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Avulsion of the Lateral Head of the Gastrocnemius in a Dog: Surgical Treatment and an Ex Vivo Study on Pathomechanisms

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Abstract

A 6-year-old Border Collie presented with a 4-month history of progressive plantigrade stance of the right hindlimb, following a jump when chasing a ball. Avulsion of the lateral head of the gastrocnemius and tearing of the medial muscular belly were confirmed radiographically and ultrasonographically. Surgical repair of the lateral head was performed using two nylon mattress sutures placed around the fabella and through femoral condylar bone tunnels, followed by the application of a cranial half cast for 5 weeks. No complications were reported and follow-up owner's questionnaire at 18 months postoperatively revealed excellent results with the dog returning to normal activity.

Avulsion of the lateral fabella was induced in a cadaveric limb and hyperflexion of the tarsus was simulated. Extreme hyperflexion of the tarsus only occurred once a subsequent tear of the medial belly of the gastrocnemius had developed, but without avulsion of the medial fabella.

Keywords

- gastrocnemius
- avulsion
- lateral head
- leader line
- cadaver

Introduction

Avulsion injuries affecting the origin of the gastrocnemius muscles are rare. Few reports are published regarding the surgical management of these lesions in dogs[1–8] and cats[9,10] (►**Table 1**). Some of these reports are poorly detailed and lack follow-up data, giving surgeons scarce evidence on how to optimally treat these types of lesions.

Most lesions are unilateral, acute and traumatic in nature; however, atraumatic bilateral avulsion of the origin of the gastrocnemius has been reported in one dog.[11]

Cases present with a history of weight-bearing lameness with different degrees of tarsal hyperflexion, eventually leading to a complete plantigrade stance. Integrity of the *musculus flexor digitorum superficialis* (mFDS) can be recognized by the characteristic abnormal contracture of the digits when the tarsus is hyperflexed.[12,13]

The aim of this report is to review the literature and to describe in a dog, the avulsion of the lateral head of the gastrocnemius combined with a tear in the medial head treated surgically using a modified technique. In addition, we studied and report the possible biomechanical mechanism of this injury in a cadaveric model.

Case Report

A 6-year-old male neutered Border Collie presented with a 4-month right hindlimb lameness, following a jump. This progressed to a plantigrade stance during the following 2 months. Concurrently the dog had hip dysplasia, managed with meloxicam (Metacam, Boehringer-Ingelheim, Germany; 0.1 mg/kg). Tramadol hydrochloride (Tramadol, Almus, United Kingdom; 2 mg/kg) was also prescribed, with no improvement seen. A 2-week course of prednisolone

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Table 1 Summary of the current literature including dogs and cats with reported isolated injuries to the gastrocnemius muscle and the different treatment modalities

