Extra-articular Stabilization of Cranial Cruciate Ligament-deficient Stifle in Dogs: a New Tibial Suture Anchor Point

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ABSTRACT

We described a new surgical procedure of extra-articular stabilization of cranial cruciate ligament (CCL) deficient stifle using nylon cable tie (NCT) anchored in a new tibial anchor point. Lateral fabellotibial tension band (LFTB) stabilization procedure was described in 10 mixed breed dogs. The degree of lameness was scored and complete physical examination of each dog was performed. Radiographic assessment of stifle osteoarthritis and postoperative complications were recorded. Mechanical properties of the NCT were determined. Clinical lameness was improved by 6 weeks postoperatively in all dogs. No joint laxity or abnormal range of motion was detected during the first 4 weeks after surgery. Minimal cranial drawer motion was apparent in three operated limbs 6 weeks postoperatively with no apparent lameness. No clinical lameness was observed 12 weeks postoperatively. Minimal progression of stifle osteoarthritis was observed in one dog. Implant loosening was the only major postoperative complication. Lateral fabellotibial tension band procedure is a simple and effective method of stabilization of CCL-deficient stifle with good to excellent clinical outcome and minimal stifle osteoarthritis. Longer-term evaluation of stifle osteoarthritis is however needed. Nylon cable tie (NCT) may be an appropriate inexpensive alternative to the traditional lateral fabellotibial suture material.

INTRODUCTION

Cranial cruciate ligament (CCL) is a critical stabilizer of the stifle, and its deficiency is a common leading cause of hind limb lameness and joint osteoarthritis in dogs.[1-3] The annual economic impact of medical and surgical management of CCL insufficiency of dogs in the United States has been estimated at $1.3 billion.[4] The purpose of surgical management is to restore stability, mimic normal kinematics, and maintain normal biology of the joint in order to prevent further deterioration of the joint, especially the medial meniscus damage and progression of degenerative joint disease (DJD).[3] Several surgical techniques have been described to

stabilize the CCL-deficient stifle with no single technique has been shown to consistently arrest development or progression of osteoarthritis, or consistently return operated limb to normal function.[5-10]

Lateral fabellar suture (LFS) has previously been used to provide joint stability through static neutralization of cranial drawer motion without alteration of the anatomy of stifle joint.[11] This is achieved through altering the extra-articular structures and thickening the periarticular tissues in response to the surgical procedure and implant suture.[12] Lateral fabellar suture placement is technically easy and highly applicable with a relatively low complication rate. However, it provides short term stabilization of the joint and forces on the suture material necessitate a material with high tensile strength, minimal elongation, and high stiffness.[3,13] The synthetic suture material should therefore be mechanically strong enough to withstand cyclic loading and tension until the developed periarticular fibrosis permanently stabilizes the joint.[3,14] Additionally, it should be handled easily, hold securely when knotted, withstand deformation during knot tying or during application of crimp-clamp, and should minimize bacterial adherence.[14,15]

Nylon leader line is a commonly used synthetic material for these procedures,[16] with joint stability maintained more effectively by crimped nylon loops, compared with knotted loops.[17] Nylon cable ties are commercially available in variable sizes and have been used successfully in surgical management of umbilical and abdominal hernias in ruminants, due to their high tensile strength and maximum secured self-locking bid.[18] They fulfill an extensive range of performance after gamma or ethylene oxide (EO) sterilization.[18] A nylon cable tie has therefore been used in the study reported here to stabilize experimentally induced CCL-deficient stifles, using a new tibial suture anchor point.

