Objective assessment of drawer test in cruciate ligament rupture in dogs

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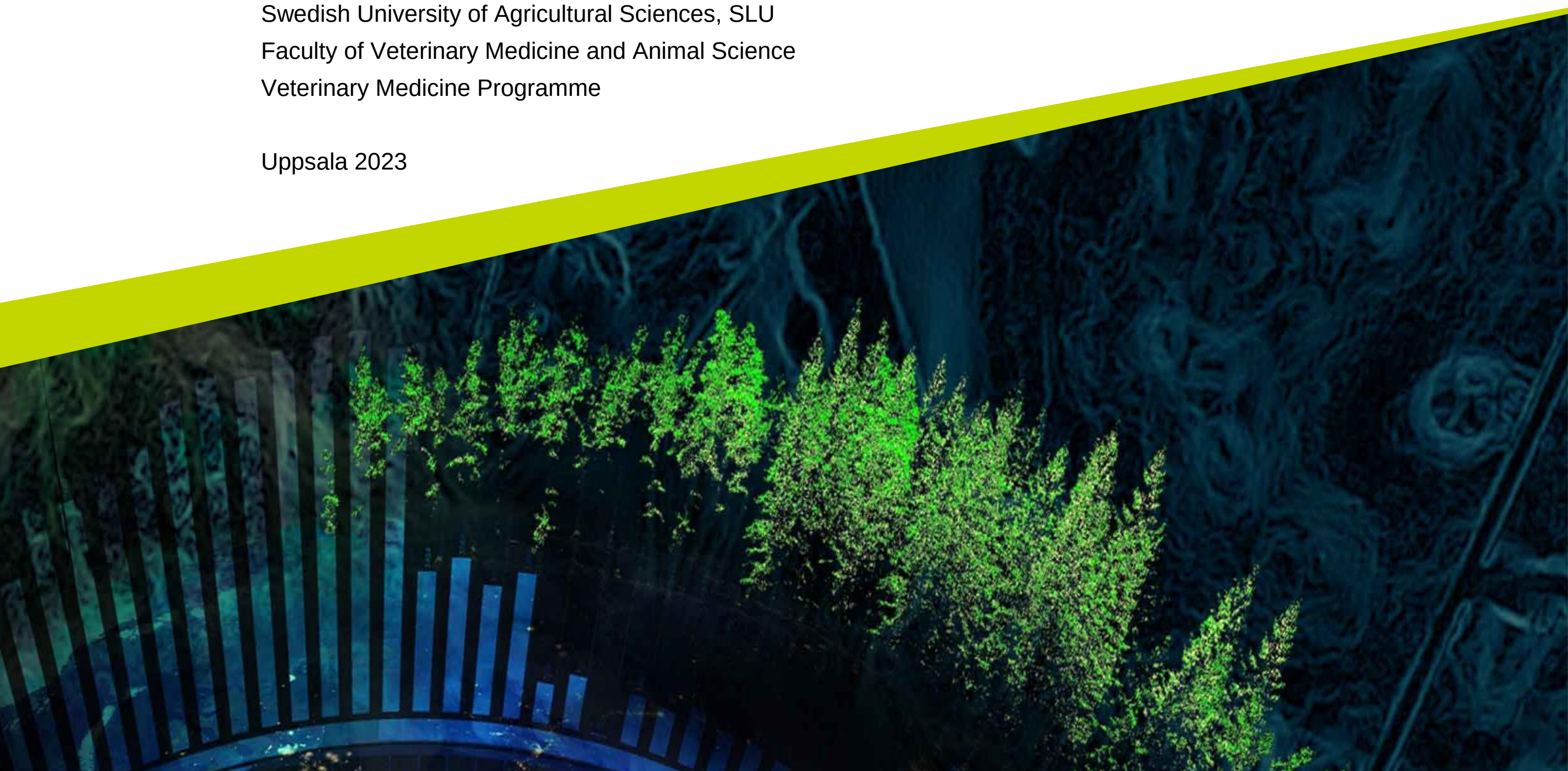

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Abstract

Cranial cruciate ligament rupture (CCLR) is one of the most common orthopaedic diagnoses in dogs. There are different methods to diagnose CCLR, but only a few can be considered as both non-invasive and objective.

This pilot study aimed to assess software for motion analysis, intended to be used for objective assessment of movements of tissue in investigation of CCLR in dogs.

Seven cadavers were used in this study, and veterinary students performed the drawer test. The study was blinded for students and for analysis.

Areas over the knees were shaved, temporary tattoos with a doted pattern were placed over the stifle joints and the drawer test was performed during video recording. The software, from the company Kneedly, generated an automatic analysis and a colour sheet for evaluation.

Sensitivity of the automatic analysis were 0.67 and specificity 0.84. Results for manual analysis of the colour sheets was 0.57 and 0.79 respectively. The test persons had a sensitivity of 0.51 and a specificity of 0.72.

The sensitivity and specificity of the software, for both manual and automatic analysis, were higher compared to those achieved by students, which may indicate that the software could be helpful for diagnosing CCLR in an educational setting.

There was a high risk that the results for sensitivity and specificity of the software were falsely low. The reason was the drawer tests performed by students were, subjectively, not always correctly performed.

The software may potentially also be useful for teaching and assessment. Further studies are needed to develop the program and to better estimate the efficiency of the software.

Keywords: Cranial cruciate ligament rupture, CCLR, canine, dog, drawer test, diagnostics, motion analysis

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Abbreviations

CCL	Cranial cruciate ligament
CCLD	Cranial cruciate ligament disease
CCLR	Cranial cruciate ligament rupture
MRI	Magnetic resonance imaging

1. Introduction

In dogs, rupture of the cranial cruciate ligament (CCL) is one of the most common orthopaedic diagnoses (Harasen 2002; Fazio *et al*. 2018; Engdahl *et al*. 2021). Cranial cruciate ligament rupture (CCLR) is also the most common cause to pelvic lameness (Engdahl *et al*. 2021; Spinella *et al*. 2021). Untreated CCLR can lead to pathological changes such as osteoarthritis (Spinella *et al*. 2021) or meniscal tears (Galindo-Zamora *et al*. 2013; Fazio *et al*. 2018). CCLR is more common in large and giant breeds (Engdahl *et al*. 2021; Spinella *et al*. 2021) and it is more prevalent in dogs that are four years or older (Witsberger *et al*. 2008; Engdahl *et al*. 2021).

It is therefore fair to say that CCLR is a highly relevant topic for veterinarians who work clinically with dogs. It is also of importance to diagnose dogs correctly and understand differential diagnosis to CCLR, i.e. other causes to lameness (Kirby 1993; Harasen 2002).

There are many ways to diagnose CCLR: the drawer test, the tibial compression test, radiographic imaging, magnetic resonance imaging (MRI), ultrasonic imaging, and arthroscopy but it is difficult to find a test that has a high sensitivity, high specificity, is objective, is inexpensive and does not require sedation.

A company (Kneedly) has developed a new way to diagnose CCLR in humans that is objective. If used on dogs it could help the clinician to assess the drawer test more objectively, and it could potentially be safer if it is possible to use this software without sedation, and the software could also potentially reduce the cost for the owners. The purpose of this pilot study was therefore to evaluate Kneedly's software, a method of analysis of movements, and investigate the sensitivity and specificity when used by people with little or no experience of orthopaedic patients. Our hypothesis was that the software could differentiate between movements of drawer tests performed by students, in ruptured and intact cranial cruciate ligaments in canine cadavers.