Author	Animal	Onset/Lesion	Presentation	Treatment	Immobilization method	Complications	Follow-up/outcome
Chaffee and Knecht (1979)[1]	7 yo Wirehaired Fox Terrier	Trauma/Medial head	NWB	Cruciate mattress sutures with 2–0 wire in figure-of-eight around fabella	MRJB (1 week)	Not specified	8 weeks—began to use limb
Vaughan (1979)[2]	5 yo Alsatian (45 kg)	Trauma/Lateral head	Not specified	Sutured tendon around fabella + reinforcing sutures + carbon fibre augmentation	External support (8 weeks)	Not specified	Months before satisfactory leg use
Vaughan (1979)[2]	7 yo Fox Terrier	Trauma/Medial head	Not specified	Sutured tendon around fabella + muscle reinforcing sutures	Not specified	Not specified	Not specified
Reinke et al (1982)[3]	9 yo Beagle mix (15 kg)	Trauma/Lateral head and distal musculotendinous lesion	Plantigrade	Supracondylar hole, cerclage wire distal to fabella. Apposition sutures (nylon) for distal end of gastrocnemius	Heavily padded bandage with hock hyperextended and flexed stifle (6 weeks)	None	9 weeks—walked and stood normally
Muir and Dueland (1994)[4]	2 yo Schipperke (6.9 kg)	Trauma/Medial head	Lameness of variable severity	Conservative (hydrotherapy, analgesia, short leash walks for 6 weeks)	None	None	3 months—occasional limp after exercise
Prior (1994)[5]	6 yo Border Collie	Trauma/Lateral head	Plantigrade	Spiked washer and 3.5 mm cortical bone screw	Support dressing with stifle in extension (10 days)	None	6 weeks—good use of the leg, no signs of lameness or pain
Robinson (1999)[11]	8.5 yo Golden Retriever (31.2 kg)	Atraumatic/Lateral & medial	Stiffness progressing to hyperflexion of the right hock	RHL: Bilateral approach + supracondylar femoral holes + Figure-of-eight wire (1 mm wire) around fabella Revision: 1.25 mm wire LHL: Same procedure only lateral head	Plantar support in extension (12 weeks total)	Wire breakage—at 6 and 9 weeks postop Bandage related sores	3 months—walking almost normally on both 3 years—normal gait. Mild distalization fabellae
Ridge and Owen (2005)[6]	5.5 yo Golden Retriever	Trauma/Lateral head	Plantigrade	Lateral supracondylar tunnel + fabellar bone tunnel + 2–0 PDS Revision: 80lb leader line + 3 femoral condylar tunnels + Bunnell-Mayo tendon sutures with L-lactid/glycolid (Panacryl)	MRJB in extension (10 days) Postrevision: Type 1a transarticular ESF in extension (6 weeks) + support dressing (2 weeks)	Wire breakage and seroma—at 10 days postop	8 weeks—no plantigrade 1 year—normal stance and gait
Ting et al (2006)[7]	6 yo Labrador	Trauma/lateral head + pelvic fracture same side	Plantigrade	Cerclage wires and tissue anchors	Immobilization in partial extension	Not specified	Not specified
Mueller et al (2009)[8]	9 yo Malinois (34 kg)	Atraumatic-chronic/ Lateral fabella avulsion fracture	Intermittent RHL lameness	Conservative (Carprofen 5 days, 13 sessions therapeutic US—5 weeks)	None	None	5 weeks—no visible lameness
Mueller et al (2009)[8]	2 yo German Shepherd dog (30 kg)	Atraumatic-acute/Medial head	3rd degree lameness	Conservative (Carprofen 5 days, 12 sessions therapeutic US—4 weeks)	None	None	2 months—no lameness
Bali (2011)[9]	7 yo Domestic Short Hair (6.7 kg)	Unknown/lateral head	Plantigrade	Supracondylar tunnels + 2 sutures (0 PDS) modified locking loop pattern	Calcaneo-tibial screw (5 weeks) + MRJB with lateral splint (7 weeks)	None	Not specified
Pratesi et al (2012)[10]	3.5 yo Domestic Short Hair	Suspected trauma/Lateral head	Plantigrade	Suture anchor + modified 3-loop pulley (0 PDS) distal to fabella	Stifle flexion device	None	6 weeks—no lameness 5 months—normal
Lideo and Milan (2013)[18]	4 yo German Hound (34 kg)	Unknown/Medial head	RHL lameness	Conservative (shortwave, twice a week for 1 month)	None	None	1 month—no lameness or pain

Abbreviations: ESF, external skeletal fixator; MRJB, modified Robert Jones bandage; NWB, non-weight bearing; PDS, Polydioxanone; RHL/LHL, right/left hindlimb; US, ultrasound; yo, year/s-old.

(Prednidale, Dechra, United Kingdom; 0.5mg/kg), combined with restricted exercise and hydrotherapy, was attempted with no success prior to referral.

On examination, the dog was overweight; 27.5 kg, body condition score 8/9[14] and displayed a right hindlimb plantigrade lameness. There was moderate muscle atrophy of his limb with pain elicited upon deep palpation of the lateral head of the gastrocnemius. With the stifle partially flexed, the lateral fabella could be palpated distal from its usual location. The tarsus could be flexed while the stifle was held in extension, without flexion of the digits, indicative of an Achilles mechanism insufficiency and damage to the mFDS. Discomfort was elicited when performing this manoeuvre. A 1-cm diameter superficial contact ulcer was present on the plantar surface of the right tarsus. On neurological examination, placing reflexes appeared delayed, although this was suspected to be mechanical rather than neurological in origin. Segmental reflexes were intact.

