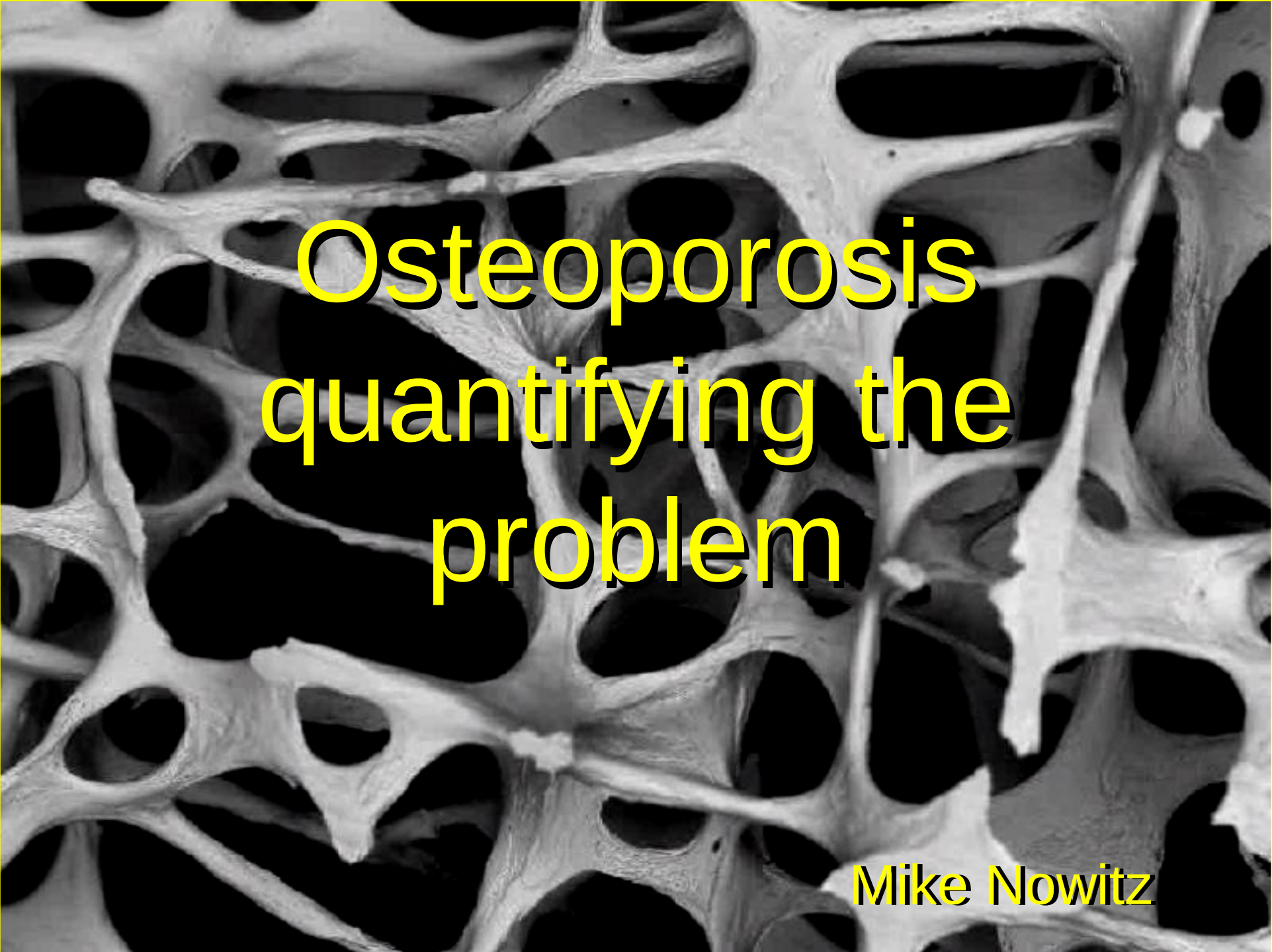


A grayscale micrograph of bone tissue, showing a complex, porous, and interconnected network of trabeculae. The structure is highly irregular, with many small, dark, circular or oval voids (trabecular spaces) interspersed among the lighter, fibrous bone tissue. The overall appearance is that of a sponge-like or honeycomb-like structure.

