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EXPERIMENTAL LAB RESEARCH

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Caudal pole meniscectomy through an arthroscopic caudomedial portal in dogs: A cadaveric study

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Abstract

Objective: To describe a caudomedial instrumental portal for caudal pole meniscectomy (CPM).

Study design: Experimental ex-vivo study.

Sample population: Ten cadaveric hindlimbs of 10 large breed dogs.

Methods: Each hindlimb was used for establishing the caudomedial portal for CPM. The surgical time was recorded. Specimens were disarticulated afterwards, and the completeness of CPM was documented. Iatrogenic injuries to the articular cartilage and the intra- and periarticular structures were assessed.

Results: The extent of the CPM (mean ± SD, percentage of the resected medial meniscus) was 29.8 ± 12.9% of the area of the medial meniscus. There were no injuries to the medial collateral ligament or caudal cruciate ligament. The mean iatrogenic articular cartilage injury (IACI) was 3.71 ± 1.78% of the area of the medial meniscus.

Conclusion: The establishment of a caudomedial portal for CPM in canine cadavers was feasible and allowed to perform a partial caudal pole meniscectomy.

Clinical significance: A caudomedial portal may be considered for CPM in selected cases when caudal tears cannot be accessed through the standard portals.

1 | INTRODUCTION

Stifle arthroscopy is routinely performed for the diagnosis and treatment of pathologies affecting the cranial or caudal cruciate ligaments, menisci, articular cartilage and synovial structures in dogs.[1–3] The benefits of arthroscopy include direct magnification and the ability to palpate and probe intraarticular anatomic structures of the stifle. These advantages make arthroscopy the best treatment modality for addressing meniscal pathologies in dogs and people.[2,4]

Results from this study were presented at the virtual 49th Annual Veterinary Orthopedic Society Conference; February 5–12, 2022.

The meniscus can be evaluated by visualizing and probing the cranial and caudal horn in flexion and extension.[2] The majority of meniscal injuries concern the caudal pole of the medial meniscus. This requires strategies to retrieve and resect the pathological meniscal tissue which is often displaced in the most caudal aspect of the joint.[5] The femorotibial joint space in dogs is narrow, making accurate visualization and treatment of the medial meniscus challenging. In addition, due to the limited space, the insertion of instruments during stifle arthroscopy holds the risk of iatrogenic cartilage damage.[6] Intra- and extra- articular stifle joint distraction has been advocated as a strategy to improve exposure and working space to avoid these injuries.[7–9]

In people a posteromedial knee portal has been used for selected procedures on the posterior horn of the medial meniscus for over 25 years.[10] The main advantages of the posteromedial portal are increased exposure and decreased risk of cartilage damage as the instruments are inserted caudal to the femoral condyle.[10–13] In dogs, a caudomedial instrument portal may facilitate resection of caudal meniscal tears, with decreased risk of cartilage damage. In addition, the absence of the shaver coming from the cranial portals may improve visualization of the tear.

The objectives of this study were to evaluate the feasibility, surgical time, assessment of iatrogenic injury and the completeness of CPM using a caudomedial instrument portal, performed in cadaveric canine stifles. Our hypotheses were: (1) it would be possible to resect the caudal pole of the medial meniscus when using a caudomedial portal; (2) the approach would not result in major iatrogenic injury.

2 | MATERIALS AND METHODS

2.1 | Study subjects

Cadaveric pelvic limbs ($n = 10$) were collected from client-owned dogs euthanized for reasons unrelated to the study. Owner consent was obtained for each cadaver. Mediolateral and craniocaudal radiographs of the stifle joint were taken immediately after euthanasia to measure the tibial plateau angle (TPA) and to exclude obvious joint disease. Furthermore, the medical records were cross-checked for orthopedic surgeries in earlier life or any evidence of pre-existing stifle joint disease. Specimens with any radiographic abnormalities of the stifle or a history of pre-existing orthopedic disease affecting the stifle joint were excluded from the study. For collection, the pelvic limbs were clipped from the mid-diaphysis of the femur to the mid-diaphysis of the tibia and disarticulated at the coxofemoral joint. Specimens were then wrapped in saline-soaked towels and stored at −20°C. Before arthroscopic evaluation and meniscal treatment, the limbs were thawed at room temperature 24 h before use.

