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Case Report

Revisiting the important role of magnetic resonance imaging (MRI) in long bone acute osteomyelitis: A case report of methicillin resistant *Staphylococcus aureus* acute tibial osteomyelitis with conventional radiography, computed tomography, and MRI ☆,☆☆

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ABSTRACT

The tibia is an atypical site of osteomyelitis (OM) in adults, and patients with this infection experience a significant degree of morbidity as well as the need for prolonged aggressive antibiotic therapy. The early diagnosis of OM remains challenging, and often relies on imaging modalities which are of variable sensitivity. We present a case of a 49-year-old male with a methicillin resistant *Staphylococcus aureus* (MRSa) left tibial OM, contiguous left knee septic arthritis, and concurrent bacteraemia. Eight days after the onset of pain in the left knee and lower limb, conventional radiography and computed tomography (CT) imaging had only subtleties of a soft tissue collection and a knee effusion. A MRI demonstrated significant involvement of his tibial bone with a collection, from which surgical specimens confirmed MRSa. This case demonstrates the difficulty of diagnosing early acute OM with conventional radiography and CT imaging, even after a week of symptoms in the affected limb. Given the

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poor sensitivity of conventional radiography and CT in the diagnosis of early acute OM, this case report illustrates how MRI is the imaging modality of choice in this setting.

Introduction

Acute osteomyelitis (OM), a bacterial infection of the bone, is a serious condition which has the potential to result in significant morbidity and high economic impacts on both the individual and the health care systems. It can develop as a complication of contiguous spread from an overlying soft tissue or joint infection, direct inoculation via an open fracture, following surgical or other procedures, or via haematogenous seeding [1]. OM has a bimodal age distribution, with acute and subacute haematogenous OM more common in children and the metaphysis of long bones being the primary site of pediatric infection [2]. In adults, direct inoculation of bone is the more common mechanism of bone infection, typically associated with open trauma in young adults, with contiguous soft tissue infection in diabetics, and with implant surgery such as hip and knee replacements in older adults. Typical sites of nonimplant-associated adult OM are the tarsal, metatarsal, toe and vertebral bones.

Adults at increased risk for hematogenous OM include intravenous drug users, patients with indwelling catheters, the immunosuppressed, and those with compromised vascular supply [3,4]. The majority of acute OM cases are monomicrobial and usually caused by *Staphylococcus aureus,* both methicillin sensitive and methicillin resistant. Polymicrobial infections are more likely to be seen on OM complicating a contiguous focus of sepsis or open trauma. In this setting, common microorganisms including coagulase negative staphylococci, streptococci, enterococci, *Pseudomonas aeruginosa,* the Enterobacterales (enteric Gram-negative rods), anaerobes, and in some epidemiological contexts *Mycobacterium tuberculosis* [1,5–7].

Goals of OM therapy includes eradication of infection, minimization of complications, and the restoration of functionality. For this to occur, many patients require a combination of both medical treatment and surgical intervention to ensure adequate drainage of all infected tissue and removal of any hardware present. However, the diagnosis of acute OM remains a challenge in clinical practice. Along with the assessment of history, clinical examination, microbiological and biochemical laboratory results, the use of imaging is central to the diagnosis of OM.

Plain X-rays are the initial imaging modality of choice and are useful in detecting noninfectious bony disease and more advanced sequelae of OM, such as destructive changes of the bone. However, plain films are of variable sensitivity and early infection may not be evident on the initial images [8]. Computed tomography (CT) also has utility in the setting of OM, where it is particularly useful in detection of sequestrum in the setting of chronic OM [9]. As with plain X-rays, though, CT is limited in its ability to demonstrate bone marrow oedema which is a key feature of acute OM [10]. Hence CT scans are often not diagnostically useful in the acute setting. Magnetic resonance imaging (MRI) on the other hand, appears to be the most sensitive imaging modality in acute OM and can demonstrate early features of infection such as bone marrow oedema just days after infection onset [11,12]. In a meta-analysis of the accuracy of diagnostic tests for OM in diabetic patients with foot ulcers, Dinh et al. showed that plain radiography had a sensitivity of 0.54 and a specificity of 0.68 whereas MRI had a sensitivity of 0.90 and a specificity of 0.79 [8]. Furthermore MRI has the ability to detect associated soft tissue changes and micro-abscesses whether intraosseous or extraosseous which can assist in surgical drainage targets and source control [13].