Orthogonal radiographs of both stifles and tarsi were taken under a combination of medetomidine (Sedator, Dechra, United Kingdom; 0.01 mg/kg) and butorphanol (Torbugesic; Zoetis, United Kingdom; 0.1 mg/kg intravenously [IV]). Radiographs confirmed distalization and remodelling of the right lateral fabella (►**Fig. 1A–C**).

Ultrasound of the gastrocnemius muscle was performed. This revealed a hypoechoic area distal to the lateral fabella, indicating avulsion of the lateral head of the gastrocnemius and the origin of the mFDS (►**Fig. 2A** and **B**). Ultrasound of the medial belly of the gastrocnemius showed an ill-defined lesion with hyperechoic and hypoechoic areas, compatible with a mid-body muscular lesion (►**Fig. 2C**).

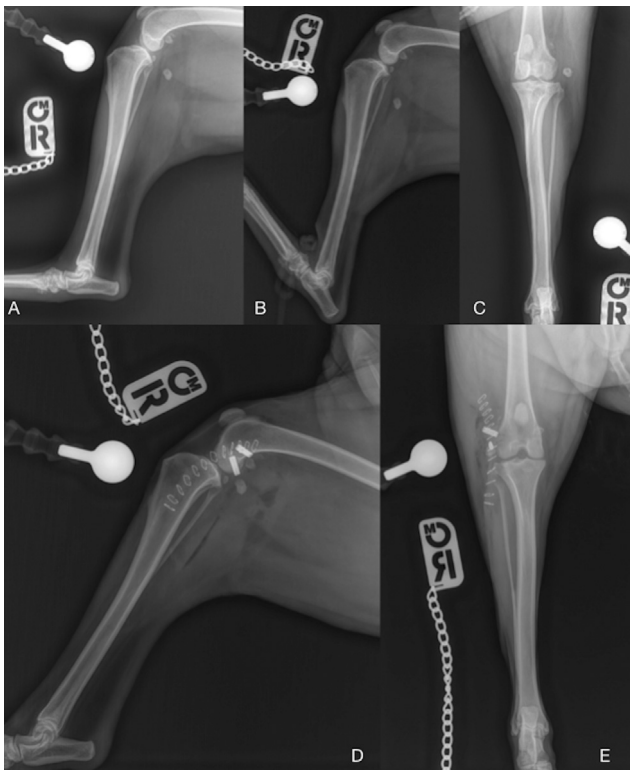

Fig. 1 Neutral mediolateral (**A**), stressed mediolateral (**B**), and caudocranial (**C**) preoperative radiographic views of the left hindlimb. Marked distalization of the lateral fabella and hyperflexion of the tarsus are evident. (**D**, **E**) Immediate postoperative radiographs illustrating residual distalization of the lateral fabella and the position of the crimps.

Surgical Management

Methadone (Comfortan, Dechra, United Kingdom; 0.3 mg/kg) and acepromazine (ACP, Elanco, United Kingdom; 0.02 mg/kg) were administered intramuscular as premedication. Induction of anaesthesia with propofol (PropoFlo, Zoetis, United Kingdom; 2 mg/kg IV) and maintained with isoflurane (IsoFlo, Zoetis, United Kingdom). Amoxicillin–clavulanate (Augmentin, GlaxoSmithKline, United Kingdom; 20 mg/kg IV) was administered 30 minutes preoperatively and every 90 minutes intraoperatively.

