Fibrotic contracture of the canine infraspinatus muscle
Pathophysiology and prevention by early surgical intervention

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Summary
Fibrotic contracture of the canine infraspinatus muscle (FCIM) is considered a rare musculotendinous disorder mainly affecting hunting dogs. After an acute onset of a painful non-weight bearing lameness, the initial pain and lameness improve over a period of one to four weeks, after which a characteristic circumducted gait abnormality develops in the forelimb. The initial injury to the infraspinatus muscle is not fully recognized or correctly interpreted in most cases, at least not with regard to its potential as a precursor of myopathy and OFCM. A mixed breed hunting dog developed an acute and extremely painful swelling of the infraspinatus muscle. The injury was easily recognized during clinical examination. The clinical signs were interpreted as an osteo-fascial compartment syndrome (OFCS) of the infraspinatus muscle. Immediate surgical decompression of the osteo-fascial compartment to prevent development of OFCM was undertaken. The histopathological and immunohistochemical examinations of the injured infraspinatus muscle revealed tissue changes that indicated acute muscle rupture, without any signs of an initiating degenerative process. On the day following surgery the dog was fully weight bearing. Restriction of activity for four weeks was recommended. Eight months after the initial injury, the dog had completely recovered and had full days of vigorous exercise and hunting activity without any apparent lameness. The findings in this case suggested that the infraspinatus muscle may be considered to be an osteo-fascial compartment in dogs and must be added to the list of compartments that may pose a potential risk for OFCS in the canine extremity.

Keywords
Canine, compartment syndrome, infraspinatus muscle

Introduction
Fibrotic contracture of the canine infraspinatus muscle (FCIM), first described in the Netherlands in 1970 (1), occurs mainly in active medium to large breed dogs. In most cases, the clinical histories do not reflect a specific traumatic episode, but it seems most likely that these dogs have been subjected to repetitive minor trauma, during periods of vigorous exercise, while hunting or working. The initial pain and lameness improve over one to four weeks (2–7) after which the dogs progressively develop a characteristic circumducted gait abnormality with the affected forelimb held in abduction and the antebrachium in supination. Affected dogs are unable to completely flex the glenohumeral joint during ambulation and during passive movement on physical examination. (Figs 1 A, B).

The recommended treatment of FCIM is tenotomy of the insertion of the infraspinatus muscle on the cranio-lateral surface of the greater tubercle of the humerus, and loosening of any syncheiace to the shoulder joint capsule (2, 3, 5–7). Unrestricted range of motion of the shoulder joint should be restored during the surgical procedure. The prognosis is good to excellent. The purpose of this clinical communication is to report a case in which an initial injury of the infraspinatus muscle was recognized and treated surgically before FCIM had developed, and to discuss the pathophysiology of this disease.

Case presentation
Case history
A four-year-old, male, German Shorthaired Pointer-English Setter cross breed dog weighing 20 kg, had been hunting grouse with its owner for three days. After two hours of rest on the third evening, the dog started to yelp and developed an acute non-weight bearing lameness of the left forelimb; exhibiting obvious signs of pain. The owner had not observed any traumatic incident involving the dog while it was hunting. The next day the lameness was unchanged in severity, and the dog was examined by a veterinarian who could not find any signs of injury of the limb nor localise the source of the pain. The veterinary administered carprofen at a dose rate of 2 mg/kg b.i.d. (Rimadyl vet tablets, Pfizer) and referred the dog to The Norwegian School of Veterinary Science for further examination.

Clinical examination
The patient was examined 36 hours after the initial lameness had been observed. There were no obvious signs of pain, but the dog had a marked lameness on its left forelimb. The region over the infraspinatus muscle on the left scapula was markedly swollen and protruded 1 to 2 cm when compared to the other side. The swollen infraspinatus muscle was under marked tension and extremely tender on palpation. Due to the swelling (Fig. 2), the spine of the scapula was not palpable.

The range of motion in the glenohumeral joint was slightly reduced, and passive movement of the joint caused pain. Other
abnormalities were not detected on the clinical examination, and radiographs of the shoulder joint were normal.

**Surgical technique**

After induction of general anaesthesia, the swollen infraspinatus muscle was palpably taut against its fascia, similar to a fully contracted muscle. A skin incision was made over the swollen area, 1 cm caudal to the spine of the scapula. There were no signs of haemorrhage or oedema in the subcutaneous tissue, in the trapezius muscle or in the scapular and acromial heads of the deltoideus muscle (Fig. 3).

Almost all of the infraspinatus muscle was damaged and could easily be removed after lavage with saline solution and suction, following which most of the caudal part of the spine of the scapula and the infraspinous fossa were visible and free from muscle attachment.