In each cadaver only one limb was used for the procedure. For the first cadaver, a coin toss was used to determine which stifle was used for the procedure. The remaining limbs were assigned by alternating left and right sides. Duration of surgery was recorded for each stifle. The duration of surgery was calculated from the first portal incision up to the end of the arthroscopic treatment. All surgical procedures were performed by an ECVS diplomate experienced in stifle arthroscopy (AP or PS).

2.2 | Arthroscopy

The cadaveric hindlimbs were placed in a custom-made holding device to allow extension and flexion of the stifle joint as well as application of valgus stress at different flexion angles. This device was designed to secure the limb in a position as in a standard stifle arthroscopy with the dog in dorsal recumbency.

A two-portal standard stifle arthroscopy was performed before proceeding with the specific treatment.[14] The position of the portals was standardized. The cranial portals were made using a #11 scalpel blade 1 cm lateral and medial to the patellar ligament and slightly proximal to the midpoint of the distance from the patella to tibial tuberosity. Arthroscopy was performed using a 30° foreoblique 2.7 mm arthroscope (Arthrex Vet Systems, Naples, Florida).

All stifles underwent resection of the fat pad using a motorized tissue shaver (Torpedo 3.5 mm, AR-7350TD, Arthrex, Naples, Florida) to improve visualization of the intra-articular structures. The caudal cruciate ligament was examined and the medial and lateral menisci were probed using a 3.4 mm hook tipped probe with 2-mm markings (AR-30000, Arthrex).

The cranio-medial band of the cranial cruciate ligament was transected using a 2.75 mm slender punch (VAR-11100, Arthrex) to simulate a partial cranial cruciate ligament rupture and therefore a difficult clinical situation regarding joint distraction. A probe was used to standardize the transection to about 50% of the cranial cruciate ligament. Subsequently a caudal medial meniscal release was performed by cutting the menisco-tibial ligament with a slender punch inserted through the cranial instrumental portal.

Distraction was achieved by using an intra-articular distractor (VAR- 4010-20, Arthrex) placed at the caudal edge of the tibia, just cranial to the caudal cruciate ligament and by manipulation, applying valgus or cranial drawer as deemed necessary by the surgeon. After completing this standard part of the protocol, the specific meniscal treatment started.

Data of intra-articular exposure and visualization of anatomical structures was documented by the photography and videography function of the arthroscopic camera (AR-3210-0023 4K SynergyUHD4, Arthrex).

2.2.1 | Establishment of the CMP and specific meniscal treatment

A 20-gauge 70 mm needle was inserted in the joint about 1 cm caudal to the most prominent aspect of the medial tibial condyle. Percutaneous transillumination indicated the site of puncture. The needle was advanced until the tip could be seen in the caudal compartment, caudal to

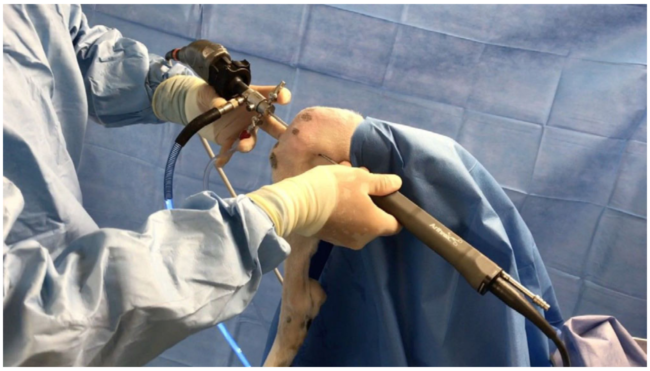

FIGURE 1 Set up performing the caudal pole meniscectomy.