In this case report, we describe a patient with acute tibial OM secondary to haematogenous dissemination who did not have diagnostic features of OM on conventional radiographs or CT. He had vivid features of OM on MRI, supporting the notion that acute OM may often require MRI for diagnosis when initial conventional imaging is unremarkable.

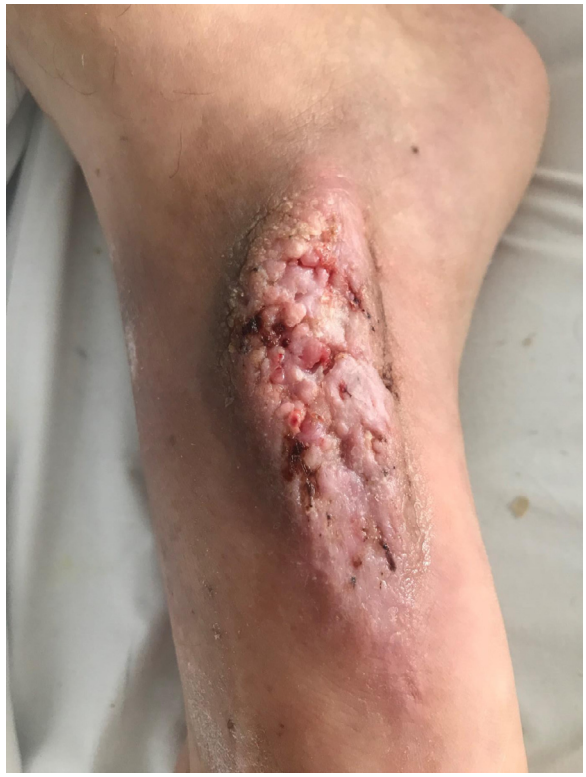

Fig. 1 – Right medial foot ovoid lesion.

