Module 5 - *Speaking of Bones*
Osteoporosis For Health Professionals:
Fracture Risk Assessment

William D. Leslie, MD MSc FRCPc
Case #1

• Age 53: 3 years post-menopause
• Has always enjoyed excellent health with no past fracture, medical or surgical history
  – Stable Height = 154 cm (60.5 in.)
  – Stable Weight = 55.5 kg (122 lbs.)
  – High Caffeine Intake
### Who Should Be Tested for Osteoporosis?

<table>
<thead>
<tr>
<th>Major risk factors</th>
<th>Minor risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Age &gt; 65 years</td>
<td>• Rheumatoid arthritis</td>
</tr>
<tr>
<td>• Vertebral compression fracture</td>
<td>• Past history of clinical hyperthyroidism</td>
</tr>
<tr>
<td>• Fragility fracture after age 40</td>
<td>• Chronic anticonvulsant therapy</td>
</tr>
<tr>
<td>• Family history of osteoporotic fracture (especially maternal hip fracture)</td>
<td>• Low dietary calcium intake (see nutrition section)</td>
</tr>
<tr>
<td>• Systemic glucocorticoid therapy of &gt; 3 months duration</td>
<td>• Smoker</td>
</tr>
<tr>
<td>• Malabsorption syndrome</td>
<td>• Excessive alcohol intake</td>
</tr>
<tr>
<td>• Primary hyperparathyroidism</td>
<td>• Excessive caffeine intake (see nutrition section)</td>
</tr>
<tr>
<td>• Propensity to fall</td>
<td>• Weight &lt; 57 kg</td>
</tr>
<tr>
<td>• Osteopenia apparent on x-ray film</td>
<td>• Weight loss &gt; 10% of weight at age 25</td>
</tr>
<tr>
<td>• Hypogonadism</td>
<td>• Chronic heparin therapy</td>
</tr>
<tr>
<td>• Early menopause (before age 45)</td>
<td></td>
</tr>
</tbody>
</table>

# T-scores and Treatment Decisions

<table>
<thead>
<tr>
<th>Age</th>
<th>BMD T-scores</th>
<th>Action taken</th>
</tr>
</thead>
</table>
| 53  | Spine: -1.8 Femoral neck: -2.4 | Ruled out secondary causes Initiated:  
  - risedronate 35 mg weekly  
  - calcium 1500 mg daily  
  - vitamin D 400 IU daily |
Question

• Does this healthy 53 year old woman with femoral neck T-score -2.4 have:
  – (A) normal BMD, (B) osteopenia, (C) osteoporosis or (D) none of the above?

• Should a healthy 53 year old woman with femoral neck T-score -2.4 receive pharmacotherapy to reduce her fracture risk?
  – Yes or No?
Who Should Be Treated for Osteoporosis?

- Long-term glucocorticoid therapy
  - Start bisphosphonate therapy
  - Obtain DXA BMD for follow-up

- Personal history of fragility fracture after age 40

- Non-traumatic vertebral compression deformities

- Clinical risk factors (1 major or 2 minor)

- Low DXA BMD (T-score ≤−2.5)

AND

- Low DXA BMD (T-score ≤−1.5)

Consider therapy

Repeat DXA BMD after 1 or 2 years

2002 Guidelines

Who Should Be Treated for Osteoporosis?

Long-term glucocorticoid therapy

Start bisphosphonate therapy

Obtain DXA BMD for follow-up

Personal history of fragility fracture after age 40

Non-traumatic vertebral compression deformities

Clinical risk factors (1 major or 2 minor)

Low DXA BMD (T-score ≤−1.5)

AND

Low DXA BMD (T-score ≤−1.5)

Consider therapy

Repeat DXA BMD after 1 or 2 years


2002 Guidelines
WHO Definition of Osteoporosis

“A disease characterized by low bone mass and microarchitectural deterioration of bone tissue leading to enhanced bone fragility and a consequent increase in fracture risk.”
## BMD Categories

<table>
<thead>
<tr>
<th>Age</th>
<th>Category</th>
<th>Criteria*</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 50 years</td>
<td>Severe (established) osteoporosis</td>
<td>T-score ≤ -2.5 with fragility fracture</td>
</tr>
<tr>
<td></td>
<td>Osteoporosis</td>
<td>T-score ≤ -2.5</td>
</tr>
<tr>
<td></td>
<td>Osteopenia Low bone mass</td>
<td>T-score -1.0 to -2.5</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>T-score ≥ -1.0</td>
</tr>
</tbody>
</table>

T-scores: white female reference.
What’s Changed?

