Pathophysiology, Epidemiology, Clinical Risk Factors & Diagnosis using DXA

Dr Karen Knapp
Associate Professor in Musculoskeletal Imaging
Outline

- Pathophysiology
- Epidemiology
- Clinical risk factors
- Diagnosis with Dual Energy X-ray Absorptiometry
- Vertebral Fracture Assessment
- Trabecular Bone Score
- Atypical femoral fracture screening
Osteoporosis - definition

“A disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and consequent increase in fracture risk”

- Consensus Development Conference 1993

American Journal of Medicine 1993; 94:646-650.
Moderate Osteoporosis

Boyde A, London

Female, age 88 years
Severe Osteoporosis

Boyd A, London

Male, age 89 years
Osteoporosis: A Multifactorial Disease

Factors:
- Age
- Gender
- Race
- Body Size
- Lifestyle Factors
- Other Illnesses
- Drug Treatments
- Family History
Osteoporosis related fractures
Epidemiology

Age and sex specific incidence rates of fracture at the femur/hip, radius/ulna, and spine 1988-2012

Curtis EM et al. Bone 2016;87:19-16
Regional variation in fragility fracture (spine, hip, wrist, rib, pelvis, and humerus) incidence in men and women aged 50+ years within the UK. Relative rates of fracture are displayed in comparison to London.

Curtis EM et al. Bone 2016;87:19-16
NICE Guidelines

- NICE Clinical Knowledge Series: Osteoporosis - prevention of fragility fractures
- All women aged 65 years and over, and all men aged 75 years and over.
- All women aged 50–64 years and all men aged 50–74 years who have any of the following risk factors:
  - A previous osteoporotic fragility fracture.
  - Current use or frequent recent use of oral corticosteroids.
  - History of falls.
  - Low body mass index (less than 18.5 kg/m²)
  - Smoker.
  - Alcohol intake of more than 14 units per week.
NICE Guidelines:

- A secondary cause of osteoporosis, including:
  - Hypogonadism in either sex, including untreated premature menopause (menopause before 40 years of age), treatment with aromatase inhibitors (such as exemastane) or gonadotrophin-releasing hormone agonists (such as goserelin).
  - Endocrine conditions, including diabetes mellitus, Cushing's disease, hyperthyroidism, hyperparathyroidism, and hyperprolactinaemia.
  - Conditions associated with malabsorption including inflammatory bowel disease, coeliac disease, and chronic pancreatitis.
  - Rheumatoid arthritis and other inflammatory arthropathies.
  - Haematological conditions such as multiple myeloma and haemoglobinopathies.
  - Chronic obstructive pulmonary disease.
  - Chronic liver failure.
  - Chronic kidney disease.
  - Immobility.
DXA

- People younger than 50 years of age with any of the following risk factors:
  - Current or frequent use of oral corticosteroids.
  - Untreated premature menopause.
  - A previous fragility fracture.

- People younger than 40 years of age with any of the following risk factors:
  - Current or recent use of high-dose oral corticosteroids equivalent to, or more than, 7.5 mg prednisolone daily for 3 months or more.
  - Previous fragility fracture of the spine, hip, forearm, or proximal humerus.
  - History of multiple fragility fractures.
Consider assessing fracture risk for people taking the following medication, especially in the presence of other risk factors:

- Selective serotonin reuptake inhibitors.
- Antiepileptic medication — particularly enzyme-inducing drugs, such as carbamazepine.
- Aromatase inhibitors, such as exemastane.
- Gonadotropin-releasing hormone agonists, such as goserelin.
- Proton pump inhibitors.
- Thiazolidinediones, such
Clinical Risk Factors

Kanis et al. Osteoporosis Int 2013; 24:23-57
| **Age** | The model accepts ages between 40 and 90 years. If ages below or above are entered, the programme will compute probabilities at 40 and 90 year, respectively. |
| **Sex** | Male or female. Enter as appropriate. |
| **Weight** | This should be entered in kg. |
| **Height** | This should be entered in cm. |
| **Previous fracture** | A previous fracture denotes more accurately a previous fracture in adult life occurring spontaneously, or a fracture arising from trauma which, in a healthy individual, would not have resulted in a fracture. Enter yes or no (see also notes on risk factors). |
| **Parent fractured hip** | This enquires for a history of hip fracture in the patient's mother or father. Enter yes or no. |
| **Current smoking** | Enter yes or no depending on whether the patient currently smokes tobacco (see also notes on risk factors). |
| **Glucocorticoids** | Enter yes if the patient is currently exposed to oral glucocorticoids or has been exposed to oral glucocorticoids for more than 3 months at a dose of prednisolone of 5mg daily or more (or equivalent doses of other glucocorticoids) (see also notes on risk factors). |
| **Rheumatoid arthritis** | Enter yes where the patient has a confirmed diagnosis of rheumatoid arthritis. Otherwise enter no (see also notes on risk factors). |
| **Secondary osteoporosis** | Enter yes if the patient has a disorder strongly associated with osteoporosis. These include type I (insulin dependent) diabetes, osteogenesis imperfecta in adults, untreated long-standing hyperthyroidism, hypogonadism or premature menopause (<45 years), chronic malnutrition, or malabsorption and chronic liver disease |
| **Alcohol 3 or more units/day** | Enter yes if the patient takes 3 or more units of alcohol daily. A unit of alcohol varies slightly in different countries from 8-10g of alcohol. This is equivalent to a standard glass of beer (285ml), a single measure of spirits (30ml), a medium-sized glass of wine (120ml), or 1 measure of an aperitif (60ml) (see also notes on risk factors). |
| **Bone mineral density (BMD)** | (BMD) Please select the make of DXA scanning equipment used and then enter the actual femoral neck BMD (in g/cm²). Alternatively, enter the T-score based on the NHANES III female reference data. In patients without a BMD test, the field should be left blank (see also notes on risk factors) (provided by Oregon Osteoporosis Center). |
Questionnaire:

