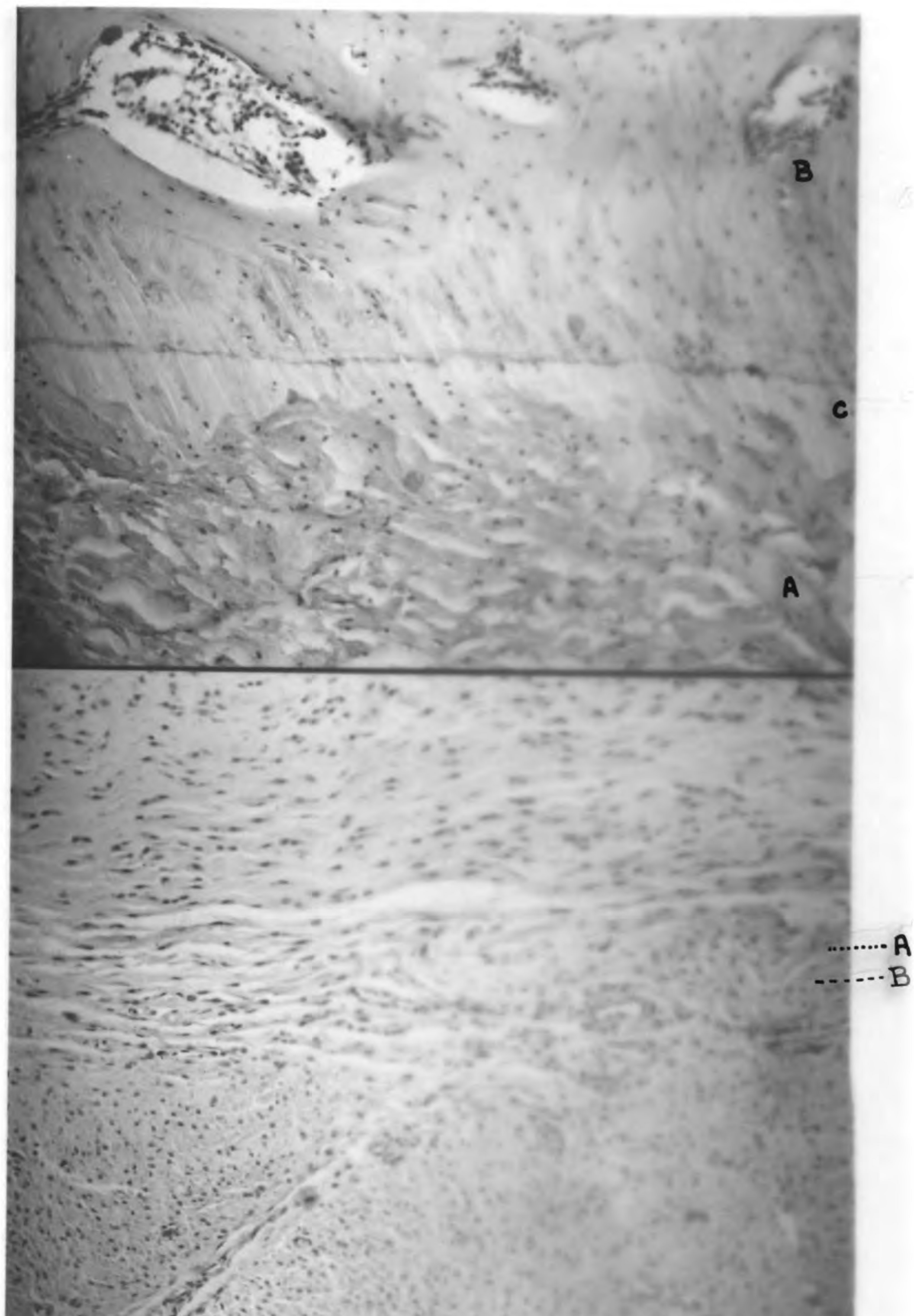


Figure 19

Figure 20

Figure 21. Articular cartilage of the femoral condyle from dog 8.

