EXTRA-ARTICULAR RECONSTRUCTION OF CRANIAL CRUCIATE LIGAMENT IN DOGS: AN EXPERIMENTAL STUDY.

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ABSTRACT

This study was carried out on the right stifle joint of thirty-five clinically healthy adult dogs of both sexes, aging from 1 - 3 years old. The cranial cruciate ligamen of the right stifle joint of all animals were severed after lateral arthrotomy. The dogs were classified into three groups. Group I (Control group = 5 dogs). Group IIA (Modified Lateral Fabellar Suture = 15 dogs). In this group, the nylon monofilament fishing line was used in the form of self-locking knot beside square knot around the fabella. The fishing line passed through the tibial crest drilled hole. Group IIB (Popliteal Tendon Transposition = 15 dogs). In this group, the popliteal muscle tendon with its sesamoid bone were transposed with nylon suture No. 5 using a Krackow suture and then passed through the tibial crest drilled hole. The suture in the medial side of the tibia was fixed by stainless steel endobutton. Dogs were examined at Zero time, 1 months, 2 months, 3 months and 6 months postoperatively. Clinical findings were joint effusion, lameness, periarticular thickening and quadriceps atrophy.
Radiographic, clinicopathological and histopathological examinations were performed to evaluate the study. Group IIB have better results than group IIA.

INTRODUCTION

Rupture of the cranial cruciate ligament (CrCL) is one of the most common orthopedic injuries involving the canine stifle joint.

Once the ligament has ruptured the stifle joint becomes unstable. The degree of instability varied in cases with partially or completely torn ligament, and the nature of the tear (acute or chronic). An inflammatory environment is created by the injury and the subsequent instability of the stifle joint. If the stifle joint remains unstable, progressive degeneration of the articular cartilage, meniscal damage and periarticular osteophyte production will result. Surgical management of this condition focuses on restoration of joint stability, as well as limiting cranial drawer movement and excessive tibial rotation ***(Brinker, Piermattei and Flo, 1990; Scavelli, Schrader, Matthiesen and Skorup, 1990; Johnson and Johnson, 1993 and Moore and Read, 1996).***

The surgical procedures for cruciate ligament repair could be either intra- or extra-articular techniques. The extra-articular techniques aim to stabilize the joint by tightening extra-articular structures ***(Newton and Nunamaker, 1985).***

The aim of this work is to assess cranial cruciate ligament reconstruction using two different extra articular techniques (Modified Lateral Fabellar Suture technique and Popliteal Tendon Transposition technique), as well as to evaluate the suitable time for surgical reconstruction surgically in dogs.

MATERIALS & METHODS

The present study was carried out at the department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Suez Canal University. Thirty-five apparently healthy adult mongrel dogs of both sexes aged from 1-3 years old were used in the present study. The dog's weight ranged between 13-26 Kg. The CrCL of the right stifle of all animals were severed after lateral arthrotomy. The animals were assigned into two main groups: *Group I* consisted of five dogs and were left without reconstruction. *Group II (extra-articular reconstruction);* consisted of 30 dogs which were operated using extra-articular reconstruction of the severed CrCL. This group was subdivided into two equal groups:

Group II A; where, CrCL was reconstructed using Modified Lateral Fabellar Suture technique according to ***McKee and Miller, (1999)*** and *Group II B;* where, CrCL was reconstructed using Popliteal Tendon Transposition technique according to ***Monnet, Schwarz, and Powers (1995)*.** Each sub group of fifteen dogs was divided into three equal subgroups as illustrated in ***Fig. (1)*** based on the starting time of reconstruction.

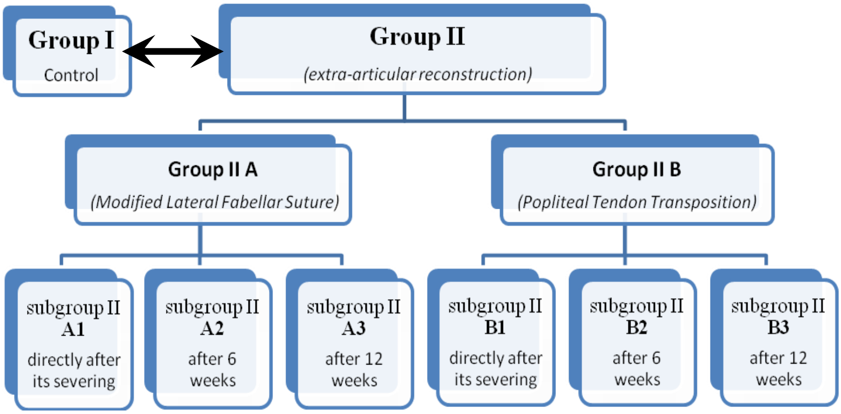
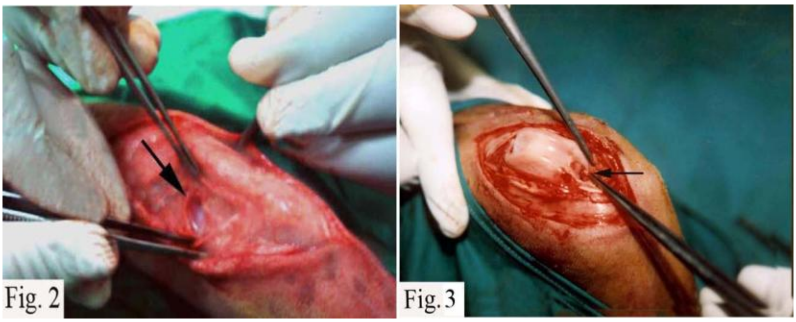


Fig. (1): **A diagram showing different groups and subgroups used in this study.**

Before surgery, each dog was pre-medicated with chlorpromazine hydr-ochloride and general anesthesia was conducted with thiopental sodium 2.5% solution. Then dogs were restrained in dorsal recumbency.

<u>The CrCL severing:</u>

The joint capsule was incised ***(Fig. 2)***, the patella was deviated medially, and then stifle joint was semiflexed to expose the cruciate ligaments. The cranial cruciate ligament would be transected by a fine scissor and a 0.25 cm section was removed ***(Fig. 3)***. The joint capsule was then closed in a simple interrupted manner using 3/0 coated vicryl.