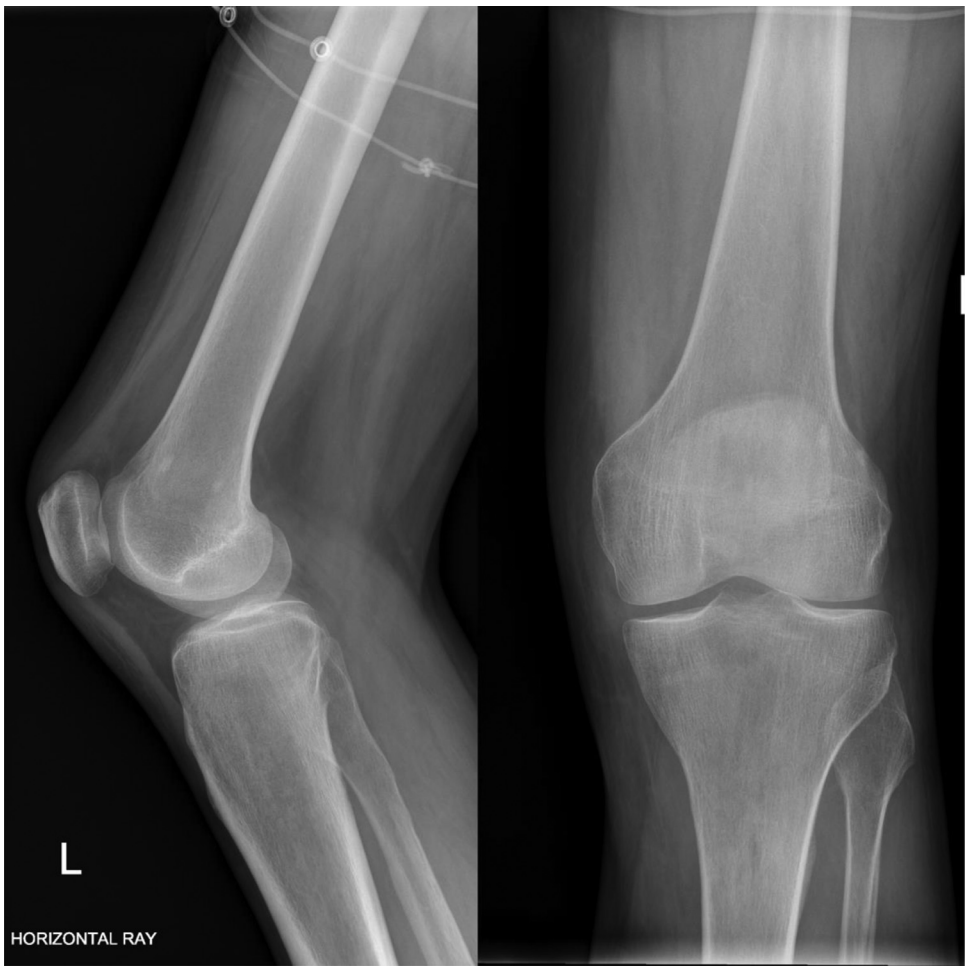

Fig. 2 – Horizontal and frontal plain films of the left knee demonstrate a small knee joint effusion. There is no aggressive periosteal reaction, or cortical destruction.

Case presentation

A 49-year-old Caucasian male who presented with a 7-day history of fevers, progressive knee pain, and limited range of motion in his left lower limb. Presentation for medical review was delayed due to concerns regarding Coronavirus disease 2019 infection (COVID-19). He had a background history of intravenous injecting drug use 10 years prior, current oral opioid maintenance, and a recent prolonged hospital admission for a left sacroiliac OM and a right wrist septic arthritis caused by *Bacteroides fragilis* and *Streptococcus agalactiae*. This had required removal of metal hardware and multiple washouts. The patient further reported a right dorsal foot injury 3 months prior to admission where he sustained a cut from an oyster which had developed into a chronic wound which was described to have had purulent discharge in the weeks prior to admission. Other relevant history included a long history of motocross sporting injuries with multiple long bone fractures in his upper limbs and previous skin grafts to these sites.

The patient's vital signs were all within normal limits and he was afebrile. Physical examination revealed warmth over the left lower limb at the tibial plateau and the left knee. The knee had no clinically evident effusion and preserved passive range of motion. The patient had mild peripheral oedema of the left leg in comparison to the right. There was no erythema, overlying skin lesion or indication of recent trauma in the left leg. He had an ulcerated ovoid wound (8 × 5 cm) over his right foot (see Fig. 1) with minor purulent discharge. There was no erythema, pain, warmth or tenderness over his left sacroiliac area or right wrist, the sites of his previous infection. His cardiorespiratory and gastrointestinal tract examination were unremarkable.

Admission investigations revealed that he had a raised white cell count of 16 × 10^9/L with a neutrophilia of 13.8 × 10^9/L. His hemoglobin was 105 with a microcytosis, his platelet count was 413 and his C-reactive protein was 212. He had normal renal function and only trivial derangement of liver function tests. Blood cultures taken on admission grew a nonmultiresistant methicillin resistant *S. aureus* with a Vancomycin minimal inhibitory concentration of 1 μg/mL. A swab of the right foot wound grew MRSa sensitive to Rifampicin, Fusidic acid, Trimethoprim/Sulfamethoxazole, Doxycycline and Clindamycin. Surgical specimens from the left knee and tibial washout grew an identical MRSa.