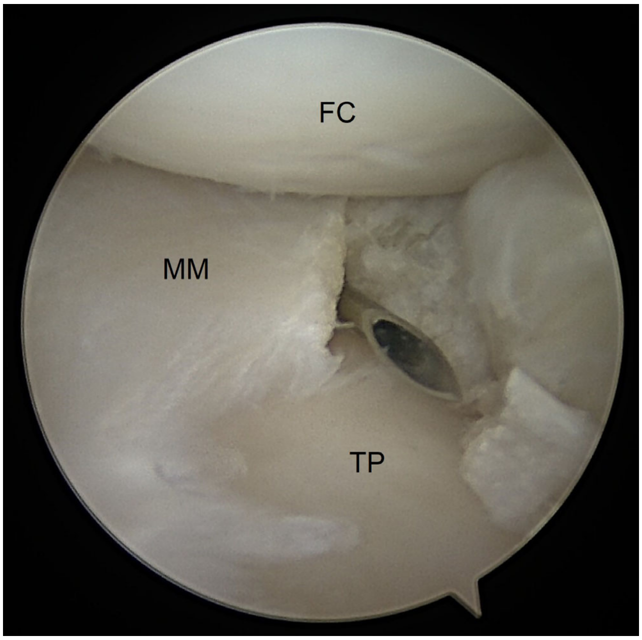

FIGURE 2 Arthroscopic view of a caudal pole meniscectomy with a hypodermic needle visualizing the instrument portal. Medial is to the left, lateral is to the right, dorsal is to the top and ventral is to the bottom of the image. FC, femoral condyle; MM, medial meniscus; TP, tibial plateau.

the medial meniscus, in the area of the transected menisco-tibial ligament. An incision was made through the joint capsule, alongside the needle, keeping an orientation of the blade parallel to the medial collateral ligament until the tip of the blade could be visualized in the same location as the needle tip. The incision was enlarged with straight mosquito hemostatic forceps.

A motorized tissue shaver was then inserted through this portal until the tip of the shaver (Excalibur 3.8 mm, AR- 8380EX, Arthrex or bone cutter 3.8 mm, AR- 8380 BC, Arthrex) was visualized distal and caudal to the meniscus (Figure 1). The shaver was then moved in a horizontal fashion with the cutting edge directed towards the meniscus to

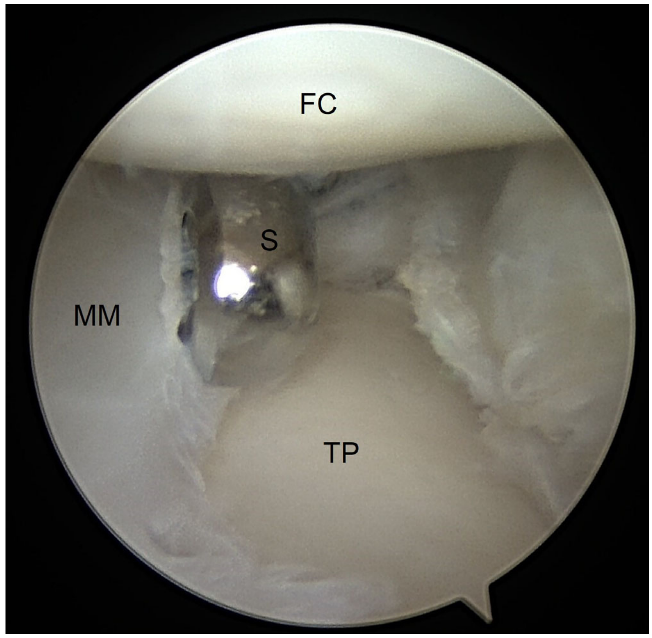

FIGURE 3 Arthroscopic view of a left stifle joint performing the caudal pole meniscectomy with a motorized tissue shaver in place. Medial is to the left, lateral is to the right, dorsal is to the top and ventral is to the bottom of the image. FC, femoral condyle; MM, medial meniscus. S, shaver; TP, tibial plateau.

complete CPM, while taking care to not touch the cartilage when moving the instrument (Figure 2, Figure 3). The procedure was stopped when the surgeon was satisfied with the completeness of the meniscectomy, or if there was high risk of IACI. The decision to stop resecting meniscus was based on the judgment as applied to a clinical case.

