Case Report

Crural Fascia Injuries and Thickening on Musculoskeletal Ultrasound in athletes with calf pain, calf 'strains', exertional compartment syndrome and botulinum toxin injections

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Abstract. Crural fascia injuries are under recognized and under reported. Only one known dedicated paper on a crural fascia injury depicting thickening exists in the literature, written in a greater context on an article on a proximal paratendon Achilles injury. The following three cases of fascia thickening surrounding the medial gastrocnemius, none of which involve the Achilles tendon, demonstrate the superiority of ultrasound imaging over the ubiquitous MRI in visualizing the crural fascia and questions whether these injuries are as rare as previously thought. One athlete suffered from recurrent 'calf strains', one athlete had exertional compartment syndrome treated with botulinum toxin, and one athlete suffered an acute injury to his superficial gastrocnemius fascia. ***Keywords:*** crural fascia thickening, fascia tear, musculoskeletal ultrasound, calf strain, exertional compartment syndrome, botulinum toxin injection.

Introduction:

Crural fascia injuries are under recognized and under reported. Only one known dedicated paper on a crural fascia injury depicting thickening exists in the literature, written in a greater context in an article on a proximal paratendon Achilles injury [1].

The following three cases of fascia thickening surrounding the medial gastrocnemius, none of which involve the Achilles tendon, demonstrate the superiority of musculoskeletal ultrasound (MSK US) imaging over the ubiquitous MRI in visualizing the crural fascia and questions whether these injuries are as rare as previously thought. The first

case involves a world record holder on the track with the clinical complaint of recurrent "calf pulls". The second case involves a high school runner with exertional compartment syndrome treated by the principal author with botulinum toxin. The third case involves an athlete with an acute injury and thickening of the superficial medial gastrocnemius fascia, the first known case to be described in the literature.

The word fascia, which comes from the Latin term meaning flat band or bandage, has been recognized historically primarily as a wrap of connective tissue to contain and house more specialized structures, viewed or ignored as less important than the muscles and structures contained within them [2]. It is only in recent years that a greater interest in fascia has emerged, with the first international fascia research conference held in 2007. A review of fascia by Benjamin [2] from the molecular level to its gross anatomy describes the multiple functions of fascia: 1. act as an ectoskeleton for muscle attachment, 2.separate muscles into compartments, 3. support venous return in the lower limb, 4. dissipate stress at the entheses, 5. act as a protective barrier, 6. coordinate muscle activity, and 7. act as a proprioceptive organ, postulated "to serve as a body-wide mechanosensitive signaling system with an integrating function analogous to that of the nervous system" [2]. The crural fascia has been further identified as a nocioceptive sensory tissue/organ [3]. Nerve fibers are present in crural fascia, thin fiber receptors responding to noxious stimuli exist in crural fascia, and noxious pinching of the crural fascia induces protein expression in the superficial dorsal horn [3]. The crural fascia is thought to "play the fundamental role in the etiology of the acute and chronic exertional compartment syndrome" [4]. It is postulated that fasciotomies may disrupt the calf muscular venous pump leading to venous insufficiency and any alteration of pressure exerted by the muscles may increase the tensile state of the fascia [4].

Anatomical dissection of the crural fascia has been reported in detail by Stecco [4] in 2008. The crural fascia is a thick lamina of connective tissue felt to be similar to an aponeurosis [4]. Histological analysis reveals a mean thickness of 924 +- 220 um, formed by three (or more, rarely two) distinct layers with a mean thickness of 277.6 +- 86.1 um [4]. Each layer is composed of parallel collagen fiber bundles as a waved arrangement, with each layer separated by thin loose connective tissue with a mean thickness of 43 +- 12 um, allowing adjacent layers to slide against one another [4]. The collagen fibers of adjacent layers are oriented along different angles of 80 to 90 degrees [4]. In some locations, due to the presence of a thin layer of loose connective tissue, there is complete independency between the fibers; in other regions, the layers are connected by isolated bundles of collagen fibers [4]. Nerve fibers are found distributed throughout all fascial layers, more commonly seen around vessels [4]. The vessels follow tortuous paths through the collagen layers [4]. Elastic fibers are present only in the borders of the crural fascia and inside the layers of loose connective tissue [4]. Elastic fibers are absent in the collagen bundles [4].

