Original Article

Suture attachment sites on stifle joint of small and large dog breeds for cranial cruciate ligament rupture repair

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Abstract

Cranial cruciate ligament rupture is one of the most common problems in dogs. Previous studies have arrived at no absolute conclusion regarding suture attachment sites using the extracapsular technique to repair cranial cruciate ligaments in dogs. Therefore, the objective of this study was to identify and compare suture attachment sites on the femur and tibia between small and large dog breeds at different stifle angles. Twenty-seven cadaveric hind limbs of small dogs and 16 cadaveric limbs of large dogs were collected, and lateral photographs were taken at different stifle angles (including 40, 60, 80, 100, 120, 140, and 160 degrees). Based on anatomical landmarks, three points were marked on the femur and five points were marked on the tibia. Distances between the center of points on the femur and tibia at different angles were measured in millimeters with a picture analysis program. The minimum change in distance at the different angles was the most isometric distance. The most isometric distance was identified in small and large dogs between the lateral condyle of the distal femur cranial to the middle part of the lateral fabella and the caudal part of the tibial tuberosity. According to the study, the most isometric distance is recommended to be used for cranial cruciate ligament repair.

Keywords: cranial cruciate ligament rupture, dogs, extracapsular technique, isometric distance

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Introduction

Cranial cruciate ligament rupture is a common problem involving canine hind limb lameness (Tonks et al., 2011). Loss of function and osteoarthritis of the stifle joint are consequences of this problem, especially in large dog breeds. Cruciate ligament rupture is not only present in large dog breeds but is also commonly found in small dog breeds (Harasen, 1988; Harasen, 2005; Hoots and Petersen, 2005; Perry and Fitzpatrick, 2010). Surgical correction through extracapsular stabilization is commonly recommended for cranial cruciate ligament rupture because this technique is less invasive than other options, easy to perform, and cost-effective. This technique has become the most popular surgical procedure for canine cranial cruciate ligament rupture in small dog breeds.

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 (Flo, 1975). 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. In contrast, Cook et al. (2010) demonstrated the TightRope® technique, in which the femur is anchored at the lateral site of the femoral condyle, while the tibia is anchored at the caudal part of the long digital extensor tendon groove of the proximal tibia (Cook et al., 2010). The smallest change in distance between anchoring points on the distal femur and proximal tibia when joint movement occurs is the most isometric distance of the stifle. In repairing cranial cruciate ligaments using the extracapsular technique, the anchoring points on the femur and tibia used to stabilize the stifle joint with the most isometric distance are important for post-operative outcomes.

In the past decade, many researchers have been interested in isometric anchoring sites on the femur and tibia used in the extracapsular stabilization technique to repair cranial cruciate ligament rupture in medium to large skeletal dog breeds (body weight 10 to 30 kg) (Haper et al., 2004; Roe et al., 2008; Fischer et al., 2010; Tonks et al., 2011). The present study compared isometric anchoring sites for lateral sutures on the femur and tibia between small (body weight less than 10 kg) and large (body weight more than 20 kg) dog breeds when using the extracapsular technique to address cranial cruciate deficiency.

Materials and Methods

Sample collection: The present study's sample included forty-three pairs of hind limbs with normal stifle joints from donated cadavers. These were from small (body weight less than 10 kg, mean±SD = 6.12±1.98, n=27) and large (body weight more than 20 kg, mean±SD = 30.37±5.90 kg, n=16) dog breeds from the Kasetsart University Veterinary Teaching Hospital (KUVTH) in Bangkok, Thailand. Soft tissues and the joint capsule were removed from each hind limb, except for the lateral collateral ligament, medial collateral ligament, cranial cruciate ligament, and caudal cruciate ligament. The cadavers were labeled and immersed in normal saline, then kept at 4°C until the day of the experiment.