# Osteoporosis quantifying the problem

Mike Nowitz

# Quantifying the problem

- Population
- Individual

# Quantifying the problem

- Population
- Individual

# Population

- Osteoporosis is a common condition.
- +/- 380,000 New Zealanders suffer from Osteoporosis.

# Population

- Estimated 80,000 people had Osteoporotic fractures in 2007.
- Equates to a fracture every 6 minutes.
- Projected 30% increase by 2020.

# Hip #

- In NZ - 3800 hip fractures occur each year
  - One hip fracture every 2.5hrs
  - 25% have a full recovery
  - 25% of patients die in the year following a hip fracture
    - » Age
    - » Sex
    - » Home vs. residential care
  - 50% loss of independence + limited ambulation

# Quantifying the problem

- Population
- Individual

# Individual

- Do I have Osteoporosis ?
- How bad is it ?

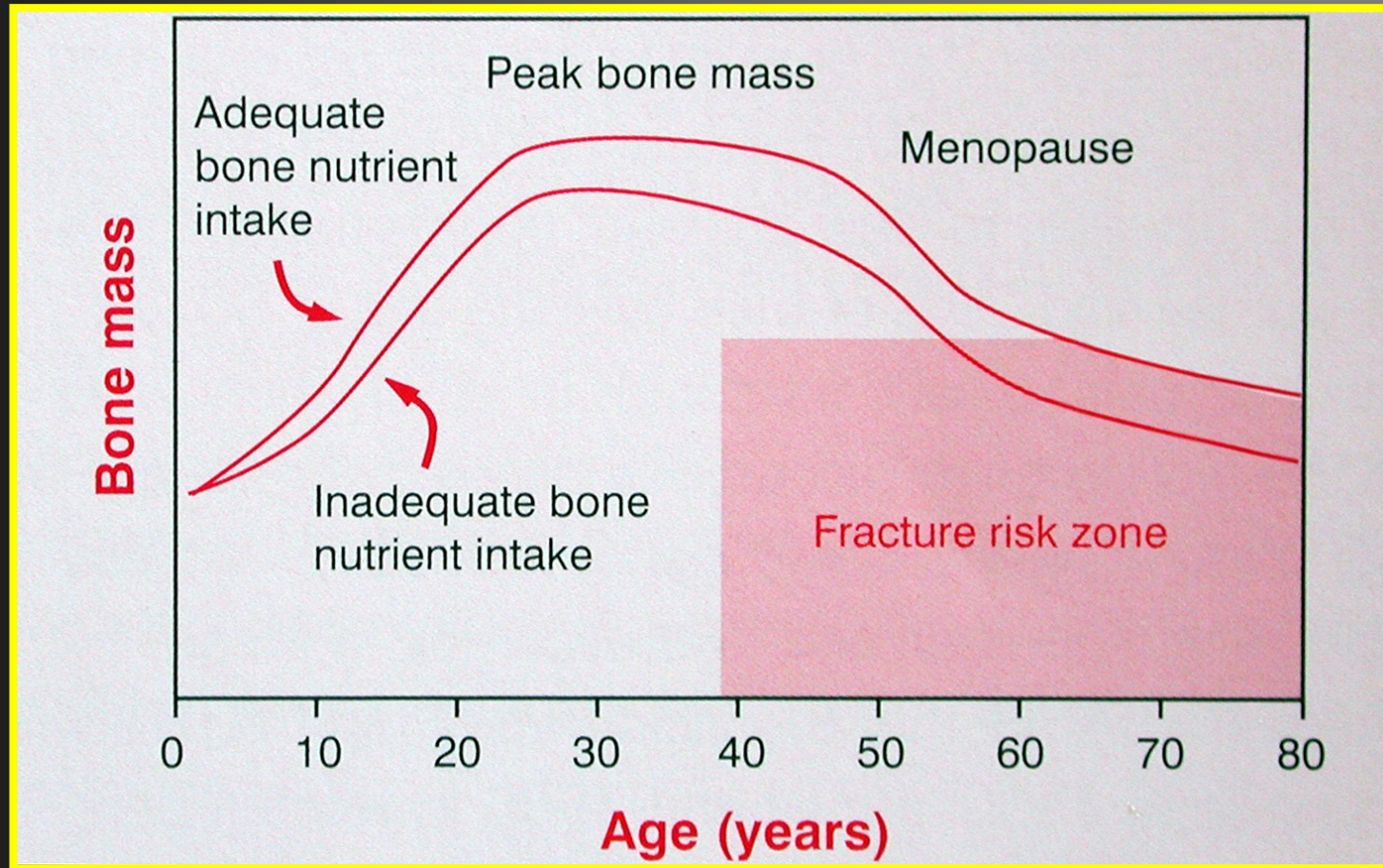
# Bone Anatomy.

