STABILIZATION OF THE FEMOROTIBIOPATELAR JOINT WITH DOUBLE FIXATION OF THE FASCIA LATA AFTER EXPERIMENTAL RUPTURE OF THE CRANIAL CRUCIATE LIGAMENT IN DOGS

ESTABILIZAÇÃO DA ARTICULAÇÃO FEMOROTIBIOPATELAR COM A FIXAÇÃO DUPLA DA FÁSCIA LATA APÓS RUPTURA EXPERIMENTAL DO LIGAMENTO CRUZADO CRANIAL EM CÃES

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SUMMARY

This study assessed the efficiency of a surgical technique with intra and extracapsular components using autogenous fascia lata graft, fixed at two points, as a technique capable of restoring function of the cranial cruciate ligament and a physiotherapy protocol to assist in post-surgical recovery. Ten healthy dogs weighing between 15 and 22 kg were used. After experimental rupture of cranial cruciate ligament, fascia lata graft was fixed on the lateral femoral condyle using a cancellous screw and washer, and subsequently on the patellar tendon with "X" sutures. All animals underwent physical therapy immediately after surgery until the end of the evaluation, 60 days after surgery. In the first two days they underwent ice therapy. From the 10th day, hot water bottle was applied locally, followed by passive kinesiotherapy and walks that were intensified up to the 60th day. On the 25th day, three limbs load-bearing exercise as introduced, and on the 39th day, the animals were encouraged to climb up and down the stairs. The signs of lameness were more intense in the first 15 days and improved progressively until the last day of evaluation. Thigh and knee diameters were not statistically different before the surgery and during the whole experiment. Motion range reduced immediately after surgery, but increased gradually during the experimental period. Postoperatively, the results of stability tests were always negative. The used technique was capable of restoring the function of the cranial cruciate ligament and the physiotherapy protocol helped to recover the femorotibiopatelar joint function while preventing muscle atrophy and allowing the return of motion range.

KEY-WORDS: Dog. Cranial cruciate ligament. Joint. Knee. Physiotherapy.

RESUMO

O presente estudo teve como objetivo avaliar a eficiência de uma técnica cirúrgica utilizando enxerto da fáscia lata autógena, fixada em dois pontos e um programa fisioterápico para auxiliar na recuperação pós-cirúrgica. Foram utilizados 10 cães hígidos pesando entre 15 e 22 kg. Após a ruptura experimental do ligamento cruzado cranial, o enxerto de fáscia lata foi fixado no côndilo femoral lateral, por meio de um parafuso esponjoso e arruela e, posteriormente, no tendão patelar com suturas em "X". Todos os animais receberam tratamento fisioterápico diário imediatamente após a cirurgia até o fim das avaliações, 60 dias após a cirurgia, que consistiu de aplicação de gelo nos primeiro dois dias. A partir do 10º dia foi feita aplicação de bolsa de água quente seguida de cinesioterapia passiva e caminhadas que foram intensificadas até o 60º dia. No 25º dia foi introduzido o exercício de três apoios e, no 39º dia, os animais foram estimulados a subir e descer escada. Os sinais de claudicação foram mais intensos nos primeiros 15 dias melhorando progressivamente até o último dia de avaliação. Os diâmetros da coxa e do joelho não foram estatisticamente diferentes nos momentos antes da cirurgia e no decorrer de todo o experimento. Houve redução da amplitude de movimento imediatamente após a cirurgia aumentando gradativamente durante o período experimental. No pós-cirúrgico, os resultados dos testes de estabilidade foram sempre negativos. A técnica utilizada foi capaz de restabelecer a função do ligamento cruzado cranial e o protocolo de fisioterapia auxiliou na recuperação da função da articulação femorotibiopatelar, preveniu a atrofia muscular e permitiu o retorno da amplitude de movimentos.

PALAVRAS-CHAVE: Articulação. Cão. Fisioterapia. Joelho. Ligamento cruzado cranial.

