Old and New:
The Current Role Of Bone Scan In Paediatrics

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Ignasi Barber
Isabel Roca-Bielsa
OLD and NEW:
The current role of bone scan in paediatrics
OLD and NEW:
The current role of bone scan in paediatrics
Correlative imaging

- **Correlative Imaging** is the best diagnostic tool that the specialists in image can offer to the clinicians

- Correlation between
  - anatomic
  - functional or metabolic images

The collaboration between clinicians, radiologists, and **NM physicians** is crucial
Correlative imaging

Feedback is necessary

Clinician

Radiologist

Nuclear Medicine Physicians
Bone diseases in paediatrics

Image Specialists: what do we have to do?

1. Inform / orient the clinician who ask for diagnostic tests to study a children with bone pain.
2. Explain the advantatges and disadvantatges of each one of the available techniques: Xrays, US, scintigrapgies, CT, MRI.
3. Comment on the indication, utility and level of evidence of each test in each clinical situation or clinical symptom.
<table>
<thead>
<tr>
<th></th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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<tr>
<td><strong>XRAY</strong></td>
<td><strong>Accessibility</strong></td>
<td>Dosimetry (low)</td>
</tr>
<tr>
<td></td>
<td><strong>Availability</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Specificity</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Bone Scintigraphy</strong></td>
<td><strong>Sensibility</strong></td>
<td>Dosimetry (med)</td>
</tr>
<tr>
<td></td>
<td><strong>Precocious test</strong></td>
<td><strong>Low specificity</strong></td>
</tr>
<tr>
<td></td>
<td><strong>WB images</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Pin-Hole SPECT</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CT</strong></td>
<td><strong>High resolution</strong></td>
<td>Dosimetry (high)</td>
</tr>
<tr>
<td></td>
<td><strong>(cortical / medulla)</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Specificity</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MRI</strong></td>
<td><strong>Sensitivity</strong></td>
<td>Low specificity</td>
</tr>
<tr>
<td></td>
<td><strong>WB images</strong></td>
<td>Sedation / Anaesthesia</td>
</tr>
<tr>
<td></td>
<td><strong>Medulla: +++</strong></td>
<td>(&lt;5a)</td>
</tr>
<tr>
<td></td>
<td><strong>Cortex: +/-</strong></td>
<td>Low availability</td>
</tr>
<tr>
<td></td>
<td><strong>High resolution</strong></td>
<td>Long study</td>
</tr>
<tr>
<td></td>
<td><strong>differentiation bone / soft tissue</strong></td>
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</tbody>
</table>
RADIATION PROTECTION 118

Referral guidelines for imaging

GUIDELINES FOR HEALTHCARE PROFESSIONALS WHO PRESCRIBE IMAGING INVESTIGATIONS INVOLVING IONISING RADIATION

Final Report to the European Commission for Grant Agreement SUBV99/134996

University Court of the University of Aberdeen
Professor Gillian Needham and Professor Jeremy Grimshaw

Classification Of Evidence Levels

→ Grades Of Recommendation

(US Dept of Health Care Policy and Research)

A
1. High quality diagnostic studies: independent, blind comparison to reference standard. N >>>
2. Systematic review and meta-analysis of high quality studies
3. Diagnostic clinical practice guidelines/clinical decision rules: validated in a test set

B
1. Studies with a blind and independent comparison of the new test and reference standard
2. In a set of non-consecutive patients or confined to a narrow spectrum of patients
3. Systematic reviews of such studies
4. Diagnostic clinical practice guidelines / clinical decision rules not validates in a test set

C
1. Studies in which the reference standard was not objective
2. Studies in which the comparison between new test and standard was not blind or independent
3. Studies in which positive and negative test results were verified using reference standards
4. Studies performed in an inappropiate set of patients
5. Expert opinion
Recommendations

1. **Indicated.** This shows an investigation most likely to contribute to clinical diagnosis and management. This may differ from the investigation requested by the clinician: e.g., US rather than venography for deep vein thrombosis.

2. **Specialised investigation.** These are frequently complex, time-consuming or resource-intensive investigations which will usually only be performed after discussion with the radiologist or in the context of locally-agreed protocols.

3. **Not indicated initially.** This includes situations where experience shows that the clinical problem usually resolves with time; we therefore suggest deferring the study for three to six weeks (timescale may be shorter for children) and only performing it then if symptoms continue. Shoulder pain is a typical example.

4. **Indicated only in specific circumstances.** These are non-routine studies which will only be carried out if a clinician provides cogent reasons or if the radiologist feels the examination represents an appropriate way of furthering the diagnosis and management of the patient. An example of such a justification would be plain radiography in a patient with backache in whom there were clinical findings to suggest something more than a degenerative disease (e.g., osteoporotic vertebral fracture).