Determination of points on femur and tibia: The specimens were mounted on a green screen. Only the femur was fixed to the screen, allowing free movement of the tibia. The stifle angles were determined at 40, 60, 80, 100, 120, 140, and 160 degrees using a goniometer (Figure 1). Pictures of the true lateral stifle at the various angles were taken at similar level and angle for each specimen. Points on the femur and tibia were marked as anatomical landmarks for easy identification during surgery, including three points on the femur (F1-F3) and five points on the tibia (T1-T5). F1 was located on the lateral area of the distal part of the femur cranial to the proximal pole of the fabella, F2 was marked on the cranial aspect of the middle part of the fabella, and F3 was marked on the distal part of the femur cranial to the distal pole of the fabella. T1 was located on the caudal part of the tibial tuberosity, T2 was located on proximal part of the tibia cranial to the long digital extensor ligament groove, T3 was located on the proximal part of the tibia caudal to the long digital extensor ligament groove, T4 was marked on the cranial part of the fibular head, and T5 was marked on the distal part of the tibia cranial to the long digital extensor ligament groove at the same horizontal level as T1 (Figure 2).

Fifteen distances were measured, including those between F_1T_1, F_1T_2, F_1T_3, F_1T_4, F_1T_5, F_2T_1, F_2T_2, F_2T_3, F_2T_4, F_2T_5, F_3T_1, F_3T_2, F_3T_3, F_3T_4, and F_3T_5, at seven different stifle angles. Distances between F and T were measured in millimeters by the AxioVision 4.8.2 (ZIESS, Germany) picture analysis program. Data were recorded in a spreadsheet using Microsoft Office Excel 2007 (Microsoft, USA).

Statistical analysis: Distances in millimeters between points on the femur (F) and points on the tibia (T) were collected for each angle. Change in distance between points on the femur and tibia was calculated, as was the average, standard deviation, and percentage of coefficient of variation (%CV) of the change in distance. %CV was analyzed with a one-way ANOVA in a Kruskal Wallis Multiple Comparison Z test (Dunn's test) using NCSS 2007 (Kaysville, UT, USA). The smallest median of the change in distance was analyzed as the most isometric point in this study.

Results

The change in distance between points on the femur and tibia was found at different stifle angles. The smallest change in distance at the various stifle angles was identified between F2 and T1 in the small dog breeds; therefore, the distance between F2 and T1 was determined to be the most isometric distance for these dogs. The median of %CV between F2 and T1 was the smallest value (4.82) compared to other %CV medians. Although the distance between F2 and T1 was the smallest change in length, it was not significantly different ($P \geq 0.05$) from the distances between F1T1, F1T2, F2T2, F2T5, and F3T1. The %CV data for the small dog breeds are shown in Figure 3.

For the large dog breeds, the most isometric distance was also between F2 and T1. However, this distance was not significantly different from the distances between F1T1, F1T2, F2T2, F2T5, and F3T1. The %CV data for the large dog breeds are shown in Figure 4.