2. Literature review

2.1 Function of the cruciate ligaments

The cranial cruciate ligament and the caudal cruciate ligament are together important for the stability in three different ways (Spinella *et al*. 2021). The cruciate ligaments minimize the hyperextension of the joint, movement in the caudo-cranial direction as well as rotation of tibia in relation to femur. If the cranial cruciate ligament ruptures, the stifle joint will lose some stability and the cranial and caudal movement of tibia in relation to the femur will increase (Harasen 2002).

2.2 Symptoms of cranial cruciate ligament rupture

Dogs with CCLR often present clinically with lameness from the affected pelvic limb (Nanda & Hans 2019; Sellon & Marcellin-Little 2022). The lameness can present in different ways, the animal could have an acute lameness with toe-touching or they could have chronic lameness that often decrease while they rest but the lameness never disappear completely (Harasen 2002). The grade of lameness can also differ between individuals, some may not want to put any weight on the affected limb while other patients are less affected and will walk almost as if normal (Kirby 1993). Even if the dogs may not show a high grade of lameness, it is important to observe the patient whilst it is standing still since dogs with CCLR tend to put their weight on the non-affected limb even if they only show a low grade of lameness (Palmer 2005, 2009). It is also important to notice other deviations in the dog’s gait than lameness. Dogs with CCLR tend to have the knee in the affected hind limb more flexed during the whole gait cycle, to compensate the hip joint and the tarsal joint will be extended instead. (Spinella *et al*. 2021)

While observing dogs with CCLR sitting down it is possible to notice that some of them might not sit normally since it could be painful or uncomfortable for them (Palmer 2005, 2009). They avoid flexing the stifle and will hold the leg in a cranial or an abducted position. If the dog suffers from CCLR in both stifles, then they tend to put more weight on their front legs instead while sitting down and while they are rising.

Dogs with CCLR can also show signs of discomfort or pain during manipulation of the joint, especially during hyperextension (Kirby 1993; Van der Vekens *et al.* 2019).

Some complications to untreated or chronic CCLR are osteoarthritis, osteophytosis, tears in the meniscus (Galindo-Zamora *et al*. 2013) and loss of muscle function in the quadriceps of the affected limb (Becker & Karlsson 2018; Toth *et al*. 2020). Therefore, there could be noticeable changes in size of the quadriceps, caused by muscle atrophy, as well (Harasen 2002).

2.3 The occurrence of cranial ligament rupture in dogs

According to many different publications CCLR is one of the most common reasons of pelvic lameness (Bleedorn *et al*. 2011; Fazio *et al*. 2018; Nanda & Hans 2019; Engdahl *et al*. 2021; Spinella *et al*. 2021; Sellon & Marcellin-Little 2022) as well as one of the most common diagnosis in orthopaedic patients (Signorelli *et al*. 2020). CCLR has been reported to be the fifth most common diagnosis for muscle skeletal injuries in humans (Clayton & Court-Brown 2008) but no comparable study on dogs was found.

In the cohort study by Engdahl *et al.* (2021), where insurance data from Agria was used, it was noticed that less specific diagnosis than CCLR, such as increased movement in the stifle joint or lameness in the pelvic limb, were sometimes used. According to the study 37% of the dogs diagnosed with CCLR had been diagnosed with musculoskeletal diseases and 16% with joint diseases before receiving the diagnosis CCLR, which could be an indication that CCLR sometimes is misdiagnosed. This may indicate that CCLR is even more common than the data shows (Engdahl *et al*. 2021).

To estimate the prevalence of cranial cruciate ligament disease (CCLD), Witsberger *et al.* (2008) did a study based on patient data from veterinary teaching hospitals in North America. During the time period 1994 to 2003 the reported prevalence of CCLD was 4.87%. The study included 230 415 patients (Witsberger *et al*. 2008).

Engdahl *et al.* 2021 used insurance data from Agria and found the incidence of stifle joint diseases per 10,000 dog-years at risk to be 40-80 cases. The calculated overall incidence of stifle joint disease was 55.4 cases per 10,000 dog-years at risk. Of all the dogs with claims of diseases in the stifle joint, 43.5% had claims for CCLR.

Of the patients who suffers from unilateral CCLR, 10-31% tend to get CCLR in both limbs within three years (Kirby 1993). They can have CCLR in both limbs at the same time but the average time from the diagnosis CCLR in one limb to the diagnosis CCLR in the other limb was eight months.

Approximately 25% of the dogs with CCLR has a partial rupture and the other 75% has a complete rupture of the CCL (Fazio *et al*. 2018).

2.3.1 Risk factors for cranial cruciate ligament rupture

There are different studies that shows that some breeds, especially large and giant breeds, are more likely to suffer from CCLR than others (Lampman *et al*. 2003; Engdahl *et al*. 2021; Rudd Garces *et al*. 2021). Both Engdahl *et al.* (2021) and Lampan *et al.* (2021) mention Rottweiler and Doberman as risk breeds. According to Engdahl *et al.* (2003) Boerboel was the breed of highest risk among the breeds studied, and according to Lampan *et al.* (2003) Rottweiler was the breed at highest risk.

A few studies have shown that higher age is a risk factor (Witsberger *et al*. 2008; Engdahl *et al*. 2021; Rudd Garces *et al*. 2021). The study by Witsberg *et al.* (2008) reported an increased risk of CCLR at the age of four years or higher, and in the study by Engdahl *et al.* (2021) the median age of CCLR diagnosis were 7.1 years.

Overweight is also a risk factor that has been identified for CCRL (Lampman *et al*. 2003; Taylor-Brown *et al*. 2015).

Regarding sex as a risk factor, studies have reported different results. According to Witsberg *et al.* (2008) and Engdahl *et al.* (2021) canine females have a higher risk of CCLR but according to Rudd Garces *et al.* (2021) gender was not considered as a significant risk factor.

Dogs that participates in sport such as agility has also been shown to be associated with increased risk of CCLR (Sellon & Marcellin-Little 2022).

If a patient ruptures the CCL in one stifle joint, there is a risk that the patient could rupture the CCL in the other stifle joint (Kirby 1993).

It has also been reported that patients that suffers from medial patellar luxation has a higher risk for developing CCLR (Spinella *et al*. 2021).

2.4 Differential diagnoses to cranial ligament rupture in dogs

According to Kirby (1993) relevant differential diagnoses to CCLR are avulsion of the long digital extensor tendon, the origin of the popliteus muscle or the origin of the gastrocnemius muscle, displacement of the long digital extensor muscle, separation of the fabella, disruption of the patellar ligament, collateral ligament rupture, luxation of the stifle, caudal cruciate ligament rupture, fractures, arthropathies and neoplasia.

According to Harasen (2002), dogs that suffers from bilateral CCLR can be misdiagnosed with neurological diseases since these dogs tend to have difficulties rising up from a lying position and sometimes, they may appear to have paresis in their hind limbs.

2.5 Diagnosing cranial cruciate ligament rupture

2.5.1 Drawers test

To do the drawers test you should start by laying the dog down on the opposite side of the stifle you want to examine, then place yourself behind the dog (Harasen 2002). Place the thumb of the proximal hand caudal of the lateral fabella and place the index finger over the proximal part of the patella. Place the thumb of the distal hand caudal of the caput fibula and place the index finger over crista tibia. The femur is held still by the proximal hand, the tibia and fibula are moved in cranial direction by the most distal hand. For illustration, se Figure 1. When the drawer test is performed on an adult dog, there will normally be no movement of the tibia in the cranial-caudal direction, if the CCL is intact (Palmer 2005). However, if the drawer test is performed on a puppy there might be some millimetres of movement in the cranial-caudal direction of the tibia.