The superficial shoulder muscles were divided. The infraspinatus muscle was markedly swollen and irregularly discoloured. When the indistinctly outlined fascia of the infraspinatus muscle was incised, a fragmented and oedematous mass of muscle fibres protruded. Most of the injured muscle fibres appeared pale and were separated by areas of haemorrhage and multifocal blood clots of variable size (Fig. 4).
A corrugated wound drain (Sims Portex Limited) was placed in the open cavity following removal of the damaged infraspinatus muscle. The fascial attachments of the superficial muscles were loosely apposed with sutures. A fentanyl skin patch (50 µg/kg Durogesic, Janssen-Cilag) was applied to the dog’s neck preoperatively as a supplement to the perioperative pain management with methadone, thus ensuring adequate analgesia for the next 72 hours. The carprofen medication was continued for 14 days postoperatively. Antibiotic drugs were not administered.

The day following surgery the dog was fully weight bearing on the affected limb and the owner was advised to walk the dog on a leash for the first 14 days. The drain was removed after eight days, and the wound cavity continued to discharge fluid for an additional week. Physical activity was restricted for the next two weeks, after which the dog was allowed to return gradually to full hunting activity.

**Histopathological and immunohistochemical examination**

Tissue samples from the infraspinatus muscle were collected and stored in 4% buffered formalin and embedded in paraffin wax. Sections were cut at 5 µm thickness and stained with haematoxylin and eosin. Immunohistochemistry was performed on tissue sections using a commercial kit (EnVision-kit, K4005 DakoCytomation A/S, Glostrup, Denmark) according to the manufacturer’s recommendations. A monoclonal anti-desmin antibody (M0760 DakoCytomation A/S) diluted to 1:50 was used as the primary antibody. The main histological findings were hyperaemia, oedema and extensive haemorrhage between the muscle fibres. The muscle fibres showed a variable degree of degeneration and necrosis. In some areas the muscle tissue showed evidence of segmental hypercontraction, discoid degenerative changes and fragmentation. Other fibres showed loss of striation with hyaline or flocculent to granularly eosinophilic cytoplasm. Numerous neutrophils and macrophages were found both intracellularly, in damaged muscle fibres and in the endomysium (Fig. 5A). Immunohistochemical staining showed a multifocal, partial or total loss of desmin. In addition, numerous muscle fibres showed an abnormal desmin pattern displaying longitudinal streaks as opposed to the normal transverse pattern (Fig. 5B).

**Postoperative results**

On re-examination eight months after the initial injury, the dog had completely recovered and was not lame. It had been participating in full days of hunting activity without any adverse consequences. Physical examination of the shoulder joint showed a normal range of motion without any evidence of pain. The size of the supraspinatus muscle on the injured limb was similar to that of the contralateral side, but the defect that had been produced by surgical removal of the infraspinatus muscle was still clearly detectable.

**Discussion**

It has been assumed that the initiating cause of FCIM is an external traumatic episode to the infraspinatus muscle (5, 7–9). However, it is difficult to understand how external trauma could damage only the infraspinatus muscle, without injuring other structures in the shoulder region because the infraspinatus muscle is protected behind and partly under the spine of the scapula. In this case, the absence of any sign of haemorrhage or oedema in the subcutaneous tissue or other shoulder muscles more superficial to the infraspinatus muscle, strongly argues against...
external trauma being the inciting cause of this injury.

In the electrophysiological studies by Pettit et al. (6), the data from the electromyographic recordings suggested that FCIM resulted from a myopathy rather than a neuropathy. Furthermore, electrical stimulation of the infraspinatus muscle evoked compound action potentials of low amplitude that also indicated reduced electrical activity of the muscle and supported a diagnosis of myopathy.

In our case the histopathologic examination of the injured infraspinatus muscle revealed changes consistent with an acute and severe hyaline degeneration. At the site of injury, the muscle fibres were surrounded by a haemorrhagic response and necrotic changes, typified by the presence of macrophages and neutrophilic granulocytes. There were no signs of fibroblastic or satellite cell proliferation or myotube formation. This indicated an acute muscle rupture rather than a response to an underlying degenerative process. Therefore, a plausible theory is that the initial injury was caused by overuse or overstretching, resulting in a strain injury and rupture of the infraspinatus muscle.

Animal models have been used to study the pathogenesis of muscle injuries (10). Loss of desmin, after eccentric exercise in these animal models, is dramatic and rapid. However, the same loss does not occur after isometric or concentric contractions. Segmental hypercontraction and loss of the intermediate filament protein desmin are significant structural abnormalities in experimental models of rabbit muscle tissue exposed to eccentric contraction-induced injury (11). Our findings of substantial loss of desmin and segmental hypercontraction, points to excessive eccentric contractions as cause of the muscle damage in the present case.

