

# The usefulness of bone scanning for the diagnosis and evaluation of otogenic skull base osteomyelitis. A description of three cases

Dominik Stodulski<sup>1</sup>, Jacek Teodorczyk<sup>2</sup>, Bożena Kowalska<sup>1</sup>,  
Czesław Stankiewicz<sup>1</sup>, Piotr Lass<sup>2</sup>

<sup>1</sup>Department of Otorhinolaryngology, Medical University, Gdańsk, Poland  
<sup>2</sup>Department of Nuclear Medicine, Medical University, Gdańsk, Poland

[Received 16 II 2005; Accepted 28 IV 2005]

## Abstract

**BACKGROUND:** The aim of this report was to assess the usefulness of bone scanning in the diagnosis and evaluation of the skull base osteomyelitis.

**MATERIAL AND METHODS:** Bone scanning was performed in three male patients with otogenic skull base osteomyelitis, aged 65–84 years utilizing Tc99m-MDP and dual-head gamma camera.

**RESULTS:** In one case, bone scanning played a crucial role in establishing the diagnosis. In two cases, it provided confirmed MRI results. CT scanning was negative in two cases.

**CONCLUSIONS:** Bone scans may give valuable information for establishing the diagnosis and assessing the severity of this disease, and add complementary physiological information to radiological imaging.

**Key words:** bone scan, skull base osteomyelitis, malignant external otitis

## Introduction

Skull base osteomyelitis is a rare, but severe disease which is usually a complication of ear and paranasal sinus infections [1–4]. Generally, it involves immuno-compromised individuals, the major subpopulation of patients are elder diabetics with long-lasting and poorly controlled disease. It was also noted in other immuno-deficiency conditions (AIDS, neoplasms), but cases with no clear immunodeficiency were also described. Otogenic skull base osteomyelitis (OSBO) usually follows malignant (necrotizing) external otitis, but it can also follow middle ear/mastoid infections. In the clinical course of malignant external otitis, the three following stages may be distinguished: I — the process limited to soft tissues; II — limited osteomyelitis; III — extensive osteomyelitis. Although *Pseudomonas aeruginosa* is responsible for most of the cases of OSBO, other pathogens have occasionally been isolated such as *Staphylococcus aureus*, *Proteus mirabilis* and *Aspergillus* species. Progressing skull base osteomyelitis may lead to neurological complications e.g. cranial nerve palsy, venous sinuses and internal jugular vein thrombosis. It may be a life-threatening condition, that may be difficult to diagnose and treat [1–4].

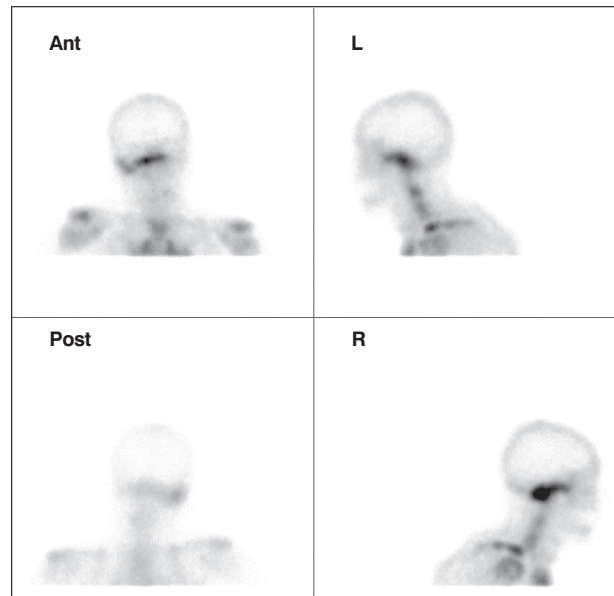
Therapy of skull base osteomyelitis is complex and long-lasting. It involves antibiotic treatment, hyperbaric oxygen therapy [2], improvement of underlying immune deficiency (e.g. diabetes mellitus regulation) and surgery. For confirmation of the disease and the start of intensive therapy typical findings of physical examinations, bacterial culture, pathological and laboratory testing are important, as well as diagnostic imaging of bone involvement.

## Material and methods

Our series comprised three male patients, aged 65–84 years, hospitalised with intense ear and head pain and neurological dysfunction. Detailed data are given below.