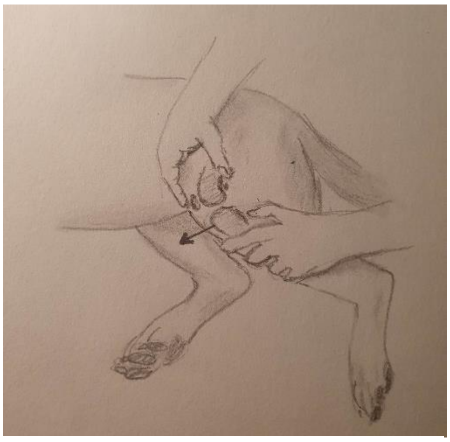

Figure 1. Shows how to perform the drawer test. If there is increased movement caused by CCLR, the tibia will move in the direction of the arrow while preforming the drawer test. Picture drawn by Ellinor Harlén.

The drawer test is a non-invasive test but some limitations has been reported. If a dog with CCLR is very excited or has high muscle tonus in the quadriceps, it is possible that the drawer test will be a false negative without anaesthesia or sedation (Harasen 2002). If the dog is in a good physical condition and has a lot of muscles, has a lot of pain, is swollen in the stifle area, has periarticular fibrosis or only has a partial rupture of the anterior cruciate ligament, it increases the risk for a false negative drawer test (Kirby 1993).

The sensitivity for correctly diagnosing a patient with CCLR with the drawer test has been reported to be 69% and the sensitivity for correctly diagnosing the CCL as intact was 97% (Might *et al*. 2013).

A study done by Lampman in 2003 showed that 98% of the patients that had received the diagnosis CCLD were diagnosed after the drawer test was performed. (Lampman *et al*. 2003).

2.5.2 Tibial compression test

Another way to evaluate the stability in the stifle is to perform the tibial compression test. It can be used in combination with the drawer test for assessment of the CCL (Harasen 2002). It is possible to perform the test while the dog is standing or while laying down. If it is performed while laying down, then the stifle should be in the same angel as if it were standing, approximately 135 degrees.

Start by grasping the paw with one hand and flex the hock joint by pulling the paw in a dorsal direction (Harasen 2002). The other hands index finger is placed over both patella and the tibial crest and if there is cranial movement of the tibia, while flexing the hock joint with the other hand, it indicates CCLR. Se Figure 2 for illustration.

However, according to Harasen (2002), the tibial compression test has a lower sensitivity compared to the drawer test, even though the sensitivity and the specificity for the tibial compression was not presented in the study for comparison. According to Might *et al.* (2013) the combination of doing both the cranial drawer test and the tibial compression test did not significantly increase the sensitivity nor specificity for diagnosing CCLR.

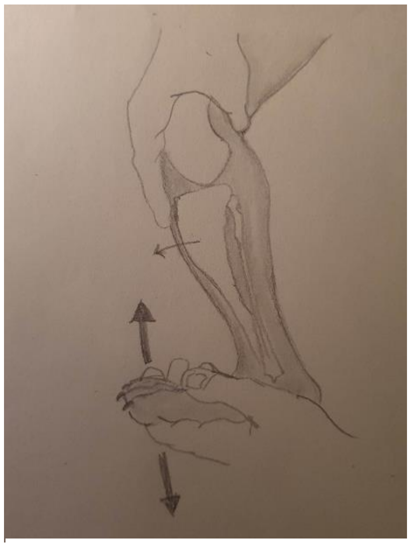

Figure 2. Shows how the tibial compression test is performed. The filled in arrows illustrates the flexion of the hock joint and the small arrow illustrate the movement of the tibia caused by CCLR. Picture drawn by Ellinor Harlén.

2.5.3 Radiography images

Radiographic images can give indications for the diagnosis CCRL, such as a cranial displacement of the tibia, effusions in the stifle joint, and/or osteophytosis (Palmer 2005, 2009). For the best chance of seeing signs for CCLR, the radiographic images should be taken while the tibial compression test is performed (Harasen 2002)

In one study, radiographic images were used in 45% of patients diagnostic tool of the patients that were diagnosed with CCRL (Lampman *et al*. 2003). Even if it is not necessary with radiographic images to determine if the patient has CCLR, it is recommended because the examination will provide information about possible pathological changes in the joint (Kirby 1993). Depending on how severe the pathological changes are, it may be crucial information for the decision-making regarding treatment. The images can also be used for comparison later, especially for patients that does not respond to treatment in the expected way.

According to Harasen (2002), in 97% of the patients who suffered from CCLR, and where radiographic images were taken while the tibial compression was performed, there was a cranial displacement of the tibia, in other word the sensitivity for this method was 97%. Both the sensitivity and specificity for taking radiographic images while the tibial compression test is preformed is higher compared to the drawer test alone (Harasen 2002), which had a sensitivity of 69% (Might *et al*. 2013).

2.5.4 Magnetic resonance imaging

It has been reported that magnetic resonance imaging (MRI) can be used to diagnose CCLR and MRI also gives information about the soft tissue and possible pathological damage to the meniscus, which is a complication to CCLR (Galindo-Zamora *et al*. 2013; Fazio *et al*. 2018). This information might be helpful when deciding treatment plan. During the MRI the patient need to be sedated (Galindo-Zamora *et al*. 2013; Fazio *et al*. 2018).

The specificity for using MRI to detect complete rupture of the CCL has been reported to be 71-89% and the reported sensitivity is 72-94% (Fazio *et al*. 2018).

2.5.5 Ultrasound/sonography

It is possible to examine the stifle with a ultrasound that generates a picture, a sonogram, of the soft tissue and it has been reported that a ultrasound can be used to detect complete CCLR (Kramer *et al*. 1999) and possible partial rupture of the CCL (Van der Vekens *et al*. 2019). The sensitivity and specificity for using ultrasound to diagnose CCLR has not been evaluated to this day.

2.5.6 Arthroscopy

Arthroscopy can be used to diagnose CCLR and to detect meniscal tears (Galindo-Zamora *et al*. 2013). Arthroscopy is an invasive method to diagnose CCLR and could therefore represent a higher risk of complications, particularly for those who have severe pathological changes in the stifle (Fazio *et al*. 2018).

In studies about both diagnosing CCLR and estimating the pathological changes due to the CCLR, arthroscopy has been used as the control method or considered as the gold standard (Bleedorn *et al*. 2011; Galindo-Zamora *et al*. 2013; Fazio *et al*. 2018).

2.5.7 Kneedly

The following text is written based on an interview with the developer of the software made by the company Kneedly (Nilsson A., & Söderholm L:, Kneedly, personal communication, 2022). Today, there is no published literature on this technique.

Figure 3. Shows how the temporary tattoo with small dots should be placed. Picture from Kneedly.

To do the analysis, the first step is to shave an area over the knees, then a temporary tattoo, that has a pattern with small dots, is placed on the knees, see Figure 3. The veterinarian performs the drawer test which is video recorded. The video is then analysed by the software which calculates the movement of the dots in relation to their original position. Results of the analysis can be presented as numbers, or colour sheets, se Figure 4 for an example of increases movement and se Figure 5 for example of how normal movement may look. The colour change indicates increased movement caused, assumingly caused by CCLR.

