Imagerie métabolique en coupe dans la prise en charge des infections musculo-squelettiques

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SFMN, La Rochelle, 29th May, 2015
NM in musculo-skeletal Infections

Outline

• Introduction
• Choice of tracer
• Clinical indications of $^{18}$F-FDG-PET
  ▫ Acute (haematogenous) osteomyelitis / chronic OM
  ▫ Infection of prosthetic material/metallic hardware
  ▫ Vertebral osteomyelitis
  ▫ Diabetic foot
• Summary
NM in musculo-skeletal Infections

Introduction: scope

Question 1: infection or not?
Specificity of the signal

Question 2: bone or soft tissue?
Anatomical localization: hybrid imaging

Question 3: evaluation of therapy
NM in musculo-skeletal Infections

Introduction: pathogeny

- Extremely complex phenomenon involving
  - Bacterial colonization and growth
  - Inflammation
  - Bone destruction and destruction of the vasculature resulting in compression, formation of pus, spread and exacerbated bone necrosis (sequestrae)
- Haematogeneous (children & elderly): bacteremia
- Contiguous: transmission from local infection
- Direct injury: trauma, surgery, prostheses
NM in musculo-skeletal Infections

Introduction: pathogeny

- Pyogenic bacterias are the most frequent
  - Staphylococcus aureus: 37-67%
  - Coagulase (-) Staphylococci (esp. epidermidis): 3-16%
  - Other pyogenic: Pseudomonas, Salmonella, Haemophilus, Streptococcus spp., E Coli,…

- Non pyogenic: Brucella mellitensis, Mycobacterium spp.
- Staph. aureus accounts for ~50% of surgical infections (UK Health Protection Agency 2008)
NM in musculo-skeletal Infections

Introduction: diagnostic challenge

- Incidence is increasing for prosthetic material and DM
- Treatment is difficult and prolonged, hence expensive
- X-Ray (and CT) is only positive when 20-50% of the bone matrix has gone (10-21 days) and often lacks specificity
- Antibiotic resistance is (more) frequent (‘small colony’) 
- MRI and 3P-BS are nonspecific in the early stages
- Nuclear medicine offers ...so (too?) many options
NM in musculo-skeletal Infections
Tracers: which one?

\[ ^{99m} \text{Tc} \text{ bone scan} \]

\[ ^{99m} \text{Tc}\text{-colloid} + ^{111}\text{In-WBC} \]
NM in musculo-skeletal Infections
Tracers: which one?

$^{111}$In-WBC

$^{18}$F-FDG PET-CT
 NM in musculo-skeletal Infections
Tracers: the ideal one

• **Targets the enemy!**
• Available, easy to use, cheap
• Good physical properties (T1/2, energy, rad. dose)
• In vivo and in vitro stability
• High sensitivity and specificity (vs inflammation)
• Rapid imaging (duration and delay)
• Marketing authorization
NM in musculo-skeletal Infections
Tracers: the ideal one

Staph. *aureus* accounts for ~50% of surgical infections
(UK Health Protection Agency 2008)

The target is bacteria!
NM in musculo-skeletal Infections
Tracers: insight in the pathophysiology

- Imaging of endothelial cell activation
- Imaging of infiltrating granulocytes
- Imaging white blood cell migration
- Imaging of bacteria

Legend:
- = antibodies
- = chemotactic factors
- = macrophages
- = bacteria
- = granulocytes
- = plasma exudate
NM in musculo-skeletal Infections
Tracers: targeting bacteria?

Take home message
Bacteria are dispersed, low mass, low binding of radiopharmaceuticals that do not allow their in vivo detection
NM in musculo-skeletal Infections

Tracers

- Labelled WBC (\(^{111}\)In or \(^{99m}\)Tc)
- \(^{99m}\)Tc-labelled antigranulocyte moAb
- \(^{67}\)Ga
- \(^{111}\)In/\(^{99m}\)Tc-human immunoglobulin G
- \(^{18}\)F-FDG
- Others… (\(^{18}\)F-FDG-WBC, \(^{68}\)Ga-citrate)
NM in musculo-skeletal Infections
Tracers: $^{18}$F-FDG - a by-product of oncology
Soft tissue Staph. \textit{aureus} in rats Day 9 (Kaïm et al, Radiology, 2002)
NM in musculo-skeletal Infections
Tracers: $^{18}$F-FDG BUT!!!!

