CLINICAL AND MICROSCOPIC EVALUATION OF EXTRACAPSULAR STABILISATION TECHNIQUE FOR TREATMENT OF CRANIAL CRUCIATE LIGAMENT RUPTURE IN LOCAL DOGS

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Veterinary Science

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Chairman : Associate Professor Loqman Haji Mohamad Yusof, PhD
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One of the most common orthopedic conditions and the cause of lameness in adult dogs is cranial cruciate ligament (CCL) rupture. The purpose of this study was to evaluate the clinical and histopathologic results of the extra capsular stabilization (lateral imbrication) technique (ECST) to treat CCL rupture using conventional thick surgical suture to stabilize the joint. Four (eight stifle, the right stifle is treatment and the left is control) adult medium size (13-18 kg) male dogs were used in this study. General physical examination and orthopedic examination are performed to all the subjects prior to the surgery. The selected dogs should be clinically sound and have no signs of muscular atrophy or other musculoskeletal problems. CCL rupture was experimentally induced, and these dogs (right leg) were surgically treated with ECST using Ethilon® size 1, but the left leg is control group we do not use any treatment. The clinical outcomes were evaluated by physical examination, radiology, postmortem and histopathological examination throughout and after 6 weeks following the surgery. The physical examination includes gait analysis and orthopedic examination. Postoperative data collection includes lameness at stance, walk and trot, Glasgow pain assessment, Gross joint swelling evaluation, tibial thrust test and anterior drawer test, were also performed. Score of 1 to 4 lameness was observed to the operated limb throughout 6 weeks post-surgery. However, radiological examination showed no obvious abnormality findings such as sclerosis or osteophytes within the 6 weeks period. Mild to moderate osteoarthritis was seen, however there was no obvious different in the presence of inflammatory cells between the operated and non-operated joint fluid. The joint swelling was not apparent despite the positive cranial drawer and tibial thrust test that suggested joint instability. There was also evidence of loosen and loss of suture integrity used to stabilize the joint upon post-mortem examination. Microscopically, the total increase of lateral articular thickness measurement in the treatment group was over 129 µm thicker than the control

group and 21 µm increase seen in medial articular thickness as compared to the control group 6 weeks post-surgery. The caudal cruciate ligament integrity showed score 0 to 2 (showed preserved full thickness to fiber rupture damage) in the treatment group as compared to the control group (score 0 to 1: preserved full thickness to superficial fraying damage). The lateral meniscus in the treatment group showed a score of 1 to 3 lesions compared to the control that showed a score of 1 lesions. In addition, there was grade 1 to 2 lesion in the treatment group in compared with no lesions observed in the control group. The study highlighted some novelty in the findings, particularly the outcome of using Ethilon® size 1 suture in extracapsular stabilization surgery for cranial cruciate ligament rupture that was assessed clinnically and microscopically.

Keywords: Clinical, cranial cruciate, extracapsular stabilization technique, histopathology, ligament rupture

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Master Sains Veterinar

PENILAIAN KLINIKAL DAN MIKROSKOPI TEKNIK PENSTABILAN EKSTRAKAPSULAR UNTUK RAWATAN RUPTUR LIGAMEN KRUSIAT KRANIAL PADA ANJING TEMPATAN

