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Case Report

MR diagnosed chronic exertional compartment syndrome successfully treated by endoscopically-assisted fasciotomy☆

Paul L. Wasserman, DO, MHCM[a,*], Matthew Montanarella, MS-4[b], David Szames, DO[a], Chandana Kurra, MD[a], Morgan Garcia, DPM[c], Kristin Taylor, MD[a], Jason A. Piraino, DPM[c]

[a] Department of Radiology, University of Florida College of Medicine-Jacksonville, 655 West 8th St. C90, Jacksonville, FL 32209

[b] Lake Erie College of Osteopathic Medicine-Brandenton Campus, 5000 Lakewood Ranch Boulevard, Bradenton, FL 34211-4909

[c] Department of Orthopaedic Surgery and Rehabilitation, University of Florida College of Medicine – Jacksonville, 655 West 8th St. C90, Jacksonville, FL 32209

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ABSTRACT

Chronic exertional compartment syndrome is a subset of compartment syndrome that most frequently affects the lower extremities, often in athletic persons. It is most often characterized by calf pain shortly after the initiation of exercise and resolution of the pain soon after rest. While the pathophysiology is not completely understood, it is believed that compartment a lack of fascial compliance and increased compartment fluid leads to increased pressure, ultimately leading to a reversible ischemic state. Chronic exertional compartment syndrome was once considered a diagnosis of exclusion; however, needle manometry is an invasive way to measure intracompartmental pressure. Similarly, fasciotomy is the treatment of choice but is not without complications. We describe a case of chronic exertional compartment syndrome diagnosed by two-stage MRI and successfully treated by endoscopically-assisted fasciotomy.

Introduction

Chronic Exertional Compartment Syndrome (CECS) is a recognized cause of leg pain during periods of exercise. This condition is a subset of compartment syndrome that is defined by increased pressure within specific muscle compartments of the extremities, causing compression of neurovascular bundles, resulting in symptoms [1]. CECS was first described in the literature by Mavor in 1956, where surgery was found to be a successful treatment [2]. The condition most commonly effects the lower limbs but cases of CECS of the upper extremities have been documented [3]. The anterior, lateral, and deep

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* Corresponding author.
E-mail address: paul.wasserman@jax.ufl.edu (P.L. Wasserman).

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posterior compartments of the lower extremity are most commonly described in cases of CECS [4,5].

Athletic patients participating in repetitive axial loading exercises such as distance running are at an increased risk of CECS [6]. Studies involving an athletic at-risk population have demonstrated that CECS has an incidence of 0.49 cases per 1000 person-years [7]. In a retrospective study of 1411 patients referred for evaluation of exercise induced leg pain, 49% met criteria for CECS using dynamic compartmental pressure measurement [8]. Patients with CECS may experience numbness, tightness, pain, and burning in the affected area that usually presents during exercise and is relieved shortly after rest [9]. Although the exact pathophysiology of chronic exertional compartment syndrome is not completely understood, theories exist in literature that infer a multifactorial etiology. The inherent lack of fascial compliance and the increase in muscle fluid during exercise may be the cause of this reversible ischemic state [10,11]. Considering the wide differential diagnosis of CECS the results of a thorough clinical history and physical exam should be corelated with diagnostic testing in all cases.

Although CECS was once a diagnosis of exclusion, objective measures have been utilized to definitively diagnose and differentiate it from other causes of exercise induced leg pain. While there has been debate in the literature regarding accurate diagnostic criteria, the most widely adopted system was established by Pedowitz et al. He proposed that at least one of the three following criteria: pre-exercise compartment pressure of 15 mm Hg, 1 minute post-exercise compartment pressure of greater than or equal to 30 mm Hg, or a 5 minute post-exercise compartment pressure of 20 mm Hg should be met in order to diagnose CECS [12]. More recent literature demonstrates the utility of dynamic intramuscular compartment pressure measurement in order to diagnose CECS with a higher sensitivity and improved diagnostic value [13]. Non-invasive exercise protocols and MRI have shown promise as alternative diagnostic modalities [14].

Non-invasive treatment options of CECS such as massage, stretching, anti-inflammatory medications, and orthotics may offer temporary symptomatic relief but ultimately do not provide long term pain or symptom control. As such, most patients usually require surgery to return to a similar pain free level of optimal physical activity [11,15]. In one study of 1,495 patients diagnosed with CECS, 86% of symptomatic patients received a compartment specific fasciotomy after conservative measures failed to control their pain [16]. While the majority of these patients underwent an open procedure, less than 2% of them underwent a minimally invasive endoscopically-assisted fasciotomy [16]. We describe the use of pre- and post-exercise MRI to diagnose a case of chronic exertional compartment syndrome. Additionally, the patient in our case underwent a minimally invasive, endoscopically-assisted fasciotomy.