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INTRODUCTION

Rupture of the cranial cruciate ligament is considered a multifactorial disease involving genetic, conformational and inflammatory factors that together create an imbalance between the mechanical forces applied to the ligament and its ability to sustain weight (GRIFFON, 2010). The loss on the cranial cruciate ligament causes joint instability, resulting in cranial tibial subluxation (TASHMAN et al., 2004) and can result in injury to the meniscus and osteoarthritis (CHU et al., 2002).

The goal of surgery is to restore joint stability (BOSCHIN et al., 2002) thus slowing down the degenerative disease progress (GAGLIARDO et al., 2008). In addition to the intra- and extra-capsular techniques, the tibial plateau leveling osteotomy (TPLO) and tibial tuberosity advancement (TTA) techniques are based on the principle of neutralizing the shear force (BOUDRIEAU, 2009). The TPLO consists of an expensive, complicated surgical procedure that can result in complications such as prolonged lameness, infection, granuloma, seroma, bleeding, patellar fracture (HARASEN, 2006), avulsion of the tibial tuberosity, the patellar tendon edema, meniscal injury and fibular fracture (TUTTLE & MANLEY, 2009). The most frequent complication related to the TTA is the fracture of the tibial tuberosity, followed by implantation of intra-articular screw and implant loss (MONTOVAN et al., 2002).

Physical therapy increases muscle mass and motion range while reducing atrophy, improving the ability to bear weight and slowing osteoarthritis (CANAPP, 2007). Early start of therapy reduces inflammation, improves homeostasis and joint biomechanics, and maintains the nutrition of cartilage (MONK et al., 2006). Starting immediately after the replacement of the cranial cruciate ligament by the fascia lata neither compromises the integrity of the graft nor changes the joint stability, moreover, it benefits collagen organization and allows the early recovery of the limb (ITO et al., 2007).

This study evaluates the efficacy of the surgical method that uses autogenous fascia lata, with intra- and extra-capsular components, fixed on two points, to the lateral femoral condyle with screw and washer, and to the patellar tendon with sutures in X. In addition, the efficiency of physiotherapy to assist in post-surgical reconstruction of the cranial cruciate ligament is also assessed.

MATERIAL AND METHODS

A total of 10 dogs, five males and five females, healthy, older than 1 year, weighing between 15 and 22 Kg, from the experimental kennel of the Departamento de Veterinária da Universidade Federal de Viçosa, were used. Clinical, haematological and orthopedic examinations including radiographs of hindlimbs were previously performed. The study was approved by the Ethics Committee on Animal Use (CEUA) of the Universidade Federal de Viçosa, under protocol number 272/2011.

To stabilize the femorotibiopatelar joint, a graft was made from a fascia lata flap about 1.5 cm wide, extending from the transition of the fascia lata tensor muscle to the crest of the tibia, over the joint capsule and lateral to the patellar tendon. The proximal portion of the flap was sectioned while the fascia was twisted about its longitudinal axis to a diameter of approximately 5.0 mm.

Subsequently, a lateral parapatellar arthrotomy was performed to allow complete rupture of the cranial cruciate ligament. On this occasion, the menisci were evaluated. Then, through a hole of approximately 1.0 cm, parallel and medial to the patellar tendon, the fascia lata graft was introduced into the joint under the infrapatellar fat pad, mimicking the cranial cruciate ligament insertions, that is, from medial in the tibia to lateral in the femoral condyle. At this time, the free end of the graft was inserted into the hole of a hook-shaped needle which, while crossing the joint, in the craniocaudal-mediolateral direction, pulled the graft until it could be visualized on the side fabela (Figure 1A).