Oleh

ABDULLAH TAHIER

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Salah satu keadaan ortopedik yang paling biasa dan punca kepincangan pada anjing dewasa ialah ruptur ligamen kranial (CCL). Tujuan kajian ini adalah untuk menilai keputusan klinikal dan histopatologi teknik penstabilan kapsul tambahan (imbrikasi sisi) (ECST) untuk merawat ruptur CCL menggunakan bahan sutur pembedahan konvensional yang tebal untuk menstabilkan sendi. Empat anjing dewasa (lapan stifle, kanan adalah rawatan dan kiri adalah kawalan) saiz sederhana (13-18 kg) anjing jantan digunakan dalam kajian ini. Pemeriksaan fizikal am dan pemeriksaan ortopedik dilakukan kepada semua subjek sebelum pembedahan. Anjing yang dipilih harus sihat secara klinikal dan tidak mempunyai tanda-tanda atrofi otot atau masalah muskuloskeletal yang lain. Ruptur CCL disebabkan oleh percubaan, dan anjing ini (kaki kanan) dirawat secara pembedahan dengan ECST menggunakan Ethilon® saiz 1, tetapi kaki kiri adalah kumpulan kawalan yang tidak diberikan sebarang rawatan. Hasil klinikal dinilai melalui pemeriksaan fizikal, radiologi, postmortem dan pemeriksaan histopatologi sepanjang dan selepas 6 minggu selepas pembedahan. Pemeriksaan fizikal termasuk analisis gaya berjalan dan pemeriksaan ortopedik. Pengumpulan data selepas pembedahan termasuk kepincangan pada pendirian, berjalan dan berlari, penilaian kesakitan Glasgow, penilaian bengkak sendi kasar, ujian tujahan tibial dan ujian laci anterior, juga dilakukan. Skor 1 hingga 4 kepincangan diperhatikan pada anggota yang dibedah sepanjang 6 minggu selepas pembedahan. Bagaimanapun, pemeriksaan radiologi tidak menunjukkan keabnormalan yang jelas seperti sklerosis atau osteofit dalam tempoh 6 minggu. Osteoartritis ringan hingga sederhana dilihat, namun tiada perbezaan yang jelas dengan kehadiran sel-sel radang antara cecair sendi yang dikendalikan dan tidak dikendalikan. Bengkak sendi tidak kelihatan walaupun laci tengkorak positif dan ujian tujahan tibial yang mencadangkan ketidakstabilan sendi. Terdapat juga bukti longgar dan kehilangan integriti jahitan yang digunakan untuk menstabilkan sendi semasa pemeriksaan bedah siasat. Secara mikroskopik, jumlah peningkatan ukuran

ketebalan artikular sisi dalam kumpulan rawatan adalah lebih 129 µm lebih tebal daripada kumpulan kawalan dan peningkatan 21 µm dilihat dalam ketebalan artikular medial berbanding kumpulan kawalan 6 minggu selepas pembedahan. Integriti ligamen salib ekor menunjukkan skor 0 hingga 2 (menunjukkan ketebalan penuh yang dikekalkan kepada kerosakan ruptur gentian) dalam kumpulan rawatan berbanding dengan kumpulan kawalan (skor 0 hingga 1: dikekalkan ketebalan penuh kepada kerosakan cetek berjumbai). Meniskus sisi dalam kumpulan rawatan menunjukkan skor 1 hingga 3 lesi berbanding kawalan yang menunjukkan skor 1 lesi. Di samping itu, terdapat lesi gred 1 hingga 2 dalam kumpulan rawatan berbanding dengan tiada lesi yang diperhatikan dalam kumpulan kawalan.Kajian ini menyerlahkan beberapa kebaharuan dalam penemuan, terutamanya hasil penggunaan jahitan saiz 1 Ethilon® dalam pembedahan penstabilan extrakapsular untuk ruptur ligamen krusiat kranial yang dinilai secara klinikal dan mikroskopi.

Kata kunci: Klinikal, krusiat kranial, teknik penstabilan extracapsular, histopatologi, ruptur ligamen

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This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
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LIST OF ABBREVIATION

AA	Antervision angles
ACL	Anterior cruciate ligament
AIC	Angle of inclination
AICUC	An institutional animal care and use committee
ALDFA	Anatomical lateral distal femoral angles
ALPFA	Anatomical lateral proximal femoral angles
APPA	American pet products association
CBC	Complete blood count
CCCL	Canine cranial cruciate ligament
CCLD	Cranial cruciate ligament disease
CLR	Cruciate ligament rupture
CMPS	Glasgow Composite Measure Pain Scale
CR	Cruciate ligament rupture
CTT	Cranial tibial translation
DJD	Degenerative Joint Disease
DPA	Proximal Tibial Axis Angle
ECM	Extracellular matrix
ECST	Extra capsular stabilization technique
FAA	Femoral antervision angles
FAIC	Femoral angle of inclination
FVA	Femoral Varus angle
LTPA	Lateral Tibial Plateau Angle
McdPTA	Mechanical Caudal Proximal Tibial Angles
McdTA	Mechanical Caudal Distal Tibial Angles