Sterile inflammation (turpentine oil)
Day 4 (Yamada et al., JNM 1995)

**FIGURE 6.** Micro-autoradiogram of abscess wall 4 days after inoculation with turpentine oil corresponding to Figure 5. Scale bar: 40 μm.
NM in musculo-skeletal Infections
Tracers: $^{18}$F-FDG

- Nonspecific targeting (neutrophils, monocytes-macrophages, fibroblasts,...)
- High quality whole-body imaging
- No blood handling
- Results in less than 2 hours
- Relatively cheap
- Multiple session imaging complicated
NM in musculo-skeletal Infections
Tracers: bone marrow signal

\[ {^{18}}\text{F-FDG} \]

\[ {^{99m}}\text{Tc-colloid} \]

\[ {^{111}}\text{In-WBC} \]
NM in musculo-skeletal Infections
Tracers: but another problem with $^{18}$F-FDG!
NM in acute osteomyelitis

- Plain X-Ray is the first-line method (MR if available)
- 3-Phase bone scanning is highly sensitive
- Labelled WBC + colloid (and antigranulocyte moAb) scintigraphy is highly sensitive and specific (~100%/95%)
- The added value of $^{18}$F-FDG PET-CT is limited
  - No blood manipulation
  - Higher spatial resolution than BS or SPECT
  - Combination with CT for localization
### NM in chronic osteomyelitis

Meta-analysis of published papers up to December 2011 on FDG-PET

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>$^{18}$F-FDG</td>
<td>287</td>
<td>94.6</td>
<td>91.5</td>
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### Meta-analysis of published papers up to December 2005 on WBC

<table>
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<tr>
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<tbody>
<tr>
<td>Primary osteomyelitis</td>
<td>617</td>
<td>85.4</td>
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<td>88.2</td>
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<tr>
<td>Osteo-muscular infections</td>
<td>1803</td>
<td>84.8</td>
<td>78.9</td>
<td>81.6</td>
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<tr>
<td>Sternal wound infections</td>
<td>369</td>
<td>83.9</td>
<td>67.3</td>
<td>75.3</td>
</tr>
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</table>

Prandini et al, Nucl Med Commun, 2006  
NM in chronic osteomyelitis

$^{18}$F-FDG PET-CT

- Globally, high sensitivity (94-100%) after exclusion of dual-head coincidence scanning
- Specificity is also high with full ring PET(-CT) 87-100%
- Specificity depends on accurate clinical information
- Most studies deal with chronic OM
NM in chronic osteomyelitis

$^{18}$F-FDG PET-CT

De Winter JBJS 2001, 83: 651
NM in subacute/chronic osteomyelitis

$^{18}$F-FDG PET-CT

$^{18}$F-FDG PET-CT 9 mo after open-chest surgery
**NM in chronic osteomyelitis**

$^{18}$F-FDG PET-CT

<table>
<thead>
<tr>
<th>Author</th>
<th>year</th>
<th>no</th>
<th>Sens.</th>
<th>Spec.</th>
<th>Acc.</th>
<th>Proof</th>
<th>comparator</th>
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<td>-</td>
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<td>92</td>
<td>96</td>
<td>16</td>
<td>&gt;$^{111}$In</td>
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<tr>
<td>Zhuang</td>
<td>2006</td>
<td>22</td>
<td>100</td>
<td>88*</td>
<td>91</td>
<td>18</td>
<td>-</td>
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<tr>
<td>Rini</td>
<td>2006</td>
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<td>87</td>
<td>82</td>
<td>84</td>
<td>31</td>
<td>=$^{111}$In</td>
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<tr>
<td>Hakim</td>
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<td>42</td>
<td>64</td>
<td>78</td>
<td>-</td>
<td>30/34</td>
<td>Bone SPECT</td>
</tr>
<tr>
<td>Hartmann</td>
<td>2007</td>
<td>33</td>
<td>94</td>
<td>87</td>
<td>91</td>
<td>All</td>
<td>&gt;$^{111}$In</td>
</tr>
</tbody>
</table>