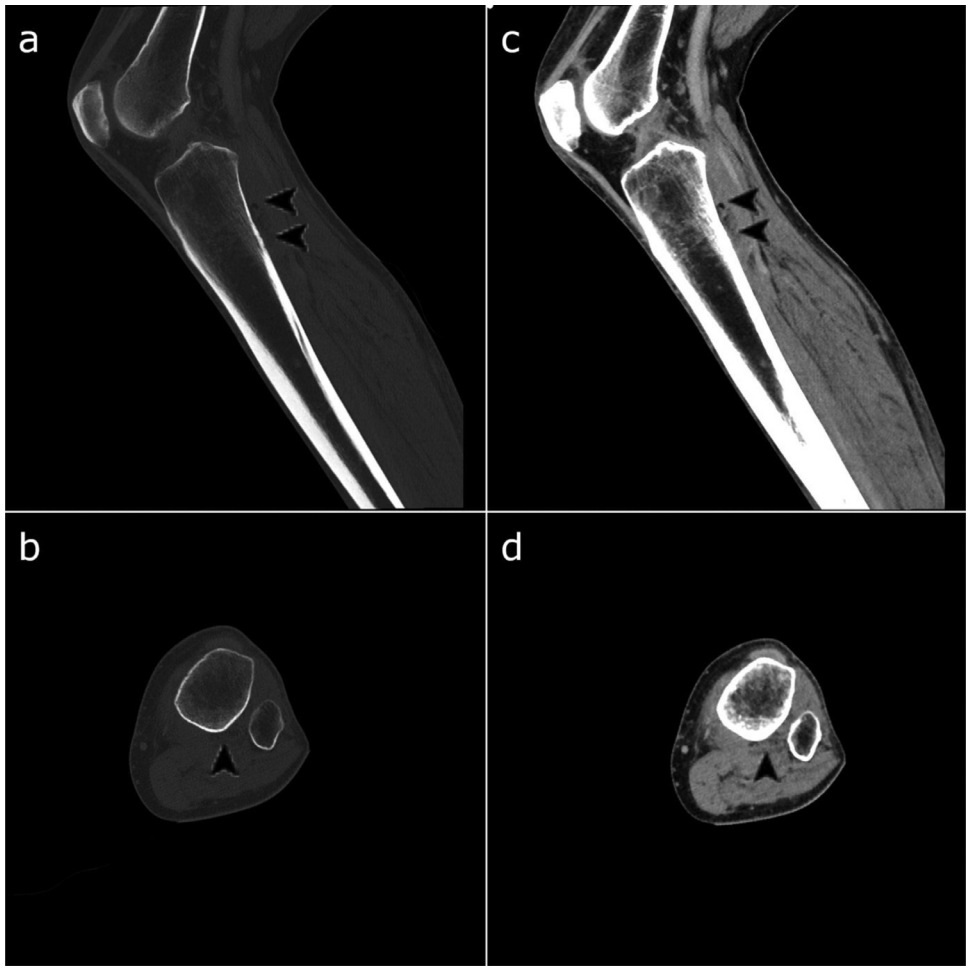

Fig. 3 – Selected sagittal and axial slices in bone (a and b) and soft tissue (c and d) windows demonstrating a small fluid collection abutting the posterior cortex of the proximal tibia (arrowheads). No underlying periosteal reaction or cortical destruction is evident.

X-ray imaging of the patient's left knee demonstrated a small joint effusion (see Fig. 2). There were no erosive or destructive changes. X-ray of the right foot was noncontributory. On CT of the left leg there was no bony erosion, periostitis, acute fracture, or left knee effusion identified (see Fig. 3). There was a small volume of complex fluid between the medial head of the gastrocnemius and soleus muscles, which was suggested to be an acute rupture of the plantaris tendon, although clinically this was unlikely in the absence of acute onset pain.

With the patient's ongoing pain, raised inflammatory markers and the identification of MRSa bacteraemia, there was a suspicion of tibial OM. MRI performed on day 12 after symptom onset demonstrated heterogeneous marrow signal with areas of T2 weighted hyperintense confluent change and patchy enhancement following Gadolinium administration in the proximal tibia, as well as a multilobulated collection extending along the posterior cortex (see Fig. 4). There was a small infected suprapatellar joint effusion and increased oedema in Hoffa's fat pad. On subsequent MRI imaging a week later, a focal defect in the posterior cortex of the tibia at the proximal metaphysis was visualized, highlighting the anatomical path of contiguous spread from the tibia into the left knee joint.

Following diagnostic confirmation of the patient's acute OM by the MRI scan, he underwent an operative washout of the areas of bony infection. Intravenous Vancomycin and oral Clindamycin 450mg 4 times daily were administered. The infected right foot wound, which presumably represented the original portal of entry of his bloodstream infection, was treated with bedside debridement, Microdacyn spray and compression bandaging. Following these interventions, the patient improved significantly, and further blood cultures were negative for MRSa. A minimum of 6 weeks aggressive antimicrobial therapy was planned.