MCrdTA	Mechanical Cranial Distal Tibial Angle
MCrPTA	Mechanical Cranial Proximal of Tibial Angles
MLDFA	Mechanical lateral distal femoral angles
MLPFA	Mechanical lateral proximal femoral angle
MmdTA	Mechanical Medial Distal Tibial Angle
MMP	Modified Maquet procedure
MmPTA	Mechanical Medial Proximal Tibial Angle
MTPA	Medial Tibial Plateau Angles
NRS	Numeric rating score
OA	Osteoarthritis
RCCL	Rupture of the cranial cruciate ligament
ROM	Range of motion
SDev	Standard deviation
SE	Standard error
TPA	Tibial plateau angle
TPLO	Tibial plateau levelling osteotomy
TTA	Tibial tuberosity advancement
TTO	Triple tibial osteotomy
VAS	Visual analog scale
VD	Ventral Dors

CHAPTER 1

GENERAL INTRODUCTION

1.1 Study Background

Extra-capsular stabilization using suture materials is a commonly performed surgical procedure to stabilize CCL deficient stifles (Tonks et al., 2011; Chang et al., 2013). Because premature slippage, broken constructs, or premature loosening can induce postoperative joint instability prior to formation of sufficient per articular fibrosis, the optimal suture material and the fixation method have been investigated to reduce the occurrence of premature failure (Rose et al., 2012; Dycus et al., 2013; Chang et al., 2016). Tibiofemoral normal motion is supported by articular surfaces, ligaments, joint capsules, and menisci. Cranial cruciate ligament (CCL) rupture changes this restriction and is the reason for abnormal motion between the articular surfaces (Anderst & Tashman., 2009). In the beginning, this condition was thought of solely because of traumatic injury. However, during the past 25 years, it was become widely accepted that both genetic and environmental contributes to the risk of disease, with expansion of the stifle instability because of progressive fiber tearing in the cruciate ligament complex (Bennett et al, 1988). In fact, the most common reason for hind limb lameness in the dogs, especially the adult dogs, is cranial cruciate ligament disease (CCLD) that finally leads to stifle osteoarthritis. The CCLD is the gradual degeneration of the ligament extracellular matrix (ECM) that subsequently leads to ligament rupture (Comerford et al., 2011). The etiopathogenesis of canine CCLD has yet to be fully explained; however, it is recognized as a degenerative process within the extracellular matrix (ECM) eventually leading to partial or complete ligament rupture, instability, and secondary degenerative joint disease (Hayashi et al., 2004; Comerford et al., 2011). CCL serves a crucial role in limb function by keeping stability of the stifle joint during the range of motion; joint instability that predispose of joint to degenerative alteration is the consequence of CCL damage. Besides that, CCL rupture is individually common in giant and large breed dogs; however, all breed, size and age of dogs may be affected (Su et al., 2015).

1.1.1 Clinical signs and Etiology of cranial cruciate ligament disease

A rupture due to a traumatic event will initially cause significant stifle effusion, and the patient will be toe-touching to non-weight-bearing lame. In chronic cases, a precipitating event may be associated with an acute notable change in limb use; however, there is often a history of intermittent lameness over a period of several weeks to months. Common findings include the patient sitting with

the affected limb extended or positioned laterally rather than flexed and tucked under the body, shifting weight off the affected limb when standing, and displaying stiffness upon rising. Concurrent meniscal injury can cause an audible click when walking or flexing the stifle (Zink and Dyke, 2018). The etiology of cranial cruciate ligament disease content to many factors, including anatomical configuration, environment and genetics, are suggested to contribute to development of CCLD, and the complex and likely multifactorial origin of the disease makes it challenging to develop preventive strategies (Comerford et al., 2011; Griffon, 2010).

1.1. 2 Diagnosis of cranial cruciate ligament disease

The diagnosis of CCL pathology is made based on signalment, history and clinical signs, orthopedic examination findings, and diagnostic imaging. While the old saying a hind limb lameness in a mature dog is cruciate disease until proven otherwise holds true, it is important to ensure that the lameness is due to CCL pathology and not another underlying pathological condition of the stifle or another anatomical structure of the pelvic limb (Amotz and Dycus 2022).

