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CLINICAL RESEARCH

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Diagnosis of medial meniscal lesions in the canine stifle using multidetector computed tomographic positive-contrast arthrography

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Abstract

Objective: To assess diagnostic value and clinical utility of multidetector computed tomographic positive contrast arthrography (CTA) for meniscal lesions in dogs.

Study design: Prospective case series.

Study population: Client-owned dogs ($n = 55$) with cranial cruciate ligament injuries.

Methods: Sedated dogs underwent CTA using a 16-slice scanner, and subsequently received mini-medial arthrotomy for meniscal assessment. Scans were anonymized, randomized, and reviewed twice for meniscal lesions by three independent observers with varying experience. Results were compared with surgical findings. Reproducibility and repeatability were assessed with kappa statistics, intraobserver changes in diagnosis by McNemar's test, and interobserver differences using Cochran's Q test. Test performance was calculated using sensitivity, specificity, proportion correctly identified, and positive and negative predictive values and likelihood ratios.

Results: Analysis was based on 52 scans from 44 dogs. Sensitivity for identifying meniscal lesions was 0.62–1.00 and specificity was 0.70–0.96. Intraobserver agreement was 0.50–0.78, and interobserver agreement was 0.47–0.83. There was a significant change between readings one and two for the least experienced observers ($p < .05$). The sum of sensitivity and specificity exceeded 1.5 for both readings and all observers.

Conclusion: Diagnostic performance was suitable for identifying meniscal lesions. An effect of experience and learning was seen in this study.

Abbreviations: CCL, cranial cruciate ligament; CT, computed tomography; CTA, computed tomographic arthography; DICOM, digital imaging and communications in medicine; MRI, magnetic resonance imaging.

1 | INTRODUCTION

Cranial cruciate ligament (CCL) disease is one of the most common causes of hindlimb lameness in dogs.[1–3] A common sequela to joint instability after CCL rupture is medial meniscal injury.[4–6] Tears of the caudal horn of the medial meniscus exacerbate pain and loss of function associated with CCL rupture, making it essential for the surgeon to accurately diagnose meniscal lesions to ensure the best possible outcome of surgery.[6,7] Meniscal injuries may be present at the time of diagnosis or surgery, or develop subsequently (late meniscal injury). Rates vary from 20%–77% for concurrent meniscal lesions,[7–11] and late meniscal injury is reported in 2%–22% of dogs following stabilization surgery.[12–14]

Diagnosis of meniscal lesions typically relies on direct invasive visualization with either arthrotomy or arthroscopy, with associated morbidity.[15,16] A canine cadaver study identified iatrogenic cartilage lesions in 13/14 stifles following arthroscopy and 4/14 following mini-medial arthrotomy, with larger lesions in the arthroscopic cases.[17] A review of human arthroscopic videos found an incidence of iatrogenic lesions of 74%, and significant cartilage cell death in a bovine model simulating these lesions.[18] These authors found it plausible that iatrogenic lesions could contribute to pain, inflammation and osteoarthritis progression, especially in prediseased joints in which the cartilage may be more sensitive to damage.[18] Noninvasive alternatives currently described include ultrasonography, MRI and positive-contrast computed tomographic arthrography (CTA), predominantly using single-detector technology.[10,19–25] Definition of soft-tissue structures of the canine stifle, including the menisci, is possible using single-detector CTA, even though single-detector technology limits image resolution, especially for multiplanar reconstruction, which negatively impacts diagnostic accuracy.[22–24] In humans, multidetector CTA has been shown to have excellent diagnostic value in evaluating menisci,[26] and similar technology is now available in veterinary referral centers and larger hospitals.

Where test sensitivity for CTA represents the ability of screening to correctly identify dogs with meniscal lesions from the population of dogs known to have a meniscal lesion, the positive likelihood ratio reflects change in odds of a dog having a meniscal lesion given a positive CTA result. Conversely, specificity for CTA represents the ability of screening to correctly identify dogs without meniscal lesions from the population of dogs known to be disease-free: the negative likelihood ratio indicates the change in odds of a dog having a meniscal lesion given a negative CTA result.[27] For a test to be useful, the sum of sensitivity and specificity should exceed 1.5.[28] How informative a test is, depends on how far the likelihood ratios are from 1.0, indicating no change in odds. A positive value ≥10 or a negative value ≤0.1 produce large and likely conclusive changes in pretest probability of disease, whereas values ≥5 or ≤0.2 generate moderate shifts in pretest probabilities.[29]

