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Case Report

Simultaneous bilateral posteromedial tibial epiphysis stress fractures in a healthy young man: A case report

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Abstract

We present a compelling case of simultaneous, bilateral tibial stress fractures occurring in a unique epiphyseal and posterior location, with unclear aetiology. An overweight, Caucasian male in his late 20s developed synchronous bilateral medial knee pain following an intense 10-day training regimen. His radiographies were normal, but MRI revealed almost identical bilateral stress fracture lines in the posteromedial tibial epiphyses. Bone mineral densitometry and a full metabolic and hormonal panel were performed to further investigate potential underlying metabolic bone disease. He was found to have normal bone mineral densitometry and low Vitamin D serum values. Symptomatology greatly improved with activity modification. There were no further complaints and complications at 12 months' follow-up. Diagnosis can be challenging and the treating physician should be acquainted with the basic science of stress fractures and main discriminating clinical, biochemical and radiological characteristics from insufficiency fractures, to avoid pitfalls in treatment decision.

Keywords: Athletic Injuries, Bone, Diagnosis, Exercise, Knee

Introduction

Pain in the medial tibial condyle may be a challenging disorder for physicians, particularly if it presents bilaterally and simultaneously. Stress fractures in this particular location are easily misdiagnosed, especially in the absence of risk factors. In the general population including the elderly, microtrabecular insufficiency fractures, also known as "spontaneous osteonecrosis", evolving osteoarthritis with or without meniscal degenerative tear, traumatic meniscal tear and pes anserinus bursitis are included in the differentials[1]. In athletes, meniscal injury, medial collateral ligament sprain, synovial plica entrapment, patellofemoral impingement, chondral pathology, medial tibial crest friction syndrome, and stress fractures are included in the differentials[2]. Stress (fatigue) fractures present more often in athletes or military recruits following sudden increased intensity of the training regimen. They are most commonly unilateral and located in the posteromedial tibia diaphysis followed by the distal third[3,4]. The anterior cortex is a rare location of a high risk fracture of this tension side, and even more rare is the tibial plateau[5,6]. We present herein a unique case of simultaneous bilateral posteromedial tibial epiphysis stress fracture in a healthy individual without underlying causative factors.

Case report

An otherwise healthy, non-smoker, obese (his BMI is 35), adult male patient in his late 20s sought medical assistance following agonizing simultaneous pain in both knees with weight bearing. His Visual Analog Score (VAS) pain was 2/10 at rest but increased to 10/10 with weight bearing, rendering him unable to walk. Pain onset was ten days before

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Table 1. Activity log.

Day	Activity	Distance (in km)
1	Walking	3.4
2	Walking	3.5
3	Running	3.7
4	Walking	5.5
5	Running	6.9
6	Running	2.4
7	Walking Running	5 5.5
8 (onset of pain)	Running	6.5
9	Walking (with bilateral pain)	3.8
10	Walking (with bilateral pain)	3.3
11-13	Rest	0
14	Running (stopped abruptly due to cripling pain - unable to walk)	6

Figure 1. Plain radiographs show no abnormalities.

his first medical consultation, without any history of specific traumatic incident. Prior to pain presentation, the patient had just completed a ten-day training period in order to meet specific criteria to join the police academy. The training consisted of long walks and running sessions on hard tarmac. Before the training period, his lifestyle was rather sedentary. The patient provided a detailed account of his daily training sessions because he was using a specific application on his smart phone (Table 1). He had no previous knee injuries or locking-like symptomatology. The patient denies altering his daily diet habits before, during or after training.

On physical examination, no limb malalignment was present. His knees had no apparent effusion/swelling and there were no skin abnormalities. Temperature of both knees was normal. There was significant tenderness over the medial tibial condyle in a wide area including the medial joint line, the pes anserinus and the medial collateral ligament insertion, consistent with the reporting pain site in both knees. Both passive and active range of motion were full and unrestricted and elicited only mild discomfort. Special tests assessing cruciate ligament instability were within normal range. Valgus force test elicited pain, without gross instability. The McMurray test for medial meniscus was positive for both knees, although the examining physician felt that it was non-specific for the patient's symptomatology. Anteroposterior and lateral plain radiographs of both knees were ordered and were reported back as normal (Figure 1). Simple painkillers were prescribed and non-weight bearing ambulation with a wheelchair was strongly advised. An MRI was requested before his next outpatient appointment.