*: 2 FP due to recent osteotomy
NM in chronic osteomyelitis

$^{18}$F-FDG PET-CT

Bone scan  $^{18}$F-FDG-PET  moAb scan

Guhlmann, JNM1998, 39: 245-52
### Table 1
Data on Patients Suspected to Have Chronic Osteomyelitis in the Peripheral Skeleton

<table>
<thead>
<tr>
<th>Patient/Age (y)</th>
<th>Site of Suspected Osteomyelitis</th>
<th>Cause of Suspected Osteomyelitis</th>
<th>FDG PET Rating*</th>
<th>Final Diagnosis</th>
<th>Results of Bacteriologic Culture</th>
<th>Accuracy of FDG PET†</th>
<th>SUV‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/27/M</td>
<td>Distal femur</td>
<td>Fracture</td>
<td>4/4</td>
<td>Osteomyelitis</td>
<td>$ aureus</td>
<td>TP/TP</td>
<td>2.8</td>
</tr>
<tr>
<td>2/63/M</td>
<td>Tibia</td>
<td>Fracture</td>
<td>4/4</td>
<td>Osteomyelitis</td>
<td>$ epidermidis</td>
<td>TP/TP</td>
<td>2.7</td>
</tr>
<tr>
<td>3/42/M</td>
<td>Patella</td>
<td>Traumatic dislocation</td>
<td>0/0</td>
<td>Synovitis</td>
<td>No growth</td>
<td>TN/TN</td>
<td>0.2</td>
</tr>
</tbody>
</table>
| 4/37/M          | Tibia                           | Orthopedic device                | 4/4             | Osteomyelitis   | $ aureus, $ faecalis, $ a- 
|                 |                                 |                                  |                 |                             |                    |      |
|                 |                                 |                                  |                 |                             |                    |        |
| 5/36/M          | Tibia                           | Orthopedic device                | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 3.4  |
| 6/36/M          | Hand                            | Fracture                         | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 2.4  |
| 7/44/M          | Hand                            | Fracture                         | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 2.1  |
| 8/37/M          | Tibia                           | Fracture                         | 4/4             | Osteomyelitis   | $ epidermidis                   | TP/TP               | 1.9  |
| 9/66/M          | Tibia                           | Fracture                         | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 3.6  |
| 10/34/M         | Knee joint                      | Injury, arthroscopy              | 0/0             | Synovitis       | No growth                       | TN/TN               | 0.1  |
| 11/32/F         | Distal femur                    | Fracture                         | 0/0             | No infection    | No growth                       | TN/TN               | 0.3  |
| 12/41/M         | Tibia                           | Orthopedic device                | 0/0             | Soft-tissue infection | $ aureus, $ 
|                 |                                 |                                  |                 |                             | β-hemolytic streptococci |        |
| 13/75/M         | Tibia                           | Shin split injury                | 1/1             | Soft-tissue infection | $ aureus                        | TN/TN               | 0.5  |
| 14/20/M         | Tibia                           | Orthopedic device                | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 3.8  |
| 15/69/F         | Knee joint                      | Avascular necrosis, empyema       | 0/0             | Synovitis       | $ aureus                        | TN/TP               | 0.2  |
| 16/56/M         | Distal femur                    | Fracture                         | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 8.6  |
| 17/36/M         | Tibia                           | Fracture                         | 3/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 3.0  |
| 18/63/M         | Calcaneus                       | Orthopedic surgery               | 0/0             | Soft-tissue infection | No growth                       | TN/TP               | 0.2  |
| 19/46/F         | Calcaneus                       | Orthopedic surgery               | 0/0             | Soft-tissue infection | No growth                       | TN/TP               | 0.3  |
| 20/76/F         | Calcaneus                       | Orthopedic surgery               | 0/0             | No infection    | No growth                       | TN/TP               | 0.1  |
| 21/32/M         | Tibia                           | Fracture                         | 4/4             | Osteomyelitis   | $ aureus                        | TP/TP               | 2.2  |

*Rating of reader 1/rating of reader 2.