Bone scanning was performed using a dual-head gamma camera Multispect-2 (Siemens, Erlangen, Germany) 3–4 hours

Correspondence to: Jacek Teodorczyk  
Department of Nuclear Medicine  
Medical University  
ul. Dębinki 7, 80–211 Gdańsk, Poland  
Tel/fax: (+ 48 58) 349 22 04  
e-mail: teodorczyk@wp.pl



**Figure 1.** The result of bone scanning of Case 1.

post i.v. injection of 740 MBq of  $^{99m}\text{Tc}$ -MDP (OBRI-Polatom, Otwock, Poland) using a low energy general purpose collimator. The data were collected into a  $128 \times 128$  matrix for anterior, posterior and both lateral projections. Raw data were processed using a Siemens ICON computer system.

## Results

### Case 1

Patient PJ, male, aged 84, was admitted to the hospital with intense left-sided ear and head pain, progressive left hypoacusis, impaired function of ipsilateral mimic muscles, swallowing and dysarthric speech. Complaints appeared a month before admission and increased gradually. Three months prior to admission, the patient was operated due to contralateral exacerbation of chronic otitis media with conservative right ear surgery, during which, sigmoid sinus delamination and mastoid region abscess drainage were performed. Comorbid conditions included recently diagnosed diabetes mellitus type II, coronary artery disease, hypertension and ulcerative gastroduodenal disease. Physical examination revealed signs of left-sided VII, IX, X, XI, XII cranial nerve dysfunction. Audiogram showed right ear deafness and left ear hypoacusis. Bacterial culture test from left ear tube revealed *Pseudomonas aeruginosa* and *Staphylococcus aureus* species.

A CT exam of the right ear showed the state after subtotal right mastoid process resection with preserved mastoid cells and tympanic cavity filled; in the left ear patent external acoustic meatus, filled tympanic cavity and partially mastoid cells; bilaterally acoustic chain bones and semicircular ducts symmetric, internal acoustic meatus symmetric, not dilated.

Scintigraphy (Figure 1) revealed significantly increased uptake of radiotracer in the right temporal bone (predominantly in external acoustic meatus region) spreading towards and slightly crossing the median plane of the body confirming skull base osteomyelitis in the presence of uncertain CT scanning result.

Four week antibiotic therapy with ceftazidime and an application of hyperbaric oxygen expositions were performed giving clinical remission supported by triple negative culture test. Cranial nerve functions were not restored.

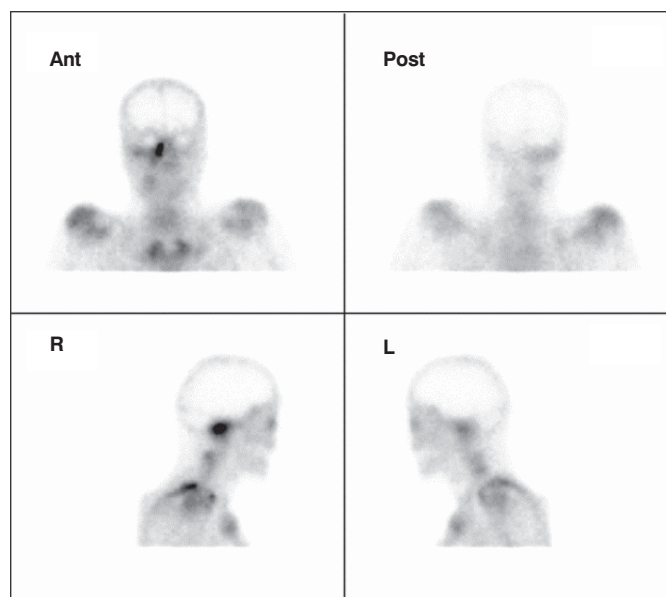
### Case 2

Patient WL, male, aged 74 years, was admitted to the hospital with strong right ear and head pain, purulent ear exudate, progressive hypoacusis, impairment of ipsilateral mimic muscles and swallowing functions. Complaints started five months before admission and gradually increased. Four months ago, the patient had right ear surgery — resection of polyps and squamiae of cholesteatoma. Three months prior to admission, granulation the from right external acoustic meatus was removed. Concomitant diseases were diabetes mellitus type II, coronary artery disease and hypertension. Physical examination revealed dysfunction of right-sided VII, IX–XII cranial nerves and left-sided pyramidal signs. Audiogram evidenced severe ipsilateral hypoacusis of mixed type. Bacterial culture test from the tube of the right ear revealed *Pseudomonas aeruginosa*.