A. Normal cartilage cells

B. Necrotic cartilage cells (X75 H&E)

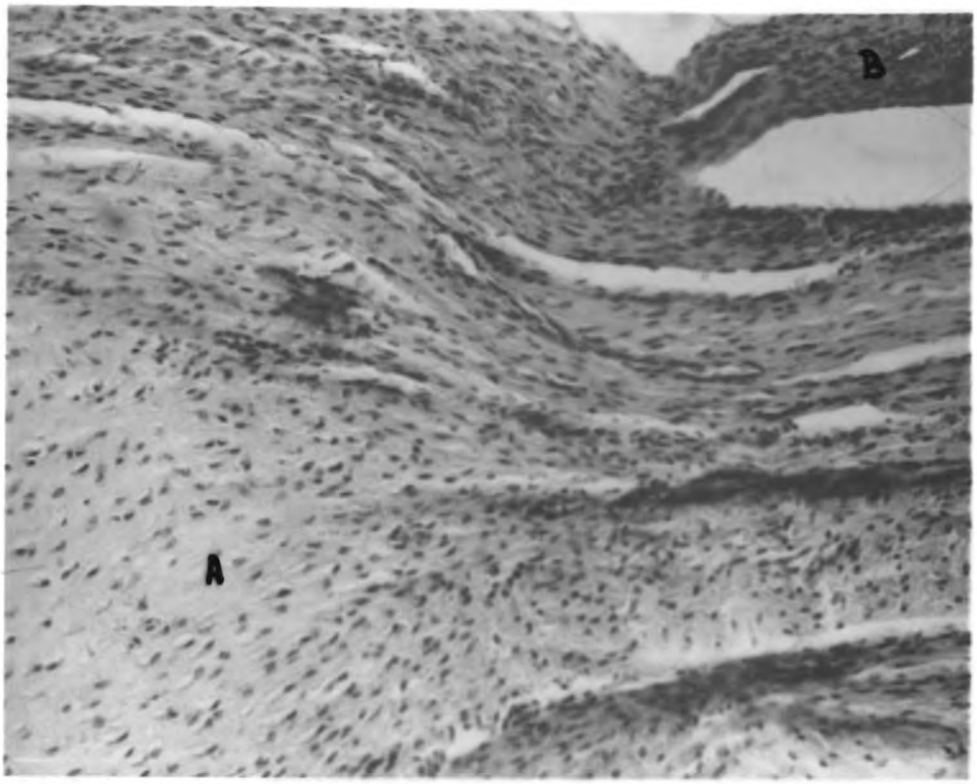

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Figure 22. Longitudinal section of fascial transplant from dog 18.

A. Fibroblast

B. Collagenous fibers (X75 H&E)

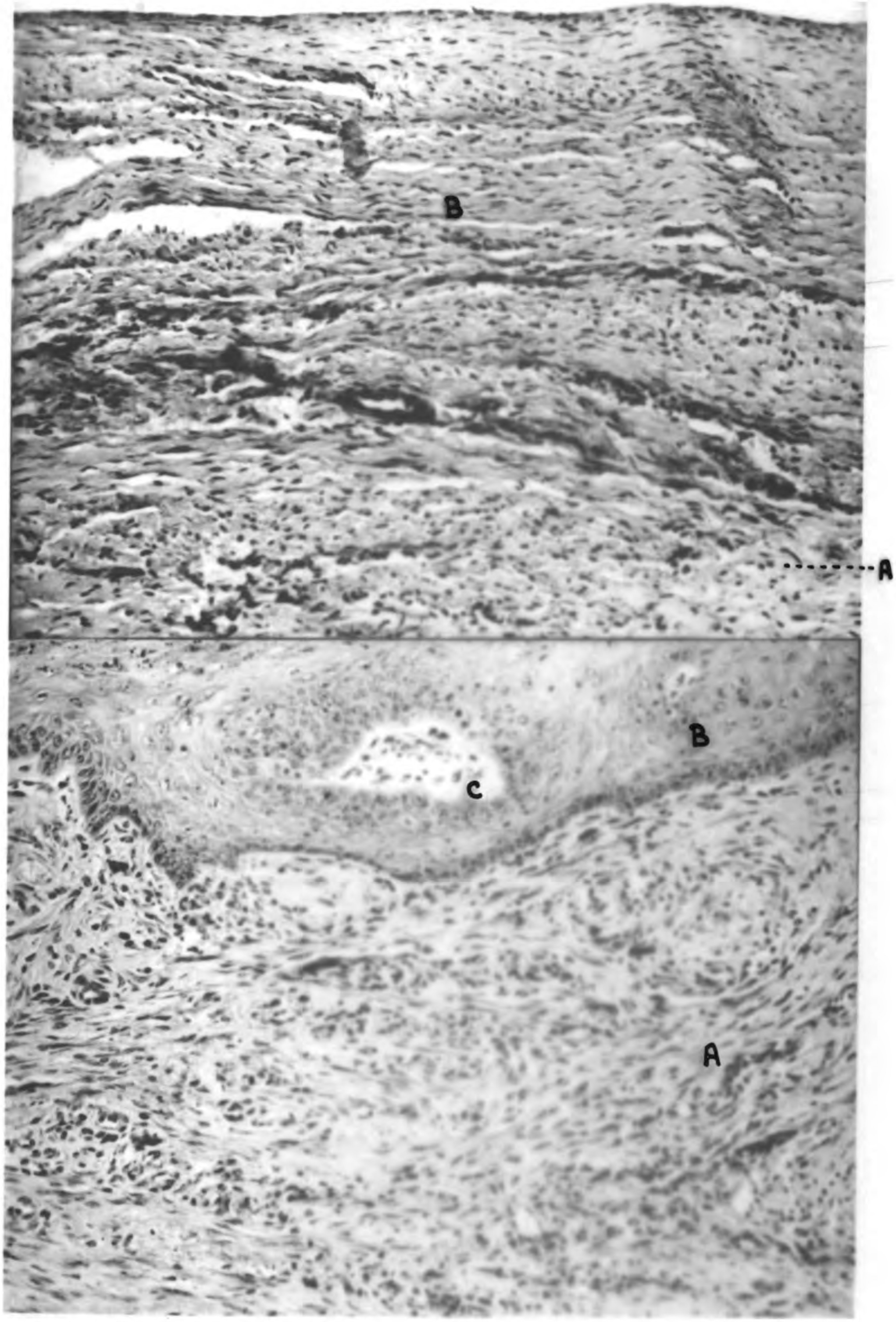
Figure 23. Transverse section of transplanted skin from dog 2.