†Rating of reader 1/rating of reader 2. TN = true-negative (score of 0 or 1), TP = true-positive (score of 3 or 4).

‡SUV = standardized uptake value (intravenous).
NM in chronic osteomyelitis

$^{18}$F-FDG PET-CT

$^{18}$F-FDG-WBC PET vs $^{111}$In-WBC:
sensitivity (87% vs 73%), specificity (82% vs 86%)

Rini, Radiology, 2006, 238: 978-87
NM in chronic osteomyelitis

$^{18}$F-FDG PET-CT

FDG-PET appears globally equivalent to or slightly less performant than labelled WBC scintigraphy

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Inconveniences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid imaging</td>
<td>Access limited</td>
</tr>
<tr>
<td>No blood handling</td>
<td>Lack of funct spec.</td>
</tr>
<tr>
<td>Not impaired by metallic implants</td>
<td>Artifacts with metal (CT)</td>
</tr>
<tr>
<td>All-in one technique</td>
<td>Lower sens. in diabetics?</td>
</tr>
<tr>
<td>Low BM uptake</td>
<td>Cost</td>
</tr>
<tr>
<td>Solute physiology</td>
<td>Reimbursement</td>
</tr>
</tbody>
</table>
NM in chronic osteomyelitis

$^{18}$F-FDG PET-CT

• Limitations
  • The level of evidence remains low (2b at best)
  • No clear report on the diagnostic impact of CT
  • Limited information about acute OM
  • Performances may be different in selected groups
  • Limited direct comparison with MRI

• At this stage, overall substitution of WBC scan by $^{18}$F-FDG-PET(CT) cannot be recommended
NM in prosthetic joint infection

- Becomes extremely frequent nowadays
- 8% will require revision
- 5-15% may be infected (70% mech. loosening)
- Major impact on treatment (success, symptoms, costs,...)
- 3-Phase bone scan available everywhere
  Sensitivity / specificity: 78% / 84% (hip)
  Sensitivity / specificity: 87% / 71% (knee)
NM in prosthetic infection
WBC scanning

- sensitivity - alone: 88% + colloids: 97%
  specificity - alone: 78% + colloids: 97%

- Very little data in low prevalence groups

NPV before revision probably around 85-90%
NM in prosthetic infection

$^{18}$F-FDG-PET?
NM in prosthetic infection

$^{18}$F-FDG-PET

Table III. Analysis of the ability of PET and TPBS to differentiate between loosening and infection. An incorrect diagnosis of infection rather than loosening was considered as a false positive while a diagnosis of loosening rather than infection was regarded as a false negative.

<table>
<thead>
<tr>
<th></th>
<th>PET*</th>
<th>TPBS†</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positive</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>True negative</td>
<td>56</td>
<td>51</td>
</tr>
<tr>
<td>False positive</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>False negative</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.94</td>
<td>0.68</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.95</td>
<td>0.76</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>0.97</td>
<td>0.86</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>0.91</td>
<td>0.52</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.95</td>
<td>0.74</td>
</tr>
</tbody>
</table>

* PET, positron-emission tomography
† TPBS, triple-phase bone scanning

Reinartz et al., JBJS, 2005
NM in prosthetic infection

\(^{18}\text{F-FDG-PET}\)

- Very variable sensitivity and specificity
- Sens: 22-100%
- Spec: 61-100%
- Criteria for assessment vary from study to study

Jiue et al., Nucl Med Commun, JBJS, 2015
NM in prosthetic infection

$^{18}$F-FDG-PET - Interpretation criteria

Reinartz et al., JBJS, 2005
**NM in prosthetic infection**

**18F-FDG-PET - Interpretation criteria**

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**Table 1. Patterns of PET findings and their clinical correlates in patients with a THA**