2.3 | Outcome measures

The feasibility of the caudomedial portal was assessed by the ability to visualize the instrument for meniscectomy and documenting the surgical time. Evaluation of iatrogenic damage to extra- and intra-articular structures was performed afterwards by anatomical dissection. The benefit of meniscectomy technique performed through a caudomedial portal was quantified by measuring the amount of meniscus removed.

2.3.1 | Anatomical dissection and joint examination

Directly after each arthroscopic procedure, each specimen was dissected and disarticulated to evaluate if there

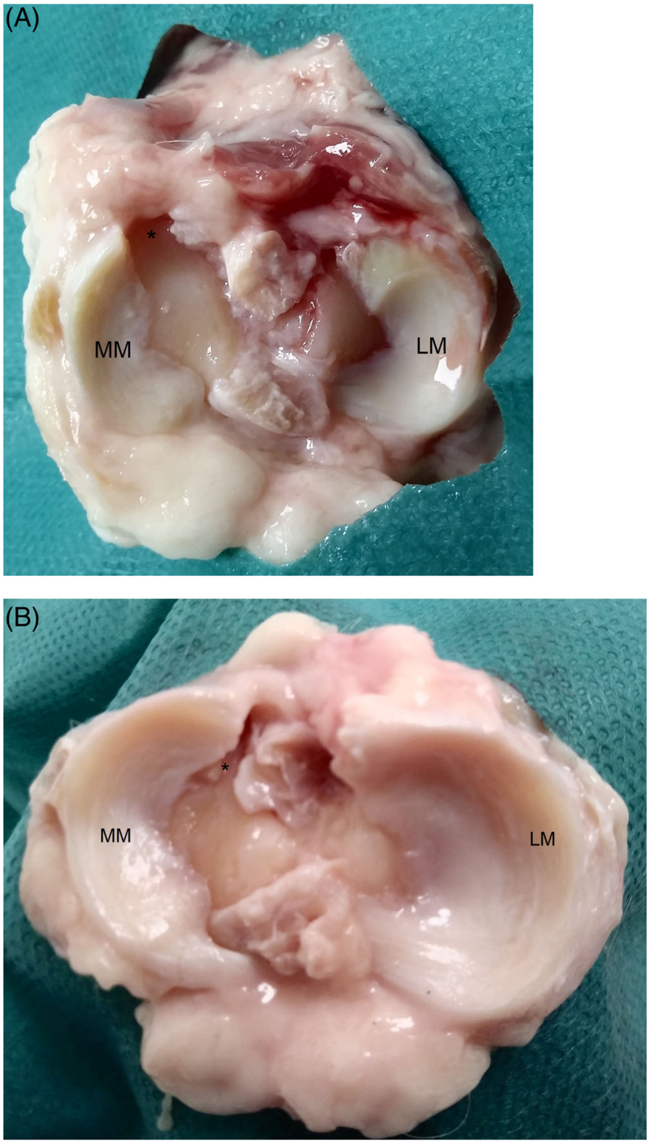

FIGURE 4 Photographs of the tibial plateau of disarticulated left stifle joints showing (A) complete and (B) incomplete caudal pole meniscectomy. The asterisk (*) marks the resected area. Medial is to the left, lateral is to the right, cranial is to the bottom and caudal is to the top of the photographs. LM, lateral meniscus; MM, medial meniscus.

was any iatrogenic injury to the extra- and intra-articular structures. The caudomedial portal was examined to identify and document any damage to the popliteal artery and vein, saphenous nerve, muscles and the medial collateral ligament. Following careful disarticulation, integrity of the caudal cruciate ligament and the lateral meniscus was evaluated and any damage was recorded (Figure 4).

Photographss of the disarticulated joints were taken with a camera positioned at a fixed distance and perpendicular to the articular surface and menisci. The area of the intact meniscus was estimated by drawing an arc from the axial and abaxial edge of the remaining meniscus to the remaining part of the caudal meniscotibial ligament. The degree of completeness of CPM was calculated by using a computer software program (ImageJ, NIH, Bethesda, Maryland) and measured as percentage of the whole medial meniscus.