The MRI revealed almost identical findings for both knees in keeping with medial-posterior epiphyseal stress fractures of the medial tibial condyle (Figures 2 and 3). Posterior slope of the medial tibia plateau, as measured from the sagittal MR images, were found to be 4.14° for the right knee and 5.4° for the left knee[7]. A complete hormonal and metabolic workout was consequently requested, as well as bone mineral densitometry (BMD). PTH was 58.7 pg/mL, serum calcium was 9.6 mg/dL, FT4 was 1,2 ng/dL and TSH was 2,1 mIU/L. The only parameter below normal values was 25(OH) Vitamin D (17 ng/mL, potential deficiency). His BMD, measured at the neck of his non-dominant (left) hip and lumbar spine by dual energy x-ray absorptiometry, were 1,01 g/cm^2 (T-score:0.5 and Z-score:0.1) and 1,166 g/cm^2 (T-score:-0.4 and Z-score:-0.3) respectively, which was within normal range for his age.

The patient was classified as low-risk for an imminent complete fracture. Vitamin D supplementation and typical anticoagulation medication was prescribed and he was directed to continue with no weight bearing (with the use of a wheelchair) for 6 weeks until the next outpatient visit. In his 6 weeks' follow-up consultation, the patient's symptoms had greatly improved. His VAS pain was 0/10 at rest and 5/10 when full weight bearing. He was advised to continue for 6 weeks with protected weight bearing with the use of a walking frame (20% of body weight). The patient continued to improve, his 25(OH) levels normalised and in his next

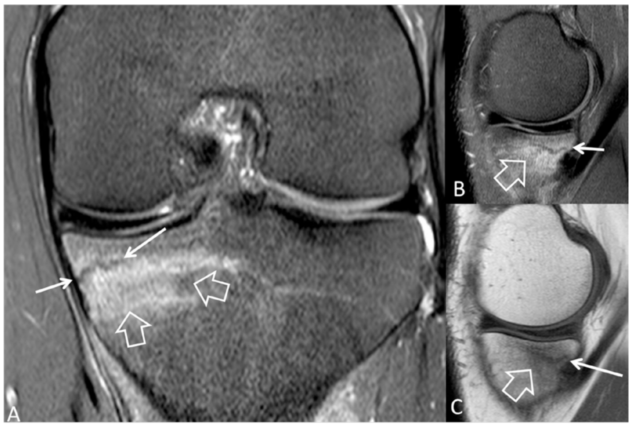

Figure 2. Left knee. The fat-suppressed coronal (a) and sagittal (b) intermediate-weighted and the sagittal T1-weighted (c) MR images showing the epiphyseal irregular low signal intensity fracture line on the medial and posterior tibial epiphysis (arrows) surrounded by bone marrow edema (open arrows).

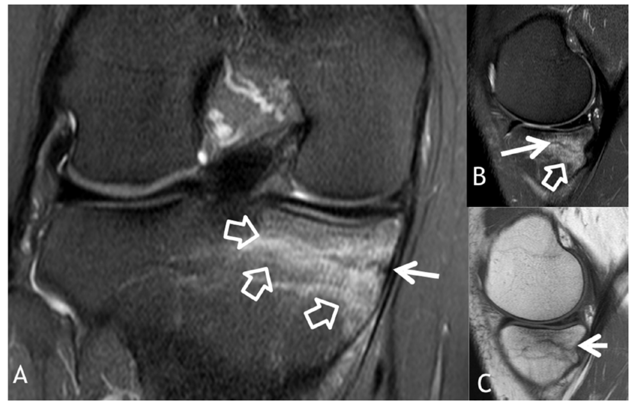

Figure 3. Right knee. The fat-suppressed coronal (a) and sagittal (b) intermediate-weighted and the sagittal T1-weighted (c) MR images showing the epiphyseal irregular low signal intensity fracture line on the medial and posterior tibial epiphysis (arrows) surrounded by bone marrow edema (open arrows).

six weeks' appointment (three months since pain onset), symptomatology was completely resolved and the patient was able to walk pain-free and without support. A 12-month follow-up consultation took place over the phone, the patient continued to be symptom-free, at both rest and exercise. The patient gave full written informed consent for publication of his history and imaging details.