- Clinical risk factors
- Absolute fracture risk
- New fracture risk assessment systems
- New integrated management paradigm
Key Changes from 2002\(^1\) to 2010\(^2\)

- Increased focus on the clinical impact of fragility fractures
- Increased focus on the care gap that exists in the identification and treatment of high-risk individuals

Most Fragility Fractures in Postmenopausal Women Occur with Low Bone Mass ("Osteopenia")

![Graph showing the relationship between T-score and fracture rate](image)

- Fracture rate (per 1000 person-years)
- No. of fractures

Fragility Fracture: Definition

- A fracture occurring spontaneously or following minor trauma such as a fall from standing height or less\(^1,\textsuperscript{,2}\)
  - Excluding craniofacial, hand, ankle, and foot fractures

Consequences of Fracture

- Increased risk of
  - Hospitalization\(^1\)
  - Institutionalization\(^2\)
  - Death\(^3-5\)
  - Subsequent fracture\(^6-8\)
  - Decreased quality of life\(^9-12\)
  - Economic burden on healthcare system\(^2\)

Undertreatment of Osteoporosis Post Fracture in women


This care gap is even wider in men and those who reside in long-term care.
Post-fracture Care Gap: Comparison with Heart Attack

- Anti-osteoporosis medication post fracture: ~15%
- Beta-blockers post heart attack: ~80%

References:
Fracture Risk Assessment: Where Are We in 2012?

Selected Fracture Systems
2010 Canadianized FRAX / CAROC
10-year Risk Assessment: CAROC

- Semiquantitative method for estimating 10-year absolute risk of a major osteoporotic fracture* in postmenopausal women and men over age 50
  - Three zones (low: < 10%, moderate, high: > 20%)

* Fractures of proximal femur, vertebra [clinical], forearm, and proximal humerus

10-year Risk Assessment for Women (CAROC Basal Risk)

Risk Assessment with CAROC: Important Additional Risk Factors

- Factors that increase CAROC basal risk by one category (i.e., from low to moderate or moderate to high)
  - Fragility fracture after age 40
  - Recent prolonged systemic glucocorticoid use
Example of Adjusting Basal Risk: Based on Additional Risk Factors

- 60-year-old woman
- Femoral neck T-score = -2.8
- Based on age and T-score alone = moderate risk
- History of fragility fracture or prolonged systemic glucocorticoid use would shift her to high risk

The FRAX® tool has been developed from studying population-based cohorts from Europe, North America, Asia, and Australia. In their most sophisticated form, the FRAX® tool is computer-driven and is available on this site. Several simplified paper versions, based on the number of risk factors are also available, and can be downloaded for office use.

The FRAX® algorithms give the 10-year probability of fracture. The output is a 10-year probability of hip fracture and the 10-year probability of a major osteoporotic fracture (clinical spine, forearm, hip or shoulder fracture).
Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

**Country:** Canada

**Name/ID:**

**Questionnaire:**

1. Age (between 40-90 years) or Date of birth
   - Age: 65
   - Date of birth: [Year] [Month] [Day]

2. Sex
   - Male
   - Female

3. Weight (kg)
   - 70

4. Height (cm)
   - 165

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 per day
    - No
    - Yes

12. Femoral neck BMD (g/cm²)
    - Select DXA
      - GE-Lunar
      - Hologic
      - Norland
      - T-Score

**Weight Conversion**

- Pounds ➔ Kgs
  - [Enter weight] ➔ [Convert]

**Height Conversion**

- Inches ➔ Cms
  - [Enter height] ➔ [Convert]
Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

Country: Canada

Questionnaire:

1. Age (between 40-90 years) or Date of birth
   - Age: 65
   - Date of birth: Y:  , M: , D: 

2. Sex
   - Male
   - Female

3. Weight (kg)
   - 70

4. Height (cm)
   - 165

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 per day
    - No
    - Yes

12. Femoral neck BMD (g/cm²)
    - Select DXA
    - 

BMI 25.7
The ten year probability of fracture (%)
without BMD

- Major osteoporotic: 15
- Hip fracture: 2.6

Weight Conversion
- Pounds
- Kgs

Height Conversion
- Inches
- Cms
Variations in Estimated 10-Year Fracture Probabilities According to Country