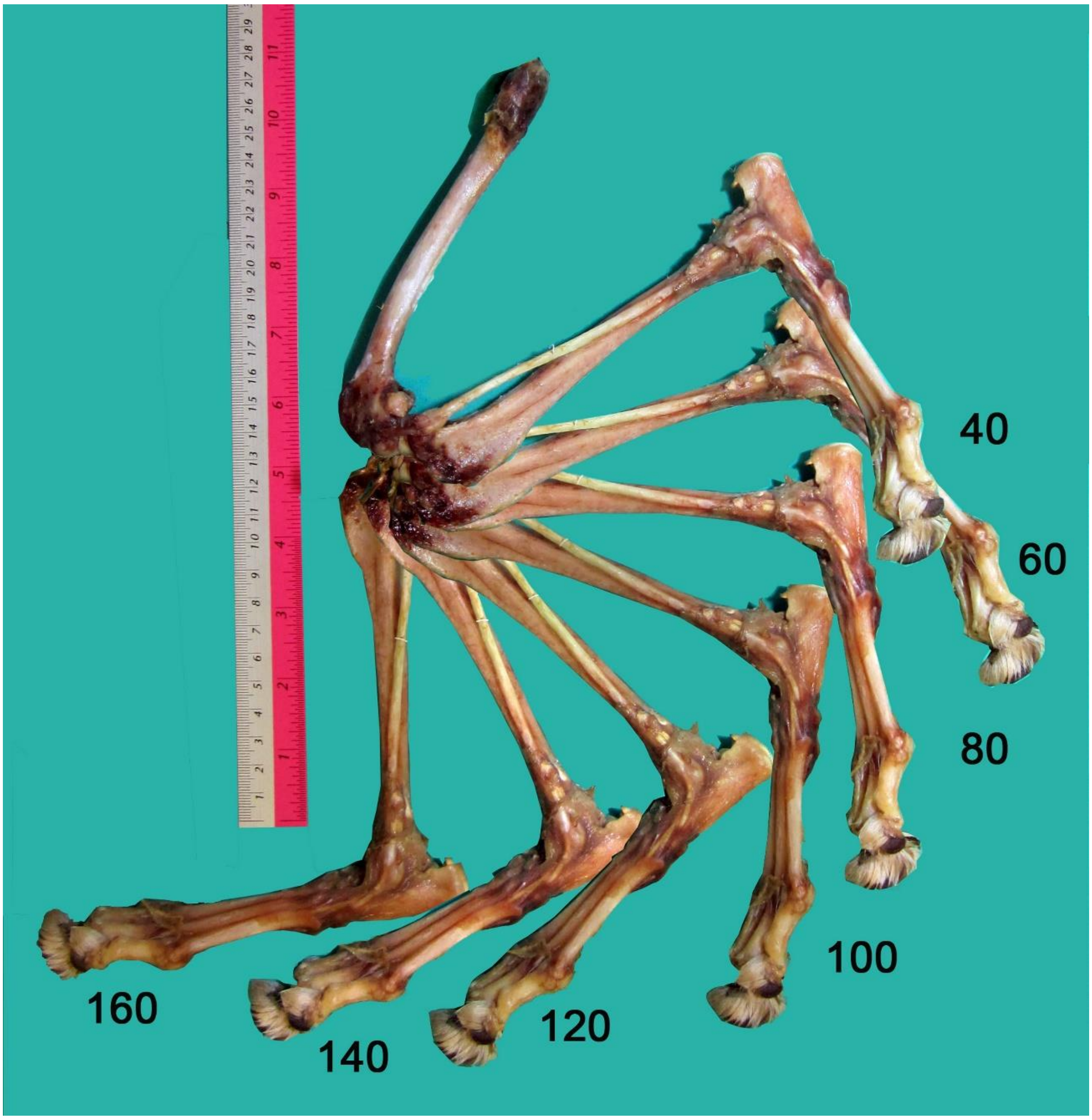

Figure 1 Measurements of suture attachment sites were determined at various stifle angles, including 40, 60, 80, 100, 120, 140, and 160 degrees.

Discussion

Isometric attachment sites on the femur and tibia used in the extracapsular stabilization technique for dogs with cranial cruciate ligament rupture have been studied closely during the past decade. Roe et al. (2008) presented a new isometry of potential attachment sites in extracapsular stabilization for cranial cruciate ligament rupture repair. In Roe et al.'s experiment, seven stifles from the cadavers of medium-sized dogs were studied. They determined 6 points on the femur and 11 points on the tibia in a true lateral of the stifle joint in radiographic images. The range of motion in this study was 50 to 150 degrees. They concluded that the distances between points on the femur were just cranial to the distal pole of the fabella (F3) to the attachment points on the tibia were tibial plateau just caudal to the long digital extensor tendon groove (T3). The tibial plateau just cranial to the long digital extensor tendon groove or caudal to tibial tuberosity (T2) could be the reasonable isometric pattern (Roe et al., 2008).