Selecting anatomical structures both proximal and distal to the canine stifle has been suggested to mimic the origin and insertion of the CCL and optimizes the function of an extra-articular stabilization technique.[19,20] The impetus for the study reported here was the observation that introducing synthetic material through the distal patellar ligament and a hole drilled in the tibial crest does not mimic the insertion point of the CCL, and may cause deterioration or malalignment of the patellar ligament or fracture of the tibial tuberosity. Additionally, anchoring the synthetic material at a site located cranial to the insertion of CCL on the tibia may eliminate the small amount of internal rotation of the tibia on the femur normally present when the joint is flexed.[21] This may even generate a degree of external rotation of the tibia and joint instability which may enhance progression of osteoarthritis.[19,21]

The objective of the study was therefore to describe a new extra-articular stabilization procedure using a specially designed tension band prosthetic material (NCT) placed between the lateral fabella and mid proximal tibia. The working hypothesis is that changing placement of the tibial anchor to a point located approximately next to the insertion of the CCL may enhance joint stability, improve clinical outcome and reduce progression of stifle osteoarthritis.

MATERIALS AND METHODS
Dogs
The study protocol was approved by the Scientific Committee of the Department of Veterinary Surgery at Cairo University prior to enrollment of the dogs. Ten skeletally mature, mixed breed dogs at a minimum of 13 months of age were selected with no history or clinical signs of orthopedic disease and normal stifle radiographs of both limbs.[22,23] Additional inclusion criteria included no history of trauma, no detectable evidence or knowledge of previous stifle surgery, and no evidence of pathologic changes in the stifle joints of both limbs of each dog. All dogs were housed individually in galvanized-steel cages (1 x 2 m) located in the same department, and were fed once daily with a standard balanced food.

Figure 1. Nylon cable tie, a tension band prosthetic implant (TBPI) system (a, plugging bid "head"; b, self-locking bid; c, tail).
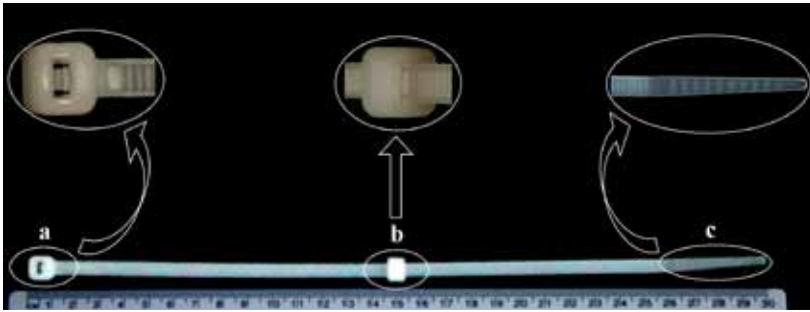
Nylon cable tie (NCT)a, a tension band-bid prosthetic implant (TBPI)

The used implant (300 × 3 mm) is a monofilamentous, non-absorbable white material known commercially as nylon cable tie (NCT)a. This tension band-bid prosthetic implant (TBPI) system consists of a 6 mm wide (4 mm thick) plugging head attached to a pliable flat strip "tension band, body" and a self-locking bid of similar size unattached to the band (Figure 1a, b). The tension band has outer smooth and inner serrated surfaces and a tapered end (tail). The tapered end is smooth, flat and small in size to facilitate passages through the tibial tunnel, the lateral femorofabellar ligament, and the self-locking bid (Figure 1c). The attached plugging head of the implant is opened from both sides and has a characteristic toothed strip from within (Figure 1a). The self-locking bid has similar structure but unattached to the band. Once the toothed strip of the self-locking bid engages the serrated surface of the band, the locking bid becomes perfectly secured (Figure 1b). All implant materials were washed with ethanol (95%) and normal saline solution, dried, and exposed to ethylene oxide gas (100% EO) for 4 hours at 133ºF.

Lateral fabellotibial tension band stabilization procedure

All dogs were premedicated with atropine sulfate (0.04 mg/kg), xylazine hydrochloride (0.50 mg/kg) and butorphanol (0.20 mg/kg) intramuscularly. After 15 minutes, thiopental sodium (20 mg/kg) was administrated in-travenously for anesthetic induction, and 4 ml of lignocaine (1%) were then injected in the lumbosacral epidural space. A surgical plane of anesthesia was maintained on halothane in oxygen. The dogs were randomly assigned to have surgery on the left hind limb. A lateral parapatellar arthrotomy was performed and the patella was displaced medially to expose the cranial cruciate ligament (CCL).24 The designated CCL was transected and removed after extreme flexion of the stifle. The cranial drawer motion of the stifle was confirmed after replacing the patella, and the joint capsule was routinely closed.