Severing of CrCL technique; *Fig. (2):* The start of joint capsule incision. *Fig. (3):* Distal stump of CrCL after its transection (arrow)

<u>Modified Lateral Fabellar Suture technique (Group II A):</u>

The biceps femoris muscle was dissected from the joint capsule surface laterally and caudally to expose the lateral fabella ***(Fig. 4)***.

Nylon fishing line passed under the lateral femoro-fabellar ligament, then around the fabella leaving a small loop ***(Fig. 5 and 6)***.

The fishing line then passed under the patellar ligament toward its insertion. The proximal part of the cranial tibial muscle was elevated to expose the tibial tuberosity ***(Fig. 7)***.

A hole was drilled in the tibial tuberosity and the two ends of the suture material passed through this hole to exit laterally. The ends of material that came from the tibial tuberosity hole passed through the loop from lateral to medial.

Proximo-caudal traction on the two ends could reduce the size of the loop. The direction of the traction was then reversed toward the tibial tuberosity (disto-cranially) ***(Fig. 8)***.

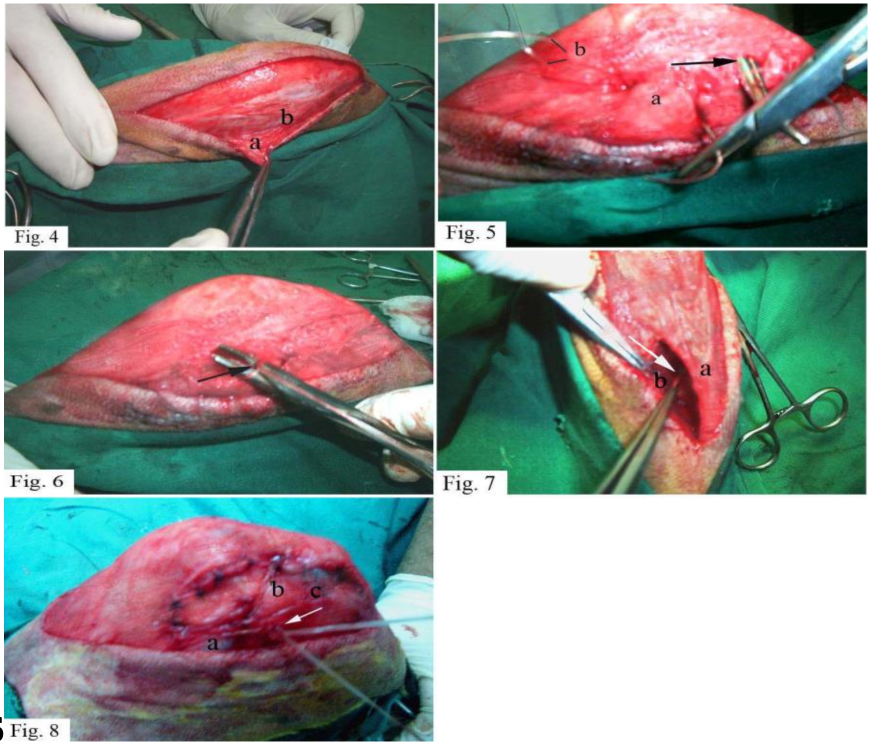
Tension on the fabellotibial suture was increased by applying disto-cranial traction and simultaneously tightening the first throw. When the suture was tightened sufficiently, four additional square throws were applied to the knot. The same technique was performed in the medial side to the medial fabella for two dogs, which were 24 and 26 kg body weight from the subgroup II A3 and subgroup II A1 respectively. The cranial edge of the biceps fascia incision was sutured to the patellar ligament.

<u>Popliteal Tendon Transposition technique (Group II B):</u>

The tendon of the popliteal muscle was bluntly dissected and isolated from the overlying collateral ligament ***(Fig. 9)***. The tendon was then transected at the point distal to the level of the sesamoid bone and dissected free from the underlying joint capsule. The proximal part of the cranial tibial muscle was elevated to expose the tibial tuberosity. A No. 5 Nylon suture was placed in the distal part of the tendon, proximal to the sesamoid bone of the popliteal tendon, using a Krackow pattern ***(Fig. 10)***.

The suture was then passed through a tunnel drilled in the tibial tuberosity ***(Fig. 11)***. The Krackow suture was tightened through a stainless steel endobutton on the medial side of the tibial tuberosity ***(Fig. 12)***.

The suture was tightened until the cranial drawer motion was completely eliminated.



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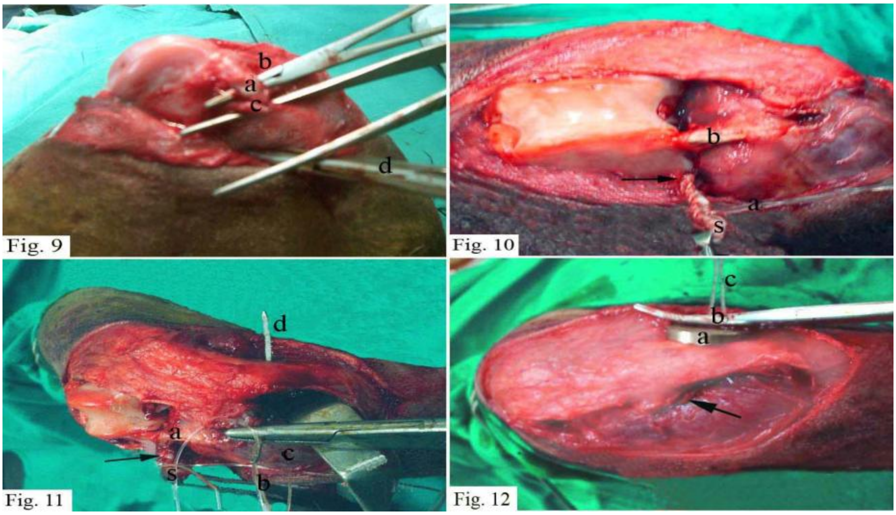
Technique of modified lateral fabellar suture: *Fig. (4):* Skin incision with dissection at biceps femoris (a) over the lateral fabella (b). *Fig. (5):* Lateral fabella (a), fishing line loop passing under the lateral fabella (b) and artery forceps to facilitate passing fishing line under common patellar tendon (arrow). *Fig. (6):* Fishing line loop over the lateral fabella (arrow). *Fig. (7):* Tibial crest (a), cranial tibial muscle (b) and periosteal reflection before drilling. *Fig. (8):* Lateral fabella (a), fishing line under the common patellar tendon (b), fishing line above cranial tibial muscle (c) and self locking knot (arrow).