A caudolateral approach to the right stifle was performed. The avulsed lateral head of the gastrocnemius was visualized; it was fibrosed and contracted. The peroneal nerve was isolated and protected (►**Fig. 3A**). Two 2 mm bone tunnels were pre-drilled in the lateral femoral condyle, craniolateral to caudomedial direction, exiting at the level of the origin of the gastrocnemius muscle (►**Fig. 3B**). Two 16 G needles facilitated passage of the suture (►**Fig. 3C**). While the tarsus was held in extension, the lateral head of the gastrocnemius and the fabella

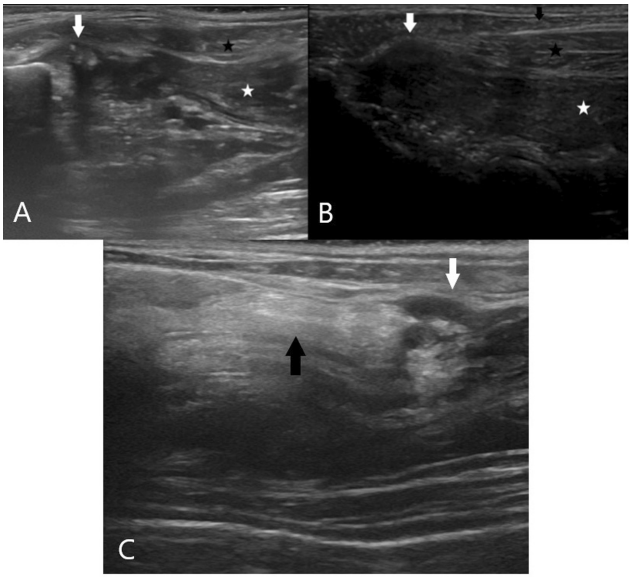

Fig. 2 Ultrasonographic image of the origin of the gastrocnemius in the present case (**A**) and in a cadaveric limb of a non-affected patient (**B**). To the left is proximal and distal to the right side of the picture. (**A**) The *white arrow* indicates the position of the lateral fabella. Distal to this, there is an ill-defined area of decreased echogenicity, indicating there is an area of muscular disruption at the level of the origin of the lateral head of the gastrocnemius (*black star*) and the *musculus flexor digitorum superficialis* (*white star*). (**B**) Ultrasonographic appearance of the origin of the lateral head of the gastrocnemius in a normal cadaveric limb. The fabella (*white arrow*), biceps femoris (*black arrow*), lateral head of the gastrocnemius muscle (*black star*) and origin of the *m. flexor digitorum superficialis* (*white star*) are identified. See that the biceps femoris is markedly atrophied in the current case. (**C**) Ultrasound of the mid-body of the medial head of the gastrocnemius. See the area of increased echogenicity within the muscle fibres (*black arrow*) and the hypoechoic areas representing oedema, haematoma and muscle damage (*white arrow*).

were pulled proximally and positioned as close as possible to its origin. Due to the amount of muscular contraction, the fabella could not be repositioned back to its anatomical position, remaining in a mildly distal location. Two 100lb Nylon (Leader Line, Veterinary Instrumentation, United Kingdom) mattress sutures were passed through the condylar bone tunnels and caudal and distal to the lateral fabella (►**Fig. 3D**). These were crimped individually on the lateral aspect, with the stifle in a standing angle position (►**Fig. 3E**). The disrupted gastrocnemius was then attached to the biceps femoris and associated soft tissues by placing four 0 Polydioxanone (PDS II, Ethicon, New Jersey, United States) mattress sutures (►**Fig. 3F**). The Achilles test was performed at the end of the procedure, confirming satisfactory function of the tendon.

Postoperative radiographs confirmed residual distalization of the lateral fabella (►**Fig. 1D** and **E**).

A half cast was placed dorsally using resin-epoxy material (VetCast Plus; 3M, Saint Paul, Minnesota, United States), extending from the digits to the proximal tibia with the tarsus extended.

The patient was discharged the following day with oral meloxicam (Metacam, Boehringer-Ingelheim, Germany; 0.1 mg/kg) every 24 hours, and oral Trazodone (Trazodone Hydrochloride, Strides Pharma, United Kingdom) at a dose of 4 mg/kg, every 12 hours, to assist with the post-surgical exercise restriction.[15] A regime of strict exercise control was advised for 6 weeks. A holding-assisting device (Help-em-up Harness, Orthopets, United Kingdom) was provided and a calorie restricted diet was initiated.