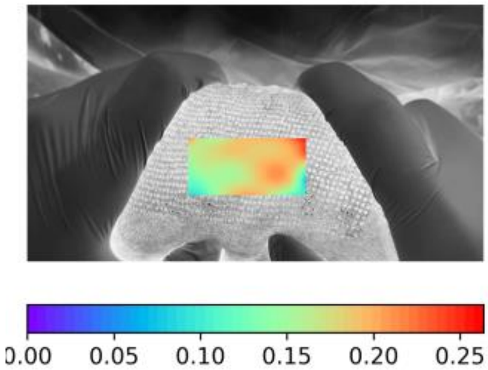

Figure 4. Shows an example for how increased movement in the stifle may look on the colour sheet. Picture from Kneedly.

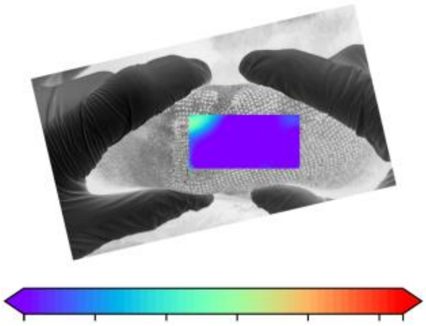

Figure 5. Shows an example for how normal movement in the stifle may look on the colour sheet. Picture from Kneedly.

When collecting data previously, to an unpublished study, patients who has been diagnosed with CCLR and are going under surgery as treatment, has been included. When the patients were sedated, before the operation, an orthopedic veterinarian did the drawer test during recording and the videos were sent to Kneedly for analysis. The drawer test was also performed on the healthy stifle and this data was used as a control. The program then compares the movement in both the left and right hind limb, the stifle with the most movement is then diagnosed as sick. In other words, the program has made the presumption that one stifle is healthy and that the other one has increased movement. There is not yet any data of when both cranial cruciate ligaments are intact, or when both ligaments are ruptured.

3. Material and Method

3.1 Study design

This pilot study was blinded for the individuals performing the analysis with the software and for the participants but not for the person who was filming the knees when the participants performed the drawer test. Two employees from Kneedly analysed the colour sheets.

The data collection was made at two different occasions but was performed in similar ways. The individuals that performed the drawer test received the same information on both occasions but at the first occasion they received the information verbally and at the second occasion they received written information distributed immediately before performing the test. The filming was performed in the same way.

There were seven canine cadavers used in the study. Owners signed a consent and donated the cadavers to research and teaching purposes. All animals were euthanized for reasons unrelated to this study.

Information regarding the cadavers in this study is presented in Table 1.

Table 1. Information about the cadavers that were included in the experiment.

Dog number	Breed	Size	Age
1	Staffordshire Bull Terrier	Medium	Adult, unknown age
Test cadaver	Medium Pincher	Small	11 weeks
2	Labrador Retriever	Large	11 years
3	Rough (long-haired) Collie	Large	10.5years
4	Cocker Spaniel	Medium	8 years
5	Mixed breed	Large	12 years
6	German Shepherd	Large/giant	6.5 years

There was no information in the medical records from the University Animal Hospital indicating diagnosis related to the hind limbs, except for Dog 1 that had been diagnosed with bilateral CCLR. Dog 5 had visible scarring on its right knee and therefore it was concluded that Dog 5 had had an operation.

3.2 Preparations

The cadavers were stored in a freezer after euthanasia and thawed approximately two weeks before this test. The cadavers were also marked on the skin with a permanent marker pen for identification purposes.

When the cadavers had been thawed, stifles were prepared. First the knees were shaved with an electric Oster shaver, 1mm blade, approximate an area of 10x10cm with the patella in the centre. A 10-blade scalpel was used for a medial incision of approximate six cm through the skin and soft tissues. The joint capsule of the stifle was visualised and an incision of approximately four cm through the capsule was made, with caution to not damage any ligaments or menisci. An otoscope with medium sized funnel was used as arthroscope to inspect the cruciate ligaments and the findings were noted. Both number and description of the cadaver, such as breed, size and age, were written down to enable correct identification, if the permanent mark were to fade.

Four of the dogs' cranial cruciate ligaments were cut with a dissecting scissor and to avoid cutting the caudal cruciate ligament the otoscope with the funnel were used to visualise the CCL. In the planning stages it was decided to have one cadaver with CCLR in both hind limbs, one cadaver with both cranial cruciate ligaments intact, one cadaver that could be used to practise on and the rest of the cadavers evenly divided between rupture in only the left hind limb and only in the right hind limb. When deciding on which hind limb to cut the cranial cruciate, earlier damage was considered, and it affected the decision for two dogs. Dog number one already had a positive drawer test in both hind limbs and was diagnosed with bilateral CCLR when still alive. Dog number one was therefore selected to be the test object with bilateral CCLR. Dog number five had already had an operation to its right knee and the joint capsule was considerably thickened. To investigate if the software could correctly identify CCLR, also when the capsule is thickened, the cranial cruciate in the right knee was cut and the left cranial cruciate was left intact.

The joint capsule of the stifle was opened in all hind limbs, to blind the test persons, except for dog number four. Dog number four represented the dog that had intact cranial cruciate ligaments in both hind limbs. An incision through the skin, but not the joint capsule, on dog four was made on both knees, to prevent bias from the test persons when evaluating the drawer test.

The joint capsule and the skin were separately sutured with simple continues suture PDS II 3-0, 2=1=1=1=1=1. The cadavers where then stored in the fridge until the day of data collection.

On the day of testing the cadavers were moved from the fridge to the testing room three and a half hour before the first test person arrived.

To make it possible for the temporary tattoo to attach to the skin, the skin was cleaned with disinfection alcohol to remove any synovial fluid. The skin was allowed to dry and the temporary tattoo with dot pattern was placed over the knee, Figure 3.

Around every right hind limb, a string was tied to minimize the risk of mistaking the right hind limb for the left one and vice versa, at the occasion of recording.

3.3 Experiment/data collection

The data collection was made at two different occasions, the preparations were made in the same way but there were some differences regarding the procedure. At the first occasion there was only one cadaver, and the test persons were given the information verbally and in the second occasion there were seven cadavers, and the test persons were given written instructions and general information on a paper.

3.3.1 The first occasion for data collection

This first occasion was intended as a trial to improve the procedure at the second occasion, but also to provide Kneedly with test data for practice evaluation. Since the procedure of the data collection was only changed to a minor degree, it was decided to include the data from this occasion as well.

The participants consisted of five veterinary year five students and one veterinary surgeon. They were given verbal information regarding the aim of the study, information about Kneedly's software and instructions on how to perform the drawer test. The participants were also given a protocol to fill in their assessment regarding the movement in the stifles. The options they had to choose between were normal movement, increased movement, don't know/unsure, see appendix 2. One at a time the participants entered the room with the cadavers, and they were shown the handplacement of the grip for the drawer test. At this occasion there was only one cadaver.

The video recordings were made during the performance of the drawer tests. The person recording stood on the opposite side of the participants and filmed in a lateral-medial-obliquely angle, se Figure 3. In the beginning of every recording, for identification purposes, the one who was filming started with saying the number of the test person who performed the test, which dog it was and which hind limb, for example "Test person five, dog three, right hind limb".

All the videos were uploaded on Kneedly's website the day after the recording and the developers of Kneedly then analysed the videos without knowing if the cranial cruciate ligaments were intact or ruptured.

3.3.2 The second occasion for data collection

The insights from the first data collection were considered when planning the second occasion for data collection. This led to some modifications of the procedure; the information was given in writing and they had a test cadaver to practise on.

The participants at this occasion consisted of three veterinary students of year five and four veterinary students of year six. There were six dogs included in the second occasion for data collection.