Single-detector positive-contrast CTA has reported sensitivity and specificity of 13.3%–73.3% and 57.1%–100%, respectively,[24] with no observer's values exceeding the 1.5 sum threshold. A similar study reported sensitivity and specificity of 57%–64% and 71%–100%, respectively.[22] While the first study concluded that CTA had limited potential for meniscal lesion diagnosis, the second was more positive in this regard.[22,24]

We hypothesized that multidetector CTA would enable combined sensitivity and specificity exceeding threshold values for clinical usefulness (≥1.5) and likelihood ratios with a strong evidence level (≥10; ≤0.1) in a clinical population of dogs affected by CCL rupture.

2 | MATERIALS AND METHODS

Client-owned dogs who presented at the first author's clinic were recruited with informed owner consent between April 2017 and September 2020. Ethical approval was obtained from the corresponding author's institution for use of obtained data but was not specifically required for the first author's clinic. Inclusion criteria were: primary presentation with a clinical history and examination consistent with the presence of partial or complete CCL rupture or suspicion of late meniscal injury following prior stabilization. Specific clinical criteria included acute or chronic onset lameness, positive sit-test, toe-touching stance, medial stifle joint thickening (buttress sign), joint effusion, and instability and/or pain when applying the cranial drawer and tibial compression tests. Exclusion criteria were: gross skin pathology around the stifle joint, other comorbidities such as severe systemic disease, interval between scan and surgery exceeding 2 weeks, and owner declined surgical exploration or stabilization. All investigative and surgical procedures were performed by the first author.

2.1 | CTA procedure

All scans were performed with a 16-slice multidetector computed tomography scanner (Brivo CT385, GE Healthcare, Japan) using the axial scan mode, 100 kV, 120 mAs, and slice width of 0.625 mm. Dogs were sedated with dexmedetomidine (Dexdomitor, Orion Pharma Animal Health, Denmark) at 12.5 μg/kg and methadone

(Comfortan Vet, Dechra Veterinary Products, Denmark) at 0.4 mg/kg given IM. Oxygen supplementation was provided with a face mask.

Dogs were positioned in dorsal recumbency with hindlimbs secured in extension and parallel to each other, with the stifle joints centered in the gantry so that the tibial plateau was approximately parallel to the scanning plane. The fur over the stifle joint was clipped and the skin prepared aseptically. Following a native scan, a 21-gauge needle was inserted medial to the patellar tendon, and joint fluid aspirated prior to injection of the contrast solution until palpable joint distension was noted. The contrast solution consisted of 50% iohexol (Omnipaque 350 mg/mL, GE Healthcare, Denmark), 40% sterile saline, and 10% of 1 mg/mL epinephrine (Takeda Pharma, Denmark), yielding a final iodine concentration of 175 mg/mL and epinephrine concentration of 0.1 mg/mL, based on reported iodine concentrations in previous studies.[22–24,30,31] Epinephrine was added to slow absorption of the contrast medium through the synovial membrane.[32] Maximal injection volume was 5 mL per stifle.

Twelve dogs with clinically normal contralateral stifle joints underwent bilateral CTA to provide comparison material for training and control purposes. Disease-free status was determined by the absence of positive findings using the same criteria as for inclusion in the study and absence of radiographic changes.

2.2 | Joint exploration

Arthrotomy was performed via a standardized mini-medial approach aided by an appropriately-sized speed-lock stifle distractor in order to visualize and probe the menisci. Findings were recorded in the patient journal, and partial or total excision of the caudal horn of the medial meniscus performed as required. Unstable joints underwent tibial tuberosity advancement, tibial plateau leveling osteotomy or lateral suture stabilization, based on owner preference, cost, and clinical factors such as patient size and tibial plateau angle.

2.3 | CTA evaluation

Training and CTA evaluation were performed using open-source DICOM viewing software (Horus 3.3.6, www.horusproject.org, accessed June 10, 2022).

To finalize the examination protocol and to gain experience with examination of the canine stifle joint using computed tomography, the 12 normal CTA were examined by all observers: these scans were excluded from the final evaluation. In addition, a number of examples of meniscal injury were also used, from patients prior to initiation of this study. Two observers were considered inexperienced, being final-year veterinary students (observers 1 and 2), and observer 3 was an experienced orthopedic surgeon with 25 years surgical experience and 8 years veterinary orthopedic CT experience including use of CTA at the time of study start. Affected stifle CTA were anonymized and randomized by observers 1 and 2 using open-source software (DICOM cleaner, www.dclunie.com, accessed 10 June 2022) into two collections each containing all scans. Each observer, working independently, read the two collections with a one-week interval between them.