Ultrasonography of medial gastrocnemius muscle tears, referred to as 'tennis leg', a common cause of posterior calf pain, has been well documented in the literature [5]. Crural fascia herniations have been previously illustrated in the literature with dynamic ultrasound demonstrating fascial defects upon standing and provocation [6]. However, there is comparatively little in the literature on ultrasound imaging demonstrating thickening of the fascia that surrounds the gastrocnemius muscle. Only one known dedicated study exists in the literature on an injury of the gastrocnemius crural fascia with thickening of the fascia interposed between the medial gastrocnemius and the soleus and it is within the context of a larger case relating to a proximal Achilles paratendonopathy [1].

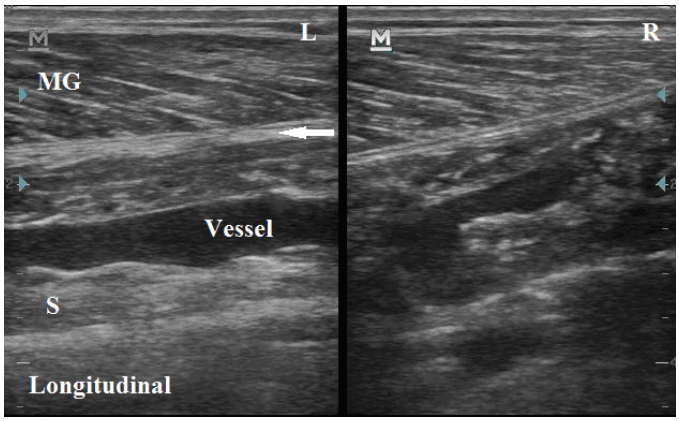

Figure 1: Left Medial Gastrocnemius (MG), Soleus (S), Fascial Thickening (Arrow).

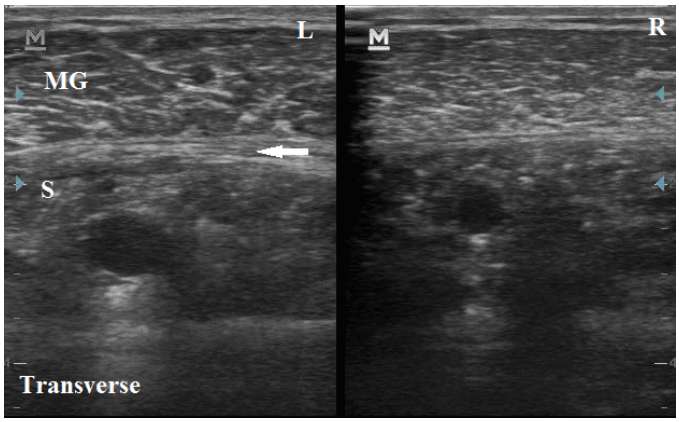

Figure 2: Left Medial Gastrocnemius (MG), Soleus (S), Fascial Thickening (Arrow).

Cases:

Case 1:

A 53 year old lifelong track runner who holds a world record in a relay event presents with a complaint of recurrent intermittent middle posterior calf pain, recurrent "pulls", and tightness in his left leg and sometimes his right leg since his 30s. At times he has to shut it down for weeks, other times pain can resolve within one week. He has learned to 'live with it' and manages it. He denies swelling. He denies any acute events with a pop or eccymosis. Pain is worse when he runs on the balls of his feet. He self diagnosed possible exertional compartment syndrome. X-rays taken at initial visit revealed long, posterior cortical thickening of the tibias, with callous and scalloped appearance on the left posterior tibia greater than the right, with no periosteal elevation or lesion. MRI was obtained to rule out any bony edema or stress fracture prior to performing a compartment test. MRI was positive for "strains involving the left soleus muscle with a small hematoma in the fascial plane between the soleus and medial head of the gastrocnemius muscle". MRI was negative for any bony edema or periosteal elevation but did note cortical thickening within the posterior aspects of both tibias more pronounced on the left, believed to be related to muscular attachments. There was also a prominence of the veins in the left leg compared to the right. He returned three weeks later to review the MRI; and at that time he was pain free for the previous week and back to running again. MSK US at that visit revealed a thickened fascia between the gastrocnemius and the soleus on the left compared to a thin fascia on the right (Figure 1, 2). The athlete was sent for physical therapy (PT), returned to sport, and did not undergo compartment testing.