The biceps femoris muscle was elevated from the lateral surface of the joint capsule to expose the gastrocnemius muscle. The insertion of the caudal belly of the sartorius muscle was partially incised from the medial aspect of the proximal tibia and retracted caudally. A 4 mm Steinmann pin was used to drill a tunnel through the mid proximal tibia at the level of proximal extent of tibial crest, from medial to lateral. The free end (tail) of the tension band was passed through the tibial tunnel from medial to lateral with its attached 6 mm plugging bid (head) anchored against the medial aspect of the mid proximal tibia. The gastrocnemius muscle was retracted caudally and the femorofabellar fascia, just proximal to the lateral fabella, was elevated.

A pointed curved mosquito hemostat was passed underneath and through the lateral femorofabellar ligament in a proximal to distal direction, close to the cranio-

Figure 2. *Illustration showing the lateral fabellotibial tension band (LFTB) stabilization procedure (a, the curved mosquito hemostat being passed underneath and through the lateral femorofabellar ligament in a proximal to distal direction, close to the cranioproximal aspect of the lateral fabella; b, A 4.5 mm drill guide being used to facilitate tension application by pulling the tension band caudally (white arrow) and pushing the self-locking bid cranially against the femorofabellar ligament and cranioproximal aspect of the lateral fabella (black arrow).*
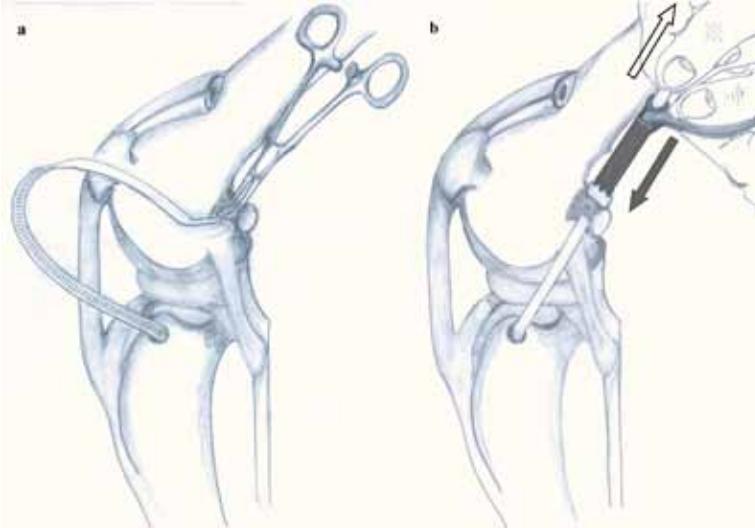
proximal aspect of the lateral fabella (Figure 2a). The free end of the tension band (tail) was grasped in the tip of the hemostat and then pulled cranial to the lateral fabella and gastrocnemius muscle stump and through the femorofabellar ligament caudally. The serrated side of the tension band was placed against the lateral aspect of the joint capsule to improve implant stability. A self-locking bid was passed along the free end of the tension band, with the serrated side of the band facing the toothed strip of the bid. A characteristic zipping-like sound was noted while passing the bid along the band.

The stifle was flexed to a normal standing angle (~135°) and the tibia was held caudally and rotated externally, to eliminate the cranial drawer motion. Tension was then applied by pulling the tension band caudally and pushing the self-locking bid cranially against the femorofabellar ligament and cranioproximal aspect of the lateral fabella, until cranial drawer motion was eliminated.

A 4.5 mm drill guide was used to facilitate tension application (Figure 2b). The tension band was then cut close to the self-locking bid and measured to calculate the actual length of the band (length between the head and self-locking bid) that stabilizes the joint. Lateral retinacular imbrication was performed by placing a series of 2-0 PDS horizontal mattress imbricating sutures along the incised lateral retinaculum. The incised portion of the caudal sartorius muscle was replaced cranially above the plugging bid and sutured. The subcutaneous tissue and skin were routinely closed after thorough irrigation of the joint with sterile normal saline.