Using multiplanar reconstruction the scans were aligned such that the transverse plane was parallel to the tibial plateau, the dorsal (frontal) plane was perpendicular to the tibial plateau and tangent to the caudal femoral condyles, and the sagittal plane was perpendicular to both transverse and dorsal planes (Figure 1). Window width and level were adjusted according to observer preferences for optimal viewing. A standardized scoring sheet was used to record the results, with menisci graded as either intact or damaged: no other interpretation was made.

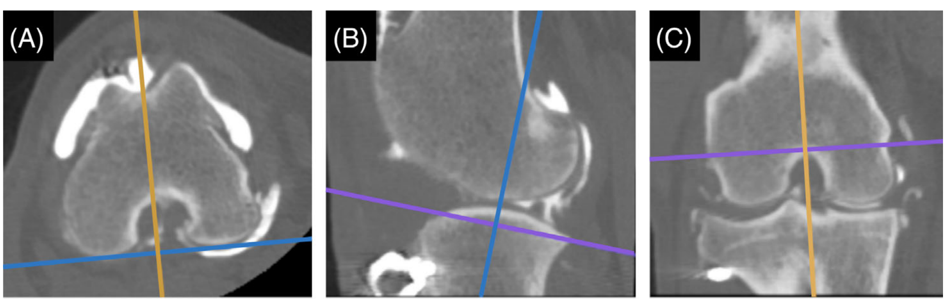

FIGURE 1 Alignment of viewing planes for multiplanar reconstruction. The transverse plane (purple) was parallel to the tibial plateau (B), the dorsal (frontal) plane (blue) was perpendicular to the tibial plateau (B) and tangent to the caudal femoral condyles (A), and the sagittal plane (yellow) was perpendicular to both transverse and dorsal planes (A, C).

2.4 | Statistical analysis

Analyses were performed using statistical software (SPSS 27, IBM Software, Armonk, New Jersey; R 4.2 with EpiR package). The Shapiro–Wilk test was used to assess normality of distribution of continuous data, which were reported as mean (standard deviation) or median (range) as appropriate. Sensitivity, specificity, positive and negative predictive values, likelihood ratios, and correctly classified proportions were calculated by reference to the recorded arthrotomy findings. Intraobserver agreement across the two readings was calculated using Cohen's kappa, and interobserver agreement between the three observers was calculated using Fleiss' kappa. Adjectival descriptions as defined by Altman[33] were used, with kappa values between 0.2–0.4 designated fair, 0.4–0.6 designated moderate, 0.6–0.8 designated good, and 0.8–1.0 designated very good. Changes in readings for each observer were assessed using McNemar's test, and between observers for each reading using Cochran's *Q* test with post hoc Bonferroni adjustment. Significance was set at the 5% level.

3 | RESULTS

A total of 66 scans from 55 dogs were obtained during the study period: an additional five dogs were excluded from scanning due to comorbidities. Seven dogs did not undergo surgical exploration, four scans exceeded the 2 week maximum interval from scanning to surgery, and three scans were excluded from analysis due to missing data and poor image quality, leaving 52 scans from 44 dogs for analysis. No issues with implant-associated artifacts were observed with the scanning protocol used here.

Median age at time of surgery was 6 years 9 months (range 1 year to 11 years 3 months). There were 19 males