Hulse et al. (2010) sought to identify isometric points for the placement of a lateral suture in the treatment of cranial cruciate ligament rupture by measuring the changing tension of the suture that attached six different distances between anchoring points on the femur and tibia. They concluded that the most isometric point was the distance between the lateral distal femoral condyle cranial to the caudal pole of the fabella (F3) and the point on the proximal tibia just caudal to the long digital extensor tendon groove (T3) in a range of motion of 50 to 150 degrees. Another study presented a new technique (TightRope®, TR) for extra-articular stabilization in cranial cruciate ligament surgery, comparing the 6-month outcome with that of the tibial plateau leveling osteotomy (TPLO). The results of this study showed no difference in the outcome in terms of radiographic progression of osteoarthritis and client evaluation of stifle function. Moreover, TR had low complications and was less invasive than TPLO. The attachment point of the TR technique on the femur was on the lateral part of the distal femoral condyle cranial to the distal pole of the fabella (F3) and the proximal tibia on the caudal part of the long digital extensor tendon groove (T3) (Cook et al., 2010).

Figure 2 Suture attachment sites on the femur (F1 = proximal pole of the fabella, F2 = cranial to the middle pole of the fabella, and F3 = distal pole of the fabella) and tibia (T1 = tibial crest, T2 = proximal part of tibia cranial to the long digital extensor ligament groove, T3 = proximal part of the tibia, caudal to the long digital extensor ligament groove, T4 = cranial to the fibular head, and T5 = distal part of the cranial aspect of the long digital extensor ligament groove)

The data suggest that, in both the large and small dogs, the distance between F2 (distal femoral condyle cranial to the middle part of the fabella) and T1 (caudal part of the tibial tuberosity) was the smallest change in length when changing the angle of the stifle joint from 40 to 160 degrees. However, the present study showed that the distances between F1T1, F1T2, F2T2, F2T5, and F3T1 were not significantly different from the distance between F2T1 in the small and large dog breeds. This finding indicates that the anchoring point on the femur can be F1, F2, or F3 when the anchoring point on the tibia is T1, while the anchoring point of T2 can be paired with F1 or F2. F2 can also be paired with T5. This experiment demonstrated that the anchoring point on the tibia should be located on the cranial part of the proximal tibia in front of the level of the long digital extensor tendon. These points were easy to be located during surgery and easy to drill a hole into when compared with T3 and T4. One study employed four different extracapsular stabilization methods. These methods used 80 lb suture to fix the femur and tibia at different points and measured the tension of the suture at stifle angles of 70, 100, and 130 degrees. The results showed that the method involving the circumfabella suture on the femur and two holes on the tibial tuberosity was a consistent force during changes to the stifle angle. This method was a slight modification to Flo's technique (Fischer et al., 2010). The results of the present study are similar to those reported by Fischer et al., which in small dog breeds the point on the tibia which has the least change in distance when the stifle angle changes is close to the tibial tuberosity (T1, T2) when the femoral marker is on the cranial aspect of the middle part of the fabella (F2).

The results of the present study indicate that the true isometric attachment site of the stifle remains unknown. In the extracapsular technique, the suture curves on the femoral condyle and the joint capsule. Stifle joint movement and the suture sliding on this structure affect the isometry. The isometry of the stifle joint can be assessed prior to knot tying. Clinical guidelines suggest that the tibia should be externally rotated while the stifle is held at a weight-bearing angle during the application of the prosthesis (Moores et al., 2006). However, the author recommends the distance between F2 and T1 as the attachment site on the femur and tibia because the distance between these two points has the smallest change and they are easy to define during surgery. It is known that the external rotation of the tibia at a weight-bearing angle can neutralize the instability of the stifle joints affected by cranial cruciate ligament rupture. Finding the likely isometric point of the stifle before securing the knot is important when using the extracapsular stabilization technique in cranial cruciate ligament surgery. A tensioning device may help in finding the isometry before knot tying by testing the drawer sign at different angles before securing the knot or crimp clamp.