The operated limb was placed in a soft padded bandage (Robert-Jones bandage) for two weeks.

Systemic antibiotic was administrated (Gentamicin 3 mg/kg I.M. once daily for five successive days).

Morphine was injected S/C as analgesic in a dose of 0.1 mg/kg once daily for three days postoperatively. A single dose of α-chymotrypsin was used for each dog immediately after operation in a dose of 5 mg I.M. The dogs were housed individually and their activity was limited to mild exercise and a leash walks only for 4 weeks as physiotherapy.



Technique of popliteal tendon transposition; *Fig. (9):* Popliteal tendon (a), long digital extensor tendon (b), lateral collateral tendon (c) and artery forceps catching musclotendenious junction of popliteal muscle (d). *Fig. (10):* Popliteal tendon after dissection (arrow), No.5 Nylon after forming the krackow suture (a), long digital extensor tendon (b) and popliteal sesamoid bone (s). *Fig. (11):* Popliteal tendon (arrow), long digital extensor tendon (a), No.5 Nylon suture material (b), cranial tibial muscle (c), needle passed through the predrilled tibial crest hole (d) and popliteal sesamoid bone (s). *Fig. (12):* Stainless steel endobutton (a), artery forceps to increase tension (b), No.5 Nylon suture after passed through endobutton (c) and No.5 Nylon suture passed above the cranial tibial muscle (arrow).

Dogs were examined (zero time, one month, two months, three months and six months) for the levels of stifle joint effusion, peri-articular thickening, quadriceps m-uscle atrophy, and degree of lame-ness or instability of each stifle joint. A four-point Likert scale [none (0), mild (1), moderate (2), severe (3)] was used to assess the pervious items ***(Innes and Barr, 1998 a).***

The cranial drawer test was performed as follows the dog was relaxed with a sedative or anaesth-etized to avoid false result. The stifle was held in flexion and was grasped at the distal femur and held firmly with the index finger of one hand on the patella and the thumb behind the lateral fabella, while the other hand was placed with the index finger on the tibial tuberosity and the thumb behind the fibula. With the femur held steady, the other hand glided the tibia cranially and caudally in relationship to the femur. Cranial displacement of the tibia was a positive sign indicating CrCL rupture according to ***Fossum, Hedlund, Hulse, Johnson, Seim, Willard and Carroll (2002)***.

According to ***Mullen and Mathiesen (1989),*** walking was graded as following: Excellent (no lameness, even after exercise); Good (transient lameness after exercise); Fair (intermittent lameness with normal activity); and Poor (chronic, persistent lameness).

Radiographic changes were evaluated with "mediolateral and craniocaudal" views at zero time, one month, two months, three months and six months. The changes were graded according to ***Mullen and Mathiesen, (1989)*** as following: Mild (evidence of periarticular osteophyte formation); Moderate (periarticular osteophytes and bony sclerosis); and Marked (peri and intra-articular osteophytes, bony sclerosis and subchonderal cysts).

Synovial fluid was aspirated from the femoro-tibial joint before and at zero time, one month, two months, three months and six months postoperatively, for total and differential cell counts ***(Innes and Barr, 1998 b).***

The animals were sacrificed by the use of an overdose of thiopental sodium injected IV.

Specimens were collected from synovial membrane of the medial surface of the operated stifle joint capsule, sesamoid bone of the popliteal muscle tendon graft, articular cartilage, menisci, graft-bone junction, and tissue reaction around fishing line suture materials or around endobutton. The specimens were collected at one month, two months, three months and six months after reconstruction and placed in 10 % formalin for at least 24 hours. Tissue specimens were thoroughly washed in tape water, dehydrated in serial ascending grades of alcohol, cleared in zylol, then embedded in paraffin wax, sectioned and stained with hematoxylin and eosin ***(Jackson, Vasseur, Griffey, Walls, and Kass, 2001).***

The significance of differences between means was compared at each subgroup using Duncan's multiple range test after ANOVA for one-way classified data ***(Snedecor and Cochran, 1989).***

RESULTS

In all dogs, recovery from anesthesia was uneventful. During the first week after surgery, all operated limbs suffered from severe degree of joint effusion ***(Fig. 13)***. The joint effusion was gradually subsided in group II by the 2^{nd} month after surgery, while dogs of control group had a mild degree of joint effusion.

Dogs of the control group showed severe degree of lameness. The severity of lameness waxed and waned over time. A clicking sound could be felt when the joint extended. The joint was tender with palpation during passive movement and the dogs could not bear their weights on the operated limbs at first week with internal rotation of the tibia and external deviation of the hock. After two weeks, the dogs could bear their weights on the limbs, walk and trot with slight struggling. The cranial drawer movement of the tibia appeared positive all-over the study period. In group II, the degree of lameness was so progressively improved that became good to excellent at the end of the 6^{th} months after reconstruction. Stifle joints were found to have normal range of motion, without instability, and with markedly reduced internal rotation of the tibia. In general, the degree of motion in this group had improved from the good to the excellent by the 3^{rd} month after reconstruction. All dogs of group IIB reached the excellent degree of motion by the end of the 3^{rd} month while one third from those of group IIA reached the excellent degree by the 3^{rd} month after reconstruction ***(Table 1)***. One case of the subgroup II B1 developed seroma over the stainless steel endobutton which retarded the improvement of the lameness degree ***(Fig. 14).*** This seroma subsided spontaneously after 2 months.

Table 1: Degree of lameness all-over postoperative period (according to Lickert scale).