1.1. 3 Pathophysiology of cranial cruciate ligament disease

CCL rupture can result from acute traumatic rupture secondary to excessive strain or progressive degeneration of unknown cause and traumatic acute rupture of the CCL typically results from hyperextension and excessive internal tibial rotation (Kowalski, 2012; Fauron and Perry, 2017). Similar to the situation in the majority of people with anterior cruciate ligament (ACL) rupture. In both scenarios, the tibial excursion results in CCL overload, causing rupture. Hyperextension probably occurs most commonly by stepping into a hole or depression at a fast gait while excessive tibial rotation occurs when the dog rapidly turns towards the limb with the foot firmly planted (Piermattei et al, 2006; Fauron and Perry, 2017).

1.1. 4 Surgical techniques in cranial cruciate ligament rupture

A number of methods for stifle stabilization exist. They are commonly characterized as extraarticular stabilization, intraarticular stabilization, and osteotomy modifying procedures. One of the complicating factors of stifle stabilization (and indeed, one of the reasons for the existence of so many surgical procedures) is the lack of definitive guidelines for what constitutes a successful postoperative outcome. While all correctly executed surgical procedures can stabilize the stifle, not one of these procedures ultimately restores completely normal stifle kinematics or kinetics. In defining a good outcome, should we consider a stable stifle to be the predominant deciding

factor? Interestingly, work has been completed that demonstrates ongoing instability following surgical stabilization (Rey et al., 2014; Kim et al., 2012).

1.1.4.1 Intra articular stabilization techniques

Includes, the use of autografts, QAallografts, xenografts, and synthetic materials to replace the affected CCL. Due to various shortcomings and limitations, they are not widely used in veterinary surgery (Paatsama, 1952; Cook et al., 2010).

1.1.4.2 Extra-articular techniques

Tend to stabilize the stifle through the application of synthetic sutures or through the modification of the anatomical relationships between bone and ligaments, externally to the joint (Vasseur, 2003). Recently, the interest about the extra-articular techniques has risen, with particular attention to the insertion points of the synthetic implant (Cook et al., 2010).

1.1.4.3 Proximal tibial osteotomy techniques

Includes, tibial plateau levelling osteotomy (TPLO), combined tibial plateau levelling osteotomy and tibial tuberosity transposition (TPLO-TTT), tibial tuberosity advancement (TTA) with the variants TTA-1, TTA-2 and TTA-rapid, triple tibial osteotomy (TTO) and modified Maquet procedure (MMP). All procedures create primarily change to the biomechanics of the stifle and required specialized and custom equipment's. The choice of source of this equipment depend on surgeons' preferences or/and their affiliation to certain product companies (Igna et al., 2014).

1.2 Extra capsular techniques

The extracapsular stabilization technique was first developed more than 50 years ago (Childers, 1966). There are wide variations in the anchoring points used in the procedure on the femur or tibia as well as in the materials used for stabilization However, one of the most favored extracapsular stabilization methods is known as Flo's technique. In brief, Flo's technique involves passing nylon through the femoropatellar ligament to anchor the femur. The tibia fixation is anchored by passing the nylon through the drilled hole one centimeter caudal to the tibia crest (Flo, 1975). Imbrication procedures were the first extra capsular stabilizations described in the literature (Pearson et al, 1971). The first imbrication technique using lateral and medial Lambert sutures on the joint capsule was proposed in the 1960s (Childers, 1966) and a modified retinacular

imbrication technique was reported later (Dietrich, 1974). Lateral retinacular imbrication for stabilization of the cranial cruciate deficient stifle was first reported in 1970 (Angelis & Lau 1970). It has been used for stabilization of the stifle of all sizes of dogs and typically works best for dogs 40–45 pounds or less (Stepnik, 2017).