Discussion

This case illustrates the diagnostic challenges often encountered in a patient clinically suspected to have acute haematogenous OM. Despite clinical features, microbiological and other laboratory findings that supported a diagnosis of

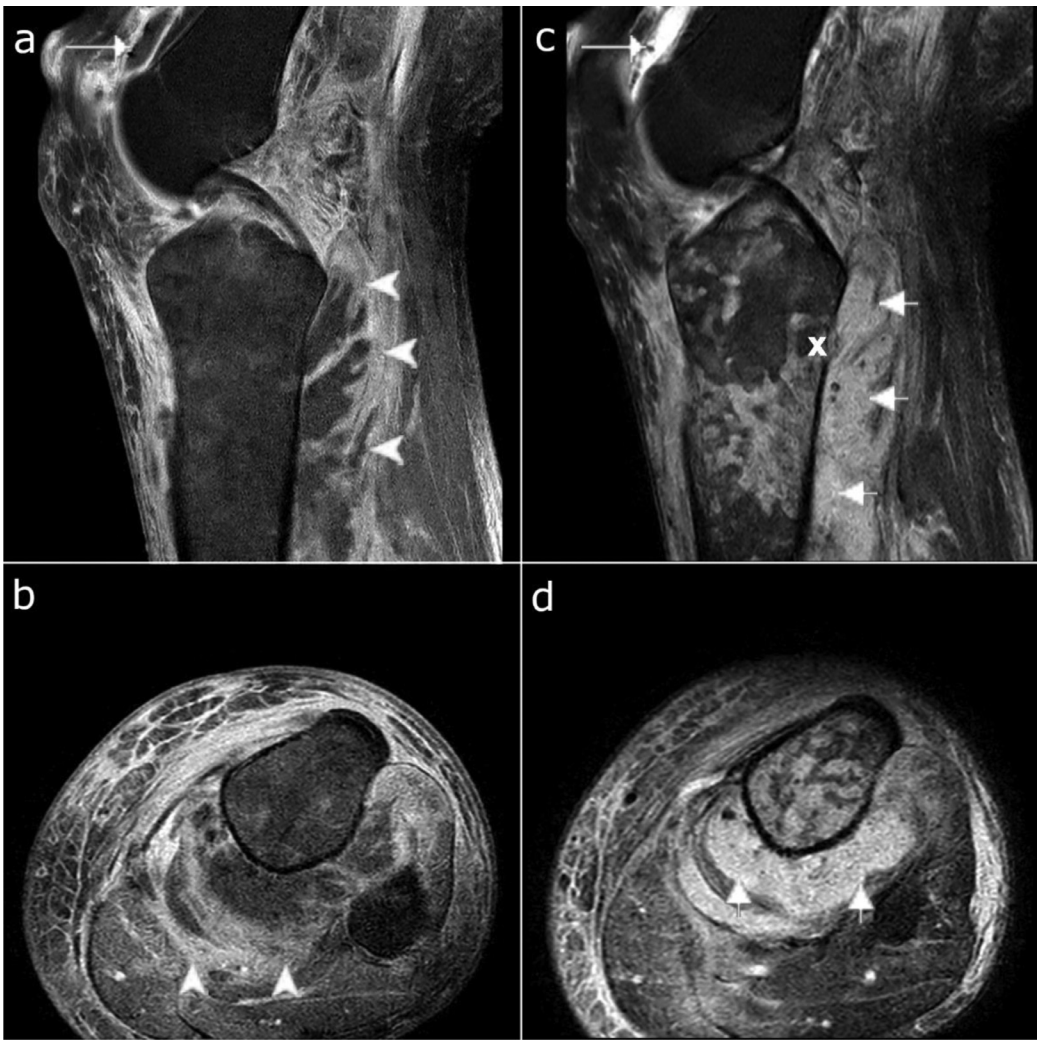

Fig. 4 – Selected sagittal and axial slices, T1 spectral presaturation with inversion recovery following the administration of gadolinium (a and b), and T2 fat saturation (c and d) sequences demonstrate marked marrow oedema in the proximal tibia with patchy gadolinium enhancement. There is a focal area (x) of cortical thinning with possible breach. No intraosseous abscess is visible. There is an adjacent fluid collection (short arrows) with peripheral enhancement consistent with abscess formation (arrowheads). Oedema and enhancement extend to the soft tissues, involving Hoffa's fatpad, the adjacent musculature, and subcutaneous tissues. There is also a small enhancing suprapatellar effusion (long arrow) suggesting articular involvement.

