Title: Over-stride-induced medial knee desmopathy: An exploration CASE series

Objective: To present nine cases of a non-contact knee medial collateral ligament (MCL) injury in runners.

Background: Nine runners of varying experience (top five ranking in state for high school cross-country, 6-time marathon competitor, first-time half marathon hopeful, and six novice runners in basic military training), but similar running gait form presented with medial knee pain. All describe an insidious and progressive onset over a two-week period with no identifiable traumatic mechanism. Gait analysis of each patient presents an over-stride, heel-strike run pattern with knee near full extension at initial contact.

Differential Diagnosis: MCL sprain, pes anserine bursitis, bone stress injury (BSI), medial hamstring tendinopathy, posteromedial friction syndrome, medial tibial crest friction syndrome, MCL bursitis

Treatment: BSI protocol to rule out stress fractures was followed. Acute management focused on functionally tight semimembranosus (SM). Once cleared of BSI, long-term management targeted retraining running gait mechanics.

Uniqueness: The presentation of insidious-onset medial knee pain requires careful consideration of various conditions including some poorly understood friction syndromes. Concurrent functional tightness of SM appears to be concomitant factor in pain presentation in these patients.

Conclusions: Bone stress injuries need to be at the forefront of differential diagnosis with insidious medial knee pain, but multiple conditions have been identified that should be considered related to an individual's biomechanics. MCL ligament injury pain can be induced by a functionally tight SM. Whether through direct fiber entanglement or nerve entrapment ultimately proves to be the source of pain, relieving the tension of SM in the short term and adjusting the over-stride during running gait for long-term appears to rectify the situation and prevent recurrence.

Key Words: Non-contact injury, insidious, desmopathy, semimembranosus, running gait

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Introduction

Patients presenting with acute pain along the medial knee tend to elicit a differential diagnosis consistent with sudden trauma such as falling or twisting and include involvement of the medial collateral ligament (MCL), medial meniscus, or hamstring tendons. When no known mechanism of acute injury coincides with the onset, then the list shifts towards overuse and chronicity-related injuries. Pes anserine bursitis, hamstring tendinopathy, meniscal tears, and bone stress injuries (BSI) may all be in the differential diagnosis. Considering the age of the patient, apophysitis of the medial femoral condyle may be considered as well.

Stress fracture incidence in Basic Military Training (BMT) can be as high as 6.9% for males and 21.0% for females cumulatively resulting in approximately $5 million dollars in annual loss to the US Air Force alone.[1] Due to the relatively high frequency of BSI diagnosed in BMT, our clinic follows evidence-based guidelines published by Nye et al. as a proactive approach to diagnose issues early while protecting against unnecessary exposure with x-ray and costs associated with MRI.[1,2] Occasionally, patients with classic clinical signs and symptoms of BSI of the medial tibial plateau (medial aspect of proximal tibial metaphysis) have x-rays and MRI which show no evidence of BSI, requiring the consideration of other diagnostic possibilities. Simeone et al (2015) described a posteromedial friction syndrome but suggested that due to its infrequency, BSI should be ruled out first.[3,4] Likewise, Klontzas et al. (2013) identified a medial tibial crest friction syndrome; the same x-rays used to begin BSI assessment would be necessary to verify the angle of the tibial crest and support this infrequent diagnosis.[5] Finally, some have described a bursa within the superficial and deep layers of the MCL that would be associated with medial knee pain.[6,7]

In this paper, we discuss nine patients with similar presentation who do not fit the currently recognized causes of atraumatic medial knee pain. The lack of evidence supporting a known diagnosis suggests their condition may not have been previously described. We seek to establish key common features seen in these cases, with the goal of enabling further research into the etiology, contributing biomechanics, and optimal rehabilitation strategies for this condition.

Methods

Patient descriptions

Patients from this case series come from civilian and military sports medicine clinics.

Private clinic:

Patient 1 was a 15-year-old female who ranked in the top five for high-school cross country runners statewide and had been running competitively for four years. Her pain began during outdoor track season when she had been spending considerable amounts of time running on a hard surfaces to which she had previously been unaccustomed. She had no remarkable history of injury. She averaged thirty miles per week in training.

Patient 2 was a 30-year-old male who competed in seven marathons over the past five years with a history of competitive cross-country running throughout high school. At the time of injury, he averaged 35 miles per week in training.