Case 2:

A High School senior track athlete planning to run in college presents with complaint of bilateral exertional calf pain of two years duration, primarily anterior lateral pain with posterior tightness and numbness into his feet. He had small posterior herniations on exam; otherwise exam was unremarkable. Working diagnosis of chronic exertional compartment syndrome was made and the athlete returned for compartment testing.

Compartment testing revealed:

Pre-Exercise Right

Anterior: 25 mm Hg
Lateral: 16 mm Hg
Deep Posterior: 14 mm Hg
Superficial Posterior: 11 mm Hg

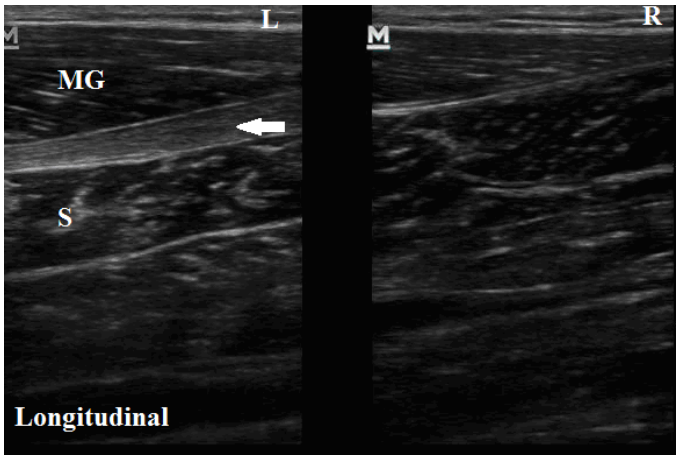

Figure 3: Left Medial Gastrocnemius (MG), Soleus (S), fascial thickening (Arrow).

Post Exercise Right

Anterior: 55 mm Hg
Lateral: 25 mm Hg
Deep Posterior: 18 mm Hg
Superficial Posterior: 13 mm Hg

Pre-Exercise Left

Anterior: 24 mm Hg
Lateral: 17 mm Hg
Deep Posterior: 17 mm Hg
Superficial Posterior: 16 mm Hg

Post-Exercise Left

Anterior: 50 mm Hg
Lateral: 23 mm Hg
Deep Posterior: 22 mm Hg
Superficial Posterior: 19 mm Hg

He was diagnosed with exertional compartment syndrome of his anterior compartment and was offered the treatment option of botulinum toxin injection therapy [7]. Nine days after the compartment test, the athlete returned for botulinum injections. The anterior compartment of each leg was injected proximally and distally with botulinum toxin divided and injected into each of his bilateral lower anterior compartment muscles under ultrasound guidance. Two weeks after botulinum injections, he started physical therapy with no complaints. On exam, strength of ankle dorsiflexion and great toe and phalangeal dorsiflexion was 4 out of 5 though he complained of no weakness. A month after botulinum treatment the athlete was running up to 12 minutes a day with no pain in his right leg, described as 100%, but complained of pain in his posterior medial calf of his left lower leg. He described no new acute event. He had no anterior lateral symptoms in his left or right leg. He complained of no weakness. On exam, strength of ankle and phalangeal dorsiflexion was 4 out of 5. MSK US performed at that visit dedicated to his posterior medial site of pain revealed a severely thickened distal crural fascia between the medial gastrocnemius and soleus on the left compared to a thin hyperechoic intact fibrillar fascia on the contralateral side (Figure 3). There was no appearance of any gastrocnemius tear. The plantaris tendon appeared intact at this level. It was recommended he continue PT and progress running as tolerated and if pain persisted, then further injections would be performed. At 5 weeks he was running up to 20 minutes pain free in both anterior compartments with tolerable discomfort in his left posterior medial calf. MRI of his left tibia/fibula obtained after that visit revealed and reported "asymmetrical fluid tracking in the intermuscular space between the medial gastrocnemius and soleus muscles centered around the plantaris tendon which appears contiguous at this level", with normal signal in the gastrocnemius and soleus, and an impression of "plantaris and/or low grade medial gastrocnemius strain" (Figure 4). PT and continued progression was allowed, and at 2 months out from treatment, he was racing and set a personal record, breaking 2 minutes for the 800. At 12 weeks post botulinum treatment, he was part of a relay team that won nationals, setting a meet record.