- **Compact bone** - 80% of the skeleton
  - Outer layer of all bones & Shafts of long bones
    - Provides support / Mechanical lever
- **Trabecular bone** – 20% Of the skeleton
  - Ends of long bones & flat bones
    - Resists multidirectional forces
    - Transfers forces

# Bone Physiology.

- Bone is constantly being remodeled.
  - Adapts to new loads
  - Repairs damage
  - Maintains circulating calcium levels
- In the first 20 years formation exceeds resorption → bone growth.
- Peak bone mass at age 20 -30.
- Then resorption exceeds formation → bone loss.

# Bone Physiology.



- Aim – maximise bone density in childhood and minimise bone loss in adulthood.

# Bone Strength

- Bone mineral density
  - Bone mineral content (g)  $\div$  Bone area (cm<sup>2</sup>) = **BMD** (g/cm<sup>2</sup>)  $\equiv$  bone strength
- Many influences
  - Genetics
  - Adequate Nutrition
  - Mechanical loading
  - Hormone status
  - Systemic illness

# Why measure bone density?

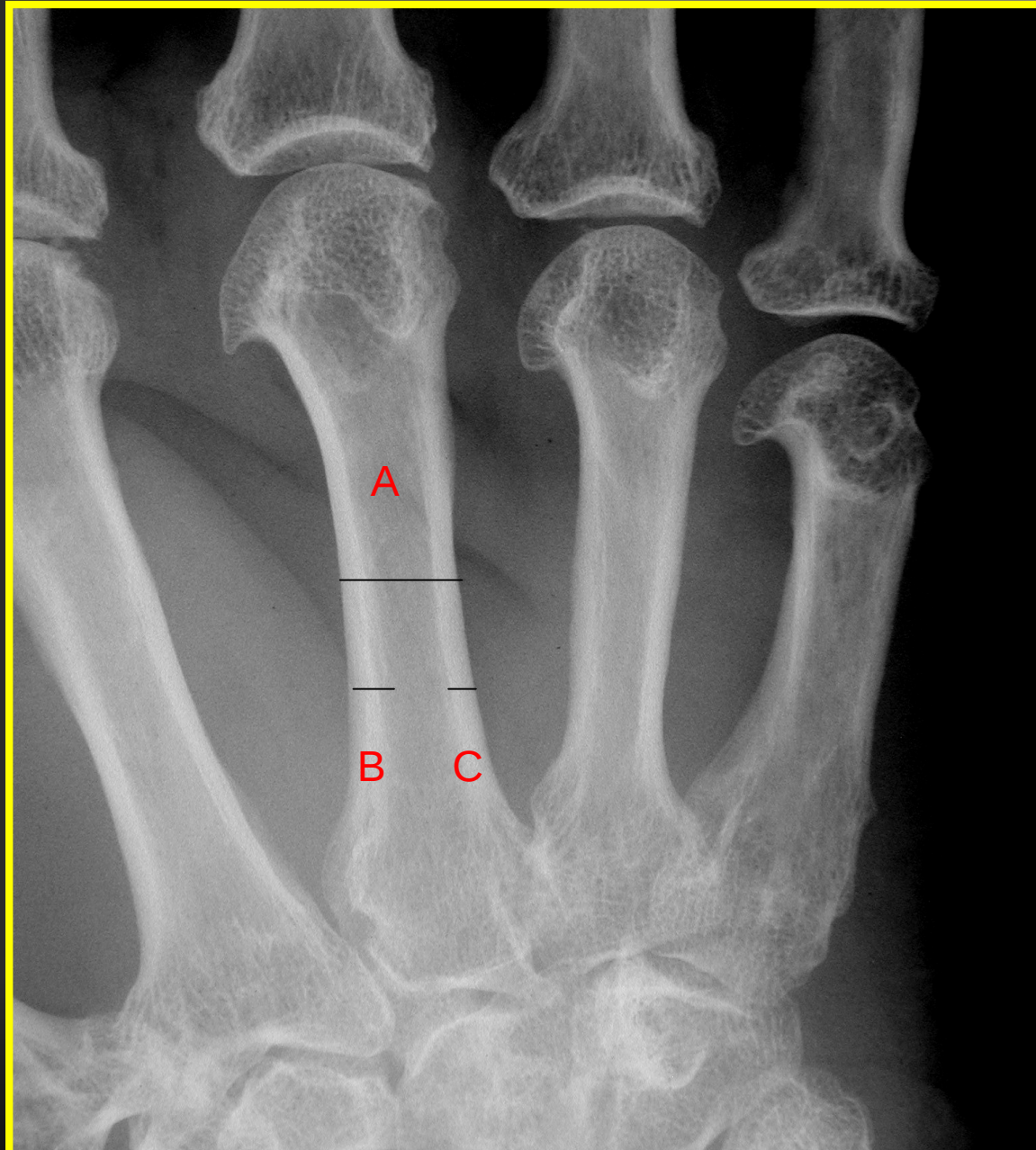
- Assess the current BMD.
- Establish a baseline for future monitoring.
- Provide information on the probability of future fractures.