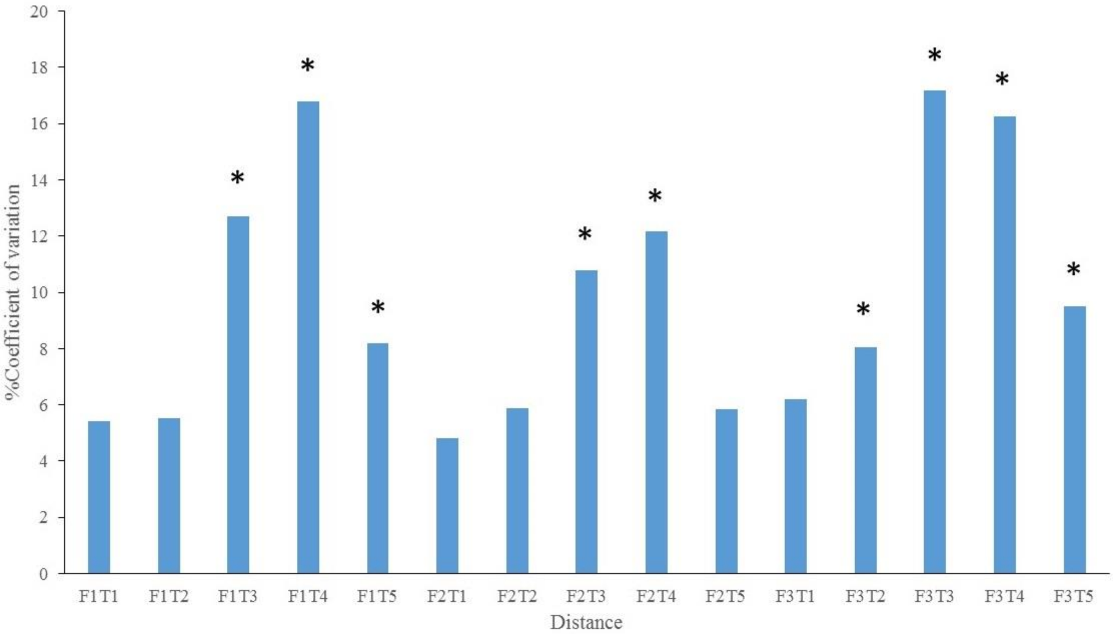

Figure 3 Median value of %CV in the small dog breeds. * Significant difference (p<0.05) compared to F2T1.