All dogs received broad spectrum antibiotic and NSAID (carprofen 5%, 1 ml/10 kg). Dogs were exposed to restricted activities for the first 7 days after surgery. Afterwards, dogs were exposed to a regular opportunity to exercise in a leash walk for approximately 5 minutes twice daily for a minimum of 12 weeks, and their gait was observed. The degree of lameness was scored as 0 (no clinical lameness), 1 (mild lameness that was evident only after strenuous exercise), 2 (moderate lameness that was evident at all gaits during normal activity or exercise; considerable weight bearing on affected limb with each step), 3 (severe lameness that was evident at all gaits with characteristic toe touching lameness), and 4 (no weight bearing on the affected limb).[23-25] All dogs underwent a complete physical examination,

including orthopedic and neurologic examinations, while awake. Assessment of the range of motion of the stifles and joint laxity (cranial drawer sign test and tibial compression test) were performed on each pelvic limb after sedation. Sedation was induced with morphine (0.5 mg/kg, IM), atropine sulfate (0.04 mg/kg, IM), and xylazine hydrochloride (0.50 mg/kg, IM).

Immediate postoperative mediolateral and craniocaudal radiographs were obtained for both operated and non-operated stifle joints. Radiography of the stifle joints was repeated at 3 and 6 months postoperatively to evaluate the development of radiographic signs of stifle osteoarthritis. For all stifle joints, assessment of radiographic signs of osteoarthritis was performed by the same radiologist. Lameness evaluation and radiographic assessment of each stifle joint were performed by individuals who were blinded to treatment. Complications were classified as intra- and post-operative complications. Post-operative complications were subdivided into major and minor complications. Major complications included those requiring additional surgical interference while minor complications included those not requiring surgical treatment.[26]

One dog was euthanized at 3 months postoperatively for histopathological examination whereas, the rest of dogs were euthanized at the end of the study (6 months after stabilization procedure). All dogs were euthanized using an overdose of intravenous thiopental sodium (1000 mg).[27] Samples for histopathological examination were fixed in 10% neutral buffer formalin for 7 days and then decalcified for 15 days in 10% formic acid. The samples were then processed by the conventional method, sectioned and stained with Hematoxylin and Eosin according to the method described by Bancroft and Gamble 2008.[28]

In vitro mechanical testing of the sterilized tension band prosthetic implants was applied at standardized conditions (Humidity 65% and temperature 20oC). Cyclic testing was performed on 3 implant samples after engagement of the self-locking bid of each sample at a distance of 7.5 cm (average distance between the head and locking bid after joint stabilization) from the head of the corresponding implant. Samples were mounted onto a material testing machineb and load was applied at a constant distraction rate of 500 mm/min to a distraction limit of 7.5 mm for 49 cycles until failure.[14] Mean load at failure (breakage), elongation, and stiffness of the tension band were then recorded. The mean load at failure (slippage) and stiffness of the self-locking bid were calculated. The elongation of the tension band at slippage of the self-locking bid was also recorded.

RESULTS

The means (± SDs) body weight and age were 20.1 ± 2.8 kg and 2.2 ± 1.2 years, respectively. Total time of surgery ranged from 30 to 45 minutes. In all dogs, clinical lameness was scored as 3 (severe) during the first week postoperatively. Limb use improved gradually. At 4 weeks after surgery all dogs showed moderate (score 2) to mild (score 1) degree of lameness. Mild lameness (score 1) was observed in nine dogs 6 weeks postoperatively. One dog, however, had recurrent lameness (score 2, moderate degree) 5 weeks after surgery. Palpable joint effusion was identified in all operated stifles. No joint laxity (indicated by negative results of the cranial drawer sign and tibial compression test) and normal range of motion were detected during orthopedic examination of all operated stifles 4 weeks after surgery. Severe cranial drawer motion was identified in one operated stifle 5 weeks after surgery associated with moderate degree of lameness. This particular dog was therefore excluded from the study.