A. Fibroblast

B. Stratified squamous epithelial cells

C. Cyst (X75 H&E)

Figure 22



CHAPTER V

DISCUSSION, SUMMARY AND CONCLUSIONS

A. Discussion

An experimental study of replacement of the ruptured anterior cruciate ligament with various materials was performed. In this study, the tendon of the peroneus longus muscle, skin and a strip of fascia lata were inserted as substitutes.

The tendon was obtained from the lateral side of the leg. In the first few dogs, a longitudinal one inch incision was made just above its attachment on the fifth metatarsal bone. In later experiments, a half inch transverse incision was used which reduced the time of operation as it required only two stitches to close the incision.

In the first series, both ends of the tendon were cut and then it was grafted in the joint. Difficulty was experienced in anchoring both ends of the tendon, and maintaining it taut. Later on, in the second series it was decided not to cut the proximal end. The tendon was pulled through the joint and the cut end was anchored to the joint capsule and the patellar tendon. This method kept the transplanted tendon taut and reduced the surgical time.

Three weeks after the splint was removed, the knee joint was examined for anterior drawer movement, which was found to be present in all dogs. Early in the study, a dog was sacrificed and the joint was opened by reflecting the patella upwards. It was noticed that the attachment of the tendon on the lateral femoral condyle was anterior to the original cruciate ligament attachment. On the tibia, the attachment was central rather than medial. Instead of crossing the joint obliquely, the transplanted tendon crossed more or less in a straight line. These abnormal attachments caused anterior drawer movement of the tibia and lameness to some extent. In the succeeding operations, care was taken to drill the hole posteriorly in the femoral condyle. In the tibia, the hole was drilled in such a way that it emerged more medially. In this way, the tendon was more oblique in its passage through the joint and more nearly approached the true position of the anterior cruciate ligament.

All dogs were kept in kennels with concrete floors. During cleaning, this concrete floor provided slippery footing due to water. A slippery surface along with other mechanical factors were responsible for constant trauma to the operated joint.

Dogs with arthritic and degenerative changes showed lameness and crepitation in the joint. In dog 8, the transplanted tendon contained cartilagenous cells which evidently signified that the tendon was undergoing a change. In the histological study of the tendon from dog 12, a partial cuboidal epithelial covering was noticed which might have been derived from the synovial membrane. No significant tissue reactions were seen in any of the dogs where vetafil was used to suture the joint capsule. Each graft was anchored firmly in the drilled holes in the bone except in dog 7, where the tendon was loose in the tibial hole. The hole was opened and no impregnation of bony tissue into the tendon was noticed. This condition may be caused by either smooth tissue around the tendon or by the tendon sheath. On post mortem, the grafted tendon looked alive but edematous. It was oblique, but not so taut as the original ligament. The tendon graft showed superiority over the skin or fascial strip, as it resembled the ligament histologically, and had more tensile strength than fascia and skin.