Discussion

Stress fracture is a common entity encountered across all patient demographics. Stress fractures do not occur from a single traumatic event and they are classified as either fatigue when there is increased loading on normal bone or insufficiency when they result from normal forces applied on weak bone. Fatigue fractures in particular, are produced by submaximal loading characterized by increased frequency, duration, or intensity over a relatively short period of time[8]. The pathophysiology is quite simple: when repetitive loading is continued without appropriate rest, the continued loading on a more porous bone may result in a positive feedback cycle of increased strain, microdamage accumulation, and bone resorption due to remodelling, until microcracks coalesce and stress fracture occurs[9]. This more porous bone with decreased elastic modulus, results from repair of microdamage accumulation via coupled remodelling, a paradoxical process that unfortunately takes time. Bone remodelling introduces an acute increase in porosity but may also prevent stress fractures by replacing damaged bone, given time. This process creates two possible candidates susceptible to the possibility of lower extremity stress fracture: a professional or semi-professional athlete suffering from overuse injury after altering his training intensity abruptly or the "weekend warrior" type of athlete, a category that our patient falls in, who only intermittently engages in strenuous activity without regular training[10]. In a recent study, examining the relationship between obesity and risk of stress fracture, risk increased in subjects with high percentage of body fat as calculated by the equation %BF=-7.53+1.43xBMI+0.13xAge-14.73xSex. According to this study, our patient's body fat percentage is at the highest decile and therefore has a 15% greater risk of stress fracture compared to men in the mean body fat decile[11]. Other studies, although some of them are statistically underpowered, have failed to show a relationship between obesity and stress fractures[12-15].

History taking is of utmost importance when stress fractured is suspected. Training regimen, footwear, training surface, and type of sport are modifiable extrinsic causative factors of stress fractures[10]. Pain pattern can also help guide diagnostic process towards or away from neoplastic causes[16]. History alone is not merely enough. The common site for stress fractures is the middle and distal thirds of the tibia. The proximal metaphysis is rarely affected and the proximity to the knee joint can make the diagnosis difficult to differentiate from a lesion within the joint or systematic disease. Furthermore, the treating physician needs to have a thorough knowledge of bone metabolism and disease, to avoid diagnostic and therapeutic pitfalls. Plain x-rays may show the fracture in 50% of cases, in more than 3 weeks after the onset of symptoms. MRI provides the most comprehensive evaluation of stress injuries and is capable of excluding other disorders which might show a similar location of the symptoms[17]. The fracture is demonstrated on MRI with a band-like low signal intensity irregular line corresponding to the fracture, which extends up to the cortex and is surrounded by bone marrow edema[18,19]. Thus, in our patient, the irregular low signal intensity fracture line with surrounding edema on fat suppressed images, had the typical appearance.

Apart from imaging, full and targeted laboratory work is required, such as thyroid and parathyroid function, vitamin D, calcium and phosphorus, in order to exclude and differentiate from insufficiency fractures. Vitamin D levels and BMD do not reliably correlate. PTH appears to predict BMD in a more predictable way, especially in young individuals. Recently published research demonstrates that loss of BMD is observed in vitamin D-deficient adults (both young and old) as long as secondary hyperparathyroidism is present[20]. The serum levels of 25(OH)D may not correlate with BMD, but definite causative relationship between low serum 25(OH)D levels at diagnosis and lower extremity stress fractures has been established among a large young athletic population (military personnel)[21,22]. The minimum 25(OH)D serum level that can guarantee adequate skeletal health in a patient with increased functional demands remains to be determined[23].