Bandage changes were performed under sedation on a weekly basis for the first 2 weeks. The calcaneal wound was healing satisfactorily, and further dressing changes were performed every 2 weeks until complete cast removal, 5 weeks post-surgery.

At 5 weeks, the dog walked with a mild lameness. Muscle atrophy and mild reduction of tarsal flexion were evident. Standing angles of both tarsi were normal and Achilles function was restored. No cast related complications were present. Short on-the-lead controlled walks were recommended for a further 4 weeks.

Upon examination during follow-up appointments at 9.5 and 12 weeks postoperatively, the animal was sound at a walk/trot and displayed a normal tarsal standing angle. Muscle atrophy had improved, and Achilles function remained normal. At the 6-month re-examination, there were no signs of lameness or discomfort on palpation of the surgical site. The medial and lateral heads of the gastrocnemius were symmetrical and comparable to the contralateral limb. Range of motion was within normal limits and Achilles tendon had normal function.

Liverpool Osteoarthritis in Dogs questionnaire (LOAD)[16] was completed 1 year and 6 months following the procedure and the dog was reported to have returned to normal exercise levels, with a total LOAD score of 3/52. No complications were reported, and no medication was required.

Cadaveric Experiment

To understand the mechanism of concurrent muscle injury, a cadaveric experiment was performed. A Border Collie was euthanatized for reasons unrelated to the study, frozen at -20°C and thawed overnight. The dog was placed in sternal