1.3 Problem statement

The CCL is the ligament that usually tears in dogs and more frequently seen in overweight, in large and giant breed dogs, neutered, and middle aged dogs (Somil & Dinesh, 2018). However, any breed, size, or age of dog may be affected. Osteoarthritis, meniscal injury, and persistent lameness commonly occur with CCL rupture. One million CCL surgical procedures performed annually in the United States alone. Of these procedures, 92% are performed by general practice veterinarians, with 8% being performed by certified Board veterinary surgeons (Wilke et al., 2005). In this country in 2010, musculoskeletal problems were the third costliest medical expense ($170 billion) behind circulatory conditions ($234 billion) and preventatives, colds, and other basic care ($207 billion) (Altman, 2015). Despite this high prevalence and obvious clinical problem, there is still controversy about the best treatment (Boudrieau, 2009; Medeiros et al., 2011) and continues to be a real problem for veterinarian clinicians (Igna & Schuszler., 2018). Additionally, treatment of this condition typically requires expensive surgery and lengthy physical rehabilitation in order to improve limb function and quality of life (Hayashi, 2011). Although, many different surgical techniques have been used to stabilize the deficient stifle with success rates reported to be 90% irrespective of the technique used, unfortunately none of the current techniques completely limits the progression of degenerative joint disease. The material used should ideally be strong, aseptic, easily handled, inexpensive, and provide excellent knot security and knot compactness (Banwell et al., 2005). Thus, heavy non-absorbable suture material (nylon, braided polyester) is used for lateral retinacular imbrication. Stainless steel wire has also been used (Tomlinson, 2001; Hulse, 1995). In addition, there is a variety of materials used for the suture, including a new generation of orthopedic suture materials which include FiberTape, FiberWire, and OrthoFiber. However, the most common material used by surgeons is monofilament nylon leader (Ledecky et al., 2012). Some studies have shown a weakening of the leader line after steam sterilization (Lewis et al., 1997) or ethylene oxide sterilization (Anderson et al., 1998), while others have shown no difference in mechanical properties after sterilization (Caporn and Roe, 1996; Sicard et al., 2002). As is the case for humans, CCL surgery is costly, totaling $1.32 billion annually (Wilke et al., 2005). The total expense of CCL surgery has increased greatly over the years. In 2005, the average cost of one CCL surgery ranged from $898.00 to $1,840.50 and now costs about $5,000 but varies substantially by geographic location (Trupanion, 2019; Wilke et al., 2005). Nowadays, there are several commercial products specifically for use in ECST available in the market. However, because of the cost and is not readily available for use by all general veterinary practitioners, conventional surgical sutures are still the practical option. For example, the price of other suture is

estimated to more than RM 1000 in comparison of Ethilon® (size 1) is only around RM 100.. Considering the expensive surgical treatment, a technique that can use easily available and nonspecific surgical materials such as extracapsular would be preferred over the technique that using relatively expensive materials/ instruments and technically demanding to perform. To date there is no documented information about the most favorable surgical techniques to treat RCCL in local dogs in this country.. Besides that, the local dog pelvic limbs conformation analysis may provide pertinent knowledge in understanding the disease development and therapy. The present study hopefully can shed some lights on the relevant information with regards to the canine CCL tear treatment in this country. This study aimed to examine the clinical and microscopic outcome using a conventional suture to treat CCL rupture using the ECST in local dogs.

1.4 Justification

There is a lack of study about the clinical outcomes of CCL rupture surgery repair for local dogs. The use of thick conventional suture, Ethilon® size 1 suture in CCL rupture in the surgery treatment is relatively inexpensive besides it is readily available.

1.5 General objectives

1. to measure the local dog's hind limb conformation based on the surveillance of the dog's hind limbs radiology for future reference to study the effect on CCL diseases

2. to determine the clinical outcomes and microscopic changes following CCL rupture treated with extra capsular stabilization surgery

1.6 Specific objectives

To study the following clinical outcomes and histological changes of the dogs following surgical treatment of CCL rupture using ECST:

1. Physical examination and gait analysis of the operated limb

2. Radiological examination of the operated stifle joint before and after surgery

3. Joint cells analysis post-surgery

4. Histology changes of caudal cruciate ligament, lateral and medial meniscus and femoral condyle articular thickness following surgery

1.7 Hypothesis

It is hypothesized that extracapsular surgical stabilization technique (ECST) through lateral imbrication with thick conventional suture material will produce good clinical results in medium-sized local dogs.

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