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Description</th>
<th>Clinical correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No increased uptake of FDG(^1) in the prosthesis-tissue interface</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Increased uptake of FDG in the area of the femoral neck</td>
<td>No loosening</td>
</tr>
<tr>
<td>3a</td>
<td>Increased uptake of FDG in the area of the femoral neck and in parts of the prosthesis-bone interface of the acetabular cup without covering the whole cup</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>Increased uptake of FDG in the area of the femoral neck and in parts of the prosthesis-bone interface of the proximal stem</td>
<td></td>
</tr>
<tr>
<td>3c</td>
<td>Pattern 3a and 3b</td>
<td></td>
</tr>
<tr>
<td>4a</td>
<td>Increased uptake of FDG in the area of the femoral neck and in the whole prosthesis-bone interface of the acetabular cup</td>
<td>Loosening</td>
</tr>
<tr>
<td>4b</td>
<td>Increased uptake of FDG in the area of the femoral neck and in wide parts of the prosthesis-bone interface of the stem</td>
<td></td>
</tr>
<tr>
<td>4c</td>
<td>Pattern 4a and 4b</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Uptake of FDG in the periprosthetic soft tissue</td>
<td>Infection</td>
</tr>
</tbody>
</table>

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**18F-FDG:** most publications since 2001 w/o CT

Hip: Sensitivity 85% / Specificity 90%

Knee: Sensitivity 85% / Specificity 98%

Reinartz et al., JBJS, 2005
FDG-PET in patients with painful hip and knee arthroplasty: technical breakthrough or just more of the same?

P. Reinartz, QJNM, 2009

...data indicate that PET is highly effective ...

Whether this holds true for PET-CT has yet to be proven...
NM in vertebral osteomyelitis / (spondylo)discitis

99mTc-HDP scintigraphy

99mTc-HMPAO-WBC scintigraphy

111In- WBC scintigraphy
NM in vertebral osteomyelitis/(spondylo)discitis

- Can involve the disk alone or both the disk and adjacent vertebra(e)
- Haematogenous or post-injury (surgery)

- WBC scanning is inadequate because of the vascular spasm that results in no migration of living leukocytes
  - Sensitivity - hyper: 39%   hypo: 54%   total: 93%
  - Specificity - hyper: 98%   hypo: 32%   total: 50%

- MRI is clearly more performant but limited due to access and metallic implants in postoperative cases
NM in vertebral osteomyelitis/(spondylo)discitis

$^{18}$F-FDG PET

- Prospective, 57 patients with previous spinal surgery
- 15 with infection, no bacteriology in all cases

Sensitivity: 100%
Specificity: 81% overall

- No metallic implants (n=27): 2 FP within 6 mo of surgery
- Metallic implants (n=30): 6 FP overall

De Winter et al. Spine 2003, 28:1314-19
NM in vertebral osteomyelitis/(spondylo)discitis

\(^{18}\)F-FDG PET

- Differential diagnosis of *compression fractures* is a difficult challenge
- Preliminary data suggested that SUV could discriminate with osteoporotic fracture
  
  SUV (spondylo): 7.5 (3.8) vs 1.4 (0.7) (osteoporotic)

Schmitz *et al.* (Osteoporosis Int 2002 and Eur J spine 2001)
NM in vertebral osteomyelitis/(spondylo)discitis

$^{18}$F-FDG PET

True Negative

True Positive

NM in vertebral osteomyelitis/(spondylo)discitis

$^{18}$F-FDG PET
NM in vertebral osteomyelitis/(spondylo)discitis

$^{18}$F-FDG PET

- Limited information in the literature
- All go in the same (good) direction for FDG-PET
- One study in low back pain and patients with Modic type 1 signal (low T1/high T2), showed 100% sensitivity and 100% specificity (Ohtori, Spine 2010, 35:1599-603)

- The evidence seems sufficient for second-line use and PET-CT can be recommended when MRI is not accessible/feasible
- Also interesting in FUO // CAVE SUV vs tumor
Clinical suspicion of spondylodiscitis with clinical and laboratory findings (CRP, ESR, WBC counts)

- Haematogenous origin
  - Contrast-enhanced MRI
    - Negative: No infection
    - Positive: Infection
    - Doubtful: CT guided bone biopsy

- Post-surgical origin
  - with fixation devices
    - Contrast-enhanced MRI
      - Doubtful
      - Positive: Infection
      - Negative: No infection
  - without fixation devices
    - Contrast-enhanced MRI
      - Doubtful
      - Positive: Infection
      - Negative: No infection