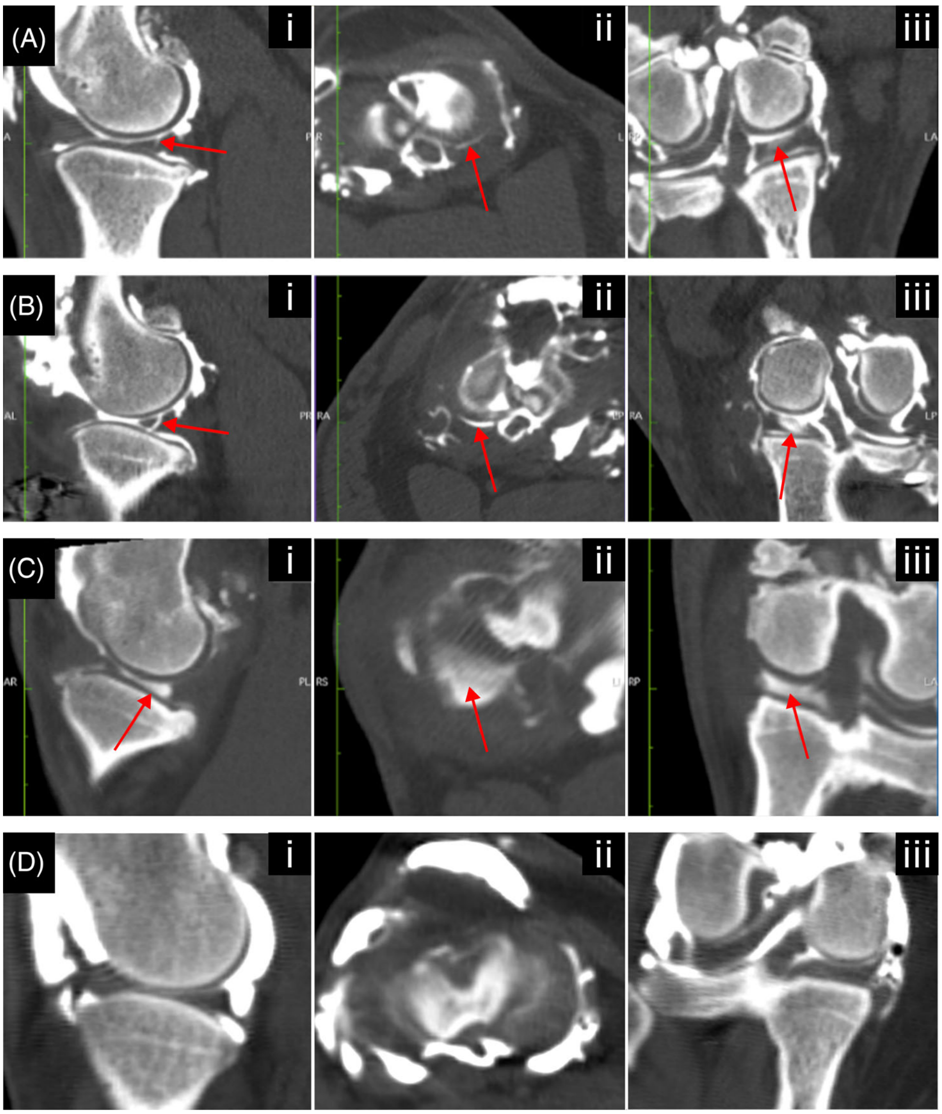

FIGURE 2 Examples of meniscal lesions seen with positive contrast computed tomographic arthrography. Three stifles with meniscal lesions (A–C) and one unaffected stifle (D) seen in sagittal (i), transverse (ii) and dorsal (frontal) (iii) sections constructed with 3D multiplanar reconstruction with WL 500 and WW 2000. A—partial thickness meniscal lesion extending from the femoral surface of the meniscus distally, but not penetrating the tibial surface (i, iii) or abaxial border (ii) of the meniscus. B—full thickness meniscal lesion extending from the femoral to tibial meniscal surfaces (i, iii), but not reaching the abaxial border (ii). C—damage to the caudal horn of the medial meniscus is appreciated as hyperintense shadowing of the meniscal tissue, without a clearly defined line of separation. D—normal wedge appearance of the medial meniscus can be appreciated (i, iii), with no contrast penetration on the transverse view (ii).

and 25 females with a mean body mass of 27.3 kg (SD 13.6 kg). Most common breed types were large mixed breed ($n = 9$), Labrador retriever ($n = 4$), Old English bulldog ($n = 3$), and medium mixed breed ($n = 3$). Thirty stifles were operated on the day of scanning, with a median interval of 0 days (range 0–13 days).

Suspected late meniscal injury was the indication for 12/52 scans, with one prior lateral suture repair and 11 tibial tuberosity advancements: meniscal lesions were identified in 9/12 at surgery. Lesions comprised bucket handle tears ($n = 5$), marked fibrillation ($n = 1$), radial tear ($n = 1$), and two unspecified lesions. In stifles without prior stabilization, meniscal lesions were identified surgically in 19/40 scans, predominantly bucket handle tears ($n = 16$), with one fragmented caudal horn, one detached bucket handle, and one nonspecified lesion. Six dogs were scanned twice due to suspected unilateral late meniscal injury and one dog was scanned on four occasions due to bilateral cruciate disease and subsequent suspicion of late meniscal injury, and these scans included as separate instances in this study. Surgical findings and observations are summarized in Table S1. Examples of meniscal lesions identified in this study with comparison normal slices are shown in Figure 2: normal joint anatomy is further detailed in Figures S1, S2 and S3.