10-Year Major Fracture Probability
Age 65 years, prior fracture with femoral neck T-score -2.5

Evaluating Prediction Models

- Independent validation
- Risk stratification
- Model calibration
## Comparison: 10y Fracture Risk Systems

<table>
<thead>
<tr>
<th></th>
<th><strong>2010 CAROC</strong></th>
<th><strong>Canadian FRAX</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>Semi-quantitative (low, moderate, high)</td>
<td>Quantitative (fracture probability)</td>
</tr>
<tr>
<td>**BMD * **</td>
<td>Femoral neck (required)</td>
<td>Femoral neck (optional)</td>
</tr>
<tr>
<td><strong>Clinical</strong></td>
<td>Fragility fracture Prolonged steroids</td>
<td>Fragility fracture Prolonged steroids BMI Parental hip fracture Current smoking High alcohol use Rheumatoid arthritis Secondary causes</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>Major fracture</td>
<td>Major fracture Hip fracture</td>
</tr>
<tr>
<td><strong>High risk</strong></td>
<td>&gt;20%</td>
<td>&gt;20%</td>
</tr>
<tr>
<td><strong>Validation</strong></td>
<td>Level 1 evidence</td>
<td>Level 1 evidence</td>
</tr>
</tbody>
</table>
Which One Is Better?

Canadian FRAX

FRAX Lite
“It’s Not the Model, It’s the Management”

“The stone age was marked by man’s clever use of crude tools;”

Anonymous
Integrated Management Model Algorithm (Basic Paradigm)

Fracture Risk Assessment

- Low Risk
  Don’t Treat

- Moderate Risk
  Stop and Think

- High Risk
  Treat
Basic Bone Health

• Calcium up to 1200 mg daily (diet and supplement)
• Vitamin D 800-2000 IU daily (over age 50)
• Regular weight bearing exercise
Integrated Management Model Algorithm, part 1 of 2

**Basic Care** (suitable for all)
Lifestyle changes; adequate calcium intake & vitamin D; falls prevention

- **Age < 50**
  - Identify medical conditions associated with osteoporosis and fractures

- **Age 50 - 64**
  - Identify medical conditions and other clinical risk factors associated with osteoporosis and fractures

- **Age ≥ 65**
  - All men and women

**Initial BMD Testing**

Continued on next slide
Integrated Management Model Algorithm, part 1 of 2

Initial BMD Testing

Fracture Risk Assessment

FRAX Canada 3.1

CAROC 2010

Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

Country: Canada

Letter ID: Name ID: About the min function

Questionnaire:
1. Age (years)
2. Sex (Male/Female)
3. Weight (kg)
4. Height (cm)
5. Previous fracture
6. Parental fracture
7. Current smoking
8. Alcohol consumption
9. Hormone replacement therapy
10. Secondary osteoporosis

Weight Conversion
Pounds Kgs

Height Conversion
Inches Cms

LOW RISK (<10%)
MODERATE RISK
HIGH RISK (>20%)

AGE (years)

FEMORAL NECK T-score

2011-01-01
Integrated Management Model Algorithm, part 2 of 2

Continued from previous slide

Fracture Risk Assessment – FRAX or CAROC

Low Risk
10-year fracture risk < 10%

Moderate Risk
10-year fracture risk 10 - 20%

High Risk
10-year fracture risk > 20%
or
Prior fragility fracture of hip or spine
or
More than one fragility fracture

continued...
Fracture Risk Assessment – FRAX or CAROC

**Low Risk**
10-year fracture risk < 10%

Unlikely to benefit from pharmacotherapy. Reassess risk in 5 years.