OM, the patient's initial tibial imaging results by conventional radiography and CT were unconvincing. Further assessment by MRI was required before a definitive diagnosis could be made and hence appropriate medical and surgical treatment initiated. This underscores the importance of pursuing bone imaging in the form of MRI in the setting of suspected early acute OM, particularly when the clinical concern for bone infection presentation is unsupported by the conventional radiography and CT findings. Despite its demonstrable utility, the limited availability of MRI and contraindications to using this modality make the appropriate imaging pathway for acute OM an ongoing challenge.

While MRI confers several advantages in the diagnosis of OM, there are several instances and settings where MRI may not be practicable or possible, placing significant limitations on its utility [10]. Some contraindications include devices, such as permanent pacemakers not compatible with MRIs, or metallic foreign objects in certain locations, such as in the eye, and even aneurysm coils that have been inserted previously. In addition, imaging artifacts from metallic hardware or prostheses may obscure findings despite the use of modern artifact suppression techniques. Similarly, hardware artifacts may also complicate CT interpretation in suspected prosthesis-associated infections. MRI is still not widely available in certain practice settings, particularly in remote and rural healthcare environments. In certain patient populations assessment with MRI may also be difficult, such as patients with claustrophobia or those who may require

general anesthesia, such as those with movement disorders or young children.

Alternative imaging methods for acute OM may also be considered in settings where MRI may not be practicable, such as the use of nuclear imaging modalities and dual energy-CT. Several nuclear imaging techniques may be considered, including positron emission tomography (PET) scans, 3-phase bone scans, and tagged white blood cell scans. In these scans, areas of increased uptake of injected radionuclide can be detected by a gamma camera, and correspond with areas of abnormal bone metabolism suggesting the presence of OM [9]. A recent meta-analysis by Treglia et al. suggested that Fluorine-18-labeled fluorodeoxyglucose PET imaging and PET/CT imaging were useful in the suspected OM related to diabetic foot with high specificity [14]. However, several other pathological processes can also result in abnormal bone metabolism, such as degenerative bone disease or tumors. There may also be poor anatomical localization of disease, even when CT co-registered images are produced, usually inferior to that achieved with MRI [15]. There has also been interest in the applications of dual energy-CT (DECT), where it has several uses, such as in the detection of monosodium urate deposition in gout, and in the detection of bone marrow oedema, particularly in the setting of fractures [16]. A systematic review by Suh et al., which included 12 studies, that assessed the sensitivity and specificity of DECT in detecting bone marrow oedema found that DECT had excellent sensitivity and specificity for bone marrow oedema detection, with a pooled specificity of 0.97 and a pooled sensitivity of 0.85 [17]. More recently, Muller et al. investigated the utility of DECT, in comparison to MRI, in assessing bone marrow oedema and fracture in those with wrist trauma and suspected wrist fracture who had negative radiographs, and found that in terms of detection of bone marrow oedema, DECT had a high specificity and moderate sensitivity [18]. However, despite increasing evidence in the use DECT in bone marrow oedema detection, whether this translates to better diagnostic utility in acute OM compared to other more established imaging modalities remains uncertain and hence should be the subject of further future research directions.

Conclusion

Acute haematogenous long bone OM with contiguous spread into an adjacent joint is a rare occurrence in adults in modern times, although it was well described in the preantibiotic era. At the onset of OM, imaging studies including conventional radiography and CT may appear unremarkable, lacking features suggestive of acute active infection. This case report highlights the significant disease severity that can be demonstrated on a MRI in the setting of a normal conventional radiography and computed tomography imaging. Whilst there are several practical limitations to the use of MRI that may preclude its universal use, this case underscores its potential utility in the early diagnosis of acute OM in order that timely and appropriate management and treatment can be initiated in such patients.

