Article published online: 2025-08-21

Original Research

Prevalence of Tendinopathy of the Gastrocnemius Muscle Origin in a Cohort of Sound Border Collies

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ABSTRACT

Objectives This study aims to report the findings of the clinical examination, gait analysis, radiographs and ultrasonographic examination of the gastrocnemius tendon of origin in sound Border Collies. This study also aims to determine if this tendinopathy could be present in isolated individuals without signs of an overt lameness.

Study Design A cohort of Border Collies, active participating in agility without a history of rear limb lameness were included in the study. A standardized general orthopaedic examination was performed in each dog with special attention given to the gastrocnemius muscle and its tendon of origin. An additional gait analysis was performed for further information about loading of each limb. Mediolateral radiographs of both stifle joints were taken to assess joint health and an ultrasound was performed to evaluate the origin of the gastrocnemius tendon.

Results 34 Border Collies were included in the study. Eighteen dogs had abnormal findings during clinical examination of the of the origin of the gastrocnemius tendon. All of these dogs also had abnormal findings on ultrasound, with six of them also having mineralization surrounding the fabellae on radiographs. Only four dogs had normal clinical, radiographic and ultrasonographic findings.

Conclusion This study supports our clinical impression that tendinopathy of the gastrocnemius muscle is likely an underestimated disorder in Border Collies that actively participate in agility.

Keywords gastrocnemius, tendinopathy, agility, Border Collies, sports injury

received January 29, 2025 | **accepted after revision** August 01, 2025 | **article published online** 2025

Bibliography Vet Comp Orthop Traumatol **DOI** 10.1055/a-2675-2700 **Art ID** VCOT-25-01-0007

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Introduction

Chronic injuries due to overuse of the musculoskeletal system are a common cause of lameness and reduced performance in sporting dogs.

Tendons are particularly at risk. They are the critical link transmitting forces from a highly elastic muscle to a completely rigid bone with as little wear and tear as possible. At the same time, tendons store and release substantial amounts of tensile energy.[1] Entheses, the attachment sites of the tendon to the bone, are sites of stress concentration and particularly vulnerable to overuse injuries.[2]

Chronic repetitive trauma prevents the injured tissue from healing and leads ultimately to a painful degeneration of the tendon. Tendinopathy is the preferred term for persistent tendon pain and loss of function related to mechanical loading.[3]

Tendinopathies are reported to be one of the most common reasons human athletes require medical treatment.[4,5] Tendinopathies are recognized with increasing frequency in canine athletes. This includes the tendons of origin of the gastrocnemius muscle.

The gastrocnemius muscle has a lateral and medial head that both arise from a strong but short tendon from the lateral and medial supracondylar tuberosity of the femur. Embedded in each of the tendons is a sesamoid bone, the fabellae, which articulates with the corresponding femoral condyle.

Tendinopathy of the gastrocnemius muscle origin (TGMO) has been described in veterinary literature as a potential but rare cause of rear limb lameness in herding or athletic dogs, but also non-sporting dogs.[6–8]

In retrospective surveys of the frequency and types of orthopaedic conditions and injuries in agility dogs, TGMO is hardly, if at all, mentioned.[9–12] This contrasts with our clinical experience. Tendinopathy of the gastrocnemius muscle origin is a leading cause of hindlimb lameness in the cohort of agility dogs we evaluate, which are mostly Border Collies. It is therefore possible that TGMO is more prevalent than recognized.

The goal of the study was to report the findings of the clinical examination, gait analysis (GA), radiographs and ultrasonographic examination of the origin of the gastrocnemius tendon in sound Border Collies competing in agility. The different examination methods were analysed and compared with each other.

In addition, we intended to determine if any of the dogs, are affected by TGMO that has been unrecognized previously.

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Hypothesis

The chosen examination methods are all valuable and sufficient to assess the condition of the gastrocnemius origin site.