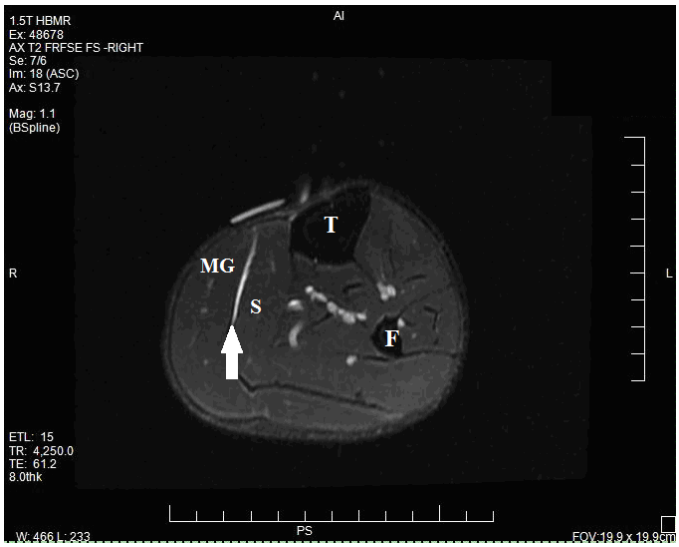

Figure 4: Fluid tracking (Arrow) between Medial Gastrocnemius (MG) and Soleus (S), Tibia (T), Fibula (F).

Figure 5: Right gastrocnemius appearance of fascial herniation.

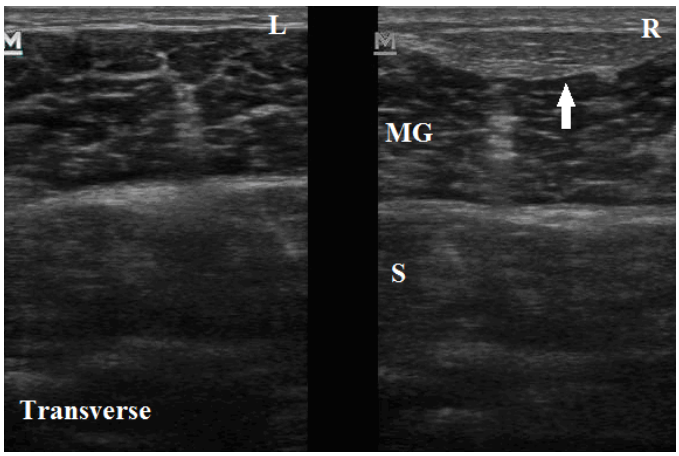

Figure 6: Right superficial Gastrocnemius (MG), Soleus (S) Fascial Thickening (Arrow).

