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Scintigraphy for Diagnosis of Pediatric Osteomyelitis

Pediatrik Osteomiyelit Tanısında Sintigrafi

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ABSTRACT
If osteomyelitis in the childhood period is not treated appropriately or if it is not diagnosed early, it may become a difficult disease causing permanent disability. There are many imaging methods used for diagnosis. If scintigraphy is considered, it provides findings for suspected cases before direct radiography does. In this study, the use of scintigraphy and new techniques in the diagnosis of pediatric osteomyelitis were reviewed in the light of the current literature.
Keywords: Pediatric, Osteomyelitis , Scintigraphy, ^{99m}Tc-MDP

ÖZET
Çocukluk çağı osteomiyeliti uygun tedavi edilmediğinde ya da erken tanı konulamadığında kalıcı sakatlık bırakabilen zor bir hastalıktır. Tanıda kullanılan birçok görüntüleme yöntemi vardır. Sintigrafi akla gelmesi durumunda şüphelenilen olgularda direkt grafiden önce bulgu vermektedir. Bu çalışmada çocukluk çağı osteomiyelit tanısında sintigrafi ve yeni teknikleri güncel literatür eşliğinde göz önüne alınarak incelenmiştir.
Anahtar Kelime: Pediatrik, Osteomiyelit, Sintigrafi, ^{99m}Tc-MDP

Introduction

Early diagnosis of acute hematogeneous osteomyelitis is very important for the effective treatment of the disease and to prevent life-long deformity in the child[1]. Bone scintigraphy is a sensitive tool to assess the musculoskeletal system in children[2]. Scintigraphy is commonly used for pediatric sport trauma, emergency trauma assessment and pediatric neoplasm diagnosis[2,3,4]. Diagnosis of pediatric osteomyelitis is frequently difficult[5]. In normal circumstances for radiography, scintigraphy may be reliably used for diagnosis[5]. The aim of this review is to investigate the place of bone scintigraphy and current varieties for diagnosis of pediatric osteomyelitis cases in light of the literature.

Pediatric osteomyelitis and scintigraphy

Pediatric osteomyelitis is most commonly observed in long bone metaphyses. Neonatal infection is generally bacterial and multifocal[6,7]. To make accurate diagnosis of osteomyelitis, it is necessary to correctly use a variety of imaging methods. Conventional radiography is always the imaging modality primarily used. Ultrasonography (US) may be used to show fluid collection and changes in soft tissue and during aspiration, drainage and tissue biopsy. Computed tomography (CT) may be useful to show early bone erosion, sequestrum, foreign objects and gas formations, but has less sensitivity compared to other imaging modalities. Magnetic Resonance Imaging (MRI) is the most sensitive and specific imaging method due to showing soft tissue and bone variations in osteomyelitis with anatomic details. Scintigraphy is beneficial, especially for multifocal bone assessment[6,7].

There are many different imaging methods to visualize pediatric osteomyelitis (Table 1). Firstly direct radiography is performed. Unfortunaley radiographic changes may be visible after 7th-10th days of infection (Figure 1). Therefore, radiography may not detect infection[8,9,5]. While 5% changes in bone turnover can be identified with scintigraphy, by the time radiographic variations are observed bone mineralization loss is between 30-50%[10,11,5].

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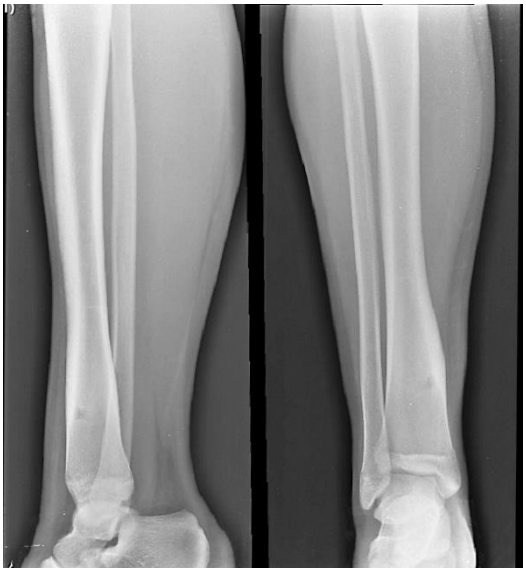

Figure 1. Direct radiography showing osteomyelitis area on the tibia distal metaphysis in a 15-year old male patient.