In this group of apparently sound active dogs, we will find isolated individuals affected by TGMO.

Methods

Dogs

In our study, we examined 39 healthy, client-owned Border Collies that were actively performing agility sport. According to the handlers, all dogs were free from lameness.

All owners were informed in writing and gave their full consent. They were allowed to stay with their dogs throughout all the examinations. All procedures were performed on non-sedated dogs.

Orthopaedic Examination

A standardized general orthopaedic examination was performed in each dog to verify the overall musculoskeletal health.

Special attention was given to the gastrocnemius muscle and its insertion site in particular. The muscle bellies were carefully palpated and their size, tension and elasticity noted. The fabellae were assessed for shape and palpability. Local digital pressure was applied to test for any pain reaction. This was done with the dogs standing in front of the examiner, allowing a direct comparison of the two limbs.

The examination was done first while the dog was weight-bearing, then it was repeated with the limb lifted to relax the muscle. The findings of both limbs were always compared with each other.

Gait Analysis

Gait analysis was performed on each dog using a GA treadmill for dogs (CanidGait®, Zebris Medical Inc., Isny im Allgäu, Germany). Highly sensitive pressure sensors recorded the weight distribution of each limb as the dog moved, capturing information about the forces exerted on each limb and paw.

The gait pattern was examined at different speeds, and measurements were taken as soon as the dog was moving smoothly at walk and trot. Key parameters to analyse force distribution, such as average pressure and maximum load expressed as a percentage of the body weight of the individual paws, were recorded. Various gait parameters, such as stride length, the distribution of stance and swing phases, gait patterns, as well as the symmetry index (SI), were also assessed. The SI is calculated from the average load forces measured. An index above 5% is considered an objective value for determining whether any differences in weight distribution are significant.[13,14]

For the purpose of this study, GA was primarily used to provide information for symmetry. A symmetrical gait pattern was expected as evidence of lameness-free limb loading.

Gait analysis was performed after the clinical examination to avoid the latter being influenced by the findings of the GA.

Radiographic and Ultrasonographic Examinations

Radiographs of both stifle joints using a standardized mediolateral view, including stifle and hock joints, were taken. Positioning was identical to lateral Tibia Plateau Levelling Osteotomy (TPLO) X-rays, with a consistent position of the limb parallel to the table and both joints kept in 90-degree flexion. These images were used to confirm joint health and to exclude any signs of osteoarthritis. Additionally, enthesiophyte formation at the supracondylar tuberosity and fabellae, as well as mineralization proximal and distal to the fabellae, were documented.

The ultrasonographic assessment of the origin of the gastrocnemius tendon was performed using a high-frequency 18-MHz linear array hockey stick probe (GE Logiq S8, GE HealthCare, Germany).

For all the sonographic examinations, the hair at the origin of the gastrocnemius tendon was clipped, and ultrasound gel was applied. The dogs were positioned in lateral recumbency with the examined lateral head of the gastrocnemius tendon upward and the stifle joint being flexed at approximately 90 degrees. The medial head of the gastrocnemius tendon of the contralateral limb was examined in the same lateral recumbency. The bone contour of the supracondylar tuberosity and the fabellae was evaluated for remodelling. Additional mineralization proximal and distal to the fabellae was also documented.

The gastrocnemius tendon was evaluated subjectively from its origin up to the musculotendinous junction with respect to echogenicity and fibre pattern. The summary of the findings was graded into four groups: Normal, mild, moderate or severe. The origin of the gastrocnemius tendon was considered *normal* if the tendon exhibited a normal echogenicity and fibre pattern. The lesions were graded as *mild* if there was one small hypoechoic area consisting of amorphous fibres or short malaligned fibres. The lesions were classified as *moderate* if two to three small hypoechoic lesions or larger mineralizations surrounded by an abnormal fibre pattern were present. A lesion was graded as *severe* when more than three hypoechoic lesions were present in the gastrocnemius tendon.