Case presentation

A 47-year-old male presents with complaints of bilateral lower leg and foot pain resulting in decreased physical activity for several years. Within 10 to20 minutes of onset of exercise he complained of calf and foot pain. The pain started in his legs but progressed distally, eventually resulting in in paresthesias of the feet. After cessation of exercise, the pain in his legs subsided quickly, but the pain in the feet persisted for several minutes. Subsequently, he experienced an overall decreased quality of life as he was unable to continue his level of physical activity. Given the above history and an unremarkable physical, CECS was suspected. A pre-and-post exercise MRI of the lower extremities was ordered to determine whether any imaging abnormalities could be discerned. After a coordinated effort between the physical therapy service and radiology, the right lower extremity was chosen for MRI imaging.

Physical therapy stress test

A joint exercise and imaging protocol was created between the physical therapy department and radiology. The protocol consisted of a pre-exercise and post-exercise MRI of the lower extremity with a field of view encompassing the tibial plateau to the tibial plafond. Available technology included a 1.5T Siemens Espree MRI to obtain axial proton density fat saturated images (PDFS), sagittal PDFS, coronal PDFS, axial short T1 inversion recovery (STIR), and axial T1 sequences. After obtaining a pre-exercise baseline scan, the patient was directed to the department of physical therapy, one floor above the MRI suite. The patient subsequently underwent a provocative treadmill exercise test until his pain symptoms were elicited. This took approximately 20 minutes of running on a treadmill without incline at the patient's normal running pace. After the patient indicated he had achieved his normal pain tolerance, the patient was then promptly escorted back to the MRI suite where the post-exercise portion of the study was completed without delay.

Imaging

Pre-exercise imaging of the patient's calf did not reveal any abnormal signal; however, a relatively hypertrophied soleus muscle was evident (Fig. 1). Of note, an accessory soleus muscle was not identified. Post exercise images demonstrated increased signal within the posterior compartments. Specifically, both the superficial and deep posterior compartments exhibited subjectively increased T2-weighted muscle signal (Fig. 2). In order to confirm and quantitate these findings, a standardized representative axial image was selected for region-of -interest (ROI) signal intensity (SI) assessment. Effort was made to use the exact placement of the ROI on the pre- and post-exercise samples. The ROI area was consistently 29.3 to 29.5 mm^2 and placed in the within the center of the compartment. In order to mitigate against the possibility of inhomogeneous fat saturation affecting the SI reading, an axial STIR sequence was selected instead of a PDFS. In addition, a standardized window and level reading was used as a precautionary measure. Fleckenstein et al. found short-lived increase in T2 signal intensity of normal muscle after

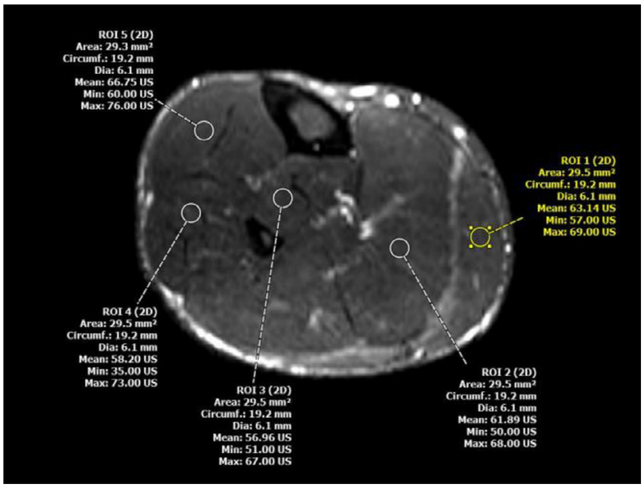

Fig. 1 – Pre-exercise STIR imaging of the right lower extremity shows no focal abnormality. Baseline ROI measurements of SI were obtained in each of the compartments within the field of view. Note: yellow annotation is merely a function of the last measurement obtained and without other significance (color version of figure is available online.)