Patient 3 was a 48-year-old female who had never run consistently. On a whim she decided to surprise her husband who was an avid runner by registering them both for a half-marathon. She presented with gradual onset of medial knee pain at week ten of a sixteen-week, half-marathon training program in which she ran an average of 20 miles per week.

USAF Sports Medicine Clinic:

Patients 4-9 consisted of four females and two males, ages ranging from 18 to 26 years old, who had done little to no running prior to entering BMT. Each presented with pain in the medial knee that began during 32-minute run training sessions (consisting of 6 minutes of higher intensity interval running, followed by 26 minutes of continuous self-paced running, with 3 such workouts per week). These trainees' weekly mileage is uncertain as the training is self-paced, based on ability, but was likely in the vicinity of 7-12 miles per week. Overall cardiovascular fitness serves as the focal point of run training during these run sessions. In order to successfully complete BMT, trainees must run 1.5 miles in under 16:22 (females) or 13:36 (males).

Clinical Presentation

All nine individuals described pain as sharp, stabbing sensation at the medial knee joint line during running at terminal swing as the knee approached full extension, with the moment of initial contact. Using video recordings of the sagittal plane and posterior frontal planes, all patients presented with a similar over-stride, heel-strike running gait. Complaints of pain with ascending and descending stairs were common among the patients. No patient suffered any traumatic incident that could correlate with the onset of the pain. Running triggered the greatest complaints. Trainees also relayed complaints of pain during facing movements, pivoting movements to change directions. As the injury progressed, walking and marching became painful as well. Several patients described further aggravation of their pain while sitting. None mentioned locking, popping, clicking, or catching in their descriptions of symptoms.

Clinician notes consistently reported a lack of ecchymosis, erythema, or edema. Palpation over the MCL at the joint line and onto the tibial plateau coinciding with the insertion of the distal semimembranosus (SM) tendon, reproduced the pain of complaint. Movement and strength profiles reflected full range of motion and full strength throughout each range except for

one 20-year-old male trainee who presented with limitations in knee flexion manual muscle test at 4/5 on the involved side. Anterior drawer, McMurray, and patellofemoral apprehension tests were all negative, and the valgus stress tests reproduced the pain of complaint but negative for laxity in all patients. All patients demonstrated a shared complaint of increased tension and subsequent discomfort along the medial hamstring muscles during straight-leg raise hip flexion assessments. In most cases, SM involvement was suspected, as it felt exceedingly taut.

The USAF BSI evaluation protocol required any patient with enough positive findings to undergo plain radiographs. Four of five BMT patients met these criteria, and radiographs were obtained, but were negative for signs of BSI in all of these cases. Two patients (patients five and six), had persistent pain 7-10 days later, and an MRI was performed in accordance with the same protocol. MR images were interpreted by two radiologists (one of whom was musculoskeletal fellowship-trained) and the sports medicine physician caring for the patients. Patient 5, an 18-year-old female trainee, did not have evidence of BSI on MR images. An axial T2-weighted image showed an intact Baker's cyst and mild infrapatellar fat pad edema that may have been associated with patella alta, neither of which reasonably explain her medial knee pain during running gait, pivoting movements, or prolonged sitting. The radiologists and chief of radiology noted inflammation tracking along the MCL and reported that a mechanism associated with a MCL sprain should be considered (image 2). Patient six, 20-year-old female trainee, on a coronal T1-weighted image showed no sign of BSI or other inflammation at the site of pain (image 2). A linear signal can be seen along the MCL, but that was determined to be a blood vessel. Her final diagnosis from the provider was a proximal, medial gastrocnemius strain, which fails to explain the point tenderness and chief complaint of pain on the MCL at the joint line. Neither patient presented with edema associated with MCL bursitis.[7]

Diagnosis

Settling on a diagnosis remains a necessity to better understand treatment and prevention. Tenderness to palpation on the MCL over the joint line and not distally at the pes anserinus or the inferior angle of the tibial crest reasonably eliminates either pes anserine bursitis or tibial crest friction syndrome. Meniscal tear is less likely noting absence of mechanical symptoms and negative McMurray tests. There was no evidence of meniscus tear in the two individuals who had MRI. Although some discomfort had been reported along the SM tendon, the point of maximal tenderness was along the MCL anterior to the SM tendon, therefore reducing the likelihood of an isolated SM strain. The interpreting musculoskeletal radiologist, with the Klontzas et al. publication as a guide, ruled out the anatomic features that were presented as causative for the tibial crest friction syndrome.[5] A lack of tenderness along posteromedial femur with associated popping, snapping, and clicking as the leg moved into extension reduced the likelihood of a posteromedial friction syndrome.[3,4] No swelling along the anterior edge of the femoral portion of the MCL existed for any of the nine patients; an expectation for MCL bursitis outlined by Corten, Vandenneucker, Lauwe, and Bellemans.[7] Radiologist interpretations of the MR imaging further excluded any significant edema presence in between the superficial and deep layers of the MCL, further supporting MCL bursitis elimination from consideration. Image 3 provides a palpation guide for some of these lesser known conditions including the distribution of pain for this current condition.