The articular cartilage of the distal femoral and proximal tibial articular surface was evaluated for iatrogenic damage. First, 2 mL of india ink was poured onto the joint surfaces with a 3 mL syringe and then washed with physiological saline 1 min later.[6] The cartilage was photographed perpendicular to the joint surface and the digital images were saved. India ink cannot enter normal articular cartilage but becomes entrapped in surface irregularities and adheres to cartilage missing the superficial lamina splendens.[15] The area of articular surface discolored with india ink was calculated by using a computer software program (ImageJ, NIH, Bethesda, Maryland) and measured as percentage of the whole articular surface.

2.4 | Statistical analysis

The data of the area of the resected meniscus and the area of damaged cartilage (IACI) are summarized as means and standard deviation. The area of IACI of the femur and tibia were documented independently and pooled together.

Descriptive statistics were performed using open source software (https://datatab.de/statistik-rechner/).

3 | RESULTS

3.1 | Specimen

Ten hindlimbs were included in this cadaveric study. All dogs were skeletally mature with a mean age of 62 month at the time of death. The median bodyweight of the specimen was 37 kg, the mean tibia plateau angle was 27.5°. An intra-articular joint distractor was used in every specimen.

3.2 | Surgical duration and completeness of meniscectomy

The surgical time needed to complete the procedure ranged from 18.1 to 48.1 min (mean = 28.7 min). The extent of the CPM ranged from 11.4%–45.1% (mean = 29.8%). A meniscal punch could not be used to resect meniscal tissue without risking severe IACI.

3.3 | Iatrogenic damage and intra-articular evaluation

No damage to the popliteal artery and vein, saphenous nerve and the medial collateral ligament were documented during anatomical dissection of the specimen. The caudal part of the M. sartorius and the caudal belly of the M. semimembranosus had signs of dissection where the portal was established. The caudal cruciate ligament and the lateral meniscus were intact in all specimens.

IACI was observed in all stifles, mainly detected in the caudal area of the medial femoral condyle and the caudal area of the medial tibial condyle. The mean total IACI was 3.71 ± 1.78 (mean % ± SD). IACI in the femur was 4.23 ± 2.71 (mean % ± SD). IACI in the tibia was 3.61 ± 2.43 (mean % ± SD).

4 | DISCUSSION

In the present study we used a combination of standard cranial arthroscopic portals and a caudomedial instrument portal to perform CPM. The study goal targets the clinical problem of the narrow joint space and limited working space when performing stifle arthroscopy in dogs. Hulse reported the use of a caudomedial arthroscopic portal in dogs but found that a caudomedial portal was narrow for the use of instruments.[16] We confirm this finding as a meniscal punch could not be safely used in our study. Instead, we found that judicious use of a shaver blade designed for aggressive soft tissue resection was effective for meniscal resection. When using a shaver in a narrow joint space it is important to continuously check that the cutting edges of the shaver are not in contact with cartilage, but only meniscus. Pressure from the femoral condyle can push the shaver against the tibial plateau cartilage and cause iatrogenic damage.

We were able to resect a median 29% of medial meniscal tissue through the caudomedial portal. This was acceptable because our aim was to remove the caudal third. The advantage of shaving through a caudal portal may be that the shaver tip has direct access to the caudal pole of the medial meniscus, without impingement with the femoral condyle. The shaver tip is placed caudal to the meniscus and therefore does not limit the view while resecting the meniscus. However, the eye-hand coordination needs to be adjusted because of the position of the shaver opposite to the arthroscope.

In this cadaveric study we found that the caudomedial portal may be associated with low morbidity as there was no major damage to peri- and intra-articular structures. This result can be explained by the absence of damage to relevant neurovascular structures and the preplacement of the needle when establishing the port. Visualizing the needle first, allows optimization of the position and the working angle of the shaver. Despite our results, this portal should be used cautiously, and further clinical safety studies should be performed. The resultsof our study are similar to the posterior medial arthroscopic portal in human knee joint treatment.[10] Ahn et al. described various indications for using this portal without injuries to popliteal neurovascular structures in human medicine including meniscal treatment. Variations on entry point to a joint are inherent, when establishing arthroscopic portals, where anatomic landmarks are identified solely via palpation. However, the needle allows to choose accurately the angle of insertion of the shaver, which is critical for performing the meniscectomy safely.