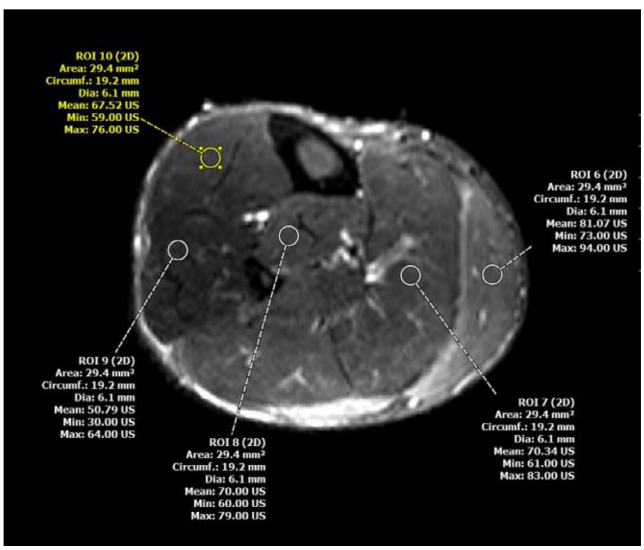

Fig. 2 – Post-exercise STIR imaging shows increased signal in the deep and superficial posterior compartments which corresponds with increased ROI measurements of SI in these compartments. Note: yellow annotation is merely a function of the last measurement obtained and without other significance (color version of figure is available online.)

exercise of approximately 12% [17]. Our findings, listed in Table 1, revealed an increase of 23% SI in the deep posterior compartment and an increase of 29% in the superficial posterior compartment (medial gastrocnemius). These data agreed with the subjective, visual assessment of the compartments exhibiting the most significant increase in post-exercise SI.

Table 1 – Standardized ROI (region of interest) measurements of signal intensity (SI) before and after exercise to level of pain tolerance.

Compartment	STIR SI pre-exercise	STIR SI post-exercise	%Change
Anterior	67	68	1%
Lateral	58	51	-12%
Post deep	57	70	23%
Post superficial medial gastrocnemius	63	81	29%
Soleus	62	70	13%

Interestingly, we recorded a decrease in the SI of the lateral compartment of 12% status post exercise. Considering the patient's clinical scenario and the MR findings, a diagnosis of chronic exertional compartment syndrome was concluded.

Given the chronicity of the symptoms and failure of conservative management, the patient elected for a surgical intervention. A minimally invasive endoscopy-assisted fasciotomy of the superficial and deep posterior compartments of the lower extremity was performed in the following fashion.

The patient was prepped, padded, and draped in the supine position. Three longitudinal incisions were subsequently made just posterior to the medial border of the tibia. First, a 4 cm incision was made distal to the tibial tuberosity. A second, 4 cm, incision was made proximal to the medial malleolus, and a third incision was made at the halfway point between the first and second incision. Blunt dissection was performed to separate the subcutaneous tissues from the underlying superficial compartment fascia (Fig. 3). Next, a longitudinal incision along the superficial fascia was made that spanned the length of the lower extremity. Subsequently, a 4 mm, 30° endoscope was then passed through the most proximal incision to help visualize and incise any remaining superficial fascia (Fig. 4). The underlying gastrocnemius and soleus muscles were retracted to the side and a similar process was repeated to the underlying deep compartment fascia to expose the flexor digitorum longus muscle. One last incision was made in a similar fashion with endoscopic guidance to separate the flexor digitorum longus and tibialis posterior muscles. The endoscope was subsequently removed, the incisions sutured in layers, and the wounds were dressed in sterile fashion.

Discussion

Post-exercise needle manometry is a widely utilized technique for diagnosing CECS [5]. This technique is invasive and has several limitations including patient pain and variability in intercompartmental measurements due to timing of reads and needle positioning [14]. Another author found needle manometry yielded highly variable results in the hands of the most competent operators, achieving acceptable standards in only 60% of the cases [18]. MRI has proved as an effec-

Fig. 3 – Intraoperative photograph obtained during blunt dissection of the lower extremity.

tive noninvasive means to diagnose chronic exertional compartment syndrome [11,19-21]. Verleisdonk et al. used MRI in the dynamic evaluation of lower leg in 21 patients (41 compartments) and successfully diagnosed CECS by using a significant increase in T2 signal within the effected compartment compared with non-exercise controls [20]. He found increased T2-weighted SI in the lower leg compartments of patients with CECS compared to a control group of 20.5% and 3.9% respectively [20]. In a later study of 76 patients, in-scanner exercise MRI protocols identified cases of CECS with a sensitivity of 96% and a specificity of 87% [14]. Our case underscores the use of MRI as a reasonable diagnostic tool as opposed to the invasive method of intracompartmental pressure measurement using manometry.