Starting at 6 weeks postoperatively, minimal cranial drawer motion (less than 2 mm) was apparent in three operated limbs with no evidence of clinical lameness. Mild atrophy of the thigh was observed in three operated limbs by 6 weeks after surgery. At 6 months postoperatively, no obvious atrophy was however identified. There was

Figure 3. *Mediolateral and craniocaudal radiographic views of the left stifle joints of 2 Mongrel dogs euthanized at 12 (a&b) and 24 (c&d) weeks postoperatively illustrating the radiographic changes associated with CCL reconstruction using lateral fabellotibial tension band (LFTB) stabilization procedure. Note the absence of radiographic signs of stifle osteoarthritis at 12 weeks postoperatively (a&b) and minimal radiographic signs of stifle osteoarthritis at 24 weeks postoperatively (c&d). Note that osteoarthritis of the stifle joint was evidenced by the presence of lateral condylar periarticular osteophytes (arrows) and osteophytosis of the intercondylar notch (arrow).*

no evidence of clinical lameness or radiographic signs of stifle osteoarthritis in the nine operated limbs at 12 weeks postoperatively (Figure 3a, b). Minimal radiographic signs of stifle osteoarthritis were observed in only one operated joint at 24 weeks after surgery. These signs were evidenced by the presence of lateral condylar periarticular osteophytes and osteophytosis of the intercondylar notch (Figure 3c, d). The contralateral

non-operated limbs of all dogs revealed no evidence of clinical lameness or abnormal stifle radiographs.

No intra-operative complications were recorded. A major post-operative complication was recorded in one dog during the follow up period of the study. There was implant loosening manifested by the presence of cranial drawer motion and recurrence of clinical lameness 5 weeks after surgery. The dog with implant failure was euthanatized to determine the actual cause of implant loosening. The tension band was found loose due to mechanical slippage of the locking bid. The minor complications included post-operative swelling in 3 dogs and a 2 cm (or less) partial incisional dehiscence in two dogs. Post-operative swelling was completely resolved within 5 days without treatment. Systemic course of antibiotic was repeated to the two dogs with incisional dehiscence.

The dog euthanized at 3 months postoperatively, for histopathological examination, showed an initial event of tibial bone hole repair by activation of osteoclast cells in order to phagocyte the necrotic bony materials (Figure 4a). Formation of callus consisting initially of loose connective tissue especially around the implant (Figure 4b) was the second event. The connective tissue appeared highly vascularized with newly formed blood vessels. Also the periosteum showed congestion of blood vessels (Figure 4c) with an increase in its thickness. Primitive mesenchymal cells in the tibial hole differentiated into chondroblasts and replaced most of the loose connective tissue with chondroid matrix meanwhile; osteoblasts began to activate producing new bone (Figure 4d). The early callus is consisting predominantly of hyaline cartilage, which was formed very rapidly and served to anchor the bone hole. Ossification within the callus led to formation of woven bone with remnants of implant noticed in between (Figure 4e).