One person at a time entered the room where the experiment took place. The participants waited outside of the test area and received information regarding the aim of this study, information about Kneedly and instruction for the drawer test on a document, appendix 1. The document included the same information that was given at occasion one. They also received a protocol, appendix 2, where they could fill in their assessment after they had performed the drawer test. They had to choose between "normal movement", "increased movement" and "don't know/unsure", same question as in occasion one.

First, the participants were in a separated area with a test cadaver so they could practise on the drawer test. Those who needed help with the technique were shown every step. The test cadaver had CCLR in one of its hind limbs and the CCL in the other hind limb was intact. In this way, they had the opportunity to feel the differences between an intact and ruptured CCL.

When they felt ready, they went further into the room where the cadavers included in the study where stored. The drawer test was performed during video recording, in the same way as on occasion one.

3.3.3 Control of the cadavers

The next step after the video recordings had been performed was to control that there were no other damages to the cruciate ligaments that was supposed to be intact and that the CCL that were supposed to be cut were fully cut. The joints were completely cut open with a scalpel. A medial incision through the skin and joint capsule was made. The joint capsule was then opened in the cranial part with caution to not damage the CCL. The incision was made wider until it was possible to visualise both the cranial and caudal cruciate ligament. Notes were made about the thickness of the joint capsule, the appearance of the surface of the joint and if the cranial and caudal cruciate ligaments were intact or not.

3.3.4 The data from the data collection

After the video recordings were analysed by the company Kneedly, the result was presented in an Excel document. The document included the result from both the automatic analysis as well as the manual analysis of the colour sheets and the result for every video recording was either normal movement or increased movement.

3.4 Calculating sensitivity and specificity

Sensitivity is a measure of true positive and specificity is a measure for true negative test (Monaghan *et al*. 2021). To calculate the sensitivity, the number of true positives was divided with the sum of the number of true positives and the number of false negatives. To calculate the specificity, the number of true negatives was divided with the sum of the number of true negative and the number of false positive.

The videos where the drawer test was performed inaccurate or when the skin was not stretched enough, which led to a false increased movement, were excluded from the calculation of the sensitivity and specificity. Therefore, when calculating the sensitivity and specificity for the test persons, the automatic analysis and the manual analysis, only the numbers in the columns including normal movement and increased movement were used.

Since the software assume that one CCL is intact and the other CCL is ruptured in the automatic analysis, the data from Dog 1 and 4 were excluded when calculating the sensitivity and specificity for the total automatic analysis.

3.5 Search of literature

The search of literature to this study was made on PubMed and the following search words were used in different combinations:
Cranial cruciate ligament rupture, CCRL, anterior cruciate ligament rupture, cruciate ligament, diagnose, diagnosis, prevalence, diagnostics, drawer test, tibial compression test, sonography, dog, canine.

4. Results

4.1 Control of the cadavers

The notes that were taken during the control of the cadavers after the data collection was made are summarised in Table 2. The results presented were if the cranial and caudal cruciate ligaments were intact or ruptured, if there were any macroscopic visible changes in the thickness of joint capsule or if there were any macroscopic visible changes in the joint surface. The caudal cruciate ligament was intact in all stifles in all dogs. The cranial cruciate ligament that was supposed to be cut were fully cut in all stifles except for Dog 2, its left cranial cruciate ligament was >90% ruptured.

Table 2. Results of the stifle joint inspection of the cadavers.

	Cranial cruciate ligament	Caudal cruciate ligament	Joint capsule	Joint
Dog 1 right leg	100% ruptured	Intact	Normal	Moderately inflamed
Dog 1 left leg	>95% ruptured	Intact	Mildly thickened	Severely inflamed
Dog 2 right leg	>90% ruptured	Intact	Normal	Normal
Dog 2 left leg	Intact	Intact	Normal	Normal
Dog 3 right leg	Intact	Intact	Normal	Normal
Dog 3 left leg	100% ruptured	Intact	Normal	Normal
Dog 4 right leg	Intact	Intact	Normal	Normal
Dog 4 left leg	Intact	Intact	Normal	Normal
Dog 5 right leg	100% ruptured	Intact	Severely thickened	Mildly inflamed
Dog 5 left leg	Intact/<10% ruptured*	Intact	Mildly thickened	Severely inflamed
Dog 6 right leg	Intact	Intact	Normal	Normal
Dog 6 left leg	100% ruptured	Intact	Normal	Normal

*The left joint in Dog 5 made the impression of being greatly inflamed and irritated, the risk of a small rupture of the cranial cruciate ligament could therefore not be excluded.

4.2 Results of the drawer test

In Table 3 the results of the test persons evaluation, Kneedly’s automatic analysis and manual analysis of the colour sheets for Dog 1 is shown. Four videos were excluded, both from the automatic analysis and the assessment of the colour sheets since the drawer test was not performed correctly.

*Table 3. Results for Dog 1, assessment / scoring provided by test persons (n=6) and software by Kneedly. Please note that both cranial cruciate ligaments were ruptured in this dog.*Excluded due to incorrectly performed drawer test or movement in the skin.*

	Normal movement	Increased movement	Don't know/unsure	Excluded*
Test persons, right knee	2	2	2	0
Test persons, left knee	2	4	0	0
Kneedly automatic analyses, right knee	2	2	0	2
Kneedly automatic analyses, left knee	2	2	0	2
Colour sheets, right knee	2	2	0	2
Colour sheets, left knee	2	2	0	2

In Table 4, the results for Dog 2 are shown. Two videos were excluded from the automatic analysis and the assessment of the colour sheets due to an incorrect performed drawer test, one more video was excluded from the assessment of the colour sheet because of movement in the skin affecting the colour sheets.

*Table 4. Results for Dog 2, assessment / scoring provided by test persons (n=7) and software by Kneedly. In this dog right CCL was ruptured. *Excluded due to incorrectly performed drawer test or movement in the skin.*

	Normal movement	Increased movement	Don't know/unsure	Excluded*
Test persons, right knee	2	5	0	0
Test persons, left knee	5	2	0	0
Kneedly automatic analyses, right knee	0	6	0	1
Kneedly automatic analyses, left knee	6	0	0	1
Colour sheets, right knee	1	5	0	1
Colour sheets, left knee	5	0	0	2

In Table 5, the results for Dog 3 are shown. Two videos were excluded from the automatic analysis and the assessment of the colour sheets due to an incorrect performed drawer test, four more videos were excluded from the assessment of the colour sheet because of movement in the skin affecting the colour sheets.

*Table 5. Results for Dog 3, assessment / scoring provided by test persons (n=7) and software by Kneedly. The left CCL was ruptured in this dog.*Excluded due to incorrectly performed drawer test or movement in the skin.*

	Normal movement	Increased movement	Don’t know/unsure	Excluded*
Test persons, right knee	6	1	0	0
Test persons, left knee	4	3	0	0
Kneedly automatic analyses, right knee	4	1	0	2
Kneedly automatic analyses, left knee	3	4	0	0
Colour sheets, right knee	3	0	0	4
Colour sheets, left knee	4	1	0	2

In Table 6, the results for Dog 4 are shown. Three videos were excluded from the automatic analysis and the assessment of the colour sheets due to an incorrect performed drawer test, two more videos were excluded from the assessment of the colour sheet because of movement in the skin affecting the colour sheets.

*Table 6. Results for Dog 4, assessment / scoring provided by test persons (n=7) and software by Kneedly. Please note that both cranial cruciate ligaments were intact in this dog.*Excluded due to incorrectly performed drawer test or movement in the skin.*

	Normal movement	Increased movement	Don't know/unsure	Excluded*
Test persons, right knee	4	3	0	0
Test persons, left knee	5	1	1	0
Kneedly automatic analyses, right knee	2	4	0	1
Kneedly automatic analyses, left knee	4	1	0	2
Colour sheets, right knee	4	1	0	2
Colour sheets, left knee	2	2	0	3

In Table 7, the results for Dog 5 are shown. Two videos were excluded from the automatic analysis and the assessment of the colour sheets due to an incorrect performed drawer test, two more videos were excluded from the assessment of the colour sheet because of movement in the skin affecting the colour sheets.