Non traumatic fractures in the proximal tibia involving the medial metaphysis, correspond to insufficiency fractures[24]. They tend to occur in the elderly, mainly postmenopausal women, located inferior to the epiphyseal scar[25]. In one study including patients with exercise-induced knee pain, bilateral location was seen in 25% of the cohort and the most common anatomic location was the medial tibial plateau (31%)[26]. However, the "tibial plateau" was not defined and indeed in one figure, it is the medial tibial metaphysis showing the lesion. Bilateral location of proximal tibial stress fractures have been described in case reports[25,27-29] and treating physicians have been misled from the clinical presentation of bilateral proximal tibia pain, performing even unnecessary surgery, before establishing diagnosis[25,28]. However, in all of them, the location was in the metaphysis and in only one report the location of the fracture was posterior[29]. In one Japanese study on the tibial plateau morphology and stress fractures, posterior and medial slope was measured from MRI a small sample of 14 patients with medial proximal tibial fractures[30]. In the aforementioned study, the "tibial plateau" again was not accurately defined and the fractures were located mostly posteriorly or posteromedially (area of greater weight-bearing stress) rather than anteromedially in the metaphysis, not in the epiphysis. The posterior slope in posterior (11.4°) or posteromedial (7.9°) type of fractures was significantly larger than that in anteromedial type (5°). In general, posteromedial and anteromedial posterior slope of medial tibial plateau fractures appeared to be lower than normal reported values (7.8-14.7°). Values range significantly between ethnicities, and different techniques have been used for measurement[7,31-34]. There were no differences between fracture types in relation to the medial slope. Our patient also had a small posterior slope of the medial tibia plateau compared to normal published values.

In runners, tibia stress fractures take up 3.35% of total injuries, and they mostly occur in the middle and distal third of the tibia diaphysis, posteromedially or anteriorly[35-37]. Proximal tibial stress fractures, metaphyseal or epiphyseal are considered a rarity and their incidence remains unknown. Our patient suffered from a stress fracture of both medial tibial epiphyses, an unexpected site, following running. Several biomechanic and simulation studies, have described medial tibial plateau contact stresses during walking, climbing stairs, or running[38-41]. The posterior portion of the medial plateau has been found to endure higher peak contact pressures than the anterior portion in the stance phase of gait at 14% of the gait cycle, which correspond to 15° knee flexion with axial loads of 2280N[38]. Wang et al also reported a contact stress pattern of the medial tibial plateau that consisted of a single peak with an average magnitude of 1.30 MPa during the stance phase of gait, which corresponded to the timing of the first axial force peak during normal gait (also at 14% of the gait cycle)[39]. Akpinar et al found that, during level walking and downhill running, the medial tibial plateau had a greater cartilage contact area across all percentages of the gait cycle (walking: 0-15%, running: 0-10%) versus the lateral compartment and a significantly smaller cartilage contact area during running versus walking from 8% to 10% of the gait cycle. Furthermore, along the tibial anterior-posterior axis, the medial compartment cartilage contact paths were significantly more posterior and longer at each percentage of the gait cycle (0-10%) during downhill running versus level walking[40].

What makes our case unique is the epiphyseal and posterior location of the stress fracture which has not been previously described, to the best of our knowledge. In our patient, MRI shows the typical findings in favor of a fatigue fracture[18]. Possible causative factors include a combined effect of the posterior tibial slope, potential Vitamin D deficiency and the increased BMI, perhaps with a poor technique of running. MRI is not required for follow-up, as the clinical improvement alone allows return to normal activities[42].

In conclusion, even in non-elite athletes, a careful history together with the increased awareness of exercise induced injuries, contribute to early and accurate diagnosis. MRI contributes to fracture detection and treatment planning.

References

1. Karantanas AH, Drakonaki E, Karachalios T, Korompilias AV, Malizos K. Acute non-traumatic marrow edema syndrome in the knee: MRI findings at presentation, correlation with spinal DEXA and outcome. Eur J Radiol 2008;67(1):22-33.
2. Klontzas ME, Akoumianakis ID, Vagios I, Karantanas AH. MR imaging findings of medial tibial crest friction. Eur J Radiol 2013;82(11):e703-6.
3. Feldman JJ, Bowman EN, Phillips BB, Weinlein JC. Tibial stress fractures in athletes. Orthop Clin North Am 2016; 47(4):733-41.
4. Ekenman I, Halvorsen K, Westbald P, Fellander-Tsai L, Rolf C. Local bone deformation at two predominant sites for stress fractures of the tibia: an *in vivo* study. Foot Ankle Int 1998;19(7):479-84.