Then, the cancellous bone screw of 4.0-mm diameter and length between 18 and 22 mm, and the washer were inserted into the femoral condyle, immediately below the distal pole of the lateral fabela and under the joint capsule. The femorotibiopatelar joint was positioned at approximately 135° of flexion, the tibia slightly forced caudally to the femur; the graft was pulled and tensioned clockwise 360º around the screw below the washer (Figure 1B). Subsequently, the screw was tightened completely, concluding the intra-articular phase of the proposed technique.

The extra-articular phase consisted of moving the free end of the graft under the patellar tendon in the lateromedial direction (Figure 1C), emerging from the previously made medial hole, followed by the fixation of the patellar tendon with "X" suture stitches using nylon thread 0[3] (Figure 1D). The joint capsule was sutured with interrupted quilting using standard nylon thread 0 and the fascia lata edges with polyglycolic acid thread 2-0[4] in a simple continuous pattern.

Immediately after surgery and every 12 hours for two days, ice packs were applied for 15 minutes around the operated femorotibiopatelar joint. Robert Jones bandages were applied and maintained for ten days.

From the 10th to the 24th day after surgery, a hot water bottle at 37ºC temperature was applied around the operated knee once a day, for 15 minutes. The hot water bottle was pressed in circular motion around the entire joint. During these days, passive kinesiotherapy consisting of slow flexion and extension of the femorotibiopatelar joint, totaling 30 cycles per day, was performed, in addition to a 15-minute light daily walking on flat grassy and sandy soil.

[3] Mononylon 0- Ethicon – São José dos Campos – SP.
[4] Polyglycolic acid 2-0 – Bioline – São Paulo – SP.