**Moderate Risk**
10-year fracture risk 10 - 20%

**High Risk**
10-year fracture risk > 20%
or
Prior fragility fracture of hip or spine or
More than one fragility fracture

Good evidence of benefit from pharmacotherapy
Integrated Management Model Algorithm, part 2 of 2

Continued from previous slide

Fracture Risk Assessment – FRAX or CAROC

Low Risk
10-year fracture risk < 10%

Moderate Risk
10-year fracture risk 10 - 20%

Perform spine imaging (x-ray or vertebral fracture assessment) to identify vertebral fractures

High Risk
10-year fracture risk > 20%
or
Prior fragility fracture of hip or spine or
More than one fragility fracture
VFA Recognition and Reporting

- Vertebral fractures unrelated to trauma are associated with a 5x risk for another vertebral fracture

- Vertebral fracture assessment (VFA) is a DXA scanning/software option.
Integrated Management Model Algorithm, part 2 of 2

Fracture Risk Assessment – FRAX or CAROC

Low Risk
10-year fracture risk < 10%
- Perform spine imaging (x-ray or vertebral fracture assessment) to identify vertebral fractures

Moderate Risk
10-year fracture risk 10 - 20%
- Look for additional factors that warrant consideration for pharmacological therapy

High Risk
10-year fracture risk > 20%
- Prior fragility fracture of hip or spine
- More than one fragility fracture

Continued from previous slide
**First Line Therapies with Evidence for Fracture Prevention in Postmenopausal Women**

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>Antiresorptive therapy</th>
<th>Bone formation therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bisphosphonates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alendronate</td>
<td>Risedronate</td>
</tr>
<tr>
<td>Vertebral</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hip</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Non-vertebral*</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Case #1: Question

• Does this healthy 53 year old woman with femoral neck T-score -2.4 have:
  – (A) normal BMD, (B) osteopenia, (C) osteoporosis or (D) none of the above?

• Should a healthy 53 year old woman with femoral neck T-score -2.4 receive pharmacotherapy to reduce her fracture risk?
  – Yes or No?
FRAX Calculation
(Age 53 – Six Years Ago)

Questionnaire:

1. Age (between 40-90 years) or Date of birth
   Age: 53
   Date of birth: Y: _ _ M: _ _ D: _ _

2. Sex
   Male Female

3. Weight (kg)
   53

4. Height (cm)
   154

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 per day
    No Yes

12. Femoral neck BMD (g/cm²)
    T-Score -2.4

BMI 22.3
The ten year probability of fracture (%)

with BMD

- Major osteoporotic 6.0
- Hip fracture 1.2
CAROC Calculation (Age 53 – Six Years Ago)

- 53-year-old woman
- Femoral neck T-score = -2.4
- Based on age and T-score alone = low risk
Case #1: Answer

• Does a healthy 53 year old woman with femoral neck T-score -2.4 have:
  – (A) normal BMD, (B) osteopenia, (C) osteoporosis or (D) **none of the above**?

• Should a healthy 53 year old woman with femoral neck T-score -2.4 receive pharmacotherapy to reduce her fracture risk?
  – Yes or **No**?
Integrated Management Model Algorithm, part 2 of 2

Fracture Risk Assessment – FRAX or CAROC

Low Risk
10-year fracture risk < 10%

Unlikely to benefit from pharmacotherapy. Reassess risk in 5 years.

Moderate Risk
10-year fracture risk 10 - 20%

High Risk
10-year fracture risk > 20%
or
Prior fragility fracture of hip or spine or
More than one fragility fracture
Case #2

- 65-year-old woman
- Natural menopause at age 50
- 10-year history of hypertension (currently)
- Body mass index (BMI): 24.8 kg/m²
- Blood Pressure: 136 / 84 mmHg
Case #2: Risk Factor Assessment

- No hormone treatment
- No personal fracture history
- Positive family history: Hip fracture in her mother at age 75 (fell in own home; ended up in personal-care home)
- Non smoker
- No history of systemic steroid use
- No history of rheumatoid arthritis
- No potential secondary causes of osteoporosis
- Alcohol use: < 3 drinks/day
- Femoral neck T-score -2.3
Case #2: Questions

- What is the fracture risk?
- What is the impact of family history of hip fracture on risk assessment?
- Is pharmacologic treatment indicated?
CAROC Calculation

- 65-year-old woman
- Femoral neck T-score = -2.3
- Based on age and T-score alone = moderate risk
FRAX Calculation with Family History