Groups	1st month	2nd month	3rd month	6th month
I	3^a	3^a	3^a	3^a
II A1	1.2 ± 0.2^b	0.25 ± 0.25^b	0^b	0^b
II A2	1.4 ± 0.245^c	0.5 ± 0.289^c	0.66 ± 0.33^c	0.5 ± 0.5^c
II A3	1.4 ± 0.245^c	0.5 ± 0.289^c	0.66 ± 0.33^c	0.5 ± 0.5^c
II B1	1.2 ± 0.2^b	0.25 ± 0.25^b	0^b	0^b
II B2	1.4 ± 0.245^c	0.5 ± 0.289^c	0^b	0^b
II B3	1.4 ± 0.245^c	0.5 ± 0.289^c	0^b	0^b
L.S.D 0.05	0.19	0.23	0.20	0.33
L.S.D 0.01	0.26	0.31	0.28	0.47

Likert scale: degree of lameness (Mean ± SE) of the operated limb (None = 0 = Excellent = [0-0.5]; Mild = 1 = Good =]0.5-1.5]; Moderate = 2 = Fair =]1.5-2.5]; Severe = 3 = Poor =]2.5-3]). Values having different letters in the same column were significantly different.

Five dogs (14.3%) developed medial patellar luxation after 2 months of surgery (one from control group, two from subgroup II A3, and two from subgroup II B3) ***(Fig. 15 a&b)***.

In control group, periarticular thickening progressively increased from moderate to sever degree all-over the study period. In group II, periarticular thickening progressively decreased from moderate to mild degree ***(Table 2)***.

In control group, quadriceps atrophy increased from mild to severe degree at the end of the study. In group II, there was no quadriceps atrophy ***(Table 2)***.

Table 2: Periarticular thickening and quadriceps atrophy (according to Lickert scale).

Item	Periarticular thickening				Quadriceps atrophy			
Group	**1st month**	**2nd month**	**3rd month**	**6th month**	**1st month**	**2nd month**	**3rd month**	**6th month**
I	2	2	3	3	1	2	3	3
II A1	1	1	1	1	0	0	0	0
II A2	1	1	1	1	0	0	0	0
II A3	1	1	1	1	0	0	0	0
II B1	1	1	1	1	0	0	0	0
II B2	2	1	1	1	0	0	0	0
II B3	2	1	1	1	0	0	0	0

Likert scale: Ranks of periatricular thickening (None = 0 =; Mild = 1 =] 0-0.5] cm; Moderate = 2 =] 0.5-1] cm; Severe = 3 = 2< cm) and ranks of quadriceps atrophy in the operated stifle (None = 0 = 0 cm; Mild = 1 =] 0-0.5] cm; Moderate = 2 =] 0.5-2] cm; Severe = 3 = 2< cm).

Radiographically, in control group, the stifle showed increased joint space between femur and tibia than non-operated stifle ***(Fig. 16)***. There were also mild radiographic changes at the 3rd month after severing of the CrCL. While at the 6th month post-operative, dogs showed moderate radiographic changes ***(Fig. 17)***. In group II, there were no evidence of radiographic changes at any time after surgery.

The baseline mean total leuckocytic count in synovia of the dog's stifle joint ranged from 800-2000 $\times 10^6$/L. In control group, the total leuckocytic count was high all-over the study period (4000 to 5200 $\times 10^6$/L). In group II, the total leuckocytic count was high in the 1st and 2nd months post reconstruction (2400 to 3800 $\times 10^6$/L), while it decreased in the 3rd and 6th months post reconstruction (800 to 2600 $\times 10^6$/L) ***(Table 3)***. In the differential leuckocytic count of all groups, the lymphocyte percent was high (68-76) %, while neutophil percent didn't exceed 36 % all-over the study period.

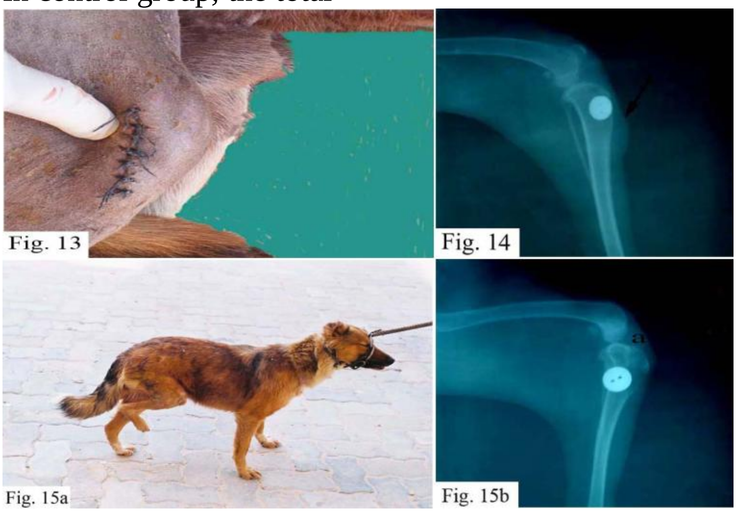


Fig. (13): **A dog from subgroup II A1 showing joint effusion one week after surgery.** ***Fig. (14):*** **Lateral radiogram of a dog stifle joint from the group II B1 after one month with seroma.** ***Fig. (15a):*** **A dog from the group IIB3 suffering from right medial patellar luxation.** ***Fig. (15b):*** **Lateral radiogram of an operated stifle joint from the group IIB3 after medial patellar luxation.**

In control group, the tearing of medial meniscus developed after 6 months from the severing of the CrCL ***(Fig. 18)***. Microscopically, medial meniscus after 6 months showed fragmentation, collagen fibers disorganization, new capillary formation and edema with degeneration of the large blood vessel. Chondrocytes were mostly few and could be seen with necrotic changes. There were rare mononuclear inflammatory cells as lymphocytes and plasma cells ***(Fig. 19)***. The cartilage fibrillation progressed by time after the CrCL transection.

Fig. (16): **Lateral radiogram of a stifle joint at zero time after CrCL severing showing wide joint space (arrow).** ***Fig. (17):*** **Lateral radiogram of severed CrCL stifle joint in a dog from the control group after 6 months showing femoral trochlear ridge's osteophytes of moderate degree (arrow).**

Table 3: Synovial Total Leuckocytic Count (Mean ± SE) all-over postoperative period.