Diagnostic accuracy varied with observer experience and between readings (Table 1). Sums of sensitivity and specificity were approximately 1.6 for the first reading and 1.8 for the second, indicating useful diagnostic performance.[28] Based on values for the second reading, identification of meniscal abnormalities on CTA had a positive predictive value of approximately 90%, whereas an absence of abnormalities had a negative predictive value of 91%–100%. The positive likelihood ratio following identification of meniscal abnormalities on CTA was at least 4.6: the negative likelihood ratio was 0.08 or lower. These values may be used in a Bayes nomogram. Assuming our 75% probability of meniscal tears in a population suspected of late meniscal injury, presence or absence of findings on CTA would indicate >93% or <19% probabilities of meniscal lesions, respectively. Correspondingly, our 48% probability of meniscal injury in first presentation cranial cruciate ligament rupture patients would give post-test probabilities for presence or absence of a meniscal lesion of >81% or <7%, respectively. Overall, the percentage of correctly classified menisci was approximately 80% for reading one and 90% for reading two.

For the two least-experienced observers, a change in classification proportions was observed between readings one and two ($p < .001$, $p = .02$), but not for the most experienced observer ($p = .22$).

Intraobserver agreement was moderate to good, and interobserver agreement moderate for reading one and very good for reading two (Table 2). Readings differed between observers for readings one and two ($X^2[2] = 13.7$, $p < .001$; $X^2[2] = 6.0$, $p = .05$). Pairwise differences were seen between observer 1 and 3 in reading one

TABLE 1 Diagnostic data. Sensitivity, specificity, positive and negative predictive values (PPV, NPV), positive and negative likelihood ratios (PLR, NLR) and correctly classified proportions (CCP), with 95% CI.

	Reading 1			Reading 2		
	Observer 1	**Observer 2**	**Observer 3**	**Observer 1**	**Observer 2**	**Observer 3**
Sensitivity	0.62 (0.42, 0.79)	0.72 (0.53, 0.87)	0.90 (0.73, 0.98)	1.00 (0.88, 1.00)	1.00 (0.88, 1.00)	0.93 (0.77, 0.99)
Specificity	0.96 (0.78, 1.00)	0.87 (0.66, 0.97)	0.70 (0.47, 0.87)	0.78 (0.56, 0.93)	0.83 (0.61, 0.95)	0.91 (0.72, 0.99)
PPV	0.95 (0.74, 1.00)	0.88 (0.68, 0.97)	0.79 (0.61, 0.91)	0.85 (0.69, 0.95)	0.88 (0.72, 0.97)	0.93 (0.77, 0.99)
NPV	0.67 (0.48, 0.82)	0.71 (0.51, 0.87)	0.84 (0.60, 0.97)	1.00 (0.81, 1.00)	1.00 (0.82, 1.00)	0.91 (0.72, 0.99)
PLR	14.28 (2.06, 99.13)	5.55 (1.89, 16.33)	2.95 (1.57, 5.53)	4.60 (2.12, 9.99)	5.75 (2.36, 14.01)	10.71 (2.84, 40.40)
NLR	0.40 (0.25, 0.64)	0.32 (0.17, 0.58)	0.15 (0.05, 0.45)	0.00	0.00	0.08 (0.02, 0.29)
CCP	0.77 (0.63, 0.87)	0.79 (0.65, 0.89)	0.81 (0.67, 0.90)	0.90 (0.79, 0.97)	0.92 (0.81, 0.98)	0.92 (0.81, 0.98)

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; NPV, negative predictive value; PLR, platelet to lymphocyte ratio.

TABLE 2 Intra- and interobserver agreement. Intraobserver agreement was assessed using Cohen's kappa, and interobserver agreement with Fleiss' kappa. Values are presented with 95% CI.