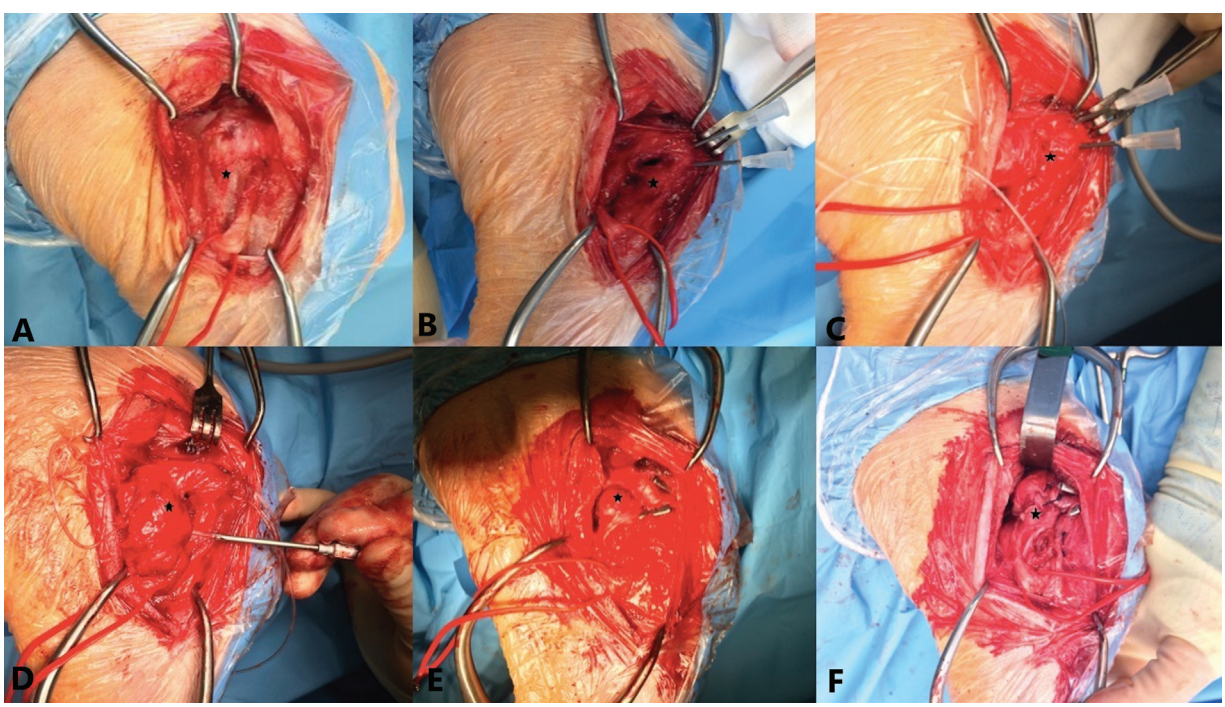

Fig. 3 Intraoperative images of the surgery to reattach the lateral head of the gastrocnemius. The lateral fabella is marked with a black star. (**A**) Approach to the lateral fabella. A vessel loop was used to isolate and protect the peroneal nerve. (**B**) Two 16-gauge needles were inserted through the pre-drilled 2 mm bone tunnels on the lateral side of the femoral condyle. (**C**) A 100 lb Nylon suture was passed through the needles and distal to the fabella with the assistance of the needle. (**D**) Both sutures were tightened and crimped on the lateral aspect. (**E**) Reinforcement mattress sutures were placed using 0 polydioxanone.

Fig. 4 Left cadaveric limb of a medium-large breed dog. The left side is lateral. (**A**) See the intact medial and lateral bellies of the gastrocnemius. (**B**) Same limb after transection of the lateral fabella and following extreme manual tarsal dorsiflexion. See the two muscle lesions that have occurred on the medial belly of the gastrocnemius muscle (*black arrows*).

recumbency with the stifle extended. The common tendon of the biceps femoris, semitendinosus and gracilis muscle was incised midline and separated, exposing both bellies of the gastrocnemius muscle (►**Fig. 4A**). The femoral attachment of the lateral fabella was incised with a no.11 blade. Manual pressure was applied to the tarsus in a cyclic fashion forcing the joint into a hyperflexed position. Hyperflexion could only be achieved following tearing of the muscle fibres of the medial head of the gastrocnemius on its medial aspect, at the level of the proximal third of the muscle belly. As tarsal flexion was continued, the muscle fibres continued to separate in a longitudinal direction. As extreme hyperflexion was reached, further disruption of the muscle was observed (►**Fig. 4B**). The medial fabella and proximal muscle attachment remained in situ at all times. The mFDS was seen to displace distally along with the lateral head of the gastrocnemius.

Discussion

Injury to the gastrocnemius muscle often results in postural changes that can be severe if left untreated. Conservative management has been successfully reported in cases where there is no plantigradism, either due to partial avulsion of the origin of the gastrocnemius or due to gastrocnemius musculo-tendinopathy[4,8,17,18] however, complete avulsion injuries require surgical repair to restore function of the Achilles tendon.[6,7,9]

Different surgical techniques have been described for the reattachment of the lateral and medial heads of the gastrocnemius, including the use of orthopaedic wire passed through supracondylar holes in the femur and either around the fabella[1,7] or through bone tunnels drilled in the fabella,[6] carbon fibre augmentation[2] and reattachment by placement of a 3.5 mm cortical screw and a washer.[3,5] Breakage of the orthopaedic wire was the main reason for failure of the repair, requiring revision surgery in two cases[6,11] and long recovery times were frequently seen[1,2] (►**Table 1**).

The use of polydioxanone or polyamide suture material for the reattachment of the origin of the gastrocnemius has been reported in one dog during revision surgery[6] and in two cats.[9,10] In our case, two 100 lb monofilament leader lines were chosen due to the size of the patient and the superior resistance to cyclic loading of the leader line when compared with orthopaedic wires.[6] In our case, the suture was encircling around the fabella instead of being passed through a bone tunnel created in the fabella. This provided excellent tissue purchase, eliminating the need to drill through the fabella, reducing the risk of fabella fracture and stress concentration effect[6]

Condylar instead of supracondylar bone tunnels were drilled in the femur, which has not been reported before. This was due to the severe distalization of the fabella and muscle contraction, impairing intraoperative approximation of the lateral fabella to its original anatomical position. This residual malposition did not appear to have any clinical significance, in agreement with previous reports.[4,11] Based on these findings, if excessive tension is found intraoperatively, such as in chronic cases, it may be prudent to use condylar instead of supracondylar tunnels. This reduces the risk of suture breakage and muscle tear, without compromising the outcome, as shown in our case.