Groups	1st month	2nd month	3rd month	6th month
I	5200 ± 141^{a}	4950 ± 95.7^{a}	4000 ± 115^{a}	4200 ± 200^{a}
II A1	3200 ± 141^{b}	3000 ± 81.6^{b}	1800 ± 115^{b}	1000 ± 105^{b}
II A2	2640 ± 147^{c}	2800 ± 115^{c}	2000 ± 115^{b}	2000 ± 400^{c}
II A3	2720 ± 120^{c}	2900 ± 57.7^{bc}	2200 ± 306^{b}	2000 ± 400^{c}
II B1	3200 ± 126^{b}	2900 ± 129^{bc}	2200 ± 115^{b}	1600 ± 200^{d}
II B2	3320 ± 80^{b}	2900 ± 577^{bc}	2465 ± 353^{bc}	1400 ± 200^{d}
II B3	3400 ± 150^{bd}	3050 ± 698^{bd}	2533 ± 353^{bc}	1600 ± 300^{d}
L.S.D 0.05	255	160.9	419.6	337.3
L.S.D 0.01	339.6	215.6	567.2	470.3

Total Leuckocytic Count was (800-2000) $\times 10^{6}$/L in average of 1400 $\times 10^{6}$/L in baseline; (1000-12000) $\times 10^{6}$/L in average of 3800 $\times 10^{6}$/L in chronic degenerative arthritis; and (4300-182000) $\times 10^{6}$/L in suppurative arthritis. Values having different letters in the same column were significantly different ($P < 0.05$) .

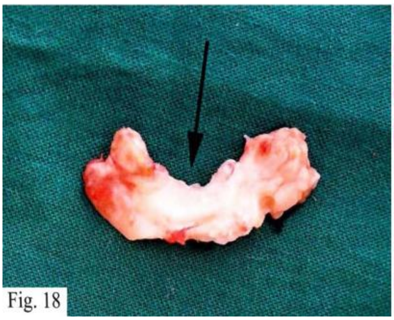


Fig. 18

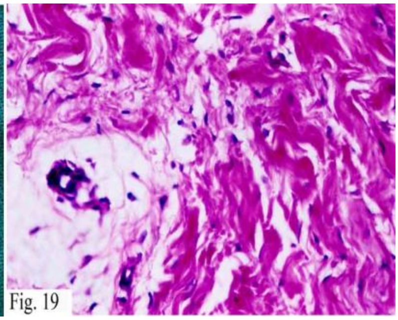
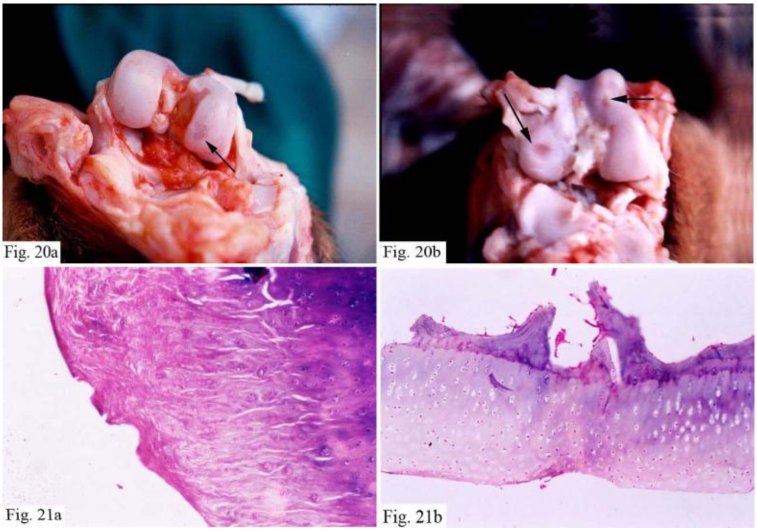


Fig. 19

(Fig. 18): **Medial meniscus of a dog from the control group, 6 months postoperatively showing severe degree of damage (arrow).** ***(Fig. 19):*** **Microscopic appearance of medial meniscus of a dog from the control group after 6 months showing collagen fibers disorganization, fragmentation, new capillary formation and edema. Chondrocytes were mostly few and could be seen with necrotic changes. Rare mononuclear inflammatory cells as lymphocytes and plasma cells were demonstrated. H&E X120.**

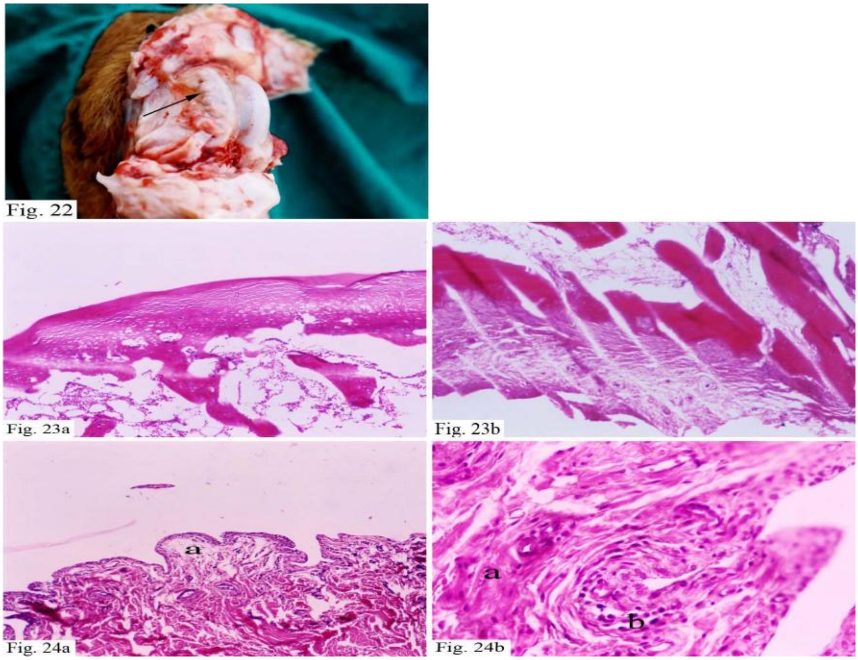


(Fig. 20a): **Femoral articular surface of a dog from the control group after 3 months postoperatively showing mild articular fibrillation (arrow).** ***(Fig. 20b):*** **Femoral articular surface of a dog from the control group 6 months postoperatively showing severe articular fibrillation (arrows).** ***(Fig. 21a):*** **Articular cartilage of the femur of a dog of the control group 6 months showing that the perichondrium became very thick, highly fibrous with irregular eroded surface. H&E X120.** ***(Fig. 21b):*** **Articular cartilage of the femur of a dog of the group II A, 6 months showing normal articular cartilage as regular layer of the perichondrium. H&E X120.**