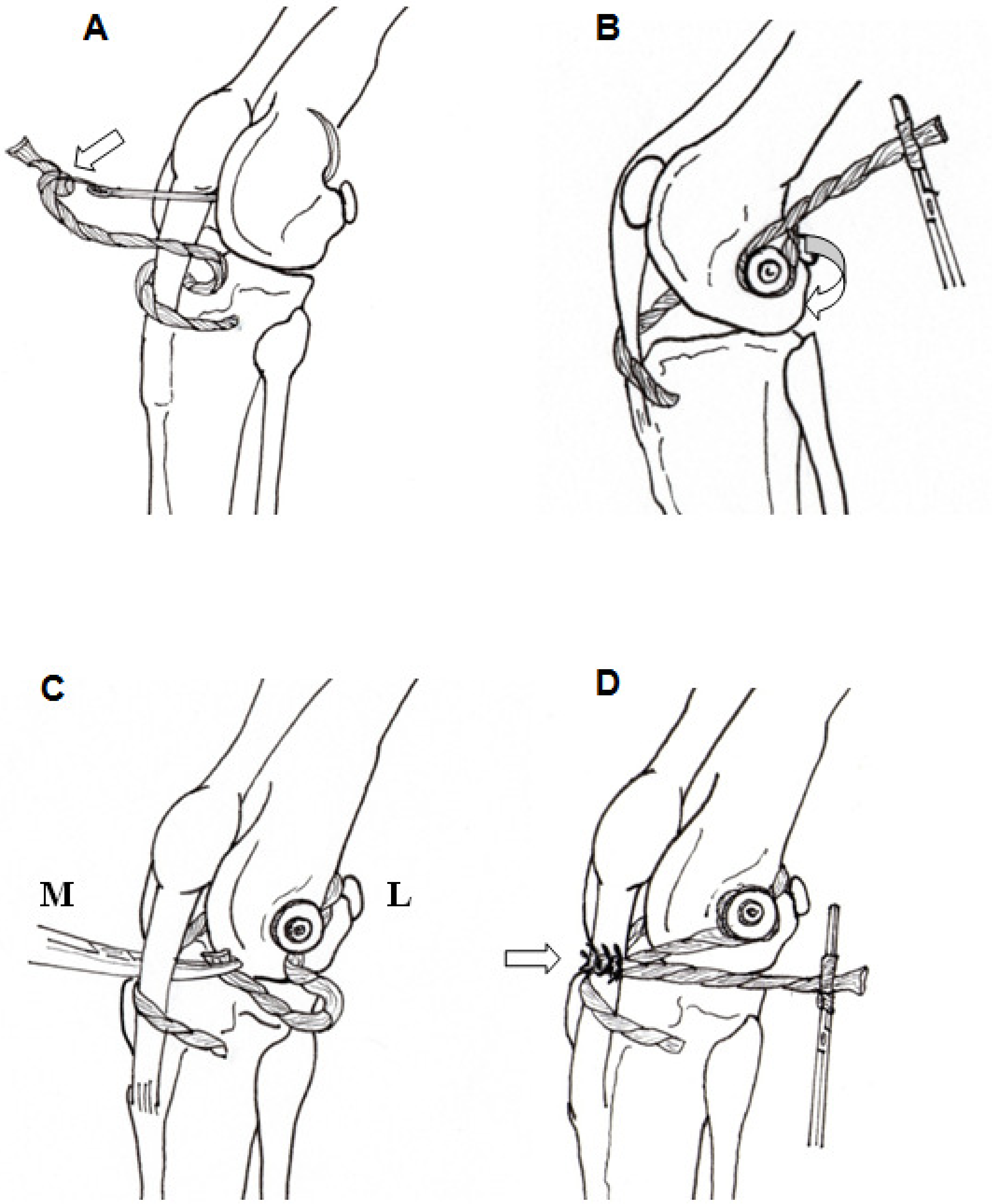

Figure 1 - Schematic representation of the stabilization technique of the femorotibiopatelar joint with double fixation of the fascia lata. A) graft free end attached to the eye of the needle (arrow) is inserted between the femoral condyles. B) graft after encircling partially the bolt. The arrow shows the remaining graft path to complete the clockwise 360° turn. C) graft free end passes under the patellar tendon in the latero-medial direction. Lateral (L), medial (M). D) suturing the fascia lata graft on to the patellar tendon. Suture stitches in "X" pattern (arrow). Side image of the femorotibiopatelar joint.

From the 25th to the 38th postoperative day, after passive kinesiotherapy, exercise on three supporting limbs was performed, for a period of 30 to 60 seconds, once a day. This exercise consisted of elevating the non-operated limb thus forcing the operated limb to support the weight. At this stage, the daily walks were intensified, on a slightly inclined terrain and alternated with trotting.

From the 39th to the 60th day after surgery, besides the activities that took place once per day, the dogs started going up and down the stairs for 10 minutes.

The clinical and orthopedic evaluations of the operated animals were performed every five days, for a period of 60 days, the expected time for medical discharge. Some of these evaluations were performed from the fifth day after surgery while others from the tenth day.

Functional recovery of the operated limb was evaluated from the fifth day after surgery according to posture and locomotion expressed by the dog while immobile in station, walking and running. The scores from 1 to 6 were attributed as follows: 1, absence of lameness; 2, full support of the digits and footpad occurred in station, walking and running, but still showed lameness; 3, full support of the digits and footpad in station and walking; 4, support of the digits but not the footpad in station and walking; 5, support of digits but not the footpad, only when walking; and, 6 no support of the limb in station, walking and running.

Immediately after surgery and every five days, the drawer tests, tibial compression and internal rotation of the tibia were performed and classified as present or absent. Every five days, from the 10th day, thigh and knee joint circumferences were measured using conventional measurement tape placed around the middle third of the thigh and the whole joint over the patella. The results were presented in centimeters (cm). Movement amplitude was also measured using a universal goniometer. The motion amplitude is defined as the difference between the maximum angles during extension and flexion of femorotibiopatelar joint. Immediately before surgery measurements were compared to post-operative measurements.

At 60 post-operative days, radiographs of the operated joint were performed in the craniocaudal and mediolateral projections. Signs of joint degeneration such as the presence of osteophytes, enthesophytes, sclerosis of the subchondral bone and effusion were also investigated.