5. Boden BP, Osbahr DC. High-risk stress fractures: evaluation and treatment. J Am Acad Orthop Surg 2000;8(6):344-53.
6. McCormick F, Nwachukwu BU, Provencher MT. Stress fractures in runners. Clin Sports Med 2012;31(2):291-306.
7. Karimi E, Norouzian M, Birjandinejad A, Zandi R, Makhmalbaf H. Measurement of Posterior Tibial Slope Using Magnetic Resonance Imaging. Arch Bone Jt Surg 2017;5(6):435-49.
8. Bennell KL, Malcolm SA, Brukner PD, Green RM, Hopper JL, Wark JD et al. A 12-month prospective study of the relationship between stress fractures and bone turnover in athletes. Calcif Tissue Int 1998;63(1):80-5.
9. Schaffler MB, Radin EL, Burr DB. Long-term fatigue behavior of compact bone at low strain magnitude and rate. Bone 1990;11(5):321-6.
10. Matcuk GR Jr, Mahanty SR, Skalski MR, Patel DB, White EA, Gottsegen CJ et al. Stress fractures: pathophysiology, clinical presentation, imaging features, and treatment options. Emerg Radiol 2016;23(4):365-75.
11. Knapik JJ, Sharp MA, Montain SJ. Association between stress fracture incidence and predicted body fat in United States Army Basic Combat Training recruits. BMC Musculoskelet Disord 2018;19(1):161.
12. Duckham RL, Peirce N, Meyer C, Summers GD, Cameron N, Brooke-Wavell K. Risk factors for stress fractures in female endurance athletes: a cross-sectional study. BMJ Open 2012;2:e001920.
13. Wakamatsu K, Sakuraba K, Suzuki Y, Maruyama A, Tsuchiya Y, Shikakura J et al. Association between stress fracture and bone metabolism/quality markers in lacrosse players. Open Access J Sports Med 2012;3:67-71.
14. Bennell KL, Malcolm SA, Thomas SA, Ebeling PR, McCrory PR, Wark JD, et al. Risk factors for stress fractures in female track-and-field athletes: a retrospective analysis. Clin J Sports Med 1995;5:229-35.
15. Mattila VM, Niva M, Kiuru M, Pihlajamäki H. Risk factors for bone stress injuries: a follow-up study of 102,515 person-years. Med Sci Sports Exerc 2007;39(7):1061-6.
16. Muthukumar T, Butt SH, Cassar-Pullicino VN. Stress fractures and related disorders in foot and ankle: plain films, scintigraphy, CT, and MR Imaging. Semin Musculoskelet Radiol 2005;9(3):210-26.
17. Sofka CM. Imaging of stress fractures. Clin Sports Med 2006;25(1):53-62, viii.
18. Moran DS, Evans RK, Hadad E. Imaging of lower extremity stress fracture injuries. Sports Med 2008;38(4):345-56.
19. Lee JK, Yao L. Stress fractures: MR imaging. Radiology 1988;169(1):217-20.
20. Sayed-Hassan R, Abazid N, Koudsi A, Alourfi Z. Vitamin D status and parathyroid hormone levels in relation to bone mineral density in apparently healthy Syrian adults. Arch Osteoporos 2016;11:18.
21. Dao D, Sodhi S, Tabasinejad R, Peterson D, Ayeni OR, Bhandari M et al. Serum 25-Hydroxyvitamin D Levels and Stress Fractures in Military Personnel: A Systematic Review and Meta-analysis. Am J Sports Med 2015;43(8):2064-72.
22. Armstrong RA, Davey T, Allsopp AJ, Lanham-New SA, Oduoza U, Cooper JA et al. Low serum 25-hydroxyvitamin D status in the pathogenesis of stress fractures in military personnel: An evidenced link to support injury risk management. PLoS One 2020;15(3):e0229638.
23. Priemel M, von Domarus C, Klatte TO, Kessler S, Schlie J, Meier S et al. Bone mineralization defects and vitamin D deficiency: histomorphometric analysis of iliac crest bone biopsies and circulating 25-hydroxyvitamin D in 675 patients. J Bone Miner Res 2010;25(2):305-12.
24. Berger FH, de Jonge MC, Maas M. Stress fractures in the lower extremity. The importance of increasing awareness amongst radiologists. Eur J Radiol 2007;62(1):16-26.
25. Scaglione M, Fabbri L, Dell'Omo D, Gambini F, Di Rollo F, Guido G. A case of bilateral stress fractures in an old woman: three years of pain. Clin Cases Miner Bone Metab 2014;11(2):149-52.
26. Niva MH, Kiuru MJ, Haataja R, Pihlajamäki HK. Bone stress injuries causing exercise-induced knee pain. Am J Sports Med 2006;34(1):78-83.
27. Carroll JJ, Kelly SP, Foster JN, Mathis DA, Alderete JF. Bilateral proximal tibia stress fractures through persistent physes. Case Rep Orthop 2018;2018:8181547.
28. Animashawun AM, Bhattee G, Ravikumar K. Bilateral tibial stress fractures: a case report. Eur J Orthop Surg Traumatol 2012;22(Suppl 1):189-91.
29. Posadzy M, Vanhoenacker F. Bilateral synchronous stress fracture of the tibia in a young female basketball player. J Belg Soc Radiol 2016;100(1):61-4.
30. Yukata K, Yamanaka I, Ueda Y, Nakai S, Ogasa H, Oishi Y et al. Medial tibial plateau morphology and stress fracture location: A magnetic resonance imaging study. World J Orthop 2017;8(6):484-90.
31. Mohamad Qoreishi M, Syavash Hemmati M, Ali Sina Shahi M, Mehrnoush Hassas Yeganeh M, Kazemi SM. Measurement of posterior tibial slope (a cross- sectional study in Tehran). JBS J 2015;2(1):10-5.
32. Matsuda S, Miura H, Nagamine R, Urabe K, Ikenoue T, Okazaki K et al. Posterior tibial slope in the normal and varus knee. Am J Knee Surg 1998;12(3):165-8.
33. Chiu KY, Zhang SD, Zhang GH. Posterior slope of tibial plateau in Chinese. J Arthroplasty 2000;15(2):224-7.
34. Hosseinzadeh HR, Zandi R, Kazemi SM, Qoreishi SM, Shahi S, Safdari F et al. Measurement of posterior tibial slope (a cross-sectional study in Tehran). Iran J Orthop Surg 2011;9(2):61-4.
35. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med 2002;36(2):95-101.
36. Gallo RA, Plakke M, Silvis ML. Common leg injuries of long-distance runners: anatomical and biomechanical approach. Sports Health 2012;4(6):485-95.