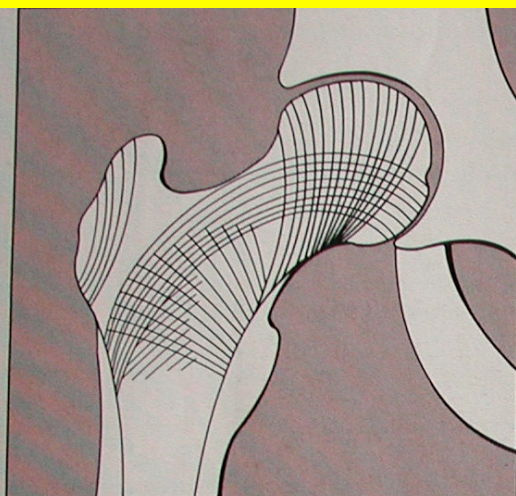
- Measuring the bone density & establish a baseline for future monitoring.
- Provide information on the probability of future fractures.

# Measurement of bone density

- Plain film
  - Carpal width
  - Singh Index
- DEXA

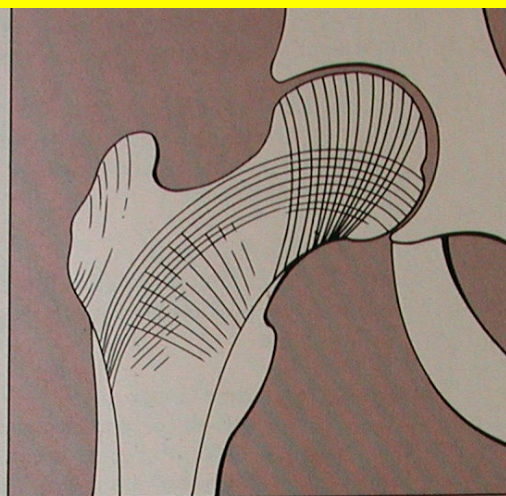






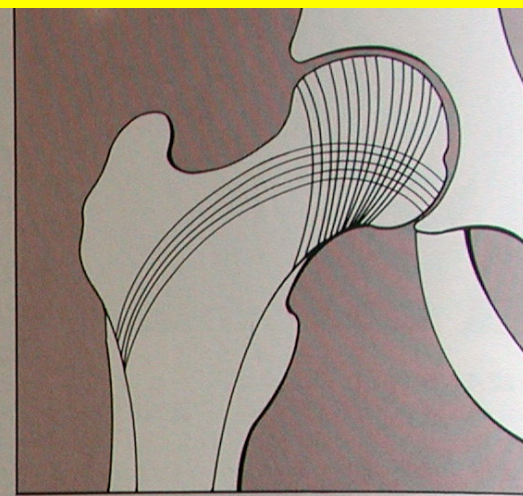
**Grade 6**

all normal trabecular groups visible; proximal end of femur completely occupied by cancellous bone