The statistical differences of the variables, thigh and knee circumferences, angles of flexion and extension, range of motion amplitude, drawer test, tibial compression, internal rotation of the tibia and functional recovery were performed using SAS 9.0. The normal distribution of variables was determined by the Kolmogorov-Smirnov test. Data that met the normality assumption were subjected to analysis of variance to determine significant differences. Significantly different data were compared by Tukey test. Data that did not meet the normality assumption were treated by the nonparametric Kruskal-Wallis test, followed by the Student-Newman-Keuls. The X-rays were analyzed descriptively. Statistical analyses were performed at 5% significance level.

RESULTS AND DISCUSSION

To enable all maneuvers intended for grafting, the flap that originated the graft needed to comprise the full length of the fascia lata. The graft was twisted about its longitudinal axis in order to become tougher. According to Brendolan et al. (2001), the twisted fascia lata has greater elasticity than the flat one, because it considers the elongation of the fibers and the unwinding of the fascia on its total deformation. Moreover, the twisted graft mimics the natural multi-fasciculate structure of the cranial cruciate ligament (LOPEZ et al., 2003).

Besides keeping the graft in the desired position, fixating the fascia lata to the lateral femoral condyle with cancellous bone screw and washer favored traction and prevented loss of tension, thus, reducing instability and preventing displacement of the tibia in relation to the femur. The insertion of a screw at 90° to the bone favored fixation and supported the load when fully screwed. On the other hand, inserting the screw at other angles as noted by Duarte et al. (2010), as it is possible when using surgical anchors, could render it unstable, allowing the graft to become loose.

According to Grover et al. (2005), the loss of tension during the placement of the implant varies with the fixation technique used. In the present experiment, the complete fastening of the screw on the washer, for definite fixation, was performed after the graft bypassed the screw, while the assistant surgeon held the graft tensioned. These precautions enabled to maintain the tension at the time of the final fixation of the graft.

One dog had partial lateral displacement of the screw on the 35th day after surgery. However, we found no evidence of loss of graft tension nor observed the displacement of the tibia. Probably, this good result can be attributed to the double fixation of the graft. As the screw is displaced, the washer loses the ability to fix the graft in the femoral condyle. So, if the graft had been fixed using only the screw/washer set, even partial displacement could have caused instability to the joint. It appears that the suturing of the graft to the patellar tendon under tension provided the resistance necessary to stabilize and prevent displacement of the tibia.

The fixation by screw and washer has made the free end of the graft independent of its intraarticular portion, thus establishing a new articular stabilization mechanism, unlike the method recommended by Leighton (1994), which sutures the graft end over the lateral fascia that covers the patellar tendon, without allocating any action to it.

The passive kinesiotherapy was initiated on the 10th day after surgery, unlike Buda et al. (2006) who introduced passive movements on the day following the procedure. This protocol is based on the data of Silva et al. (2000) who reported that the graft reaches characteristics similar to the ligament only 90 and 120 days after surgery. Therefore, in the first 10 days after the surgery, the graft is under tension and more prone to loosening and stretching, causing loss of joint stability.

In the present experiment, the eight-week physical therapy program proposed is shorter and with shorter stages while the exercises are intensified more frequently than that proposed by Edge-Hughes and Nicholson (2007). Early in the first phase, walking exercises were instituted in order to stimulate the muscles and support the limb, as well as passive exercises to increase motion range amplitude.

Graft fixation with cancellous screw and washer maintained graft tension even when rehabilitation started before ligament maturation which, according to Silva et al. (2000), occurs at 90 days postoperatively. This result is in agreement with the observations of Milano et al. (2006) who stated that corticocancellous fixation systems are more efficient regarding resistance to stretching and rupturing of the implant compared to other methods. The non-use of fascia lata through tunnels made in the tibia or femur also prevented loss of tension of the implant. This statement is based on the results of Lopez et al. (2007), who attributed the loss of tension of the semitendinosus muscle tendon and gracilis graft to the friction caused by the bone when the graft crosses the tunnel made in the femur.