5. **Not indicated.** Examinations in this group are those where the supposed rationale for the investigation is untenable (e.g., skull radiograph for dementia).
EBM RECOMMENDATION

1. Indicated
2. Specialised investigation
3. Not indicated initially
4. Indicated only in specific circumstances
5. Not indicated
### TABLE  Classification of the typical effective doses of ionising radiation from common imaging procedures

<table>
<thead>
<tr>
<th>Band</th>
<th>Typical effective dose (mSv)</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>US, MRI</td>
</tr>
<tr>
<td>I</td>
<td>&lt;1</td>
<td>CXR, XR limb, XR pelvis</td>
</tr>
<tr>
<td>II*</td>
<td>1-5</td>
<td>IVU, XR lumbar spine, NM (e.g. skeletal scintigram), CT head &amp; neck</td>
</tr>
<tr>
<td>III</td>
<td>5-10</td>
<td>CT chest and abdomen, NM (e.g. cardiac)</td>
</tr>
<tr>
<td>IV</td>
<td>&gt;10</td>
<td>Some NM studies (e.g. some PET)</td>
</tr>
</tbody>
</table>

**Average annual background radiation dose in most parts of Europe**

- **UK 2.2 mSv/year**
- **Others 1.5 to 7.5 mSv/year**
<table>
<thead>
<tr>
<th>CLINICAL/DIAGNOSTIC PROBLEM</th>
<th>INVESTIGATION</th>
<th>RECOMMENDATION [GRADE]</th>
<th>COMMENT</th>
<th>DOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Musculoskeletal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-accidental injury / child abuse</td>
<td>Skeletal survey</td>
<td>Indicated (age 0–2 years) [A]</td>
<td>Age 0–2 years, CT of the head is mandatory. Age 3–5 years, XR clinically suspicious area. Age &gt; 3 years skeletal survey is not generally indicated, as children &gt;3 years can usually describe where pain is located. Examinations should be performed by radiographers trained in paediatric radiographic techniques.</td>
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<tr>
<td>(For head injury see section K)</td>
<td>NM</td>
<td>Indicated [B]</td>
<td>Bone scintigraphy is indicated in children &gt; 2 years if the skeletal survey is equivocal. Abnormal bone findings must always be correlated with clinical history, physical examination, and pertinent XRs.</td>
<td>II</td>
</tr>
</tbody>
</table>

**CHILD ABUSE**

**SKELETAL SURVEY**

**BONE SCINTIGRAPHY**
Age 0–2 years, CT of the head is mandatory. Age 3–5 years, XR clinically suspicious area.
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<td>11</td>
</tr>
<tr>
<td>(For head injury see section K)</td>
<td>NM</td>
<td>Indicated [B]</td>
<td></td>
<td>11</td>
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</table>

Age > 3 years skeletal survey is not generally indicated, as children >3 years can usually describe where pain is located.
Bone scintigraphy is indicated in children > 2 years if the skeletal survey is equivocal. Abnormal bone findings must always be correlated with clinical history, physical examination, and pertinent XRs.
Bone scintigraphy

• detects occult fractures
• high sensitivity

• babies < 1 year: all diaphysis

• blood pool image:
  DD between old and new fractures

  new fractures → BP +
  old lesions → BP +/-
**HEAD INJURY**

X Ray

- NOT INDICATED
- when CT is not available, could be justified for triage

**HEAD INJURY**

CT

- should be performed within 1 hour
- risk of clinically significant brain injury requiring neurosurgical intervention
3 year old boy
- Found alone in a room
- Tied in a chair
- Multiple injuries: face, neck, clavicle, right arm and left leg

Questions
- Fractures (recent and old)
- Bone infection?
- Open Fx L clavicle
- Open Fx R humerus
- Closed Fx R and L forearm
- Closed Fx L tibia & fibula
Development of the healing process
5 month old baby
- Right limb pseudoparalysis
- Swelling in right thigh

Questions
- Fractures (recent and old)
- Closed Fx R femur
- Closed Fx R forearm
- Closed Fx Skull
- Multiple rib Fx
Development of the healing process
<table>
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<tr>
<th>Osteomyelitis</th>
<th>XR</th>
<th>Indicated [C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td>Specialised investigation [C]</td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>Specialised investigation [C]</td>
<td></td>
</tr>
<tr>
<td>US</td>
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<td></td>
</tr>
</tbody>
</table>

**Initial investigation.**

MRI accurately demonstrates infection, especially in the spine.

CT is valuable for demonstration of sequestra.

US may be valuable in acute osteomyelitis to demonstrate subperiosteal abscess, but there is a high false negative rate.

The two- or three-phase skeletal scintigram is more sensitive than XR in detecting suspected focal osteomyelitis. If osteomyelitis is suspected but there are no localising signs or symptoms, a skeletal scintigram is useful. Findings on a skeletal scintigram are not specific and further specialist NM imaging with alternative agents may be required.