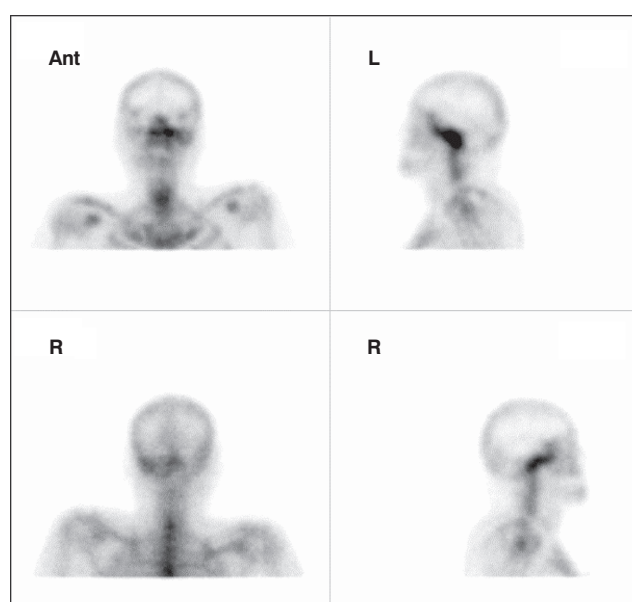
Computed tomography and MRI visualized an extensive infiltration of skull base bones and regional soft tissues, including the following right-sided bone structures: portion of clivus and greater wing of sphenoid bone, partially the pyramid of the temporal bone, inferior part of mastoid process, alveolar process of maxilla and anterior arch of atlas and subtemporal and pterygopalatal fossa.

Scintigraphy (Figure 2) revealed significantly increased uptake of radiotracer in the right temporal bone spreading towards median plane of the body. Radiotracer uptake was additionally intensively increased in the paramedial region suggesting involvement of other skull base bones on the right.

Six week antibiotic therapy with ceftazidime and ciprofloxacin and a course of hyperbaric oxygen therapy were performed with clinical remission supported by triple negative culture test. Cranial nerve functions were not restored.



**Figure 2.** The result of bone scanning of Case 2.



**Figure 3.** The result of bone scanning of Case 3.

### Case 3

Patient BJ, male, aged 65 years, was admitted to the hospital with intense left-sided head pain, vertigo, nausea, balance disturbances impaired function of ipsilateral facial muscles and swallowing. These complaints appeared three weeks before admission. For the three years prior to admission, the patient suffered from ipsilateral hypoacusis and temporal, intermittent purulent ear exudates were observed. Two months before admission, the patient was hospitalized two times in another ENT department, where chronic otitis media was diagnosed and *i.v.* antibacterial therapy was applied. Concomitantly, diabetes mellitus type 2 and hypertension were additionally noted. Physical

examination revealed peripheral dysfunction of VII, IX–XII ipsilateral cranial nerves. Audiogram evidenced left-sided conductive hypoacusis. Bacterial culture test was repeated three times and was negative.

Computed tomography exam showed no osteolysis. MRI exam revealed extensive skull base infiltration expanding to contralateral side.

Scintigraphy showed involvement of left temporal bone reaching the median plane of the body with predominance in the paramedial region (Figure 3). Scintigraphy confirmed extensive skull base osteomyelitis.

A bactericidal therapy with ceftazidime and ciprofloxacin augmented by hyperbaric oxygen was applied with no clinical improve-

ment. A second MRI exam revealed a progression of disease. Bacterial culture tests were repeated, finding *Aspergillus fumigatus*. Finally, an otogenic invasive fungal infection with extensive skull base osteomyelitis was diagnosed. Antifungal therapy with i.v. amphotericin B and oral itraconazole was introduced, but gradual worsening of clinical condition occurred and the patient died 53 days post admission to the hospital.

## Discussion

The origin of pathological chain leading to skull base osteomyelitis might be very innocent. For instance, scaring the skin of the external ear canal with cotton swab or traumatic injury of external ear soft tissues can result in regional infection and inflammation (benign external otitis), in immunodeficient individuals, tending to spread to adjacent bone.

Long-lasting chronic otitis media is more likely to invade bone in immunocompromised patients. It may happen in an occult way during one of the exacerbations. The time of soft tissue progression into osteomyelitic disease may be unremarkable.