The sonographic examination was performed by a board-certified imaging specialist (Dipl. European College of Veterinary Diagnostic Imaging (DECVDI)), who also evaluated all the radiographic and sonographic images.

Results

Of the 39 dogs examined, 5 were excluded from the study. Although they were free from lameness at the time of the study, we excluded them from the study because they had signs of TGMO, but also a history of an ill-defined rear limb lameness. We eliminated those dogs from our study to avoid any bias, as they might have been affected previously by TGMO.

Of the 34 remaining dogs, there were 10 females, 10 female-spayed, 10 males and 4 castrated males.

Their average age was 4.61 years, ranging from 1.6 to 7.8 years.

The results are summarized in **Appendix Table 1** (available in the online version).

Orthopaedic Examination

We recorded the findings of the lateral fabellar area, as the medial side was difficult and not reliable to examine due to its more hidden location.

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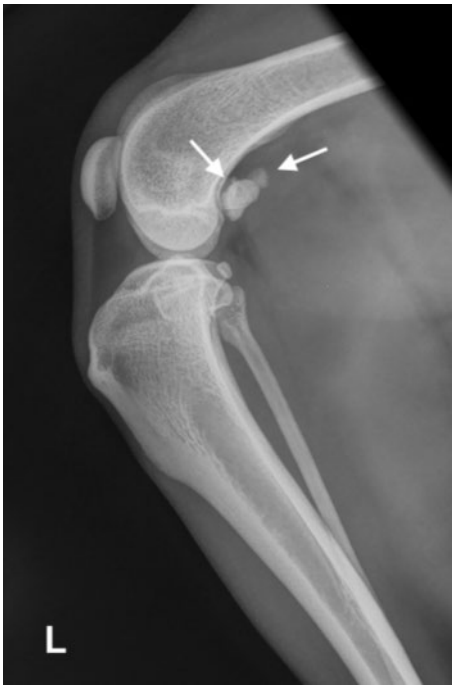

Fig. 1 Mediolateral radiograph of the left stifle joint of dog number 107, revealing mild irregular-shaped mineralizations adjacent to the fabellae (arrows).

The clinical examination was normal in 16 dogs.

When standing and loaded, the muscles of both limbs were symmetrical in size and felt well-tensioned, but still elastic. When unloaded, the muscle relaxed completely and became soft and pliable.

The lateral fabellae could be well-delineated by palpation, were slightly movable and not painful under pressure.

Six dogs showed an obvious pain reaction to digital pressure over the lateral fabella and abnormal palpation findings, such as an enlarged fabella that was difficult to delineate and/or the affected muscle felt thicker and rigid compared with the opposite side. In three dogs, there was only pain on palpation. Nine dogs had abnormal palpation findings, but no pain could be induced.

Palpation of the stifle joint was normal in all dogs with a full Range of motion (ROM), a clear medial joint line with no medial buttress and no pain on palpation and manipulation.

Gait Analysis

Measurements were taken at walk and trot with an average speed of 5.05 ± 0.33 km/h and 7.13 ± 0.3 km/h. Gait analysis showed a symmetrical gait and a weight distribution in 17 dogs. Pressure and force distribution in percentage of Body weight was balanced, and body load distribution was even. Gait patterns were symmetrical, both at the walk and trot, and the SI was below 5%.

In 17 dogs, GA showed an asymmetry, either only at walk (3 dogs) or trot or at walk and trot.[6,8] In all of them, the SI was greater than 5%.

In 10 dogs, lameness seen on GA correlated well with other abnormal findings compatible with TGMO. In six dogs, mild ultrasonographic findings in the same limb were the only additional finding. In one dog with gait asymmetry, all other findings were normal.

Radiographic and Ultrasonographic Examinations

There were no signs of osteoarthritis in any of the stifles.

The tarsal joints were normal in all dogs.

Radiographic abnormalities in the origin of the gastrocnemius muscle were seen in seven dogs.