B. Summary and Conclusions

In this study, the anterior cruciate

ligament was cut surgically and various materials inserted as substitute. In 15 dogs, the tendon of the peroneus longus muscle was used while in two dogs a strip of skin and in two dogs a strip of fascia lata were inserted.

A Thomas splint was prepared according to the size of the dog and the leg was fixed in the splint for three weeks postoperatively. Most of the dogs after eight weeks did not show lameness while walking and running, but did show varying degrees of anterior drawer movement of the tibia. Mechanical factors as a concrete floor in the kennels and jumping of the dogs from the top kennels were causes of constant trauma to the operated joint. Relative superiority was exhibited by the tendon due to its greater tensile strength over the skin and fascia. A comparative study of histological structures of normal and transplanted tissue was also performed. The peroneus longus tendon was histologically similar to the anterior cruciate ligament.

On the basis of the present data, the following conslusions were drawn:

1. Transplantation of the tendon in the knee joint exhibited superiority over fascia and skin. The tendon with the

proximal attachment intact was easier to anchor and was more tense than the tendon cut from both its attachments.

2. Because the anterior cruciate ligament has broad attachments on the femur and the tibia, and also a half twist lengthwise, it is regarded as impossible to replace completely the ligament by any of these tissues.
3. Mechanical factors are also responsible in making it impossible to replace the anterior cruciate ligament completely in the dog.

BIBLIOGRAPHY

1. Anderson, R. L.: The repair of knee ligaments by cutis graft transplants. J. Bone & Joint Surg., 38(A), (1956): 1369-1378.

2. Armistead, W. W.: The experimental use of skin autografts intraperitoneally. Plastic & Reconstructive Surgery, 18,(1956): 9-29.

3. Battle, W. H.: A case of suture of the crucial ligaments after section of the knee joint for irreducible traumatic dislocation. Clinical Society's Transactions, 33,(1900): 232-233.

4. Blair, H. C.: A simple operation for stabilization of the knee joint. Surg., Gynec. & Obst., 74,(1942): 855-859.

5. Bosworth, D. M. and Boardman, M.: Use of fascia lata to stabilize the knee in case of ruptured crucial ligaments. J. Bone & Joint Surg., 18,(1936): 178-179.

6. Campbell, W. C.: Repair of the ligaments of the knee. Report of a new operation for repair of the anterior cruciate ligament. Surg., Gynec. & Obst., 62,(1936): 964-968.

7. Carrell, W. B.: Use of fascia lata in knee stability. J. Bone & Joint Surg., 19,(1937): 1018-1026.

8. Colonna, P. C.: <u>Regional Orthopedic Surgery</u>. 1st. Ed., W. B. Saunders Co., Philadelphia, 1950.

9. Copenhaver, W. M. and Johnson, D. D.: <u>Bailey's Text Book of Histology</u>. The Williams and Wilkins Co., Baltimore, 1953.

10. Cubbins, W. R., Conley, A. H., Callahan, J. J. and Scuderi, C. S.: A new method of operating for the repair of ruptured cruciate ligaments of the knee joint. Surg., Gynec. & Obst., 54, (1932): 299-306.

11. Cubbins, W. R., Callahan, J. J. and Scuderi, C. S.: Cruciate ligament injuries. Surg., Gynec. & Obst., 64,(1937): 218-225.

12. ______________________: Cruciate ligaments. A resume of operative attacks and results obtained. Am. J. Surg., 43,(1939): 481-485.

13. DePalma, A. F.: Disease of the Knee Joint. 1st. Ed., J. B. Lippincott Co., Philadelphia, 1954.

14. Eikenbary, C. F.: A suggested method for repair of crucial ligaments of the knee. Surg., Gynec. & Obst., 45,(1927): 93-94.

15. Fairhank, H. A. T.: Congenital absence of crucial ligaments. Results after fascial graft. Proc. Roy. Soc. Med., 23(3),(1930): 257-259.

16. Ficarra, B. J.: Emergency Surgery. 1st. Ed., F. A. Davis Co., Philadelphia, 1953.

17. Forrester, C. R. G.: Rupture of the crucial ligaments in the knee joint. Am. J. Surg., 4,(1928): 323-327.

18. Fried, A. and Hendel, C.: Paralytic valgus deformity of the ankle. Replacement of the paralyzed tibialis posterior by the peroneus longus. J. Bone & Joint Surg., 39(A),(1957): 921-932.

19. Gibbens, R.: Patellectomy and a variation of Paatsama's operation on the anterior cruciate ligament of a dog. J.A.V.M.A., 131,(1957): 557-558.