	Observer (intraobserver)			Reading (interobserver)	
	1	**2**	**3**	**1**	**2**
Kappa	0.50 (0.31–0.69)	0.55 (0.34–0.75)	0.78 (0.62–0.95)	0.47 (0.32–0.63)	0.83 (0.68–0.98)

(corrected $p = .001$) but not between observers 1 and 2, or between 2 and 3 (corrected $p = .58$, corrected $p = .06$). No pairwise differences were found for reading two after correction of p-values (1 vs. 2 $p = 1.0$; 1 vs. 3 $p = .06$; 2 vs. 3 $p = .19$).

4 | DISCUSSION

Positive-contrast arthrography with multidetector computed tomography demonstrated clinically useful sensitivity and specificity for identification of meniscal lesions in this population, but our likelihood ratios while moderate in strength did not reach the predetermined thresholds of ≥10 and ≤0.1. Our hypothesis could only be partially accepted. We found evidence of an effect of observer experience and a training effect during this study.

Sum values of 1.59–1.63 for reading one, and 1.81–1.85 for reading two, suggest that CTA is a useful test for diagnosing meniscal lesions, particularly given the incidence of diagnosed meniscal damage here.[28] The likelihood ratios suggest that a positive CTA finding gives a moderate to large increase in the likelihood of meniscal lesions being present, whereas negative findings give a large decrease in this likelihood. Use of CTA appears to be symmetric, favoring neither positive nor negative diagnoses.

Test performance is defined in relation to the reference standard. Diagnoses in this study were achieved using arthrotomy, probing and visual inspection by an experienced orthopedic surgeon. This modality was used as the sole reference standard in some[24] or all[22] of dogs assessed in previous clinical CTA studies. Arthroscopy is considered superior to arthrotomy for the diagnosis of meniscal lesions,[7,16] although even arthroscopy may miss some lesions due to inability to evaluate the internal structure of the meniscus.[23,34] False positive CTA diagnoses might therefore reflect inability to correctly confirm a meniscal lesion rather than a real test failure. While our results can thus be compared with previous CTA studies, it remains possible that test performance is overstated in comparison to using arthroscopy as the reference standard.

While all stifles in this study underwent surgical exploration, if CTA is to be used as a screening tool then arthrotomy or arthroscopy will not necessarily be performed. Our results indicate that when postliminary tears are suspected less than one in five dogs will have a tear despite a negative reading, and that for first-presentation dogs, less than one in 14 will have tears with a negative reading. These values will change depending on the actual clinical probabilities of meniscal lesions in different patient populations-with rates of 0%–84.6% reported in a systematic review[35] - and clinicians should therefore make an informed estimate of likely post-test probabilities. For comparison, analysis of data from cadaver studies with simulated meniscal lesions yielded positive and negative likelihood ratios of 21.3 and 0.16,[36] and 16.0 and 0.21,[16] for arthroscopic examination with probing. Arthroscopy with probing will thus give higher positive post-tests probabilities for meniscal injury than CTA in our population, but the negative post-test probabilities would be worse at 32%–39% for postliminary tears and similar at 13%–16% for the first-presentation. Finally, the client should be fully informed of the potential risks and benefits of each course of action.

There was a clear effect of experience, both in terms of test performance between observers 1 and 2 and observer 3, but also in terms of continued learning through the study period despite a training protocol implemented before starting this study. The mix in abilities probably contributed to the moderate interobserver kappa value obtained in the first reading. The training protocol used was similar to one previously reported for board-certified radiologists with limited experience of CTA,[24] with our inexperienced observers achieving similar sensitivity and specificity to theirs. This may indicate the advantages of multidetector technology on image quality. Similarly limited training materials were used in another study by two board-certified radiologists and a board-certified surgeon.[22] This second study included a repeat reading by one observer, with an apparent improvement in performance. The significant improvement in performance noted for the two inexperienced observers in our study indicates that the training protocol was insufficient to achieve clinical competence, and that previous studies' results may have been hampered by this. It is possible that further improvement might have been noted in a third reading. The reasons for improvement given that no information on correct diagnosis was available to the observers may be due to improved familiarity with multiplanar reconstruction, stifle anatomy, and use of imaging software during the intensive reading period.