Six months postoperatively, a band of smooth whitish dense connective tissue

Figure 4. *Tibia of a dog at 3 months postoperatively. (a) Tibia showing focal necrosis in parts of bony materials with activation of osteoclast cells (arrows). H&EX400. (b) Tibial bone showing newly formed collagen fibers. Note the remnants of the tension band prosthetic implant "TBPI" (arrow). H&EX200. (c) The TBPI is in between the lateral fabella and the vascularized organized tissue (arrow). Note the congestion of periosteum. H&EX100. (d) Tibial bone showing newly formed osteoid tissues. Note the activation of osteoblast cells. H&EX400. (e) Newly formed calcified osteoid tissue and the remnant of TBPI in between (arrow). H&EX100.*
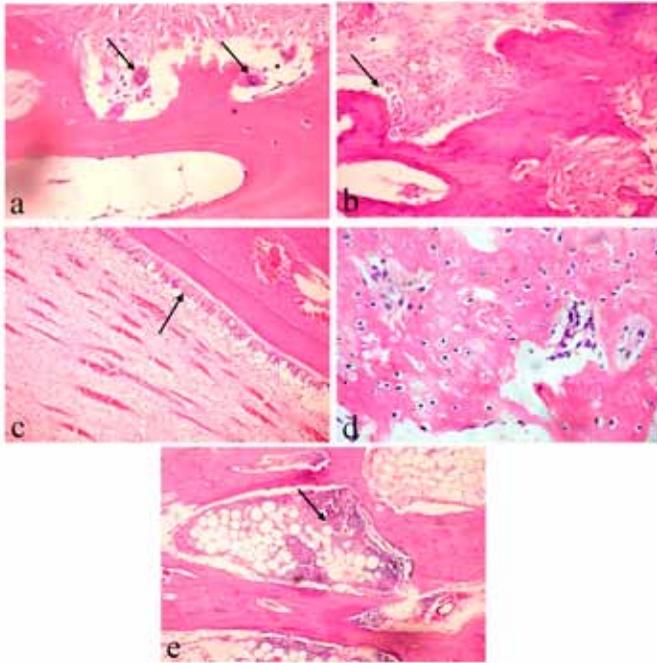
enclosing each implant was seen across the nine operated stifle joints. No remarkable gross abnormalities were identified within the articular surfaces and menisci of all operated and contralateral non-operated joint specimens. Variable degrees of slight yellowish discolorations were however evidenced in the medial menisci of six operated stifles. Histopathologically, the loose connective tissue around and along the entire implant became mature collagen fibers (Figure 5a). The remodeling period began to take place in which the large callus was reduced and the woven/primary bone was replaced with secondary lamellar bone which was mixed with connective tissue to occupy most of the hole of the proximal tibia (Figure 5b, c).

The mean (± SD) distance between the head and self-locking bid after joint stabilization was 73.8 ± 5.3 mm. The means load at failure (breakage), elongation, and stiffness of the tension band were 316.17 N, 0.3 mm, and 14.34 N/mm, respectively. The means load at failure (slippage) and stiffness of the self-locking bid were 112.15 N and 10.38 N/mm, respectively. The elongation of the tension band at slippage of the self-locking bid was 0.1 mm.

DISCUSSION

Lateral fabellar suture (LFS) with placement of the tibial anchor at tibial crest is reportedly one of the most common techniques used to stabilize the CCL-deficient stifle in dogs.[16] This popularity could be related to the simplicity, the low cost, and the relatively low incidence of post-operative complications associated with this technique. The more simplicity and shorter duration of surgery reported in our study could be attributed to the ultimate one-way self-lock criteria of the implant system that provided immediate knot security while tension being applied. No assistance is therefore required while the surgeon applies this tension. Another advantage is the ability of this particular synthetic material to be encapsulated with fibrous connective tissue intermingled with blood capillaries along the tension band as early as 3 months after joint stabilization. Six months postoperatively, the amount of con-