Nonoperative management of CECS initially consists of cessation of the physical activity inciting patient symptoms; however, patients are usually reluctant to give up their routine activity [22]. Patients that received surgery for their CECS had a higher post-treatment satisfaction rate than those using nonoperative treatment plans [23]. Operative management options for CECS in the lower extremity include open fasciotomy, single incision fasciotomy, percutaneous fasciotomy, and endoscopy-assisted-compartment release [22]. Lohrer and Nauck described the use of endoscopic fasciotomy in 17 athletes with CECS [22,24]. In these patients, the technique was performed on 19 deep posterior compartments [22,24]. Also, 59% of these patients had a good or excellent outcome [22,24]. Endoscopic technique has been described in the release of the deep posterior compartment while minimizing the risk of hemorrhage and nerve damage by avoiding saphenous nerve and vein [25].

Previous studies have suggested an increased chance of post-procedure hematoma formation following endoscopic fasciotomy of the deep posterior compartment. [22]. However, this approach demonstrated a positive outcome in our patient with a return of functional status and no short-term post-operative complications. Additional studies regarding the use of endoscopy-assisted compartment release may be warranted to better elucidate procedural outcomes and benefits over traditional surgical approaches of the lower extremity.

Pre-and Post-exercise magnetic resonance imaging continues to be viable means of diagnosing CECS of the lower extremity. Potential limitations of this protocol include the use of two imaging time slots, given the need for a two-stage MRI, and the use of a treadmill to reproduce the patient's symptoms. In order to ensure the most advantageous field-of-view, only a single extremity was imaged in this case; however, it is conceivable that the same protocol could be applied in order to image both lower extremities simultaneously. In our case, we were fortunate to have a physical therapy center within the same building as our imaging center; however, having a

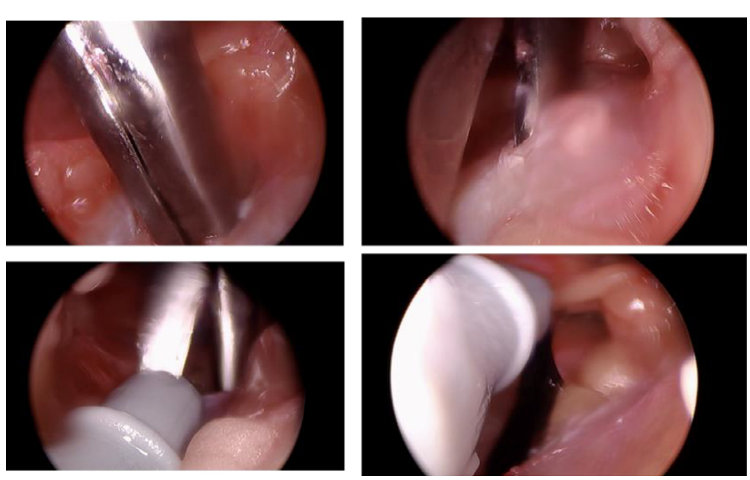

Fig. 4 – Intraoperative photographs obtained during the arthroscopically-assisted release of fascia.

treadmill within the imaging center would not be implausible. In addition, our interpretation of the data relied on the premise that an increase of over 12% SI was a significant finding as per Fleckenstein et al. We found abnormally increased SI in the deep and superficial compartments of the lower extremity. Unexpectedly, the data also revealed a decrease in SI within the lateral compartment. While uncertain, we have speculated that imperfect ROI placement between the pre- and post-exercise scans may have caused this finding; however, repeated ROI measurements yielded similar results. An alternative explanation offered might be a shunt-effect of intramuscular, extracellular water (edema) from one compartment to another, thereby decreasing the SI of the contributing compartment and increasing the SI of the receiving compartment. This theory would suggest either a congenital or acquired fascial defect or possibly an alternative, insufficient, venous drainage from one compartment to another. Either hypothesis would explain increased pressure and hence increased SI of the affected compartment. A case of CECS following the resolution of deep venous thrombosis as a result of venous insufficiency has been described in the literature [26]. From the surgical perspective, our team found minimally invasive endoscopically-assisted fasciotomy to be an effective and safe means of lasting treatment of CECS. After recovering from surgery, the patient showed significant improvement in exercise endurance without the pain that had previously prevented him from running and participating in sports. He testified that the surgery was a success and he subsequently had the same surgery performed on the contralateral leg based on a consistent physical exam. Admittedly, our case would be strengthened if a post-surgical MR revealed a decreased in SI of the previously affected compartments; however, at this time, 6 months post-surgery, the patient continues to exercise pain free.

Patient consent

All information within this case report was obtained with the patient's written informed consent.

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