The common intra-capsular changes after 6 months included tearing and wearing of the articular surface of the femur ***(Fig. 20 a&b)***. Microscopically, articular cartilage of the femur, after 6 months, showed that the perichondrium became very thick, highly fibrous with irregular eroded surface. Some cavities appeared in the mid-zoon ***(Fig. 21 a)***. While articular cartilage of the femur in group IIA after 6 months showed, normal articular cartilage as regular layer of the perichondrium ***(Fig. 21 b)***.

Peri-articular osteophytes were detected, in control group, on the medial and more frequently on lateral femoro-trochlear ridges ***(Fig. 22)***. Osteophytes section after 6 months showed, normal perichondrium ***(Fig. 23 a,b)***. Synovial membrane after 6 months showed, synovial cells hyperplasia. The synovial folds were elongated. There were 5-6 thick synovial cells with underlying loose connective tissue containing numerous capillaries. In group IIB, mild to moderate edema was seen in the joint capsule. Beside the edema, there were mild focal aggregation of lymphocytes and plasma cells ***(Fig. 24 a,b)***.

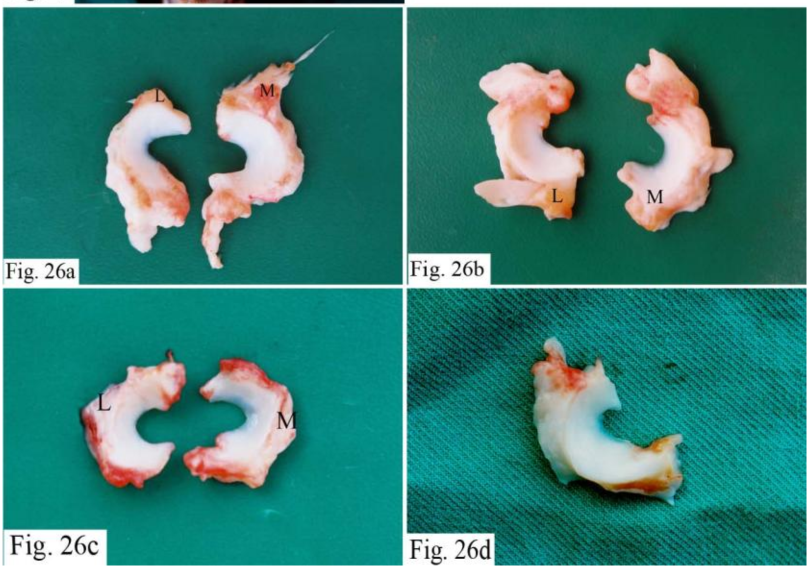
Macroscopically in group II, there were minimal changes in the articular cartilage, especially in group IIA ***(Fig. 25)***. Moreover, no meniscal damage was noticed ***(Fig. 26 (a, b, c& d))***.



(Fig. 22): **A dog from the control group 6 months postoperatively showing intra-articular osteophytes at lateral femoral trochlear ridge (arrow).** ***(Fig. 23):*** **Osteophytes section of an operated stifle from the control group, 6 months showing normal perichondrium (A) H&E X120. High magnification of A (B) H&E X440.** ***(Fig. 24a):*** **Synovial membrane of a dog from the control group 6 months showing synovial cells hyperplasia. The synovial folds were elongated (a). H&E X120.** ***(Fig. 24b):*** **Synovial membrane of a dog from the group II B, 6 months showing 2-3 thick synovial cells, more fibrous synovial membrane less vascular (a) with mild focal infiltration by lymphocytes and plasma cells (b). H&E X440.**

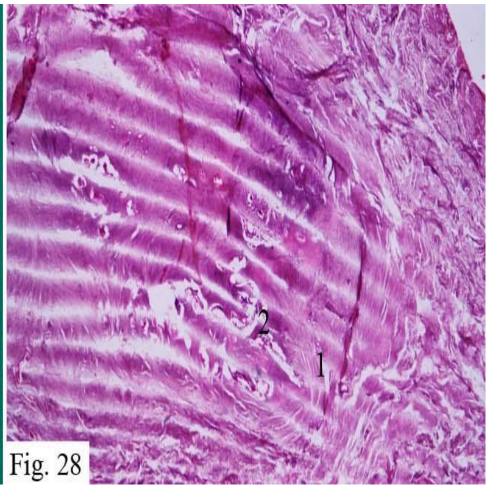
Macroscopically in cases complicated with medial patellar luxation, the medial meniscus was severely affected ***(Fig. 27)***.

Microscopically, area of the sesamoid bone from the group IIB after 6 months showed, remnants of the osseous tissue were present in the supposed site of the popliteal sesamoid bone. Notice that the remnants of the osseous tissue were surrounded with regular bundles of collagen fibers. Remnants of osseous tissue contained some osteoclasts, osteoblasts, osteocytes and some vascular cavities of bone marrow ***(Fig. 28)***.