White cells: the use of Tc-99m-HMPAO or In-111-labelled white cells may be useful in confirming infection in bone or joint. False negative results may be encountered in the spine.
Osteomyelitis

<table>
<thead>
<tr>
<th>Investigations</th>
<th>Indication</th>
</tr>
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<tbody>
<tr>
<td>XR Initial investigation</td>
<td>Indicated [C]</td>
</tr>
<tr>
<td>MRI</td>
<td>Specialised investigation [C]</td>
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<tr>
<td>CT</td>
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<tr>
<td>NM</td>
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- **Initial investigation.**
  MRI accurately demonstrates infection, especially in the spine.
  CT is valuable for demonstration of sequestra.

- **OSTEOMYELITIS**

- **Initial investigation**
  XR
  **INDICATED**
  C

- **White cells:** The use of Tc-99m-HMPAO or In-111-labelled white cells may be useful in confirming infection in bone or joint. False negative results may be encountered in the spine.
OSTEOMYELITIS

MRI

Accurately demonstrates infection, specially in the spine

XR

Indicated [C]

SPECIALISED INVESTIGATION

C

Initial investigation.

MRI accurately demonstrates infection, especially in the spine.

XR

Indicated [C]

MRI

Specialised investigation [C]

Initial investigation.

MRI accurately demonstrates infection, especially in the spine.

XR

Indicated [C]

MR

CT

US

NM

OSTEOMYELITIS

MRI

Accurately demonstrates infection, specially in the spine

XR

Indicated [C]

MRI

Specialised investigation [C]

OSTEOMYELITIS

MRI

Accurately demonstrates infection, specially in the spine

XR

Indicated [C]

MRI

Specialised investigation [C]

OSTEOMYELITIS

MRI

Accurately demonstrates infection, specially in the spine

XR

Indicated [C]

MRI

Specialised investigation [C]
OSTEOMYELITIS

CT

Demonstration of sequestra

SPECIALISED INVESTIGATION

MRI

Indicated [C]

Initial investigation.

XR

Specialised investigation

MRI accurately demonstrates infection, especially in the spine.

CT

Demonstration of sequestra.

Osteomyelitis to differentiate from cellulitis but there is a high false positive rate.

US

Skeletal scintigraphy is more sensitive than US for detecting focal infection. However, in cases where infection is suspected but there are no localising signs or symptoms, a skeletal scintigram is useful. Findings on a skeletal scintigram are not specific and further specialist NM imaging with alternative agents may be required.

NM

White cells: the use of Tc-99m-HMPAO or In-111-labelled white cells may be useful in confirming infection in bone or joint. False negative results may be encountered in the spine.
OSTEOMYELITIS

US

Subperiostal abcess
High false positive rate

Initial investigation.

MRI accurately demonstrates infection, especially in the spine.

MRI
Indicated [C]
Specialised investigation

OSTEOMYELITIS

US
Subperiostal abcess
High false positive rate
BONE SCINTIGRAPHY
2 or 3 phase bone scan
More sensitive than XR in detecting focal osteomyelitis
Useful in suspicion of OM without focal symptoms
HMPAO-WBC

Confirming infection in bone or joint. False negative in spine.

OSTEOMYELITIS

White cells: the use of Tc-99m-HMPAO or In-111-labelled white cells may be useful in confirming infection in bone or joint. False negative results may be encountered in the spine.
9 year old boy (Senegal)
- 7 years history of suppuration in right tibia
- Tumefaction in lateral L thigh

Questions
- More than one focus?
- Activity?
- Tibial OM with bone destruction
- Femoral OM with cystic formation
- Humeral OM
BONE SCAN

99mTc-WBC
Development of the healing process

- Sequestrum resection
- Curettage
- Cement & AB
- In progress
10 year old girl
- Chronic suppuration
  L humerus

Questions
- Diagnoses (OM, Tumor)
- More than one focus?
- Extension?
10 year old girl
- Chronic suppuration L humerus

Questions
- Diagnoses (OM, Tumor)
- More than one focus?
- Extension?
- Extensive humeral Om
- Cold area in metaphysis (sequestrum, oedema, post-surgery?)
- Cold area in humeral head: lack of perfusion
- No other foci
- Debridement and sequestrum resection
- Neck fracture
- Focal head collapse
- Good results (no pain, complete function)
<table>
<thead>
<tr>
<th>Condition</th>
<th>US</th>
<th>XR</th>
<th>MRI</th>
<th>NM</th>
</tr>
</thead>
<tbody>
<tr>
<td>(See also M19, M21) M18</td>
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<td></td>
</tr>
<tr>
<td>Limping</td>
<td>Indicated [B]</td>
<td>Not indicated initially [B]</td>
<td></td>
<td>Not indicated initially [B]</td>
</tr>
<tr>
<td>M19</td>
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</table>

**US** will confirm presence of an effusion but will not discriminate sepsis from transient synovitis.

**XR**, which may include a frog lateral view, is required if slipped upper femoral epiphysis or Perthes’ disease is suspected or if symptoms persist. If symptoms persist, then follow-up should be as for the limping child.