A degree of IACI occurred in all joints but only with a median of 3.71% area of the meniscus. IACI is still the most frequently under-recognized complication in human arthroscopy[17,18] and one of the most common complications during stifle arthroscopy in dogs.[19] Rogatko et al. and Cortés III et al. reported IACI in 13 out of 14 canine stifles joints undergoing standard exploratory arthroscopy. Our results emphasize that a minimally invasive procedure such as arthroscopy is not without risks and strategies including joint distraction and use of small diameter instruments should be considered when the joint is too narrow.

In all specimens the cartilage damage was mainly detected in the caudal area of the medial femoral condyle and the caudal area of the medial tibial condyle. Therefore, instrument manipulation during meniscectomy was the primary cause of IACI. Bush et al. demonstrated that if higher than physiological loads are concentrated on small areas, significant chondrocyte death can occur. This problem is also valid for blunt instruments such as probes[20,21] and must also be suspected for the tip of the shaver.

Intra-articular distraction and the use of shavers and instruments of smaller diameter are strategies to decrease the risk of cartilage damage. In our study, stifle distraction was not standardized because each cadaver limb may have had different tissue characteristics. Instead, the primary surgeon standardized the amount of distraction by using the two techniques currently used in dogs, distraction by manipulation or by application of a distractor. An intra-articular distractor was selected based on the surgeon's preference, but we cannot exclude that greater distraction could have been achieved with an external distractor.[22]

Because of the extremely limited healing capacity of articular cartilage,[23,24] further studies to investigate methods to limit IACI are still warranted.[25] The current study had several limitations, including the use of cadavers, because the freeze–thaw cycle and post-mortem changes negatively affect the integrity of the articular cartilage, making IACI more likely in cadavers than in live patients.[6] On the other hand, many dogs undergoing arthroscopic surgery have some degree of intra-articular osteoarthritic cartilage, which would therefore be predisposed to injury because of softening.[25,26] Another limitation of our cadaveric model is the lack of fibrosis expected in dogs with chronic cranial cruciate ligament disease, which might limit distraction and exposure of the meniscus. The wide range of degree of joint degeneration in cruciate ligament deficient patients led the authors to use healthy joints of cadavers to achieve a better intra-group comparability. To which degree these findings can be translated to cruciate ligament injured live patients cannot be exactly defined. It is possible that an external distractor might have achieved more distraction allowing greater resection in the standard portal group. However, the primary surgeon selected an intra-articular distractor because there was enough space for placing the tip, after simulating a partial CCLR with a resection of the cranio-medial band of the CrCrL.

The timing and extent of using the different motorized tissue shavers was at the discretion of the surgeons. This nonstandardized instrument use is another limitation of this study.

Apart from performing CPM, this new caudomedial portal could be used for other applications. The posteromedial portal is routinely used for diagnostic and intraarticular repair of medial meniscus posterior horn tears in humans.[27,28] In this regard, the caudomedial portal could be of use for repair of vertical longitudinal meniscal tears in dogs. The possible extended clinical utility of this portal warrants further research.

5 | CONCLUSION

A caudomedial portal for CPM was feasible and allowed a partial meniscectomy to be performed. No major damage to neurovascular or intra-articular structures was recorded. The amount of IACI was acceptable for potential clinical use of the procedure. However, this portal may be used in selected cases when caudal tears cannot be accessed through the standard portals. Even if we did not observe iatrogenic injuries to MCL and caudal cruciate ligament in this cadaveric study, surgeons should be aware of the potential risk for these injuries.

AUTHOR CONTRIBUTIONS

Keider S, med vet: Study conception, design, acquisition of data, drafting of the manuscript and analyzing the data. Schmierer Dr. med.vet., DECVS: Study conception, design, acquisition of data and drafting of the manuscript. Pozzi A, Dr. med.vet., DECVS, DACVS (Small Animal), DACVSMR: Study conception, design, acquisition of data and drafting of the manuscript.

CONFLICT OF INTEREST STATEMENT

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