*Table 7. Results for Dog 5, assessment / scoring provided by test persons (n=7) and software by Kneedly. The right CCL was ruptured in this dog.*Excluded due to incorrectly performed drawer test or movement in the skin.*

	Normal movement	Increased movement	Don't know/unsure	Excluded*
Test persons, right knee	4	1	2	0
Test persons, left knee	4	1	2	0
Kneedly automatic analyses, right knee	2	4	0	1
Kneedly automatic analyses, left knee	4	2	0	1
Colour sheets, right knee	4	1	0	2
Colour sheets, left knee	5	0	0	2

In Table 8, the results for Dog 6 are shown. Five videos were excluded from the automatic analysis and the assessment of the colour sheets due to an incorrect performed drawer test, two more videos were excluded from the assessment of the colour sheet because of movement in the skin affecting the colour sheets.

*Table 8. Results for Dog 6, assessment / scoring provided by test persons (n=7) and software by Kneedly. The left CCL was ruptured in this dog.*Excluded due to incorrectly performed drawer test or movement in the skin.*

	Normal movement	Increased movement	Don’t know/unsure	Excluded*
Test persons, right knee	4	3	0	0
Test persons, left knee	3	4	0	0
Kneedly automatic analyses, right knee	2	0	0	5
Kneedly automatic analyses, left knee	3	2	0	2
Colour sheets, right knee	0	2	0	5
Colour sheets, left knee	3	3	0	1

In Table 9 the sensitivity and specificity for Dog 1-6 for the test persons, the automatic analyse and for the manually analyse of the colour sheets is presented.

For the test person the lowest sensitivity was 0.2 and the highest was 0.67. The lowest specificity was 0.57 and the highest was 0.86. When calculating the sensitivity and specificity for all dogs together, the sensitivity was 0.51 and the specificity was 0.72.

For the automatic analysis the lowest sensitivity was 0.4 and the highest was 1. The lowest specificity was 0.5 and the highest was 1. Please note that when calculating the sensitivity and specificity for all dogs together, when Dog 1 and 4 were excluded, the obtained sensitivity was 0.67 and the specificity was 0.84.

For the manual analysis of the colour sheets the lowest sensitivity was 0.2 and the highest was 0.83. The lowest specificity was 0.67 and the highest was 1. When calculating the sensitivity and specificity for all dogs together the sensitivity was 0.57 and the specificity was 0.79.

Table 9. The sensitivity and specificity for all cadavers included in the study, and the sensitivity and specificity of all the data of this study.

	Sensitivity	Specificity
Dog 1 test person	0.60	-
Dog 1 automatic analysis	0.50	-
Dog 1 colour sheets	0.50	-
Dog 2 test person	0.71	0.71
Dog 2 automatic analysis	1	1
Dog 2 colour sheets	0.83	1
Dog 3 test person	0.43	0.86
Dog 3 automatic analysis	0.57	0.80
Dog 3 colour sheets	0.80	1
Dog 4 test person	-	0.69
Dog 4 automatic analysis	-	0.50
Dog 4 colour sheets	-	0.67
Dog 5 test person	0.20	0.80
Dog 5 automatic analysis	0.67	0.67
Dog 5 colour sheets	0.20	1
Dog 6 test person	0.57	0.57
Dog 6 automatic analysis	0.40	1
Dog 6 colour sheets	0.5	-
Totally test person	0.51	0.72
Totally automatic analysis all cadavers	0.63	0.73
Totally automatic analysis*	0.67	0.84
Totally colour sheets	0.57	0.79

*The results from Dog 1 and Dog 4 were excluded when calculating the total sensitivity and specificity.

5. Discussion

5.1 Method

To avoid bias from the test persons some precautions were taken. Firstly, it was desirable that the knees with CCLR had the same appearance as the knees without CCLR. To accomplice this every single joint was cut open, except for the cadaver with both cranial cruciate ligaments intact, Dog 4. Only the skin was cut in Dog 4, this decision was made to avoid unnecessary risk to damaging the ligaments and increased movement in the stifle. Secondly, the person filming the drawer test was not allowed to help or interact with the test persons during the experiment. Thirdly, all the test persons were given the same information, and performed the tests one at a time to avoid being affected by each other.

To avoid false negative drawer test caused by stiffness, the cadavers were first moved from the freezer to the fridge two to three weeks prior to the experiment, and on the day of the data collection the cadavers were moved from the fridge three and a half hours before the data collection took place.

Even if the test persons had the chance to practice on the technique of the drawer test, a lot of data still had to be excluded due to a poorly preformed drawer test or excessive movement in the skin. In hindsight it would have been better if there was a veterinarian who had more experience of the drawer test that could have helped the test persons to get the technique right.

The number of cadavers was not optimal, as a few of the test persons said their hands got tired and weakened during the experiment. Subjectively, as the test went on, it took longer time for the participants to get the right grip and some lost their grip during the procedure, therefore it might be questionable if they managed to perform a proper drawer test towards the end of tests.

In this study, most of the test persons were veterinary students, only one certified veterinarian participated. On one hand, it was beneficial to have mainly students since it could give some indications whether the software could be useful for teaching and evaluation purposes, involving veterinarians or veterinary students with little or no experience. On the other hand, one might question if this study evaluated the sensitivity and specificity of the software fairly, since it was of importance that the drawer test was preformed correctly. If the drawer tests were not performed correctly, it will be difficult to assess the software separately from the test person's proficiency.

5.2 Results and literature review

The obtained results for the automatic analysis of the drawer test were a sensitivity of 0.67 and a specificity of 0.84, for the manual analysis of the colour sheets the sensitivity was 0.57 and the specificity was 0.79. Furthermore, the sensitivity for the test persons was 0.51 and the specificity was 0.72. On one hand, both the manual and automatic analyses had a higher sensitivity and a higher specificity than the test persons' achievements in this study, which could indicate that this software can be a useful tool in diagnosing CCLR. On the other hand, both the manual and automatic analyses had a lower sensitivity and specificity compared to the literature of the drawer test, which was 0.69 and 0.97 respectively (Might *et al*. 2013). There was also a wide spread of the results regarding the sensitivity for the manual analysis of the colour sheets, the lowest sensitivity was 0.2 and the highest 0.67. The lowest obtained sensitivity was lower than random, which would be 0.5. Some results of both sensitivity and specificity were 0.5 or close to 0.5. The sensitivity and specificity for the automatic analysis when the CCL was cut in one knee and intact in the other was better compared to when cadavers with double-sided intact or double-sided cut CCL were included. This could mean that the software needs further development, if the results correctly represent the sensitivity and specificity of the software, in order to be useful to diagnose CCLR in dogs.

There is also a possibility that the result of this study is falsely low. The test persons in this study had a lower sensitivity and specificity compared to the literature, 0.51 compared to 0.69, and 0.72 compared to 0.97. It was not the aim of the study to assess the test persons' execution of the drawer test, however the results of this pilot study deviated from earlier reports and since some data were excluded due to low quality, it may be suspected that poor quality of performing the drawer test resulted in challenging input data. Every video was reviewed and if there were much movement in the skin or if the drawer test clearly was incorrectly performed, the video was excluded. There is still a possibility that some of the results were based on an incorrect performed drawer test, for example if the error was small enough not to be seen on the videos. It is therefore difficult to know what the sensitivity and specificity for this software truly is, if the results were falsely low because the execution of the drawer test was substandard.