Three dogs had enthesiophyte formation at the supracondylar tuberosity and/or fabellae in the right hindlimb, one in the left hindlimb and one dog had bilateral enthesiophyte formation. Three dogs had additional bilateral mineralizations in the origin of the gastrocnemius tendon, one only on the right and two only on the left (**Fig. 1**).

The results of the ultrasonographic examination were graded as bilaterally normal (**Fig. 2A, B**) in 5 dogs and as mildly abnormal in 19 dogs. Moderate lesions were present in 10 dogs.

In the mildly affected cases, 5 dogs were only one side affected and 14 dogs had both sides affected. The most common finding consisted of a small lesion adjacent to the supracondylar tuberosity. It consisted of one small hypoechoic area of amorphous or short malaligned fibres (**Fig. 3A, B**). Eight of the dogs with mild lesions also had a mild irregular bone contour of the supracondylar

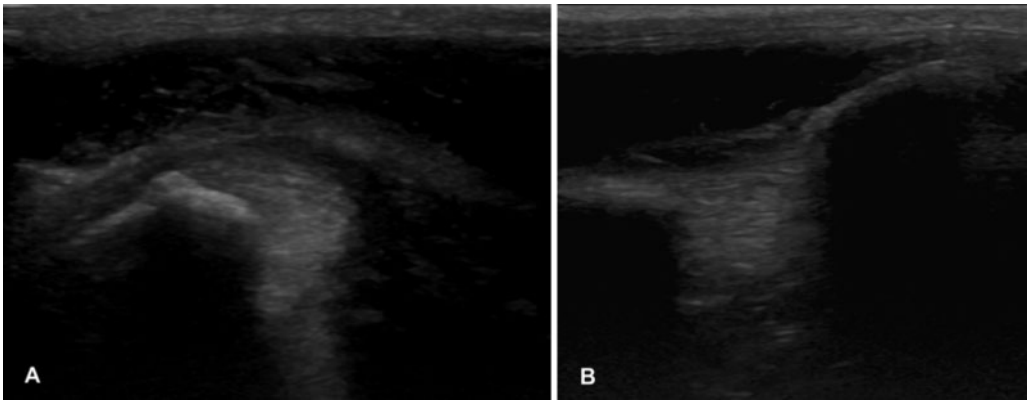

Fig. 2 (**A**) Transverse and (**B**) longitudinal ultrasonographic images of the origin of the left hind gastrocnemius tendon of dog number 100 classified as normal. The echogenicity of the tendon is maintained and the fibre pattern consists of well-aligned fibres.

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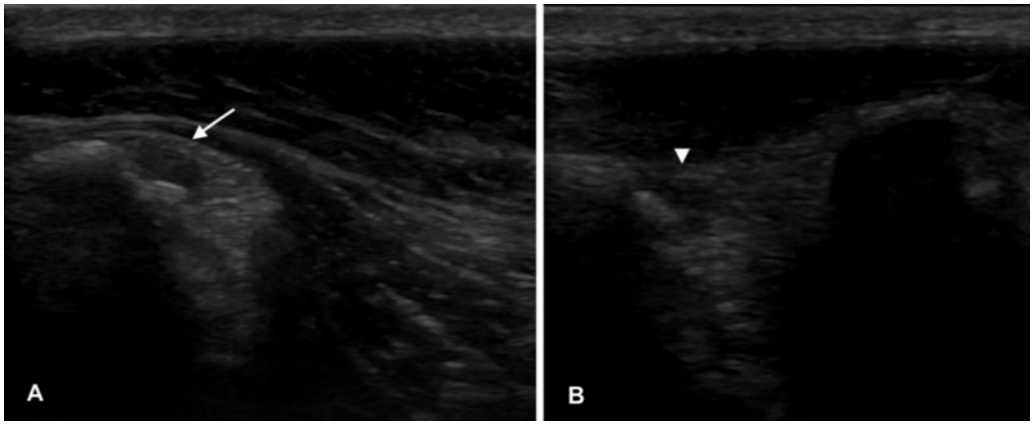

Fig. 3 (**A**) Transverse and (**B**) longitudinal ultrasonographic image of the origin of the right gastrocnemius tendon of dog number 122 showing a small hypoechoic lesion in the origin of the tendon (arrow, image **A**) with the fibre pattern appearing amorphous (arrowhead, image **B**). These lesions were classified as mild.