REFERENCES

[1] Lew DP, Waldvogel FA. Osteomyelitis. Lancet 2004;364(9431):369–79.
[2] Mader JT, Shirtliff M, Calhoun JH. The host and the skeletal infection: classification and pathogenesis of acute bacterial bone and joint sepsis. Best Pract Res Clin Rheumatol 1999;13(1):1–20.
[3] Bennett JE, Dolin R, Blaser MJ. Mandell, Douglas, and Bennett's principles and practice of infectious diseases. 9 ed. Saunders: Elsevier; 2019.
[4] Radcliffe G. (iii) Osteomyelitis–a historical and basic sciences review. Orthop Trauma 2015;29(4):243–52.
[5] del Pozo EG, Collazos J, Cartón JA, Camporro D, Asensi V. Bacterial osteomyelitis: microbiological, clinical, therapeutic, and evolutive characteristics of 344 episodes. Revista Española de Quimioterapia 2018;31(3):217.
[6] Brook I. Microbiology and management of joint and bone infections due to anaerobic bacteria. J Orthop Sci 2008;13(2):160–9.
[7] Kremers HM, Nwojo ME, Ransom JE, Wood-Wentz CM, Melton LJ III, Huddleston PM III. Trends in the epidemiology of osteomyelitis: a population-based study, 1969 to 2009. J Bone Joint Surg Am Vol 2015;97(10):837.
[8] Dinh MT, Abad CL, Safdar N. Diagnostic accuracy of the physical examination and imaging tests for osteomyelitis underlying diabetic foot ulcers: meta-analysis. Clin Infect Dis 2008;47(4):519–27.
[9] Pineda C, Espinosa R, Pena A, editors. Radiographic imaging in osteomyelitis: the role of plain radiography, computed tomography, ultrasonography, magnetic resonance imaging, and scintigraphy. Seminars in plastic surgery. © Thieme Medical Publishers; 2009.
[10] Lee YJ, Sadigh S, Mankad K, Kapse N, Rajeswaran G. The imaging of osteomyelitis. Quant Imaging Med Surg 2016;6(2):184.
[11] Simpfendorfer CS. Radiologic approach to musculoskeletal infections. Infect Dis Clin 2017;31(2):299–324.
[12] Jaramillo D. Infection: musculoskeletal. Pediatr Radiol 2011;41(1):127–34.
[13] Hayeri MR, Ziai P, Shehata ML, Teytelboym OM, Huang BK. Soft-tissue infections and their imaging mimics: from cellulitis to necrotizing fasciitis. Radiographics 2016;36(6):1888–910.
[14] Treglia G, Sadeghi R, Annunziata S, Zakavi SR, Caldarella C, Muoio B, et al. Diagnostic performance of Fluorine-18-Fluorodeoxyglucose positron emission tomography for the diagnosis of osteomyelitis related to diabetic foot: a systematic review and a meta-analysis. The Foot 2013;23(4):140–8.
[15] Gross T, Kaim AH, Regazzoni P, Widmer AF. Current concepts in posttraumatic osteomyelitis: a diagnostic challenge with new imaging options. J Trauma Acute Care Surg 2002;52(6):1210–19.
[16] Nicolaou S, Liang T, Murphy DT, Korzan JR, Ouellette H, Munk P. Dual-energy CT: a promising new technique for assessment of the musculoskeletal system. Am J Roentgenol 2012;199(5_Suppl):S78–86.
[17] Suh CH, Yun SJ, Jin W, Lee SH, Park SY, Ryu C-W. Diagnostic performance of dual-energy CT for the detection of bone marrow oedema: a systematic review and meta-analysis. Eur Radiol 2018;28(10):4182–94.
[18] Müller FC, Gosvig KK, Børgesen H, Gade JS, Brejnebøl M, Rodell A, et al. Dual-energy CT for suspected radiographically negative wrist fractures: a prospective diagnostic test accuracy study. Radiology 2020:192701.