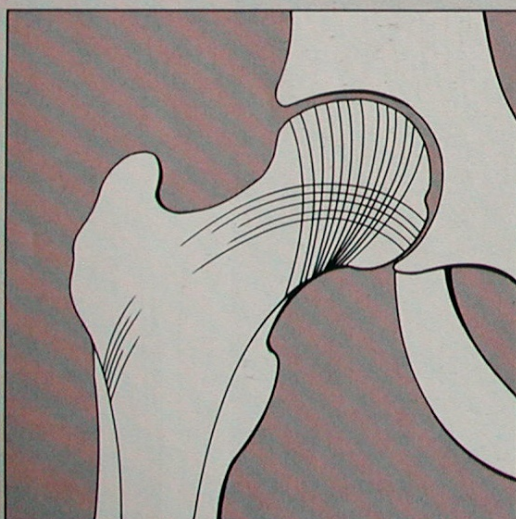
**Grade 5**

principal tensile and compressive trabeculae accentuated; Ward triangle prominent



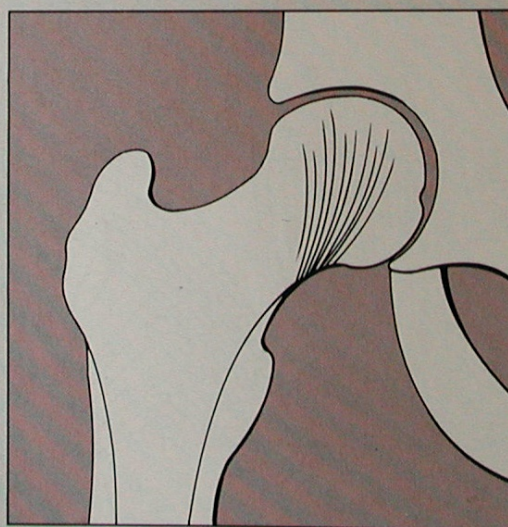
**Grade 4**

principal tensile trabeculae reduced in number but still can be traced from lateral cortex to femoral neck



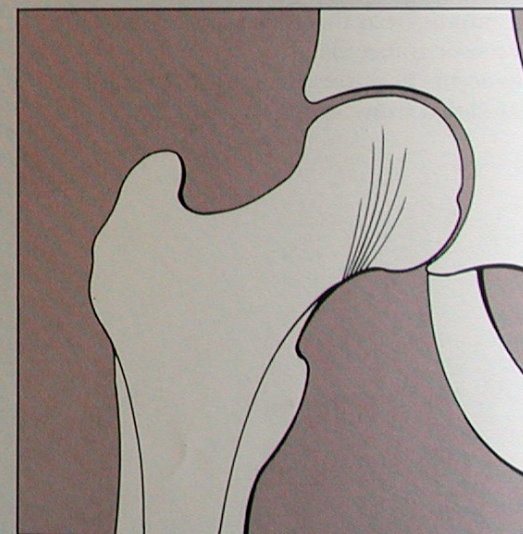
**Grade 3**

break in continuity of principal tensile trabeculae opposite greater trochanter



**Grade 2**

only principal compressive trabeculae can be seen; all tensile trabeculae have been lost