Following Achilles tendon repair, reported postoperative complications have also been attributable to the immobilization method.[19] These methods included application of a transarticular external fixator,[20] placement of a calcaneotibial bone screw,[9,19,21–23] a stifle flexion device[10] and different configurations of splints and casts. No clear superiority of one specific method has been proven and immobilization periods vary among authors.[19] Brinker and colleagues[24] suggested placement of a cast or lateral splint for 8 to 10 weeks followed by a Robert Jones bandage for 7 to 10 days, with a total of 8 to 10 weeks of severely restricted exercise.

In our case, a calcaneotibial screw was not placed due to the presence of a pressure ulcer near the point of insertion of a screw, which, if placed, would increase the risks of infection and wound complications. Despite the dog being overweight and very active, 5 weeks of immobilization with a cranial cast with the tarsus in extension, followed by gradual increases in exercise over 10 weeks, resulted in complete muscle healing, normal posture and gait. No complications associated with the duration or type of coaptation were seen and the preexisting ulcer healed uneventfully.

The gastrocnemius muscle is the most powerful tarsal extensor during stance and locomotion.[13] The lateral head of this muscle is firmly united to the superficial digital flexor muscle proximally, sharing attachment to the lateral fabella.[3,13] By repairing the lateral head of the gastrocnemius with an encircling leader line around the fabella, including

enough healthy tissue to provide good suture purchase, the mFDS is also returned to its anatomical location, restoring function of both muscles, as shown in this case. Lesions distal to the fabella (►**Fig. 2A**) may be repaired using mattress PDS sutures. It is unknown if these muscular tears occurred at the time of injury or subsequently.

A review of the literature shows that all cases that sustained isolated avulsion injury to the lateral head of the gastrocnemius progressed into complete plantigrade stance.[2,3,5–7,10,11] Only one of the published cases had an additional lesion at the distal musculotendinous unit of the gastrocnemius muscle.[3] In all cases, including in the latter, repair to the lateral head of the gastrocnemius alone resulted in restoration of the Achilles function. In addition to this, the literature suggests that isolated injury to the medial head of the gastrocnemius does not cause complete plantigradism.[4,18]

Different hypotheses have been raised to explain the various degrees of plantigradism, in cases where only the lateral head of the gastrocnemius has been grossly affected. Reinke and colleagues[3] suggested that tarsal hyperflexion only occurs whenever the three components of the Achilles tendon are severed, based on an undetailed cadaveric study cited in the same report. It was speculated that, in cases where a lesion had occurred at the origin of the muscle, to develop a full plantigrade stance, injury to the medial head of the gastrocnemius must have occurred simultaneously but been undiagnosed and healed spontaneously. This was confirmed by ultrasound assessment in our case report and equally observed in the cadaveric experiment we performed.

Based on our findings, we believe that initially the lateral head of the gastrocnemius combined with the associated mFDS, avulses with the fabella. Damage to the medial head of the gastrocnemius occurs subsequently as the forces continue to act on the Achilles musculotendinous unit, resulting in a complete plantigrade stance.

We conclude that in this one case, repair of the lateral head of the gastrocnemius was sufficient to restore Achilles mechanism function, even if the muscular unit of the medial head of the gastrocnemius has been damaged. This may be taken into consideration when treating similar injuries.

To the author's knowledge, this is the first report in a dog of a lateral head of the gastrocnemius muscle avulsion repaired using two 100 lb Nylon (Leader Line, Veterinary Instrumentation, United Kingdom) mattress sutures through two condylar bone tunnels and around the lateral fabella, without surgical repair of the medial gastrocnemius, with no complications and an excellent long-term outcome. We also tried to describe on a cadaver model, the biomechanical mechanism whereby an isolated avulsion of the lateral head of the gastrocnemius may progress into a complete plantigrade stand due to subsequent medial gastrocnemius muscular tear.

Authors' Contributions

D.A. performed the surgery described. L.R. drafted the manuscript and D.A. approved the final version prior to submission.

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None.

Conflict of Interest

The authors declare no conflict of interest related to this report.

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