Table 1. Diagnostic tools for evaluation of pediatric osteomyelitis

Method	**Clinical setting**
Radiography	First applied method
Ultrasonography	Fluid collection and changes in soft tissue
Computed tomography	Early bone erosion, sequestrum
Magnetic Resonance Imaging	Detailed soft tissue anatomical information
Three phase bone scintigraphy	Acute osteomyelitis
SPECT/CT	MRI contraindicated patients
PET/MRI	Detailed soft tissue anatomical information
^{18}F-NaF PET/CT	Detailed anatomic localization
^{18}F-FDG PET/CT	Chronic osteomyelitis

Three phase bone scintigraphy namely dynamic bone scan is performed in three phases; perfusion phase, blood pool phase and bone phase. Technetium-99m (^{99m}Tc) labeled diphosphonates as radiopharmaceutical agents are used for bone scintigraphy. This radioactive agent is injected to patient through intravenous (i.v.) way. Perfusion and blood pool phases' images are taken according to patient's symptomatic area such as thorax, pelvis, lower extremity etc. These phases also called early phases. The first phase (perfusion phase) is carried out dynamically. In other words, while patient lies down under the gamma camera, as soon as radiopharmaceutical is administrated to patient, perfusion phase images are achieved (first 2 min). The first phase consists of multiple images (etc 15-20 images). The second phase (blood pool phase) is achieved following first phase (2–5 min after injection). The third phase (bone phase, static phase, late phase) is generally performed 2-3 hours later after i.v. injection[12].

Pediatric scintigraphy is most commonly used for extremity or back pain, suspected trauma, infection, early stage tumor or inflammation diagnosis[2]. Disease history and physical examination findings should be assessed together with scintigraphy findings[2]. Scintigraphy can be used for diagnosis of trauma when the pain is not localized or the child cannot express themselves[2]. Bone scintigraphy screens the whole body and provides information about bone and soft tissue variations[2]. Scintigraphy is used for diagnosis areas of trauma, low back pain, chronic regional pain syndrome, infection and neoplasm among children[2]. Scintigraphy is not sensitive for findings of less than 24 hours in cases suspected of osteomyelitis[2]. Another topic that should not be forgotten is that in children younger than 2 years, osteomyelitis generally has

hematogeneous distribution and is multifocal[2]. Another osteomyelitis type showing multifocal distribution is chronic nonbacterial osteomyelitis[2]. This type generally affects children in the adolescent period. The scintigraphy findings of these two types of osteomyelitis are similar[2].

Normally, bone is resistant to infection. However, osteomyelitis may occur in situations with trauma, bacteremia, surgery or foreign objects. As osteomyelitis causes progressive destruction of bone, treatment is difficult. Imaging methods play a key role in early diagnosis and monitoring of osteomyelitis[7].

Ten to fourteen days before direct radiography, scintigraphy may observe osteomyelitis changes. A variety of agents are used for scintigraphy. These include technetium-99m methylene diphosphonate (^{99m}Tc-MDP), Gallium-67 citrate and indium -111- labeled White blood cell (Figure 2). For children, ^{99m}Tc-MDP is most commonly used for osteomyelitis[13,14]. On scintigraphy, osteomyelitis is difficult to differentiate from crystal arthropathy, arthritis, fractures, neoplasms and cellulitis[7]. Gallium scintigraphy is linked to gallium transfer. It shows increased involvement in sterile inflammatory situations and malignancy[15].