The use of the software had earlier only been tested on dogs where the CCL was ruptured in one knee and intact in the other. The design of the software means that it is anticipated that one knee has normal movement, and the other has increased movement. It is therefore not surprising that the automatic analysis had a specificity on 0.5 for Dog 1 where both CCL where ruptured. This led to exclusion of the data obtained for Dog 1 and 4 when calculating the sensitivity and specificity, since these two dogs represented patients with both CCL ruptured or both intact.

Comparing the results obtained from this study with MRI, the software had a comparatively similar specificity, but the sensitivity obtained was lower for the software (Fazio *et al*. 2018). The results from this pilot study also showed a lower sensitivity and specificity than compared with radiographic images while the tibial compression test is performed, which has a sensitivity up to 0.97 (Harasen 2002). This indicates that taking radiographic images while preforming the tibial compression test is preferable compared to Kneedly's software as it is today, but if the clinician prefers to avoid sedation and the patient allows it, or has no access to radiographic equipment, Kneedly's software could be a helpful alternative in the future. At the same time, one must not forget that in this pilot study, mainly veterinary students were used as test persons and in the study made by Harasen, veterinarians were used. It could therefore be difficult to make a rightful comparison with the results obtained in this study and the results obtained in Harasen's study, since the test persons has different experience.

When taking radiographic images, performing a MRI or doing an arthroscopic surgery to diagnose or exclude the presence of CCLR, there is always a risk since all of these options requires the patient to be sedated or to be under anaesthesia for a good result (Harasen 2002; Galindo-Zamora *et al*. 2013; Fazio *et al*. 2018). It is also commonly known that radiographic images expose the patient to radiation, which comes with a certain risk for both the patient and for the clinician. However, using imaging to diagnose CCLR may also give information regarding pathological changes in the soft tissue or skeletal changes that might affect the treatment (Galindo-Zamora *et al*. 2013; Might *et al*. 2013; Fazio *et al*. 2018), which would not be obtained by using the software from Kneedly.

5.3 Potential further product development

Before this study, Kneedly's software had only been tested and developed on dogs that had CCLR in one hind limb and the cranial cruciate was intact in the other (Nilsson A., & Söderholm L.:, Kneedly, personal communication, 2022). For the program to be a helpful diagnostic tool, it would be preferable if the software could analyse one hind limb without being dependent on the other limb, since bilateral ruptures and bilateral intact ligaments occurs. To get around this, more data is needed on stifles with and without CCLR, from different types of breeds and dogs of different ages. This would give us a better understanding of what normal movement and increased movement is. Then, the automatic analysis could have a span of referential numbers that would indicate an intact cruciate ligament, a span for results that are difficult to interpret or possible partial ruptures and a span for CCLR.

The software could potentially indicate when further diagnostics is recommended and encourage its users to evaluate the results of the automatic analysis and the colour sheet together with their own evaluation of the drawer test.

If the sensitivity and specificity of the method could be increased, Kneedly's software may be used as a first step to diagnose or exclude CCLR as a differential diagnosis. In this way, the exposure for invasive diagnostics for patients without CCLR could decrease. If a patient is diagnosed with CCLR and more information is needed for deciding how to treat the patient, further diagnostics can still be made. If the software could be developed further it might be possible to diagnose CCLR without needing sedation, which could lead to Kneedly's software being a safer and objective way to diagnose CCLR compared to today's diagnostics methods.

5.4 Limitations and further studies

There were some limitations in this study. Firstly, cadavers were used, which can be compared to heavily sedated dogs but there could still be some differences between sedated dogs and cadavers when it comes to muscle tonus. Muscle tonus can lead to a false negative drawer test. To properly assess if this would affect the sensitivity and specificity for Kneedly's software, in vivo data on live dogs with and without CCLR is needed.

Some data were excluded due to movement in the skin that led to a false positive, which was known as a potential limitation in the planning of this pilot study (Nilsson A., & Söderholm L.:, Kneedly, personal communication, 2022). This will likely be a limitation affecting the clinical use in the future as well.

The automatic analysis compares the movement in the hind limbs with each other and the hind limb with most movement is considered to have increased movement, independent on how small the difference between the hind limbs might be (Nilsson A., & Söderholm L.:, Kneedly, personal communication, 2022). From some perspectives, this can be seen as a limitation. For example, with this analysis method one knee will always obtain the result as normal and the other one as increased movement, even if both cranial cruciate ligaments are intact or ruptured.

In further studies, to better assess Kneedly's analyses method, the test participants should see the results of automatic analysis or the colour sheets before filling in their evaluation. To investigate if this software could be helpful in the diagnosing CCLR it would be interesting to investigate if the test persons would improve their sensitivity and specificity of the drawer test if they were to see the result of the automatic analysis and colour sheet.

As mentioned before, students as test persons may have limited the study, since it is quite hard to know if the sensitivity and specificity obtained for Kneedly's software are representable or if they are falsely low. There were two reasons why students were chosen as test persons. Firstly, to obtain enough data to have more statistic reliable numbers. Secondly, to assess if the software could be useful as a diagnostic tool for people with little or no experience of orthopaedic patients. In hindsight it might have been better to first assess the sensitivity and specific of the software with help of orthopaedic experienced veterinaries and then investigate if it could be a useful diagnostic tool for CCLR. In future studies, it would therefore be beneficial to have orthopedic experienced veterinaries as test persons.

To avoid false negative drawer tests caused by people getting tired in their hands, it would be preferable to have fewer cadavers, more test persons and more occasions for data collection.

One more aspect to think of in the future is if the colour sheets are difficult to read for colourblind people.

6. Conclusion

The conclusion of this study is that Kneedly's software could be a useful tool for diagnosing CCLR in dogs in the future, if the software could be further developed to higher the sensitivity and specificity. However, a properly performed drawer test remains the foundation for a proper analysis for Kneedly's method.

Today, the gold standard method for diagnosing CCLR, is taking radiographic images while performing the tibial compression test.

Further studies are needed for enabling development of the software to improve the sensitivity and specificity. This should involve veterinary clinicians with orthopaedic experience and test subjects of different ages and breeds.

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Popular science summary

Like humans, dogs can be affected by orthopaedic problems. In dogs, one of the most common orthopaedic diagnosis is rupture of the cranial cruciate ligament in the knee. Symptoms that the dog can show is lameness from the affected hind limb, other deviations from their normal movement pattern, pain, signs of discomfort, instability in the knee and increased movement of the stifle. All these symptoms can occur suddenly or stealthily.

There are many ways to diagnose cranial cruciate ligament rupture (CCLR) today, for example a veterinarian can perform certain examinations, magnetic resonance imaging, radiographic images or arthroscopy. Even if there are different ways to diagnose CCLR, only a few can be considered as both non-invasive and objective. The company Kneedly has therefore invented a computer program and the purpose of this study is to assess if this program can be used to diagnose CCLR in a non-invasive and objective way.

To use Kneedly's program, both knees on the patient needs to be shaved first, then a temporary tattoo with a pattern of small dots is placed over the knee. Then the veterinarian performs a special examination that is called the drawer test during video recording, the video is uploaded on Kneedly's platform and the program calculates the movement of the dots in relation to each other. If there is increased movement, it will presumably be caused by a rupture in the cranial cruciate ligament.