A crucial factor for the success of therapy of several skull base osteomyelitis variants is early diagnosis, which is difficult to achieve without confirmation by imaging modalities. Commonly occurring severe benign external otitis can mimic malignant external otitis and undermining diagnosis of the latter as a result [2]. Exacerbation of chronic otitis media and bone invasion may be overlooked among patients with long-lasting complaints. The necessity for early diagnosis (especially in immunocompromised individuals), risk of diagnostic pitfalls and limitations of radiographic methods in detecting early osteomyelitic changes open a diagnostic field for bone scans.

Bone scintigraphy reveals areas of increased osteoblastic activity, which may be developed by osteomyelitic, neoplastic and post-traumatic processes, and must therefore be interpreted in a clinical context. Bone scintigraphy has a high diagnostic value, as it allows the detection of osteomyelitic changes before bone demineralization [5, 6]. The biggest disadvantage of bone scanning is the lack of specificity [7].

Traditionally used conventional X-ray tomograms usually fail to image the early stages of bone destruction where only a small amount of demineralization has occurred.

Computed tomography is a sensitive modality regarding detectable bone demineralization levels, but also may fail for small demineralisation [8]. CT findings are generally unhelpful for monitoring response to treatment, because the CT scan may not even be abnormal initially or, if abnormal, may remain abnormal for as long as 2 years after treatment [8].

Magnetic resonance imaging offers important, sensitive information about regional soft tissue involvement and neurological

complications. Recognition of characteristic imaging findings such as diffuse clival hypointensity on T1-weighted MR images due to bone marrow infiltration [9, 10] is crucial to making a timely diagnosis, but is of limited value in direct diagnosis of early bony changes. Changes in bone scans tend to be present many years post osteomyelitis eradication, so the method is of limited value in statement of therapeutic success. In the final stages of therapy,  $^{67}\text{Ga}$  scanning is useful, which has a significantly less pronounced tendency to persist positively after osteomyelitis eradication.

Therefore, regarding coordinated diagnostic imaging, some authors postulate that CT is best for differentiation between soft-tissue and bone infection, MR imaging is best for assessment of the calvaria and skull base and SPECT is best for assessment of altered bone and may be the best technique for follow-up [5].

In our first case, bone scanning proved to be crucial in establishing the diagnosis of early osteomyelitic changes in the presence of unspecific CT exam results. In the two latter cases, it correlated with CT and MRI findings. Bone scans seem to be valuable diagnostic tool, particularly important in immunodeficient individuals cases where early diagnosis is crucial for therapeutic success.

## References

1. Chandler JR, Grobman L, Quencer R, Serafini A. Osteomyelitis of the base of the skull. *Laryngoscope* 1986; 96 :245–251.
2. Amorosa L, Modugno GC, Pirodda A. Malignant external otitis: review and personal experience. *Acta Otolaryngol Suppl* 1996; 521: 3–16.
3. Sreepada GS, Kwartler JA. Skull base osteomyelitis secondary to malignant otitis externa. *Curr Opin Otolaryngol Head Neck Surg* 2003, 11: 316–323.
4. Grandis JR, Branstetter BF IV, Yu VL. The changing face of malignant (necrotising) external otitis: clinical, radiological, and anatomic correlations. *Lancet Infect Dis* 2004; 4: 34–39.
5. Seabold JE, Simonson TM, Weber PC et al. Cranial osteomyelitis: diagnosis and follow-up with In-111 white blood cell and Tc-99m methylene diphosphonate bone SPECT, CT, and MR imaging. *Radiology* 1995; 196:779–788.
6. Ohta H, Yonamine Y, Narabayashi I. What is the diagnosis? Malignant external otitis (MEO) (*Pseudomonas* osteomyelitis of the temporal bone). *Ann Nucl Med* 2003; 17: 698.
7. Ceruse P, Mohammedi I, Muller P, Vautrin R, Truy E. Diagnostic criteria for progressive necrotizing external otitis. Are scintigraphic findings reliable? *Presse Med* 1998; 27: 11–14.
8. Rubin J, Curtin HD, Yu VL, Kamerer DB. Malignant external otitis: utility of CT in diagnosis and follow-up. *Radiology* 1990; 174: 391–394.
9. Kimura F, Kim KS, Friedman H et al. MR imaging of the normal and abnormal clivus. *AJR Am J Roentgenol* 1990; 155: 1285–1291.
10. Erdman WA, Tamburro F, Jayson HT et al. Osteomyelitis: characteristics and pitfalls of diagnosis with MR imaging. *Radiology* 1991; 180: 533–539.