Country: Canada
Name/ID: Mrs. BR

Questionnaire:
1. Age (between 40-90 years) or Date of birth
   Age: 65
   Date of birth: Y: [ ] M: [ ] D: [ ]
2. Sex
   Male [ ] Female [ ]
3. Weight (kg) 63.5
4. Height (cm) 160
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 per day
    No [ ] Yes [ ]
12. Femoral neck BMD (g/cm²)
    T-Score [ ] -2.3

BMI 24.8
The ten year probability of fracture (%)
with BMD
- Major osteoporotic 19
- Hip fracture 2.1
FRAX Calculation without Family History

Questionnaire:

1. Age (between 40-90 years) or Date of birth
   Age: 65
   Date of birth: Y:   M:   D:   

2. Sex
   Male
   Female

3. Weight (kg)  63.5

4. Height (cm)  160

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 per day
    No
    Yes

12. Femoral neck BMD (g/cm²)
    T-Score: -2.3

BMI 24.8
The ten year probability of fracture (%) with BMD
- Major osteoporotic: 10
- Hip fracture: 2.0
Integrated Management Model Algorithm, part 2 of 2

Fracture Risk Assessment – FRAX or CAROC

Low Risk
10-year fracture risk < 10%

Moderate Risk
10-year fracture risk 10 - 20%

- Perform spine imaging (x-ray or vertebral fracture assessment) to identify vertebral fractures
- Look for additional factors that warrant consideration for pharmacological therapy

High Risk
10-year fracture risk > 20%
or
Prior fragility fracture of hip or spineor
More than one fragility fracture

Continued from previous slide
Impact of Family History of Hip Fracture on Risk Assessment

• For Case #2, the family history of parental hip fracture increases absolute 10-year risk of major osteoporotic fractures by 9.0%
  – This moves her from the lower end to the higher end of the moderate-risk range using FRAX
Case #2: To Treat or Not to Treat?

• Decision on whether to treat patients at moderate risk with pharmacologic therapy also involves
  – Discussion of benefits (e.g., fracture risk reduction) and risks (e.g., adverse events) of treatment
  – Assessment of patient preferences and health priorities to come up with an "individualized intervention threshold"
Case #3

- 66-year-old retired firefighter
- Complaining his back has been “worse than usual” the past three weeks
- Height: 180 cm (5'11"
  - Patient recalls being 185.5 cm (6'1"
- Weight: 80 kg (up 5 kg from one year ago)
- Body mass index (BMI): 24.7 kg/m²
Case #3: Risk Factor Assessment

- Family history: none significant
- No medications, systemic glucocorticoids or androgen-deprivation therapy
- No history of secondary causes of osteoporosis
- Historical height loss
- No previous trauma
- Prior smoker (45 pack/year history)
- Alcohol use: approximately two drinks per week
Case #3: Further Testing

• Screening for osteoporosis with dual energy X-ray absorptiometry (DXA) is indicated
  – T-score -1.9 at femoral neck
• Lateral thoraco-lumbar spine x-ray is ordered to rule out fractures
  – X-ray shows two vertebral compression fractures
Case #3: Questions

• What is the fracture risk?
• What is the impact of vertebral fractures on risk assessment?
• Is pharmacologic treatment indicated?
Case #3: CAROC Calculation

- 66-year-old man
- Femoral neck T-score = -1.9
- Based on age and T-score alone = low risk
- History of fragility fracture = moderate risk
Integrated Management Model Algorithm, part 2 of 2

Fracture Risk Assessment – FRAX or CAROC

Low Risk
10-year fracture risk < 10%

Moderate Risk
10-year fracture risk 10 - 20%

High Risk
10-year fracture risk > 20% or
Prior fragility fracture of hip or spine or
More than one fragility fracture

Good evidence of benefit from pharmacotherapy
Case #3: Conclusions

• High risk because of vertebral fractures

• In this case, 10-year assessment tools underestimate risk

• Patients at high risk benefit from pharmacologic therapy
  – Recommended agents for first-line use in men are alendronate, risedronate, or zoledronic acid
Key Points

• The management of osteoporosis should be guided by an assessment of the patient’s absolute risk of osteoporosis related fractures.

• Fragility fracture increases the risk of further fractures and should be considered in the assessment.

• Lifestyle modification and pharmacologic therapy should be individualized to enhance adherence to the treatment plan.
FRACTURE ASSESSMENT

RISKY BUSINESS