Eccentric muscle contractions produce a significantly greater force, compared to concentric contractions or passive stretch (12), and muscle strain injuries are believed to occur more frequently after eccentric muscle contractions. Strain injuries are disruptions of muscle fibres, defined as partial or complete tears of the musculotendinous unit (11, 13–15). The cause of the muscle injury is considered to be a violent contraction of the musculotendinous unit during an excessively forced stretch (16). In human athletes, muscle strains are the most frequent injury (13, 17, 18), and these injuries have been graded into four levels, depending upon their severity (19). The least severe, grade 1 strain, involves tearing of only a few muscle fibres, causing minor pain and local spasm. Grade 4 strain involves complete muscle rupture and is associated with extreme pain, swelling and tenderness at the injury site. In many instances, strain injuries in athletic performing dogs probably go undiagnosed. The consequences of unrecognised and untreated severe muscle strain injuries may include complications such as FCIM (13, 20, 21).

A grade 4 strain with a ruptured muscle, which is anatomically confined by fascia and bony structures, may rapidly develop into an osteo-fascial compartment syndrome (OFCS) (22, 23).

We propose that the rapid progression from the initial injury of the infraspinatus muscle into the condition of FCIM is a result of an OFCS with build up of supraphysiological tissue pressures within the confined osteo-fascial space surrounding the infraspinatus muscle (Fig. 6).

In human medicine, osteo-fascial compartment syndrome is primarily a result of fractures, crush injuries, circumferential burns and muscle rupture. In order to avoid serious sequelae, the condition must be recognised and treated immediately by a fasciotomy (19, 21, 24–26). Few reports have been published on osteo-fascial compartment syndrome in dogs (21, 22, 25, 27, 28), although the use of dogs as models of experimentally induced OFCS in the crus for study of the problem in humans is well documented (29–33). Osteo-fascial compartment syndrome should be suspected in dogs with acute and excessive pain and extensive swelling in a tense compartment. The condition can be recognised by the typical clinical signs, or by measuring the intracompartmental tissue pressure.

Normal intrafascial pressure is –2 to +8 mm Hg. Pressures exceeding 30 mm Hg for more than eight hours will cause necrosis of skeletal muscles (13, 21, 22, 27). Osteo-fascial compartment syndrome can be diagnosed by monitoring the intrafascial pressure with a wick or slit catheter (21, 34–36) or with a solid-state transducer intracompartmental catheter (21, 37). It is also possible to use a central venous pressure manometer and a three-way stopcock connected with 0.9% saline-solution and an extension set to a hypodermic needle inserted into the compartment (21). Osteo-fascial compartment syndrome may warrant an immediate fasciotomy to achieve surgical decompression to restore vascular perfusion (21, 22, 25). Because the required equipment for measuring elevated tissue pressure may not be readily available in veterinary practices, the decision to make a fasciotomy must be based on the surgeon’s interpretation of the clinical signs. In the present case, the extremely tense and tender swelling of the infraspinatus muscle and the hardness of the surface of the compartment (30), were the reasons for performing immediate surgical decompression.

Four osteo-fascial compartments have been previously described in dogs; the caudal antebrachium, the cranial crus, the caudal crus and the quadriceps compartments (22). The present case suggests that the infraspinatus muscle may be considered to be a fifth compartment in dogs.
In Norway, Sweden and Finland, FCIM in hunting dogs is a well known muscular disorder that is often called ‘the grey dog disease’ of the Norwegian elkhound breed (9). In a study by Gustafsson and Hofstad (7), 14 Norwegian Elkhounds and the closely related Swedish Jämthound were amongst a total of 18 dogs with surgically treated FCIM. Similar numbers were registered between 1994 and 1999 at The Norwegian School of Veterinary Science, where 10 out of 13 hunting dogs that underwent surgery for FCIM were Norwegian elkhounds (unpublished data).

In Norway the Norwegian Elkhound is the second most numerous breed. Although the animal in our report had been hunting grousers, the Norwegian Elkhound is represented amongst hunting dogs diagnosed with FCIM. During the elk hunt, or in other similar and vigorous hunting, or working situations, the activity of the dog is extremely strenuous. It is likely that the infraspinatus muscle is ruptured after a violent contraction of the musculotendineous unit during an excessively forced stretch.

To the authors’ knowledge, this is the first published report describing an initial injury that is assumed to cause fibrotic contracture of the infraspinatus muscle in dogs. We propose that the initial injury was not an external trauma as commonly presumed, but a strain injury and rupture of the infraspinatus muscle initiating an OFCS. If the initial injury is recognised early, it is possible to perform immediate surgical decompression of the osteo-fascial compartment of the infraspinatus muscle, thereby avoiding the development of fibrotic myopathy and FCIM.

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References
1. Meutstege FJ. Contractuur van de m. infraspinatus als oorzaak van boegkreupelheid bij een hond (Contracture of the m. infraspinatus as a cause of shoulder lameness in a dog.) Tijdschr Dierge- neesk 1970; 95: 24–6.

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