NM in diabetic foot infection

Management of osteomyelitis of the foot in diabetes mellitus

Fran Game

« Identifies MRI as superior to X-ray and CT, prior to biopsy, before deciding for surgical or conservative treatment of suspected OM in diabetic foot that may occur in ~20% of DM patients with ulcers and Charcot osteoarthropathy »

FDG PET-CT even not cited...
NM in diabetic foot infection

- Bone scan is very sensitive but nonspecific (vs Charcot!)
- WBC scanning is sensitive and specific but lacks anatomical resolution
- $^{18}$F-FDG PET/CT is promising but data are conflictual (clearly helps with anatomic delineation, bone vs soft tissue infection)
# NM in diabetic foot infection

**$^{18}$F-FDG PET**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
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<th>Sens.</th>
<th>Spec.</th>
<th>Acc.</th>
<th>comparator</th>
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<td>16/39</td>
<td>0</td>
<td>–</td>
<td>0</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Keidar</td>
<td>2005</td>
<td>14/18</td>
<td>8/5</td>
<td>100</td>
<td>80</td>
<td>94</td>
<td>&gt; MR</td>
</tr>
<tr>
<td>Basu</td>
<td>2007</td>
<td>22</td>
<td>6/7</td>
<td>100</td>
<td>89</td>
<td>94</td>
<td>&gt; MR</td>
</tr>
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<td>Schwegler</td>
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<td>20</td>
<td>7/–</td>
<td>29</td>
<td>92</td>
<td>70</td>
<td>&lt; MR</td>
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<tr>
<td>Nawaz</td>
<td>2010</td>
<td>110</td>
<td>27/–</td>
<td>81</td>
<td>93</td>
<td>90</td>
<td>S&gt;MR, Sp&lt;MR</td>
</tr>
<tr>
<td>Familliari</td>
<td>2011</td>
<td>13</td>
<td>7/2</td>
<td>43</td>
<td>67</td>
<td>54</td>
<td>&lt; $^{99m}$Tc-WBC</td>
</tr>
</tbody>
</table>

**Basu et al., Nuc Med Comm, 2007**
NM in diabetic foot infection

$^{18}$F-FDG PET: A meta-analysis (4/44 studies)

- Highly variable sensitivity: 29-100% (Pooled sensitivity: 74%)
- Variable specificity: 67-93% (Pooled specificity: 90%)

- Most (other) studies lack biopsy as a proof for biopsy

- Nawaz et al. (level 2) - best study
  - 106 patients
  - prospective
  - consecutive
  - 37 biopsies

Treglia et al., The Foot, 2013
NM in diabetic foot infection

$^{18}$F-FDG PET

Keidar et al, JNM, 2005

Nawaz et al. Mol Imaging Biol, 2010
Patient with diabetes & foot wound with suspected osteomyelitis (DFO)

Plain X-rays

DFO

Equivocal

MRI

WBC [SPECT/CT] or FDG PET/CT

Appropriate infection management

Appropriate wound care

Soft tissue infection or Charcot

DFO

Negative

Appropriate wound care

Negative
NM in musculoskeletal Infections
Summary on the role of $^{18}$F-FDG PET

- Acute OM: limited role (BS / WBC)
- Chronic OM: WBC++ (FDG?)
- Prostheses: WBC++ (FDG: no)
- Vertebral OM: BS nonspecific / FDG++
- Diabetic foot: WBC with BS ++ /FDG controversial
NM in musculoskeletal Infections
Perspectives of molecular imaging

- $^{68}$Ga-citrate? $^{18}$F-FDG-WBC??
- $^{18}$F-FDG-PET/MRI
- Innovative tracers for infection (antibiotics, $^{18}$F, $^{89}$Zr)
- Large prospective trials with standardized protocols and diagnostic criteria and blinded review
- This is being started under the umbrella of EANM
NM in musculoskeletal Infections Perspectives: $^{18}$F-FDG-PET/MRI?

Patient with bacteraemia and lucent zone on X-Ray

Demirev et al., Skeletal Radiol, 2014
NM in musculoskeletal Infections: $^{18}$F-FDG-PET/MRI?

Demirev et al., Skeletal Radiol, 2014