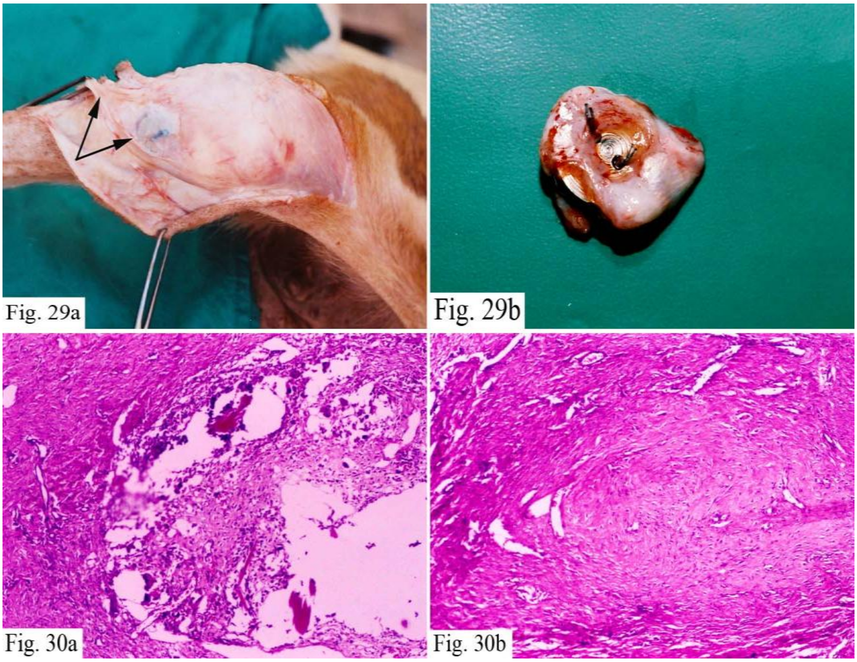


(Fig. 25): **Stifle joint of an euthanatized dog from the subgroup II A1, 6 months postoperatively showing no evidence of articular cartilage fibrillation or osteophytes formation, lateral meniscus (1) and nylon fishing line (2).** ***(Fig. 26a):*** **Lateral (L) and medial (M) menisci from a dog of the subgroup II A1, 6 months postoperatively showing no evidence of meniscal damage.** ***(Fig. 26b):*** **Lateral (L) and medial (M) menisci from a dog of the subgroup II B2, 6 months postoperatively showing no evidence of meniscal damage.** ***(Fig. 26c):*** **Lateral (L) and medial (M) menisci from a dog of the subgroup II A3, 6 months postoperatively showing mild degree of meniscal damage of the medial meniscus (thinning of the surface).** ***(Fig. 26d):*** **Medial meniscus from a dog of the subgroup II B3, 6 months postoperatively showing no evidence of meniscal damage.**

Grossly, tissue reaction covered all around the endobutton ***(Fig. 29 a & b)***. Histopathological finding around the endobutton revealed tissue reaction and mature granulation tissue with massive collagen fibrous formation and spindle shape fibrocytes. Numerous well-developed blood vessels while closed to the endobutton. The fibroblasts were still active with reasonable amount of collagen fibrous and numerous capillaries. There were some inflammatory cells. There was also a tendency for foreign body giant cell formation. The tissue reaction after 2 months in the area of the removed endobutton showed that the gape of the removed endobutton was fully filled with granulation tissue, with regular orientation of the collagen and good vascularization ***(Fig. 30 a & b).***



(Fig. 27): **Lateral (L) and medial (M) menisci from a dog of the medial luxated patella showing severe meniscal damage of the medial meniscus.** ***(Fig. 28):*** **An area of the sesamoid bone of an operated stifle from group II B, 6 months showing remainants of the osseous tissue were present and surrounded with a regular bundles of collagen fibers (1). Remainants of osseous tissue were contained some osteoclasts, osteoblasts, osteocytes and some vascular cavities (2) of bone marrow. H&E X120**.



(Fig. 29a): **A dog from the subgroup II B2, 3 months postoperatively showing increased fibrous tissue formation around the stainless steel endobutton (arrows).** ***(Fig. 29b):*** **Fibrous tissue covering the stainless steel endobutton all around from a dog of the subgroup II B2, 3 months postoperatively.** ***(Fig. 30a):*** **Tissue reaction around the endobutton showing,, mature granulation tissue with spindle shape fibrocytes. Notice that numerous well developed blood vessels. The fibroblasts were still active with reasonable amount of collagen and numerous capillaries. There were some inflammatory cells in this area mainly lymphocytes, macrophages, plasma cells and some neutrophiles. H&E X120.** ***(Fig. 30b):*** **Tissue reaction after 2 months in the area of the removed endobutton showing the gape was fully filled with granulation tissue, with regular orientation of the collagen with good vascularization. H&E X120.**

DISCUSSION

The most important goal for this study was the evaluation of two different surgical techniques belonging to extra articular reconstruction (Modified Lateral Fabellar Suture technique and Popliteal Tendon Transposition technique) with estimation of the best time of surgical interference for CrCL reconstruction.

The cranial cruciate ligament reconstruction in this study was chosen because its rupture is one of the most common orthopedic problems involving the canine stifle joint ***(Johnson and Johnson, 1993; and Moore, and Read, 1996)***.

In this study, the menisci of the stifle joint act as good mirror for joint changes after joint surgery. The medial meniscus was more frequently affected than lateral one in the non surgically managed ruptured CrCL. The damage of that meniscus was more obvious in cases that are more chronic. These results go hand to hand with those reported by ***Ralphs and Whitney (2002)*** in dogs.

In general, the two goals of the CrCL reconstruction were to re-establish normal joint function and resist future damages. The limiting of the internal rotation of the tibia beside the negative test of the tibial drawer against the femur was considered good indication for success in this study. This opinion was similar to reported by ***Smith and Torg (1985)*** in dogs.

In this study, the experimental severing of the CrCL developed severe lameness. All dogs after severing of the CrCL initially had mild degree of lameness. Without reconstruction, the severity of the lameness increased gradually. Six months after severing the CrCL, lameness was in the severest degree. The same results were obtained by ***Scavelli, et al. (1990) and Johnson and Johnson (1993)*** in dogs.

The dogs of the control group showed increase of the stifle joint lameness, effusion, periarticular thickening, quadriceps atrophy, osteophytosis, and cartilage fibrillation, while these complications were less severe in the surgically corrected cases. These results were similar to those reported by ***Elikins, Pechman, Kearney, and Herron, (1991) and Innes and Barr (1998 b)*** in dogs.

Early physiotherapy should be considered as part of the postoperative management to prevent muscle atrophy, build muscle mass and strength, as well as increase stifle joint flexion and extension range of motion. These results agreed with those reported by ***Monk, Preston, and McGowan, (2006)*** in dogs.