The hot water bottle was used to warm up the soft tissue, providing muscle relaxation and increased extensibility of tendons, ligaments and joint capsule facilitating the implementation of the exercise routine and decreasing pain transmission. Moreover, preheating of the involved structures optimizes the exercises reducing the risks of causing iatrogenic lesions (HEINRICHS et al., 2004; SOUZA et al., 2006).

In the first days of therapy, passive movements of flexion and extension of the femorotibiopatelar joint caused discomfort and animals were reluctant to accept them. However, as the days passed and the exercises continued, clinical improvement was evident. Also, in the three limbs load-bearing exercise, the supporting time of the operated limb gradually increased from 30 to 60 seconds from the 25th to the 60th day.

Some animals manifested pain in the first evaluation after physical therapy had started and during the periods when the rehabilitation protocol changed. The introduction of new exercises and intensification of the walk forced the dogs to use more and more the operated limb, causing increased pain. According to Canapp (2007), the change of activities, such as intensification of exercises during physical therapy, should be individualized since it is dependent on the clinical course and the level of tolerance of each patient. Rehabilitation protocol changes were predetermined at the beginning of the experiment without taking into account the clinical evolution of each dog. Thus, not all dogs were able to intensify the activities.

The assessment of functional recovery of the limb showed that all dogs had higher degree of lameness and lower support of the operated limb in the first 15 days postoperatively. During the evaluation period, posture and locomotion improved progressively (Figure 2). On the 60th postoperative day, five dogs showed no lameness and began to support the limb on the ground while standing, walking and running.

Only dog number 7 did not evolved satisfactorily regarding its posture and locomotion, and on the 60th day after surgery, still had severe claudication demonstrated by lack of support from the operated limb while running. This dog showed mild pain, from the 35th postoperative day and remained so until the last day of evaluation while showing signs of crepitus during femorotibiopatelar joint motion. Although, characteristic radiographic signs of joint disease had not been found, it is known that the sign of crackling occurs due to contact between bone surfaces as in degenerative changes (JOHNSON & JOHNSON, 1993) and meniscus injuries (WEINSTEIN et al., 1995; CHU et al., 2002). These cannot be ruled out, even in the absence of arthroscopy and degenerative joint disease in this dog, since they are consequences of cranial cruciate ligament rupture, causing pain and lameness (CHU et al., 2002).

Drawer tests, tibial compression and internal rotation of the tibia were positive only during the surgical procedure when the cranial cruciate ligament rupture was performed. The results of the tests performed immediately before surgery and until the 60th day after surgery were always negative. Unlike Muzzi et al., 2009, who reported positive values for the drawer test when the fascia lata was fixed on to the tibia with a screw and washer, indicating discrete joint instability.

Measures of thigh and femorotibiopatelar joint circumference of the operated limbs were not significantly different between the observation periods. The fact that thigh circumference did not change throughout the experiment suggests that the physiotherapy protocol prevented muscle atrophy from occurring. Even with periods of disuse when the limb was not being used to support the weight, there was no loss of muscle mass.

Although the femorotibiopatelar joint circumference was not significantly different pre- and post-operatively, from the 35th PO day and on, the diameter increased and persisted until the end of observations. This increase is likely due to fibrosis and consequent thickening of the joint capsule and other periarticular tissues. The thickening of the capsule is desirable since it contributes to the stability of the knee and for surgical methods to try to stabilize the joint while fibrosis occurs (COOK et al., 2010).

Immediately after surgical stabilization of the joint, significant reduction in motion range amplitude was observed, similar to that reported by Buda et al. (2006). At this point, the extension angle decreased while the flexion angle increased, thus resulting in diminished motion range (Figure 3).