Figure 5. *Tibia of a dog at 6 months postoperatively. (a) Tibia showing large amount of mature fibrous connective tissue. H&EX200. (b) Tibia showing mature collagen fibers surrounds the TBPI with presence of mature woven bone. H&EX100. (c) Mature collagen fibers mixed with secondary lamellar bone (arrow). H&EX200.*
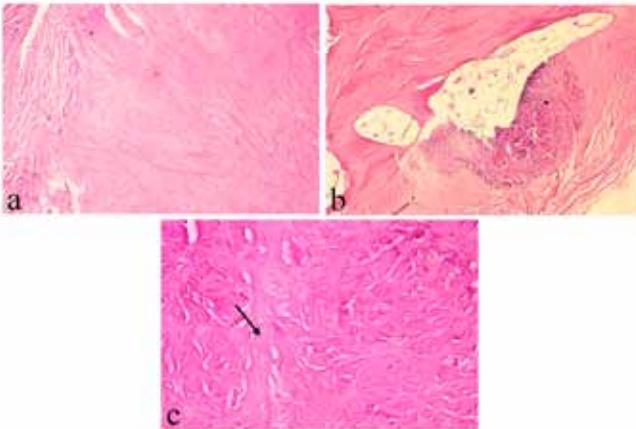
nective tissue was increased and appeared as mature collagen fibers around and along the implant. Our histopathological findings are therefore consistent with a previous study that had successfully used the same tension band (nylon cable tie, NCT) in surgical management of umbilical and abdominal hernias in ruminants.[18] These findings are expected to additionally support the implant and permanently stabilize the joint. It is clear from our study that the pathological changes observed were monitoring the process of bone healing as well. The immediate stabilization following CCL-transection and short term follow up (6 months) may explain the lack of remarkable gross abnormalities (such as erosions of articular surfaces, torn menisci, or osteophytosis) in our operated joint specimens. The decrease in pliability of medial meniscus and accompanied inflammatory changes, secondary to CCL transaction, may explain the yellowish discoloration associated with most of the joint specimen at 6 months postoperatively.

Several synthetic suture materials, such as stainless steel wire, Nylon leader line and other fishing lines, or braided silicon polyester, have previously been described as extra-articular stabilizers for CCL-deficient stifle,[14] with Nylon leader line being the most successfully used material. However, Nylon leader line is difficult to adequately tighten a knot and at least five throws are required to ensure knot stability which results in a large knot that causes soft tissue irritation and swelling.[15] Although, a greater load before breaking was resisted by these square knots, much greater elongation of the implant was a major disadvantage of the knot tying procedure. Metal crimpers for loop fixation of nylon lines have therefore been used to secure the knot, thus preventing a large suture mass lateral to the stifle joint[29] and reduce incidence of elongation.[17] However, crimp-clamp technique requires specially designed and relatively expensive equipments, and assistance is essential to apply the clamp while the surgeon applies tension to the Nylon loop.[17] The Nylon cable tie (NCT) used in this study was a modified version of the implant successfully used to substitute suture materials in surgical management of umbilical and abdominal hernias in ruminants, castration in stallions and ovariohysterectomy in bitches.[18] This material is capable of being shaped or formed without rupture or relaxation and has the property of building connective tissue after implantation.[18] The mechanical and morphological properties of the NCT used in the study reported here allowed for superior handling, excellent secured tension, minimal elongation, and relatively high tensile strength. The implant is also commercially available in variable sizes at low cost and easily sterilized.

The load at failure of our Nylon cable tie "tension band prosthetic implant" (316.2 N) is relatively comparable with that of the Securos Crimp-Clamp loops formed with 27.3

kgt nylon leader line (359.9 N) previously reported in another study.[14] Our implant system was however less stiff (14.338 versus 58.1 N/mm) and less elongated (0.3 versus 6.7mm) compared to the Securos Crimp-Clamp System using monofilament nylon leader line. These variations may be related to the differences in implant construction and molecular component of each polymer. The relatively high tensile strength and limited elongation may provide the evidence that our implant (NCT) has minimal permanent deformation after application of the anticipated physiologic loads on the joint. The relatively low load at failure (112.15 N) and decreased stiffness (10.38 N/mm) of the self-locking bid are the main disadvantages of our implant system that may explain the slippage of the bid and implant loosening within the stifle of the dog reported in this study. Future placing of an additional self-locking bid may therefore be recommended to improve the biomechanics of our reported tension band prosthetic implant (TBPI) system and prevent loosening of the implant.

The effectiveness of the tension band prosthetic implant (TBPI) system in restricting cranial drawer motion and neutralizing cranial tibial thrust would depend on how tightly the free end of the tension band was pulled and the self-locking bid was pushed against the femorofabellar ligament. The amount of tension required to eliminate cranial drawer motion would also depend on the position of the limb during tightening of the implant and the strength of the person doing the surgery. In the study reported here, these variations were minimized by standardizing the angle of the stifle joint (~135°) during tightening and by doing all surgeries using the same individual.