Case 3:

A 48 year old male complained of right posterior calf pain with limping and swelling after a weekend of two long bike rides, coaching lacrosse, and demonstrating running drills, without any pop or acute event recalled. Weight bearing and stretching were painful. Limited MSK US of his posterior medial gastrocnemius at initial visit revealed diffuse hyperechoic complex blood appearance within the distal medial gastrocnemius without any anechoic echotexture or usual hypoechoic disruption as seen with tears of the medial gastrocnemius. He was given heel lifts and was scheduled for repeat imaging in one week. At one week post injury, he still complained of swelling but had less pain and was able to get his heel down with weight bearing without using lifts. MSK US, at that visit revealed a 3cm bulbous wide and long tear in the superficial medial gastrocnemius fascia beneath skin, with a tear of his gastrocnemius muscle beneath fascia, with hypoechoic disruption and a hyperechoic diffuse blood appearance within the musculature. In transverse, the fascial thickening protruded downward like a window shade pulled down into the gastrocnemius muscle. Home exercises were given and he was instructed to modify activity with no running but was cleared for cycling. Six weeks after the injury he was completely pain free but complained of a visible deformity. On exam, he had an appearance of a herniation in his posterior medial gastrocnemius with full range of motion and full strength (Figure 5). MSK US revealed no change with a bulbous wide and long thickened superficial medial gastrocnemius fascia but no fascial disruption (Figure 6). He was cleared for full activity and instructed to wear a compression wrap for any symptoms until fully pain free.

Discussion:

The author believes fascial injuries resulting in thickening are both underreported and unrecognized as a source of injury and pain due to the limitations of the ubiquitous MRI in evaluating the thin crural fascia. Ultrasound is an excellent imaging modality, felt to be superior to MRI when examining the fascia of the gastrocnemius, due to its superficial location, hyperechoic appearance, thinness of structure, and the ability to perform dynamic imaging and rapid contra lateral comparison. MRI is superior in evaluating the deeper structures of the soleus (within the superficial compartment) and muscles of the deep posterior compartment.

Webborn [8] in 2014 was the first to describe using ultrasound the acute tear of the fascia cruris at the attachment to the Achilles tendon[1]. Mattiussi [1] reported using ultrasound on a soccer player who sustained an acute Achilles paratendinopathy following a severe injury of the crural fascia interposed between the medial gastrocnemius (MG) and soleus muscle (S).

Two of the cases reported above in this article demonstrate via ultrasound imaging a similar thickening of the fascia between the MG and S, though in these cases the injury finding was located at the distal medial gastrocnemius, the most common site of fascial tears in this author's experience, and not at the origin of the Achilles.

The third case in this paper demonstrates using ultrasound thickening of the superficial fascia between the MG and the subcutaneous tissue, the first known case of its kind in the literature. Netter's depiction of the compartments of the lower leg does not even include the fascia between the gastrocnemius and soleus, nor is it labeled on the cross sectional anatomical imaging of the muscles [9]. It is contended that these injuries to the crural fascia surrounding the gastrocnemius muscle, that results in thickening as visualized on MSK US, are not as rare as postulated, but rather under recognized on MRI and under reported clinically.

In Mattiussi [1] the MRI of the soccer's player tibia was "reported very generally" as "gastrocnemius and soleus strain with the presence of fluid between the two muscles". The MRI report of the track runner above was reported vaguely as well, as a "plantaris or low grade medial gastrocnemius strain" with "asymmetric fluid tracking in the intermuscular space between the medial gastrocnemius and soleus muscles" (Figure 4). In Mattiussi et al. [1] it was MSK US that revealed "considerable enlargement of the connective component interposed between the muscle…compatible with structural injury and retractions of the CF" with normal appearance and no disruption of the gastrocnemius or soleus muscle. The normal crural fascia under ultrasound examination should appear as a thin lamina of hyperechoic connective tissue estimated to have a mean thickness of 1.1mm in healthy subjects [10]. In all three cases reported above in this article, it is MSK US that depicts considerable fascial thickening in the injured legs when compared to the contra-lateral uninjured limbs.

Conclusion:

There is a dearth of reports on fascial injuries of the gastrocnemius in the literature. Crural fascia injuries surrounding the medial gastrocnemius are well visualized on MSK US. They are under recognized and under reported due to the limited use of MSK US in orthopedic clinics. More research as to why they occur, how to best treat them, and how they relate to exertional and acute calf injuries are needed.

Competing Interests:

The authors declare they have no competing interests.

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