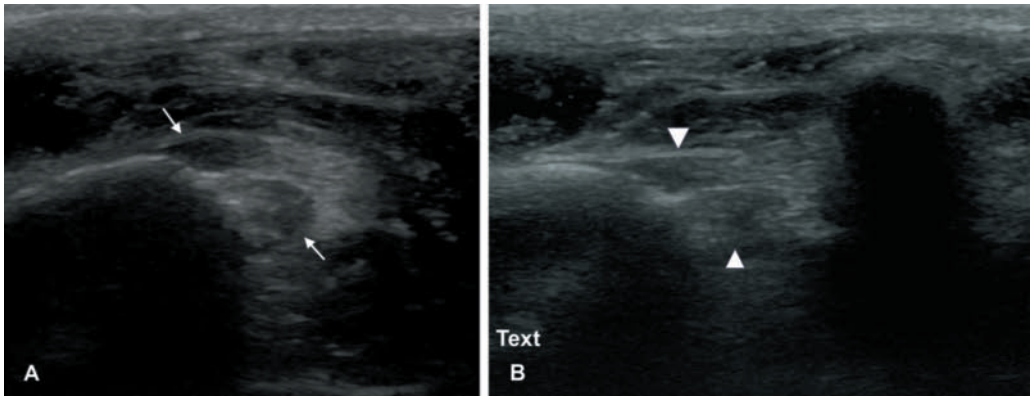

Fig. 4 (**A**) Transverse and (**B**) longitudinal ultrasonographic images of the origin of the left gastrocnemius tendon of dog number 132 showing two larger hypoechoic lesions (white arrows, image **A**) consisting of an amorphous fibre pattern mixed with short fibres (arrowheads, image **B**). These findings were classified as moderate tendinosis at the origin of the gastrocnemius tendon.

tuberosity in either the left or the right hindlimb, with six of the dogs having an irregular bone surface in both hindlimbs.

Ten of the dogs had moderate lesions in the origin of the gastrocnemius tendon (**Fig. 4A, B**). In all these dogs, the bone contour of the supracondylar tuberosity was also mildly irregular. In four dogs, these lesions involved both hindlimbs. In five dogs, moderate lesions were only seen in the left hindlimb, and in one dog, only in the right hindlimb. Two of the dogs with moderate lesions in the right hindlimb had no abnormal findings during the clinical examination and GA. One of the dogs with moderate lesions in the right hindlimb was also painful and showed an abnormal GA. Three of the dogs with moderate lesion in the left hindlimb were also painful during the clinical examination and two of these dogs also had an abnormal GA. Mineralization proximal and/or distal to the fabellae were noted in five dogs. In these dogs, both hindlimbs were affected. One of these dogs had a moderate associated tendon lesion and four had mild-associated tendon lesions. One of the dogs with mineralizations and associated moderate tendon lesions had only mild abnormal findings during palpation in the left hindlimb and an abnormal GA during trot.

None of the dogs had severe lesions.

The musculotendinous junction was normal in all dogs.