Two previous studies compared the biomechanics of normal joint motion with those of a joint in which standard extra-articular stabilization procedures were used.[19,21] The standard extra-articular stabilization techniques, with the tibial suture anchor point located cranial to the insertion of CCL (tibial crest and/or distal patellar ligament), result-

ed primarily in external rotation of the tibia, with no rotation was recorded in most stifles with intact CCL.[19] Prosthetic implants anchored in these standard tibial anchor points are expected to be less isometric which may increase the incidence of overstretching or even failure of the implant. Furthermore, these techniques place additional constraints on the joint motion, and subsequently eliminate the small amount of internal tibial rotation that naturally generated when the stifle is flexed.[21] These constraints on the joint motion could affect the biomechanics of the stifle and enhance progression of osteoarthritis. One potential advantage of the use of patellar ligament/fascia lata graft stabilization was that with time the graft would be expected to minimally stretch and remodel during weight bearing, thus decreasing the amount of external rotation to less than that occurring in the immediate post-operative period.[24] However, it is possible for the joint laxity to redevelop due to graft overstretching.

In the study reported here, the amount of external rotation that could be generated after LFTB procedure is unknown. However, changing placement of the tibial anchor point to a relatively more isometric point located approximately next to the insertion of CCL is expected to minimize the amount of external rotation of the tibia and provide effective stabilization of the CCL-deficient stifle. This relative isometric positioning may maintain similar tension on the NCT throughout the range of stifle motion, thereby reducing the incidence of stretching or breaking the implant. We therefore propose that the minimal radiographic changes observed in only one dog after 6 months of surgery could be related to this new isometric tibial anchor point that minimized the external rotation of the tibia and allowed more normal stifle movement, thereby reducing progression of stifle osteoarthritis. Additionally, this new tibial anchor point is expected to allow for the small amount of internal tibial rotation that naturally generated when the stifle is flexed.[21] Further investigation of this relative isometric location of the pros-

thetic implant and longer-term (> 6 months) evaluation of the progression of stifle osteoarthritis are however needed to prove these theories. Unlike standard fabellotibial suture, LFTB procedure is also expected to minimize the mechanical compression created by the suture material on the proximal portion of the lateral tibial muscles, due to the mid-proximal location of the new tibial anchor point.

Although some degree of postoperative lameness is not an unusual finding especially in large breed dogs,30 a quicker return to normal limb function is expected in clinical cases treated with LFTB stabilization procedure, as arthrotomy will not be required in most of the cases unless medial meniscectomy is indicated. The main disadvantage of our implant system is the relatively low load at failure (slippage) and decreased stiffness of the self-locking bid that caused an implant failure in one dog. Therefore, engagement of an additional self-locking bid is expected to increase stiffness of our new implant. The limitations of the study reported here were the limited number of dogs enrolled in the study and the short-term assessment of the stifle osteoarthritis. Another limitation is that we failed to perform an in vivo mechanical evaluation of our implant. Although our study is the first to suggest the use of a tension band prosthetic material, anchored to the mid proximal tibia, to stabilize the CCL deficient stifle in dogs, a future study is warranted to assess the long-term (> 6 months) effect of this technique on the progression of stifle osteoarthritis. Clinical studies are also warranted to validate the use of different sizes of these implants in small and giant breed dogs with CCL disease.

CONCLUSIONS

Despite the reported limitations, we believe that the LFTB procedure is a simple and effective extra-articular technique for stabilization of the CCL-deficient stifle with good clinical outcome and minimal radiographic incidence of stifle osteoarthritis. The mechanical and morphological properties of our implant, and the fact that it is com-

mercially available and inexpensive, make the implant a worthwhile alternative to the standard suture materials traditionally used for lateral fabellotibial stabilization of the CCL-deficient stifle.

FOOTNOTES

a: Nylon Cable Ties, Y.Y. Cable Accessories Co. LTD, TSL-370-S, Taiwan

b: Instron 3345, ASTM-D-2256, England

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