Short-term management

Most of our insidious onset cases, especially around the medial tibial plateau, are ultimately found to be BSI, which justifies close adherence to the BSI diagnostic protocol using

activity restriction and early imaging. Conservative commensurate treatment typically addresses patient symptoms. The two principal findings that guided treatment in our patients included an over-stride, heel-strike running gait and the exceptionally tight SM muscle and tendon. Medial hamstring muscle tension was addressed using a figure-four static stretch in which the involved leg is extended and the ipsilateral hand reaches towards in the instep of the foot and held for 30 seconds. At the end of the static stretch, patients were instructed to flex their knee 10-20 degrees and dig their heel into the table for 10 seconds then resume the static stretch. The combination was repeated five times with patients instructed to repeat the exercise three to five times throughout the day. Patients further stretched using a knee-flexion, hold-relax technique to elicit autogenic inhibition. Addressing the muscular tightness in the SM reduced pain ratings to 3/10 in six of the nine patients within the first 48 hours, returning to running within 72 hours. Patient 3 and patient 5 reached symptom resolution by day 7, and both returned to running within 14 days. All patients were concurrently treated as described in the long-term care below.

Patient 6 did not respond to therapy initially. Despite the patient relating that the medial hamstring tension had resolved, she still had pain at initial contact in walking and marching (running had been restricted). Upon reevaluation we found increased external tibial torsion on the involved leg. Presuming at this point that over-stride, heel-strike run mechanics were involved and those closely mimic walking and marching mechanics, we adapted a derotation ACL knee taping procedure using Elastikon™ (Johnson and Johnson, New Brunswick, NJ) in attempt to limit the external rotation from the screw home mechanism throughout the day. The patient relayed an immediate reduction in symptoms while walking with the tape on. Her symptoms resolved within another two days. The taping procedure was no longer needed, and she was returned to training with unrestricted running.

Long-term management

As part of the rehabilitation protocol in the military sports-medicine clinic, all trainees with complaints of lower extremity pain are assessed for running gait irregularities and retrained accordingly when appropriate during their care. Patients 1-3 did not have this concurrent education and had recurrence of previous symptoms upon return to running, reinforcing the suspicion of a biomechanical cause of pain. As the pain presented in the final degrees of terminal knee extension and spiked at initial contact, retraining running gait to avoid this position was pivotal for long-term management. Patients underwent gait retraining to encourage a higher cadence with an initial contact point closer to the center of mass. The resulting knee flexion at initial contact removes the exacerbating knee position. Concurrent strengthening and activation of pelvic stabilizers and gluteus medius muscles are necessary to maintain this running form and were intensively included in the reconditioning program. The condition did not return for any patient post-gait retraining.

Discussion

The source of pain in this case series is poorly understood, but seems likely to be a SM-mediated traction desmopathy of the MCL. The quick resolution of symptoms stemming from focused attention on SM tightness must point to its involvement in the development of injury. SM is intimately intertwined with fibers of the MCL[8,9] and innervated by branches of the saphenous nerve.[10] The SM tension at terminal knee extension could be an irritant to the MCL by creating a posterior torque that counters the normal external tibial rotation during the screw-home mechanism. Removing the tension of SM thereby removes the source of irritation on the ligament. Abnormal tension in the SM could also trigger inflammatory mediators in and around

the tendon causing sensitivity and pain as identified on palpation. In either case, the resulting desmopathy to the MCL could be the focal point of injury for the patient.