Alternative modalities for meniscal lesion diagnosis include ultrasonography and MRI. Reported sensitivity and specificity for canine meniscal lesion diagnosis are 82%–90% and 93%, respectively, but is highly dependent on the equipment and operator.[10,19] In humans, the modality of choice is MRI, with a diagnostic accuracy of 86%–91% and sensitivity and specificity for medial meniscal tears of 91%–93% and 81%–88%, respectively.[37,38] Similar findings were reported in dogs with cranial cruciate ligament disease.[20,21] Availability of veterinary MRI facilities remains limited, scanning costs are high, and scan times are longer in comparison to multidetector CT, and MRI image quality is reduced adjacent to metal implants, limiting applicability for late meniscal injury. Additionally, MRI requires full anesthesia while CT may be performed under sedation. Our results compare favorably to the above modalities and given the wider availability of CT and of radiological reporting services, multidetector CTA appears to be a promising diagnostic tool for identifying meniscal lesions in dogs. Clinicians should consider the cost–benefit ratio of these diagnostic modalities in light of local costs. While arthroscopy remains the reference standard, the costs of this procedure include time involved in setting up and removing equipment, procedure time, which impact total anesthesia time for surgery, as well as technician time for cleaning and sterilizing for subsequent use.

We found that the positioning protocol used here for scanning, with the tibial plateau positioned approximately vertical and thus parallel to the plane of the scanner, resulted in implants (if present) being imaged in slices distant to the structures of interest. As a result, we did not experience any problems with overlap apart from one of the excluded dogs with a lateral fabellar suture crimp overlying the joint space. Previous clinical experience had shown that failure to position appropriately can result in the native scan including part of a plate or cage in the slices covering the meniscus, giving significant artifacts.

We elected to exclude patients with an interval from scanning to surgery exceeding 14 days. While most dogs were operated the day of scanning, both practice and owner scheduling conflicts caused a delay in some cases. It is logical to assume that the longer the stifle joint remains unstable, the greater the chance that the medial meniscus will incur an injury, and that greater intervals might risk development of a meniscal lesion in a meniscus previously scanned and assessed to be normal. We are not aware of solid epidemiological data on this point, and 14 days was arbitrarily selected as a cut-off.

Of the stifles suspected of postliminary tears, the majority had previous tibial tuberosity advancement surgery, reflecting the popularity of this procedure regionally and within the first author's practice. While later cases were primarily operated with tibial plateau leveling osteotomy, the follow-up times between for the two procedures were not equivalent, and it would be inadvisable to draw conclusions from this population.

This study has some additional limitations. The interval between scanning and surgical exploration was inconsistent, due to a combination of clinical scheduling issues, owner expectations and wishes, economics, and clinical urgency. Some dogs may have developed meniscal lesions after scanning, and the possibility of this could increase with increasing interval to surgery. Follow-up was at least 6 months postoperatively, but cases may have been lost to follow-up, or have had occult lesions at surgical exploration which became apparent after this time. Surgical exploration was not blinded, as one observer was the lead surgeon. Although subsequent measurements for the purposes of this report were performed in a blinded fashion, there remains a possibility of bias at the initial surgical evaluation. The volume of contrast medium used was subjectively based on joint distension, which could risk over- or underdosing and consequent obscuration or loss of detail in the images. However, no leakage was noted, and contrast detail appeared subjectively good in all cases. Standardization of injection volume to body mass or surface area might be considered in the future. No pain or other adverse effects were noted following contrast injection, but pain is listed as a common adverse effect of arthrography in people with the product used: this may have been masked by concurrent sedation and administration of analgesics in our population. The effect of experience and apparent improvement in identification of meniscal lesions during the study period indicates that longer periods of training and familiarization are necessary for similar studies and for clinical proficiency.

4.1 | Clinical significance

Multidetector CTA can be considered for assessment of medial meniscal integrity in dogs due to clinically useful sensitivity and specificity, and moderate likelihood ratios. Extensive familiarization with and training on CTA images are recommended prior to clinical use.

AUTHOR CONTRIBUTIONS

Knudsen L, DVM, MS CACS (Diagnostic Imaging): Conception and design, data acquisition and analysis, drafting of manuscript. Østergaard E, DVM: Data acquisition, analysis and drafting. Jensen JJ, DVM: Data acquisition and analysis. Miles JE, BSc, BVetMed, PhD; Design, analysis, and critical revision of the manuscript. Buelund LE, DVM, PhD: Design, and critical revision of the manuscript. All authors gave their final approval.

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None declared.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this report. Preliminary results are presented as part of the

qualification process for the DVM degree (Esben Østergaard and Jakob J. Jensen) and MS degree (Lars Knudsen) at University of Copenhagen.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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