20. Greep, R. O.: Histology. 1st. Ed., The Blakiston Co., Inc., New York, 1954.

21. Guyer, M. F.: Animal Micrology. 1st Ed., University of Chicago Press, Chicago, 1891.

22. Hauser, E. D. M.: Extra articular repair of ruptured cruciate and collateral ligaments. Surg., Gynec. & Obst., 84,(1947): 339-345.

23. Helfet, A. J.: Function of cruciate ligaments of the knee joint. Lancet, 254,(1948): 665-667.

24. Herdon, C. H. and Chase, S. W.: Experimental studies in the transplantation of the whole joints. J. Bone & Joint Surg., 34(A), (1952): 564-578.

25. HeyGroves, E. W.: Operation for the repair of the crucial ligaments. Lancet, 2,(1917): 674-675.

26. ______________: The cruciate ligaments of the knee joint. Brit. J. Surg., 7,(1919): 505-515.

27. Johnson, E., Andrews, F. N. and Shrewsbury, C. L.: The preparation of muscular tissue for histological study. J. Am. Sc., 2,(1943): 244-250.

28. Jonas, K. C.: Babcock's Principles and Practice of Surgery. 2nd. Ed., Lea and Febiger, Philadelphia, 1954.

29. Jones, R. and Smith, A. S.: On rupture of the crucial ligaments of the knee and on fracture of the spine of the tibia. Brit. J. Surg., 1,(1913): 70-89.

30. Kernvecin, G. A.: A study of tendon implantation in bone. Surg., Gynec. & Obst., 75,(1942): 794-796.

31. Key, J. A. and Conwell, H. E.: Fractures, Dislocations and Sprains. 2nd. Ed., The C. V. Mosby Co., St. Louis, 1937.

32. Lee, H. G.: Avulsion fracture of the tibia attachment of the crucial ligament. J. Bone & Joint Surg., 19(A),(1937): 460-468.

33. Macey, H. B.: A new operative procedure for repair of ruptured cruciate ligaments of the knee joint. Surg., Gynec. & Obst., 69, (1939): 108-109.

34. Markowitz, J.: Experimental Surgery. 3rd. Ed., The Williams and Wilkins Co., Baltimore, 1954.

35. MayoRobson, A. W.: Ruptured crucial ligaments and their repair by operation. Ann. Surg., 37,(1903): 716.

36. Miller, M. E.: Guide to the Dissection of the Dog. 3rd. Ed., Ithaca, New York, 1952.

37. Nilson, F.: Meniscal injuries in dogs. North Am. Vet., 30,(1949): 509-516.

38. O'Donoghue, D. H.: Surgical treatment of fresh injuries to the major ligaments of the knee. J. Bone and Joint Surg., 32(A),(1950): 721-738.

39. Paatsama, S.: Ligament injuries in the canine stifle joint. A Clinical and experimental study. (Thesis), Helsinki, 1952.

40. Peer, L. A.: Transplantation of Tissue. 1st. Ed., The Williams & Wilkins Co., Baltimore, 1955.

41. Schnelle, G. B.: Osteoarthritis and osteomyelitis. North Am. Vet., 22,(1941): 220-225.

42. Schroeder, E. F. and Schnelle, G. B.: Stifle injuries. North Am. Vet., 17,(1936): 43-53.

43. ________________: The stifle joint. North Am. Vet., 22,(1941): 353-360.

44. Sisson, S. and Grossman, J. D.: The Anatomy of the Domestic Animals. 4th Ed., W. B. Saunders Co., Philadelphia, 1956.

45. Smith, A.: Diagnosis, treatment of injuries of cruciate ligaments. Brit. J. Surg., 6,(1918): 176-189.

46. Soevr, R.: The synovial membranes of the knee in pathological conditions. J. Bone & Joint Surg., 31(A),(1949): 317-340.

47. Speed, J. S.: Campbell's Orthopedics. 3rd. Ed., The C. V. Mosby Co., St. Louis, 1956.

48. Titkemeyer, C. W. and Brinker, W. O.: Applied anatomy of the stifle joint. M.S.U. Vet., 18,(1958): 84-88.

49. Trautman, A. and Fiebeger, J.: Fundamentals of the Histology of Domestic Animals. Comstock Publishing Associates, Ithaca, New York, 1952.

50. Valls, J.: Rupture of the lateral ligament of the knee joint. Am. J. Surg., 43,(1939): 486-491.

51. Wagner, L. C.: Fracture of lateral condyle of femur associated with tearing of anterior cruciate ligament. Am. J. Surg., 8,(1930): 623-626.