**US** will confirm the presence of an effusion but will not discriminate sepsis from transient synovitis.

Children with a limp need proper clinical assessment. If pain persists, or localising signs are present, **XR** is indicated.

Should be used after discussion with radiologist.

**XR** and **US** should be performed before **NM**. **NM** is useful for localisation when **XR** and **US** are normal. The age of the child is an important factor in limiting the diagnostic possibilities.

**LIMPING**

**IRRITABLE HIP**
### Irritable hip

<table>
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<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>XR</td>
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US will confirm presence of an effusion but will not discriminate sepsis from transient synovitis.

XR, which may include a frog lateral view, is required if slipped upper femoral epiphysis or Perthes’ disease is suspected or if symptoms persist. If symptoms persist despite normal XR findings, MRI may be indicated.

### Limping

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</table>

Confirm the presence of an effusion. Not discriminate sepsis from transient synovitis.

(MRI is not indicated initially for limping.)
LIMPING
IRRITABLE HIP

XR

Indicated if suspicion:
- Slipped upper femoral epiphysis
- Perthes’ disease
- Persistence of symptoms

US

Indicated [B]

US will confirm presence of an effusion but will not discriminate sepsis from transient synovitis.

XR

Not indicated initially

XR, which may include a frog lateral view, is required if slipped upper femoral epiphysis or Perthes’ disease is suspected, or if there is persisting limping.

MRI

Specialised investigation

Not indicated initially

The age of the child is an important factor in limiting the diagnostic possibilities.
LIMPING

IRRITABLE HIP

MRI

Should be used after discussion with the radiologist

(See also M19)

US

Indicated
[B]

US will confirm presence of an effusion but will not discriminate sepsis from transient synovitis.

XR

Not indicated initially

XR, which may include a frog lateral view, is required if slipped upper femoral epiphysis or Perthes’ disease is suspected.

MRI

Specialised investigation

C

Should be used after discussion with the radiologist.

NM

Not indicated initially

NM is normal. Limiting the diagnostic possibilities.

Specialised investigation

C

Should be used after discussion with the radiologist.
<table>
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<tr>
<th>LIMPING</th>
<th>IRRITABLE HIP</th>
</tr>
</thead>
</table>

**NM**

**XR and US should be performed before NM: when XR and US are normal**

- **US** indicated
- **XR** not indicated initially
- **MRI** indicated
- **NM** not indicated initially

US will confirm presence of an effusion but will not discriminate sepsis from transient synovitis.

XR, which may include a frog lateral view, is required if slipped upper femoral epiphysis or Perthes’ disease is suspected.

NM is indicated only if XR and US are normal. MRI will then be required in order to exclude the diagnostic possibilities.
7 year old girl
- Child with progressive pain in the groin
- She has a limp
- History of fever
- Physical exploration: limited motion R hip
- Abnormal laboratory findings: ↑ CRP, ↑ erythrocyte sedimentation rate (ESR), ↑ serum white blood-cell count

Questions
- Arthritis? OM?
- Transient synovitis
- Other causes of synovitis
- Transient synovitis
5 year old boy
- Child with progressive pain in the groin
- He refuses to bear weight
- History of fever
- Physical exploration: limited motion R hip
- Abnormal laboratory findings: ↑ CRP, ↑ erythrocyte sedimentation rate (ESR), ↑ serum white blood-cell count

Questions
- Arthritis? OM?
- Transient synovitis
- Other causes of synovitis
Surgery is mandatory
- arthrotomy for joint decompression
- pulsed lavage (irrigation)
- gram stain with culture
- intravenous administration of antibiotics
9 months later...
Non-reversible sequelae in the femoral head
Development of the healing process
4 year old girl
- Pain in left hip
- Fever
- Hip exploration not conclusive
- ESR high, white cell count high

- Arthroscopy and irrigation
- Bad evolution

Questions
- Arthritis? OM?
**4 year old boy**
- Pain in the groin
- He has a limp
- Physical exploration: limited motion L hip
- Normal laboratory findings

Questions
- DD Meyer Dysplasia
- Extension of the necrosis
- Prognostic signs
PROGNOSTIC SIGNS:

- extension cold area in femoral head
- external column: degree of uptake
- hipoactivity proximal metaphysis
Shell procedure to enlarge the containment of the femoral head

Development of the healing process