In this study we used seven dog cadavers that was donated to science after they died. The knees were shaved and an incision in the knee was made on both knees, to inspect the cruciate ligaments and to cut the cranial cruciate ligament in some of the knees. The wound was then sutured to minimize movement in the skin that could interfere with the analysis. The temporary tattoo was placed over the knees and then some test persons, which were veterinarian students, performed the drawer test during recording, without knowing which knees that had intact or cut cranial cruciate ligaments. The test persons filled in their answers on a paper as well.

The result comes in two different ways; the program can do an automatic analysis of the videos, but it can also generate a colour sheet where a lot of change in colour indicates increased movement and can therefore be used as an indicator for CCLR. The results of this study regarding the automatic analysis were a sensitivity on 63%, which means that of all knees that has a cranial cruciate ligament rupture the program can correctly identify 63% of them, and a specificity on 73%, which means that of all the knees that get the result as normal/healthy, 73% of them are normal/healthy. The results of the assessment of the colour sheet were a sensitivity on 57% and a specificity on 79%. The results for the test persons were a sensitivity on 51% and a specificity on 72%. Both the sensitivity and specificity for the automatic analysis and the manual analysis of the colour sheets were higher than for the test person's evaluation of the drawer test, which could indicate that the program could be used to diagnose CCLR in educational situations. Even if it is possible to use the program, the other options on the market are currently more efficient, but there is also a possibility that the obtained result from this study is falsely low. All the test persons did not perform a proper drawer test, which could have affected the results. If more data is collected, then the company can use it to develop the program and a new evaluation of the programs sensitivity and specificity can be made.

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Appendix 1

Instructions to the participants.

Försöksdag kadaver

Bakgrund

Detta examensarbete har i syfte att samla in data för att utvärdera ett diagnostiskt program som kan tänkas användas i framtid på djursidan som hjälp vid diagnostisering av korsbandsrupturer. För att diagnostisera korsbandsruptur kan man som veterinär utföra draglådetestet på patienten och bedöma om det finns en ökad rörelse, vilket indikerar korsbands-skada/korsbandsruptur. För att använda Kneedly som ett diagnostiskt verktyg rakas ett område över knäleden och ett prick-mönster fästes över knäleden (se Figur 1), därefter utförs draglådetestet under video-inspelning och programmet utför en video-analys, för att bedöma prickarnas rörelse i förhållande till varandra; och på så sätt bedöma om det finns en ökad rörlighet.

Figur 1: En hunds knä som är rakat och ett prickmönster är fäst över knäleden. Bild hämtad från Kneedly's protokoll av metoden.

Information inför test

Inne i rummet finns det 5 hundkadaver och samtliga av deras knäleder är förberedda för att ni skall kunna göra draglådetestet (instruktioner för draglådetest finns nedan). Vi har även kirurgiskt öppnat samtliga knäleder medialt och i vissa leder har det främre korsbandet kapats av. Det blir er uppgift att dels utföra draglådetestet på samtliga extremiteter och att fylla i ett skriftligt svarsprotokoll för er bedömning av ökad rörelse eller ej.

Under testets gång får ni inte fråga mig frågor gällande hur ni skall utföra draglådetestet, ni får inte delge eran bedömning muntligt och ni får inte fråga om rätt svar. Facit kommer att lämnas ut så fort samtliga har genomfört testarna, dvs någon gång under helgen. Det är heller inte tillåtet för er att diskutera era egna bedömningar av draglådetestet med någon innan facit har lämnats ut. Detta för att undvika bias.

Vid varje test börjar filmning med att jag säger testpersonens kodnummer, vilken hund och vilket ben draglådetestet genomförs på, exempelvis *”Testperson 3, hund 1 höger ben”* därefter utför ni draglådetestet på samma inspelning.

Instruktioner draglådetest

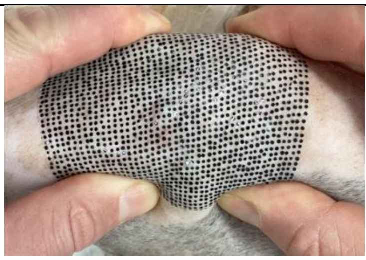
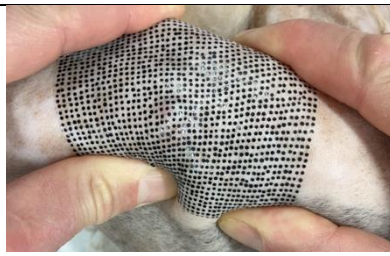
Figur 2: Illustrerar utförandet av draglådetestet.

Standardutförande av draglådetest instruktioner:

1. Ställ dig bakom hunden.
2. Handen som är mest proximalt på benet: Tummen placeras kaudalt om den laterala fabellen och pekfingret placeras över patellas proximala del.
3. Handen som är mest distalt: Tummen placeras kaudalt om caput fibula och pekfingret placeras över crista tibia
4. Femur hålls stabilt samtidigt som tibia och fibula rörs i kranial riktigt

Saker att tänka på vid utförande av draglådetestet

- Sträck ut huden när greppet för draglåde-testet tas, detta för att undvika ökad rörelse i huden vilket kan ge missvisande resultat.
- Under utförandet av draglådetestet skall du vid ytterlägena pausa kort och säga ”tibia kaudalt” respektive ”tibia kranialt”, illustration ses på Figur 3.

“Tibia kaudalt”	“Tibia kranialt”
	

Figur 3: Illustrerar när tibia är i kaudal respektive kranial position under utförandet av draglåde-testet. I båda bilder i figuren är femur till höger och tibia till vänster.

Signatur och godkännande

En signatur innebär att detta dokument är igenomläst och att man deltar i försöket under premisserna som beskrivits ovan. Man godkänner även att filmerna som spelas in får användas i examensarbetet samt får användas av företaget Kneedly.

Datum och ort	Signatur av Försöksansvarig: Ellinor Harlén
___________________________	___________________________
Namnförtydligande testperson	Signatur testperson
___________________________	___________________________

Appendix 2

A protocol that was given to the participants so that they could fill in their assessment.

KODNUMMER:

Svarsblankett

De hundar som används vid dagens försök är kadaver men de kan jämföras med djupt sederade hundar. Föreställ dig att du jobbar på smådjursakuten och får in några hundar som varit med om varsin traumatisk skada och nu är alla halta. Från hältundersökningen ser du att hundarna är halta men du kan inte säga från vilket/vilka ben. Du misstänker att det kan röra sig om en främre korsbandsruptur men hundarna låter dig inte undersöka något av benen vaket varav de måste få en djup sedering för att du skall kunna utföra draglådetestet.

Nedan ses en tabell där du skall fylla i din bedömning efter utfört draglådetest, var lika ärlig i ditt svar som du hade varit om det hade varit verkliga fall. Om du upplever ett normalt rörelseomfång (oskadat korsband) sätter du ett kryss i den rutan. Om du upplever ett ökat rörelseomfång, vilket indikerar skada på det främre korsbandet, sätter du ett kryss i den rutan. Om du känner dig osäker på din bedömning kryssar du i rutan för vet ej/osäker.

	Normalt rörelseomfång	**Ökat rörelseomfång**	**Vet ej/osäker**
Hund 1, Övningskadaver: Höger knä			
Hund 1, Övningskadaver: Vänster knä			
Hund 2: Höger knä			
Hund 2: Vänster knä			
Hund 3: Höger knä			
Hund 3: Vänster knä			
Hund 4: Höger knä			
Hund 4: Vänster knä			
Hund 5: Höger knä			
Hund 5: Vänster knä			
Hund 6: Höger knä			
Hund 6: Vänster knä			

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