1. Age (between 40 and 90 years) or Date of Birth
   Age: 75
   Date of Birth: Y: __ M: __ D: __
2. Sex
   - Male
   - Female
3. Weight (kg)
   54
4. Height (cm)
   156
5. Previous Fracture
   - No
   - Yes
6. Parent Fractured Hip
   - No
   - Yes
7. Current Smoking
   - No
   - Yes
8. Glucocorticoids
   - No
   - Yes
9. Rheumatoid arthritis
   - No
   - Yes
10. Secondary osteoporosis
    - No
    - Yes
11. Alcohol 3 or more units/day
    - No
    - Yes
12. Femoral neck BMD (g/cm²)

BMI: 22.2
The ten year probability of fracture (%)

without BMD

- Major osteoporotic: 67
- Hip Fracture: 59

View NOGG Guidance

www.exeter.ac.uk/medicine
Assessment threshold - Major fracture

10 year probability of major osteoporotic fracture (%)

If treatment is indicated, please click on the Treat item above to view guidance on related treatment options.

NOGG recommends treatment in this patient without the need for a BMD measurement, particularly if a scan is clinically inappropriate or unfeasible.
Questionnaire:

1. Age (between 40 and 90 years) or Date of Birth
   Age: 75
   Date of Birth: Y: [ ] M: [ ] D: [ ]

2. Sex
   Male [ ] Female [ ]

3. Weight (kg)
   54

4. Height (cm)
   156

5. Previous Fracture
   No [ ] Yes [ ]

6. Parent Fractured Hip
   No [ ] Yes [ ]

7. Current Smoking
   No [ ] Yes [ ]

8. Glucocorticoids
   No [ ] Yes [ ]

9. Rheumatoid arthritis
   No [ ] Yes [ ]

10. Secondary osteoporosis
    No [ ] Yes [ ]

11. Alcohol 3 or more units/day
    No [ ] Yes [ ]

12. Femoral neck BMD (g/cm²)
    T-Score [ ] -2.2

BMI: 22.2
The ten year probability of fracture (%)

with BMD

Major osteoporotic: 41
Hip Fracture: 28

View NOGG Guidance

Intervention Threshold

If you have a TBS value, click here: Adjust with TBS
Fracture discrimination

Fracture population

General population

$\Delta Z = \ln(\text{RR})$

<table>
<thead>
<tr>
<th>RR</th>
<th>$\Delta Z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1.5</td>
<td>0.41</td>
</tr>
<tr>
<td>2.0</td>
<td>0.69</td>
</tr>
<tr>
<td>2.5</td>
<td>0.92</td>
</tr>
<tr>
<td>3.0</td>
<td>1.10</td>
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</table>

Fracture cases (%)

All patients (%)
DXA
# WHO Classification

T-scores are used to decide whether a patient has reduced BMD consistent with osteopenia or osteoporosis.

<table>
<thead>
<tr>
<th>T-score</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>T &gt; -1 SD</td>
<td>Normal</td>
</tr>
<tr>
<td>T &gt; –1 SD to &lt; -2.5</td>
<td>Osteopenic</td>
</tr>
<tr>
<td>T &lt; -2.5 SD</td>
<td>Osteoporotic</td>
</tr>
</tbody>
</table>

For every SD decrease in BMD fracture risk increases x2 - WHO 1994
DXA results 2

- Premenopausal women and men <50 years
- ISCD guidelines
- Z-score -2

- Children – specialist service

- Bloods
- FBC
- plasma viscosity
- bone profile
- renal profile
- liver profile
- Vitamin D
- males: serum testosterone
- Tissue Transglutaminase Antibodies (tTG-IgA) – coeliac disease
VFA using DXA

- Low dose
- L4 to T4
- SE or DE
- Fan beam – no divergent rays
- High level of accuracy
- Morphometry – grade fractures
TBS

- Predicts fracture independently of BMD
- Compliments BMD
- Low precision errors
- Added to FRAX

<table>
<thead>
<tr>
<th></th>
<th>BMD (g/cm²)</th>
<th>T-score</th>
<th>TBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>1.123</td>
<td>-0.06</td>
<td>1.356</td>
</tr>
<tr>
<td>L2</td>
<td>1.323</td>
<td>1.02</td>
<td>1.474</td>
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<tr>
<td>L3</td>
<td>1.293</td>
<td>0.78</td>
<td>1.340</td>
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<tr>
<td>L4</td>
<td>1.109</td>
<td>-0.78</td>
<td>1.259</td>
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<tr>
<td>L1-L4</td>
<td>1.207</td>
<td>0.22</td>
<td>1.357</td>
</tr>
</tbody>
</table>
Conclusion

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- Epidemiology
- Clinical risk factors
- Diagnosis with Dual Energy X-ray Absorptiometry
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