Ten days after surgery, the bending angle decreased significantly compared to the immediate postoperative period. This fact was solely responsible for the increase of the motion range observed on this date, since no significant increase of the extension angle was observed in the same period. From there, the motion range increased until the last day of evaluation, reaching a value close to that observed before surgery.

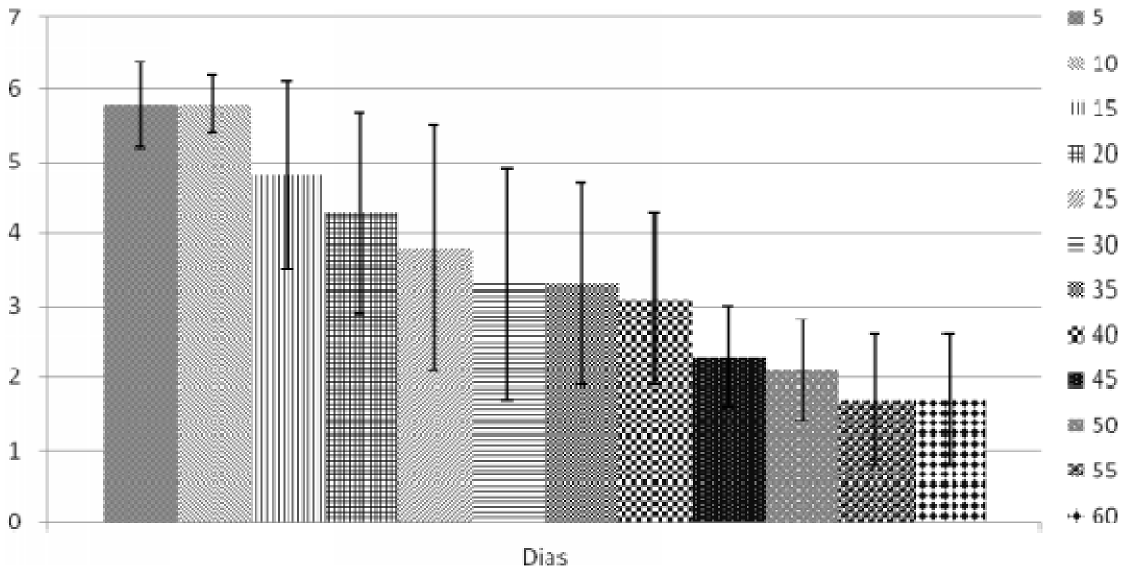

Figure 2 - Mean and standard deviation of functional recovery grading.