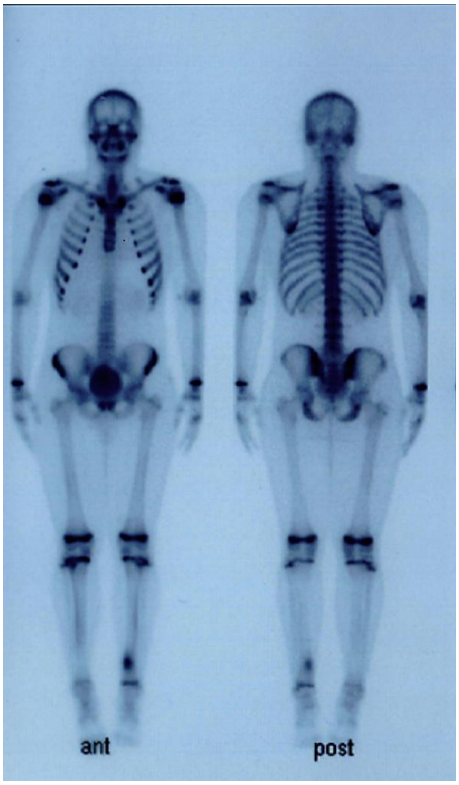

Figure 2. Tc-99 MDP whole body bone scintigraphy image of the same patient with focal increased activity involvement of the distal tibia observed.

Single Photon Emission Computed Tomography

Planar bone images may not show some lesions. As a result, single photon emission computed tomography (SPECT) is used to increase sensitivity for bone screening. SPECT is an imaging method equal to CT and MRI. In addition to the area suspected of osteomyelitis, it may ensure the whole bone is screened. Additionally, SPECT remains weak for some anatomic localizations[16,17].

Single Photon Emission Computed Tomography/ Computed Tomography

Single Photon Emission Computed Tomography/ Computed Tomography (SPECT/CT) is a hybrid imaging method. SPECT is combined with multi-slice CT. SPECT/CT is very beneficial for musculo-

skeletal system disorders in extremities with abnormal bone turnover like osteomyelitis. SPECT/CT may be used in situations where osteomyelitis is suspected on direct radiography, situations where MRI is contraindicated and where MRI cannot be used due to metal implants. In addition to the use of very low dose CT, there is good anatomic correlation. It provides superior imaging for determination of local pathologies in complex anatomic localizations like the foot or hand[11,16].

Positron Emission Tomography/Magnetic Resonance Imaging

^{18}F-Fluoride Positron Emission Tomography/Magnetic Resonance Imaging (PET/MRI) is a new method and ensures morphologic and functional imaging. It provides information about bone and soft tissue changes together. It is a very beneficial method for diagnosis of osteomyelitis or stress fractures especially in complex anatomic regions. In early periods than normal for direct radiography, PET/MRI is a beneficial method to show bone or soft tissue changes[16,17].

^{18}F-Sodium Fluoride Positron Emission Tomography / Computed Tomography:

Compared to standard scintigraphy this method provides better quality images with high sensitivity in a shorter period. It is a strong alternative to standard bone scintigraphy for identification of unexplained bone pain[18]. Bone involvement of^{18} F- sodium fluoride (NaF) occurs by the chemical absorption route. Binding to serum proteins is very low and renal excretion is rapid. As a result, the image quality is very good. Compared with other marking agents like ^{99m}Tc, the bone background activity rate is high[18]. F- NaF is beneficial for the assessment of benign bone pathologies and osteomyelitis. The CT component of PET/CT ensures both full anatomic localization and assessment of non-bone structures[16,18].

^{18}F-Fluorodeoxyglucose Positron Emission Tomography/ Computed Tomography

Positron Emission Tomography/Computed Tomography (PET/CT) using with ^{18}F-Fluorodeoxyglucose (^{18}F-FDG) is commonly preferred for oncological patients for staging, restaging, evaluation of therapy response. One of the biggest advantages of FDG PET/CT is high spatial resulution. ^{18}F-FDG is not specific for tumor cells, this agent also can accumulate in benign conditions such as inflammation and infection. This method is helpful used for detecting fever of unknown origin in children. Whereas, three phase bone scintigraphy has important value for acute osteomyelitis, ^{18}F-FDG PET/CT is not preferred method for acute osteomyelitis. ^{18}F-FDG PET/CT plays an important role for diagnosis of chronic osteomyelitis especially in complicated patients. Although, PET/CT provides high-resolution images, high target-to-background contrast ratio, high sensitivity for chronic infections, it is stil not first choice for infectious patients[19,20].

Conclusion

Early diagnosis of osteomyelitis in pediatric cases is very important. Scintigraphy and newly-developed methods have an effective place in this area. It should be remembered that they provide findings for suspected osteomyelitis cases before direct radiography. MRI/CT-aided scintigraphy has high sensitivity and specificity for identification of local pathologies in complex anatomic regions like hands or feet.

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