Discussion

Based on the results of this study, both of our hypotheses were accepted: The chosen examination methods were all useful to assess the health of the gastrocnemius tendon with the optimal informative value being achieved when the different examination methods were used in combination. If obvious pain on palpation, tendon mineralizations and moderate changes seen on ultrasound are considered strong indicators of tendinopathy, we found 17 dogs affected. The large number of dogs being affected was surprising, considering that they were all regarded as sound and lameness-free by the owners and fully active in sports. This could be explained by the typical pathogenesis of insertional tendinopathies described by Fredberg and Stengaard-Pedersen as 'tendinopathic iceberg' with a long period of asymptomatic changes in the tendon with the exposed tip of the iceberg being the painful tendon (**Fig. 5**). An acute

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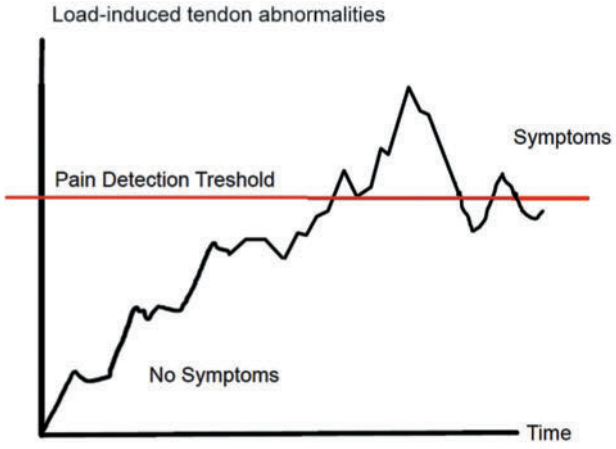

Fig. 5 The tendinopathic iceberg. (Adapted from Fredberg and Stengaaard-Pedersen, 2008[15].) The clinical course of chronic tendinopathies has been compared with an iceberg.[15] Patients may suffer from tendinopathy for several months before it becomes severe enough to cause obvious clinical symptoms. Pain is therefore only the tip of the iceberg. It also explains why the disappearance of clinical symptoms alone is not a sufficient criterion for a tendon healing.

lameness might be simply a temporary exacerbation of a chronic process.[15,16]

Pain on pressure directly over the fabella is considered a very reliable indication of TGMO.

Tendinopathies are defined in human medicine as pain on palpation with loss of muscle function.[17,18] Loss of muscle function is primarily an anamnestic finding, which is difficult to objectively assess in the canine athlete.

We are aware that pain assessment in dogs is certainly subjective. However, the pain response was obvious and repeatable when it was compared with the opposite limb. Some dogs with pain at the insertion site also unloaded their limb after palpation.

Gait analysis correlated in five of nine dogs with a painful insertion site. In four dogs with pain on palpation, GA was normal. Although a painful response could be triggered by direct digital pressure, during normal gait, the limb loading was apparently not strong enough to cause lameness.

Gait asymmetry was also seen in a sound dog and six dogs, being only mildly affected on ultrasound. Gait analysis is a highly sensitive system but is not capable of discriminating the specific causes of a gait asymmetry. Asymmetry could have been caused by any other minor problem that was missed during the clinical examination.

We consider GA as a nonspecific indicator for TGMO, only helpful to support or raise suspicion that a problem exists. An asymmetric gait seen on GA as the only finding was therefore not used to consider these dogs as being affected by TGMO.

In this study, seven dogs (20% of the patients) had signs of chronic disease with mineralization and/or enthesiophytes at the origin of the gastrocnemius tendon.

Interestingly, one of the dogs had marked mineralizations associated with the origin of the gastrocnemius tendon but was clinically sound and performing at world class level. This patient could have had an episode of tendinopathy in the past, which went unnoticed. Bony spurs and areas of calcifications have been described as the 'tombstone of tendon pathology' but recent investigations have shown that they have little impact on the development of symptoms.[19]

When evaluating tendons using conventional B-mode ultrasonography, echogenicity and fibre pattern are key factors in determining the presence of pathology. There was a poor correlation between abnormal sonographic findings and the presence of pain in our study. Twenty-nine of the dogs examined (85%) were determined to have abnormal echogenicity and fibre pattern in one or both limbs. In human medicine, abnormal imaging has been reported in various tendons in as many as 59% of asymptomatic individuals.[19] This highlights the complexity of tendon pain, suggesting that it is not solely caused by changes in tendon architecture but likely involves interaction between the local tissue and both the peripheral and central nervous system.[20] Evaluating tendon pain in veterinary medicine is particularly challenging due to the inability to directly communicate with the patient.