The medial patellar luxation developed after experimental severing of the CrCL in dogs as a result of stitches removal by dogs' teeth leading to septic arthritis. This result was supported by ***Smith and Torg (1985) and Innes and Barr (1998 a)*** who recommended application of Elizabethan collars to prevent such complication.

In accordance with ***Timmermann, Meyer-Lindenberg, and Nolte, (1996)***, dogs operated with the Extra-articular techniques showed high rates of normal limb function and walked early without lameness. The Extra-articular stabilization for the CrCL deficient stifle showed minimum joint surface trauma resulting in minimal degenerative changes in the affected stifle joint.

Dogs with modified lateral fabellar suture used the affected limb very early (two weeks postoperatively). This was supported by the early healing and the accompanied physiotherapy. Such result was in agreement with that of ***Ali (2002)*** in dogs.

The popliteal tendon transposition was chosen to replace the fibular head transposition. ***Dupuis, Harari, Papageorges, Gallina, and Ratzlaff, (1994)*** in dogs mentioned that, the most common complication of the fibular head transposition was fracture of the fibular head or neck.

They added also that the postoperative complications were seroma over the pin, cranial drawer instability and tearing of the lateral collateral ligament.

The application of popliteal tendon transposition limited cranial drawer motion and preserved normal internal rotation of the tibia during flexion of the stifle joint. In this technique, the immediate stability of the bone-ligament interface was important. Similar results were obtained by ***Monnet, et al., (1995)*** in dogs.

In this work, nylon suture material was preferable than polyester suture. This material was excellent term of strength while maintaining low bacterial adherence and minimal plastic deformation. This observation agreed with ***Sicard, Meinen, Phillips, and Manley, (1999)*** in dogs.

The Krackow suture pattern, used in this study to anchor the popliteal tendon graft decreased maximum strength and stiffness. These results were supported by ***Monnet, et al., (1995)*** in dogs who reported that, the Krackow suture pattern, used to anchor the popliteal tendon graft decreased maximum strength and stiffness when compared with the locking loop pattern for tenorrhaphy of a flat tendon. The incorporation of the sesamoid bone in the suture pattern prevented slipping of the suture from the tendon and increased the maximum strength.

In agreement with ***Mullen and Matthiesen (1989)*** in dogs, the subcutaneous seroma developed on the medial portion of the tibia adjacent to the stainless steel endobutton. In this study, the developed seroma in one case within one month after surgery would have been related to tissue reaction over the endobutton, which reabsorbed spontaneously.

The synovial leuckocytic count in dogs of the control group was high throughout the study period as the level of non-suppurative arthritis indicating the development of the chronic degenerative disease. While dogs of group II showed high synovial leuckocytic count only at the first period of the study. Thereafter, they gradually returned to approximately normal level. ***Monnet, et al. (1995) and Lumsden (2000)*** supported this result in dogs.

The high percentage of lymphocytes and low percentage of neutrophils in the synovial fluid throughout the study period indicated the development of the chronic degenerative disease without evidence of suppurative arthritis. This result was supported by ***Bennett and Taylor (1988) and Lumsden (2000)***.

In this study, the medial meniscus and articular cartilage in the surgically managed groups showed very mild changes throughout the study period. These results coincided with ***Monnet, et al. (1995)*** who mentioned that, meniscal injury was not evident in their 6 months study. On contrary ***Dupuis, et al. (1994)*** reported that, meniscal damage was reported 25% and 50% of dogs using fibular head transposition during 4 and 10 months study period, respectively. While in control group, there were medial meniscus damage, synovitis with hyperplasia, osteophytes along the abaxial surfaces of the ridges of the trochlear groove and articular cartilage damage. These results were coinciding with ***Innes and Barr (1998b), Jackson, et al., (2001); and Ralphs and Whitney (2002)*** in dogs.

It could be concluded that the early surgical interference of extra-articular reconstruction of the experimentally severed CrCL was better than delayed interference. The popliteal tendon transposition technique was better than modified lateral fabellar suture.

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الملخص العربى

إعادة البناء التجريبى الخارجى للرباط الصليبى الأمامى فى الكلاب "دراسة تجريبية"

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أجريت هذه الدراسة على مفصل الركبة الأيمن لعدد ٣٥ كلب بالغ وسليم من الناحية الإكلينيكية يتراوح عمرها بين (١-٣) سنة. تم قطع الرباط الصليبي الآمامي لكل الكلاب بطريقة الفتح الخارجي للمفصل. حيث قسمت الكلاب المختارة إلى ثلاث مجموعات وهي كالأني: **المجموعة الأولى** (المجموعة الضابطة) مكونة من خمس كلاب، **المجموعة II** أ (خياطة

خارجية مطورة حول الغضروف الليفي السمسمي)**:** استخدم في هذه المجموعة خيط صيد السمك المفرد بعمل عقدة الغلق الذاتي إلى جانب عقدة رباعية حول الغضروف الليفي ألسمسمي، وتم فيها مرور الخيط خلال فتحة في عرف عظمة القصبة بعد مروره تحت وتر الرضفة. **المجموعة II ب** (طريقة تغيير مكان الوتر المأبضي): تم في هذه المجموعة قطع الوتر المأبضي عند الوصلة بين الوتر والعضلة. ثم خياطة الوتر بخياطة كراكوه باستخدام النايلون الأحادي رقم ٥، ثم مرر طرفي الخيط خلال فتحة في عرف عظمة القصبة. وتم تثبيت الخيط على الجهة الداخلية لعظمة القصبة بزرار من الاستانلس استيل. تم الفحص الاكلينيكى في صورة زيادة السائل داخل المفصل، العرج، زيادة حجم الأنسجة حول المفصل، ودرجة ضمور العضلة الرباعية. تم عمل الفحص بالأشعة والفحص الباثولوجي الإكلينيكي والفحص الهستوباثولوجي لتقييم الدراسة. وقد خلصت الدراسة إلى أن استخدام طريقة تغيير مكان الوتر افضل من طريقة خياطة خارجية مطورة حول الغضروف الليفي ألسمسمي كوسيلة لإعادة البناء التجريبى الخارجى للرباط الصليبى الأمامى فى الكلاب.