37. Drabicki RR, Greer WJ, DeMeo PJ. Stress fractures around the knee. Clin Sports Med 2006;25(1):105-15, ix.
38. Bedi A, Kelly NH, Baad M, Fox AJ, Brophy RH, Warren RF et al. Dynamic contact mechanics of the medial meniscus as a function of radial tear, repair, and partial meniscectomy. J Bone Joint Surg Am 2010; 92(6):1398-1408.
39. Wang H, Chen T, Torzilli P, Warren R, Maher S. Dynamic contact stress patterns on the tibial plateaus during simulated gait: a novel application of normalized cross correlation. J Biomech 2014;47(2):568-74.
40. Akpinar B, Thorhauer E, Tashman S, Irrgang JJ, Fu FH, Anderst WJ. Tibiofemoral Cartilage Contact Differences Between Level Walking and Downhill Running. Orthop J Sports Med 2019;7(4):2325967119836164.
41. Gilbert S, Chen T, Hutchinson ID, Choi D, Voigt C, Warren RF et al. Dynamic contact mechanics on the tibial plateau of the human knee during activities of daily living. J Biomech 2014;47(9):2006-12.
42. Karantanas AH. Natural history and monitoring of fractures and microfractures. In: Vanhoenacker FM, Maas M, Gielen JL, editors. Imaging of Orthopedic Sports Injuries. Springer 2007; p. 469-487.