An increasing body of evidence supports the use of serial tendon scans in human athletes during training to identify subclinical changes in tendon structure.[21,22] We did not follow-up on the dogs of our study found to have ultrasonographic changes without pain. This would have been interesting, as it has been shown in human medicine that the presence of such asymptomatic structural abnormalities detected on ultrasound may increase the risk of developing pain.[15,23,24] Further studies in veterinary medicine are needed to determine if this can also be applied to pathologies seen during the sonographic examination of the gastrocnemius tendon in dogs.

There are several reasons why Border Collies may be more at risk for developing tendon injuries. They are the most commonly used breed in agility and well-known to have a higher risk of injuries because of their fast and driven nature.[9–12]

Agility itself is a fast and high impact type of sport, requiring intensive training to perform successfully. In humans, musculotendinous strain of the gastrocnemius is typically observed in sports that require rapid acceleration, sudden stops and turns, such as racquet sports.[25] During agility, dogs are subject to similar movements. Muscle injuries occur most likely during rapid eccentric contraction. This forces the muscle to stretch during contraction and develops the highest forces observed in skeletal muscles.[26] Strong eccentric contractions are provoked by many actions during agility, such as running up the A-frame or the dog walk (**Fig. 6**).

The gastrocnemius muscle itself might also be predisposed to injury. It has a two-joint function – flexion of the knee and extension of the tarsal joint. It is known that these muscles crossing two joints have an increased number of type II fibres and are more susceptible to injury.[27]

As TGMO is also diagnosed in Border Collies, not involved with agility, the question arises whether there might be genetic factors involved as well. Genetic constitution is considered an intrinsic risk factor triggering tendinopathies.[28] This could also explain why TGMO is so common in our area but barely recognized in the United States.

Limitations of the Study

One limitation of the study is the fact that we focused primarily on the lateral head of the gastrocnemius origin and did not fully evaluate the medial side.

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Fig. 6 Forceful eccentric contraction occurs in the gastrocnemius muscle when the dog pushes itself up the A-frame.

The medial fabella is difficult to assess clinically. Also, on ultrasound, the origin of the medial gastrocnemius tendon was more difficult to assess, with the tendon and bone structures being less well visible when compared with the lateral. We considered, therefore, the information obtained to be of limited value.

Another limitation of this study is that all the sonographic examinations were performed and interpreted by one board-certified diagnostic imaging specialist to provide consistent assessment and grading of the lesions. However, ultrasound is highly user-dependent and subjective and there is the possibility that a different person would have evaluated and graded the lesions differently. Magnetic resonance imaging was not used, but could have provided more overall information for imaging the muscle and tendons, especially medially. However, as magnetic resonance imaging requires anaesthesia of the dog, it would have been more difficult to find owners participating in this screening study.

Conclusion

Clinical examination revealing pain on palpation is important to detect clinically significant TGMO. Diagnostic imaging is helpful to further evaluate the tendon and to confirm the clinical findings but is not able to make a conclusion about the clinical relevance, as pain and ultrasonographic changes seen do not correlate necessarily.[19]

This study supports our clinical impression that TGMO is an underestimated disorder in Border Collies that actively participate in agility.

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Statements and Additional Information

Conflict of Interest The authors declare that they have no conflict of interest.

Contributors' Statement All authors made meaningful contributions to this study and the study design. R.V. und A.E. performed all the examinations and data acquisition, -analysis and -interpretation and prepared the manuscript. G.S. and M.K. made critical revisions and helped editing the manuscript.

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