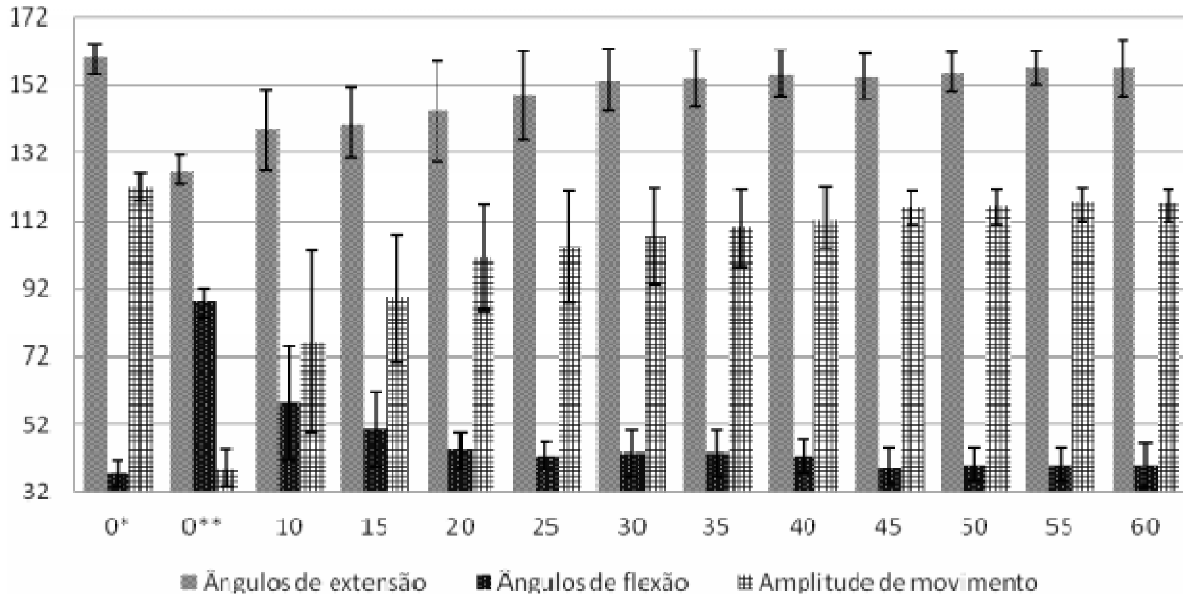

Figure 3 - Mean and standard deviation of flexion and extension angles and motion range of femorotibiopatelar joint before (0*), immediately after (0**) and from the 10th day after surgery.

The angles of flexion and extension are statistically identical to those obtained before surgery from the 20th and 25th PO day, respectively.

The decreasing motion range of the operated joint was due to the suturing of the graft to the patellar tendon, causing excessive strain on this tendon, restricting the flexion and extension movements. The graft fixation on this site is at odds with Lopez et al. (2003) who stated that this should occur at the natural maintain regular joint mobility. Another factor that significantly decreased motion range was the presence of the screw and the washer under the joint capsule, causing the edges to be pushed away during capsulorrhaphy and consequent tension and reduced ability to flex the knee.

The observed motion range improvement may be a consequence of the rehabilitation protocol established, because, according to Manning et al. (1997), passive motion exercises of the joint do not prevent muscle atrophy, but reduce the formation of adhesions and joint contractures, maintaining motion range. Thus, the factors that caused the reduction of femorotibiopatelar movements were outweighed by exercises performed postoperatively. And, the benefits provided by the fixation of the patellar tendon graft were superior to the temporary motion range decrease.

Also, Souza et al. (2006) reported better results regarding the extension angulation in animals performing therapeutic exercises. However, only on the 90th PO day, the extension angle reached the values measured before surgery. According to these authors, passive stretching and warming of the joint surface were responsible for the result. Passive stretching of the limb was not included in the rehabilitation protocol of the present experiment; however, the recovery of motion range occurred earlier. This result is believed to be the consequence of not only one type of exercise, but the sum of exercises performed in this rehabilitation protocol.

This rehabilitation protocol for surgical treatment of pathological rupture of the cranial cruciate ligament is expected to promote functional recovery of the limb in less time, restrict muscle atrophy and maintain normal femorotibiopatelar motion range.

At 60 days after surgery, all dogs, except 3 and 9, showed X-rays consistent with bone lysis around the screw, which is expected with the insertion of metal implants in the bone. There were no radiographic changes characteristic of osteoarthritis.

CONCLUSION

It is concluded that the proposed technique of using autogenous fascia lata fixed in two points was capable of restoring femorotibiopatelar joint stability after experimental rupture of cranial cruciate ligament in dogs and that the fixation of the fascia lata graft on to the patellar tendon adds more resistance to the intracapsular phase. Furthermore, the cancellous bone screw and washer implanted in the femur are able to allow the fixation and favor traction while maintaining graft tension, thereby preventing cranial displacement of the tibia. The proposed rehabilitation protocol was able to assist in the recovery of limb function after surgery, prevent muscle atrophy and allow motion range to return to regular angles. In addition, intensification and addition of new exercises should be carried out gradually and according to patient clinical recovery.

insertion site of the cranial cruciate ligament to

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