Another consideration from the taut SM could be entrapment of the infrapatellar branch of the saphenous nerve. Saphenous nerve entrapments have been reported to mimic patellofemoral disorders, suprapatellar plica irritation, medial meniscus tears, tibial stress fractures, and pes anserine bursitis among others.[11,12] Several of those conditions were on our initial differential diagnosis list. The infrapatellar branch forms a subsartorial plexus that provides sensory innervation to the MCL. Porr, Chrobak and Muir (2013) reported two case studies of possible saphenous nerve entrapment at the adductor canal that used manual neural tensioning techniques for diagnosis as an alternative to injected nerve blocks.[13,14] Both subjects were runners and presented with pain reproduction when running and traversing stairs making them similar to our presented patient population. The SM is not involved with the adductor canal and so it may be that the distal fibers of the infrapatellar branch intermingle with the SM at the point of innervation of the MCL, creating a distal irritation that is localized to the ligament. This could explain some of the heightened symptoms when the SM was on full stretch and peak activation during gait, approaching and at initial contact. Releasing tension of the SM would therefore make sense in alleviating symptoms.

Conclusion

A subset of nine patients is a limitation; clearly more cases need to be identified to validate the diagnosis. Those cases need to be weighed against saphenous nerve entrapments to connect or differentiate that as a related construct. Recognizing that the exact pathomechanics of the syndrome are not fully rectified, an avenue for future research, we suggest that the similarity in these nine patients represent a previously unreported injury mechanism. Common features

include run mechanics that lead to pain at initial contact localized to the MCL with concurrent tightness in the SM. Releasing SM tightness is a temporary but effective solution. Long-term resolution comes from addressing the over-stride run form.

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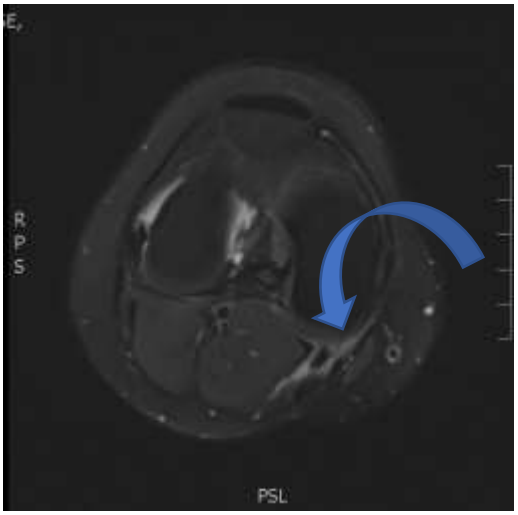

Image 1: Axial T2 weighted image with arrow indicating inflammation tracking along the MCL

Image 2: Coronal T1-weighted image demonstrating no evidence of BSI or other inflammation at the site of pain.

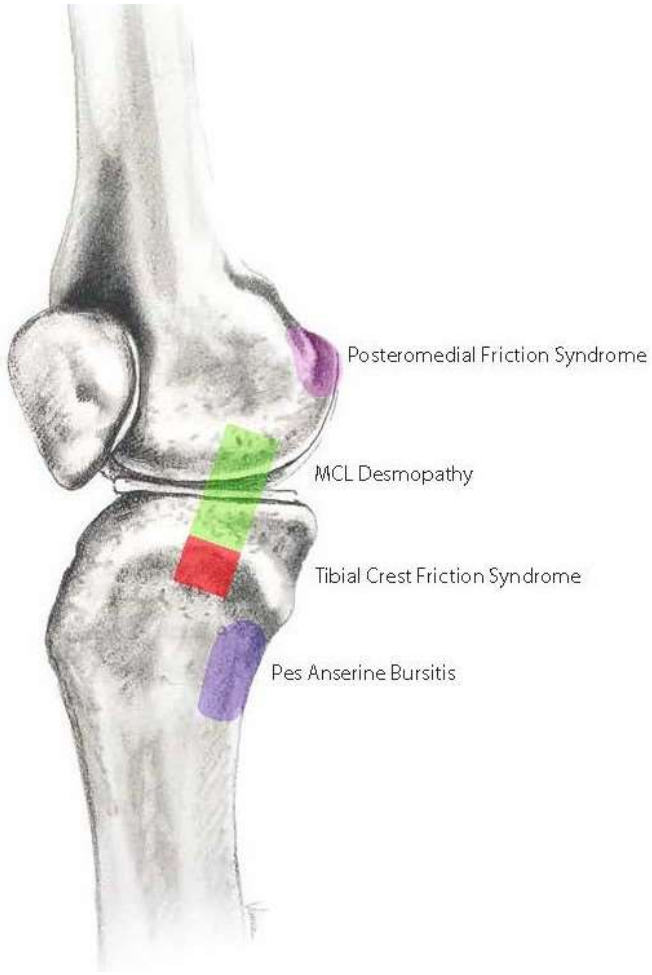

Image 3. Palpation locations for insidious onset medial knee conditions