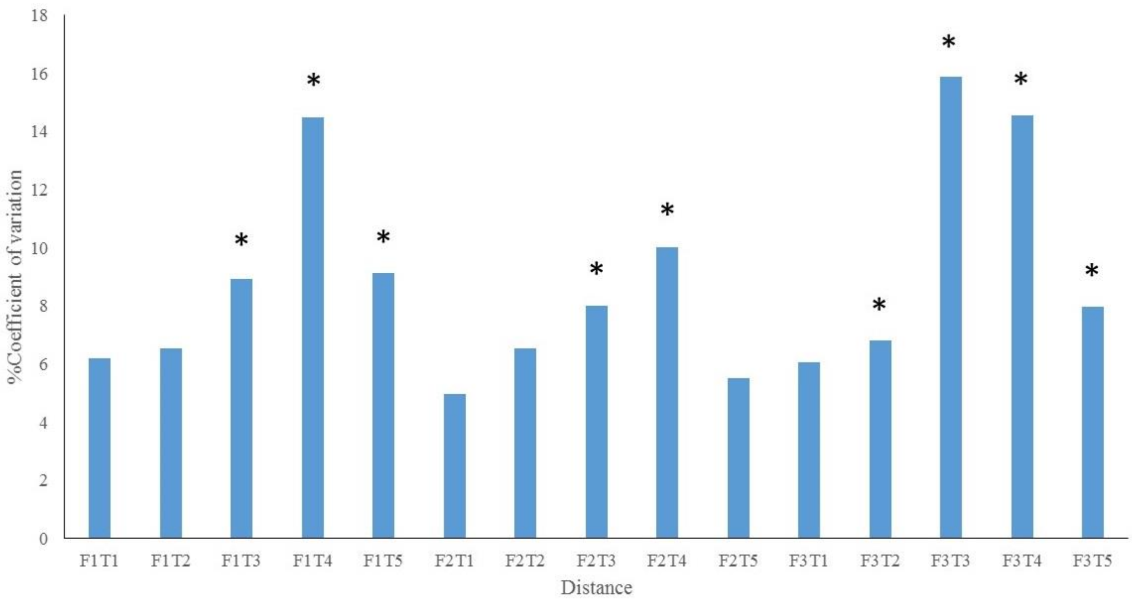

Figure 4 Median value of %CV in the large dog breeds. * Significant difference (p<0.05) compared to F2T1.

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บทคัดย่อ

ตำแหน่งยึดเอ็นเทียมหัวเข่าของสุนัขพันธุ์เล็กและพันธุ์ใหญ่เพื่อการแก้ไขภาวะเอ็นไขว้หน้าฉีกขาด

ชัยกร ฐิติญาณพร[1*]

ปัญหาเอ็นไขว้หน้าฉีกขาดเป็นปัญหาที่พบได้บ่อยในสุนัข การศึกษาก่อนหน้านี้ไม่ได้มีการระบุตำแหน่งที่แน่ชัดในการเป็นจุดยึดของเอ็นเทียมเพื่อแก้ไขการฉีกขาดของเส้นเอ็นไขว้หน้าด้วยวิธีการแก้ไขด้านนอกข้อต่อในสุนัข จุดประสงค์ของการศึกษาครั้งนี้ คือ เพื่อระบุตำแหน่งและเปรียบเทียบตำแหน่งในการยึดของเส้นเอ็นบนกระดูกฟีเมอร์และทิเบียระหว่างสุนัขพันธุ์เล็กและสุนัขพันธุ์ใหญ่ในมุมหัวเข่าที่แตกต่างกัน เก็บซากขาหลังของสุนัขพันธุ์เล็กยี่สิบเจ็ดขาและของสุนัขพันธุ์ใหญ่สิบหกขา และถ่ายรูปในท่าด้านข้างในแต่ละมุมของข้อเข่า (ประกอบด้วย 40°, 60°, 80°, 100°, 120°, 140° และ 160°) บนพื้นฐานทางกายวิภาคศาสตร์ ระบุสามตำแหน่งบนกระดูกฟีเมอร์และห้าตำแหน่งบนกระดูกทิเบียในแต่ละมุม และวัดระยะทางระหว่างตำแหน่งในหน่วยมิลลิเมตรด้วยโปรแกรมวิเคราะห์ภาพ ระยะทางที่เปลี่ยนแปลงน้อยที่สุดเมื่อข้อเข่าเปลี่ยนมุมไป คือ ระยะทางที่มีมิติเท่ากันมากที่สุด ซึ่งระยะทางที่มีมิติเท่ากันมากที่สุดที่ระบุได้ในทั้งสุนัขพันธุ์เล็กและพันธุ์ใหญ่ คือ ระยะทางระหว่างบริเวณด้านข้างของส่วนปลายของกระดูกฟีเมอร์ที่บริเวณด้านหน้าของกลางกระดูกฟาเบลล่า และบริเวณด้านท้ายของปุ่มกระดูกทิเบีย ดังนั้น ผู้เขียนแนะนำให้ใช้ระยะทางที่มีมิติเท่ากันมากที่สุดในการแก้ไขภาวะเอ็นไขว้หน้าฉีกขาด

คำสำคัญ: เอ็นไขว้หน้าฉีกขาด สุนัข เทคนิคการยึดตรึงด้านนอกข้อต่อ ระยะทางที่มีมิติเท่ากัน

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