**Grade 1**

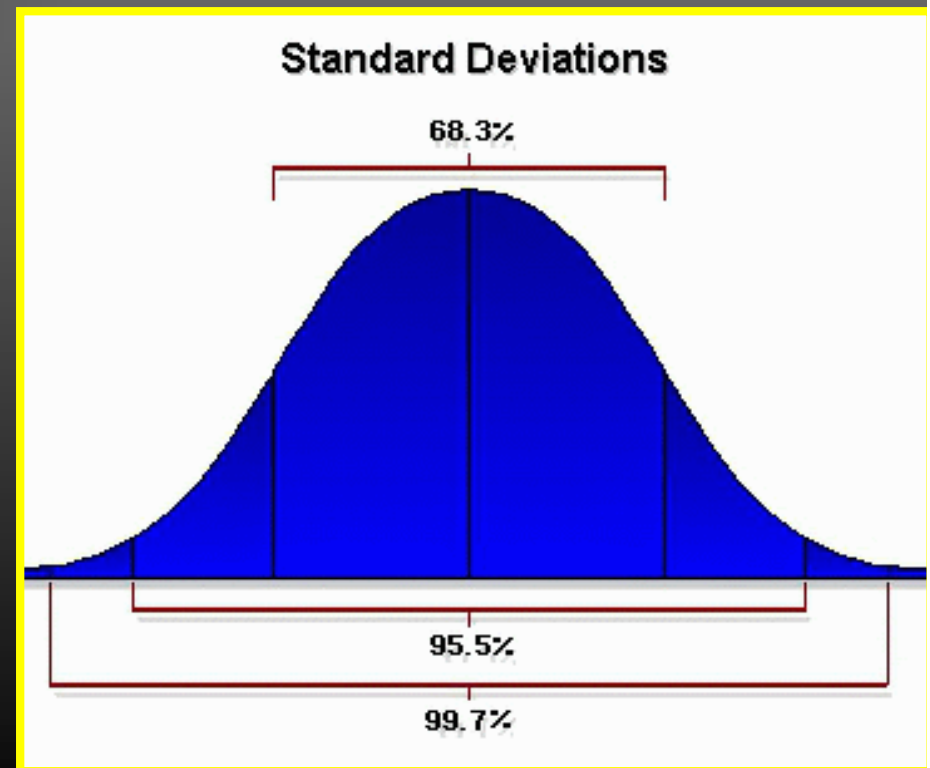
principal compressive trabeculae markedly reduced in number

# DEXA



# WHO Classification 1994

- The bone density can be
  - Normal
  - Decreased
  - Increased



# T and Z scores.

- T-score

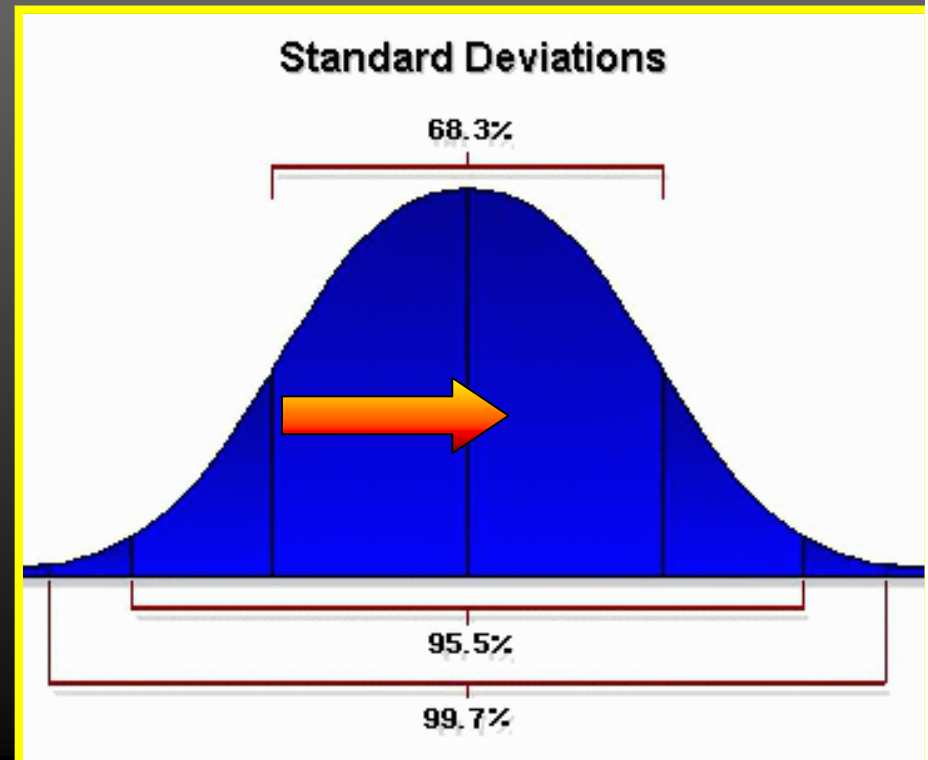
- The number of standard deviations below / above the average of a young adult at peak bone density.

- Z-score

- The number of standard deviations below / above an average person of the same age, race and gender.

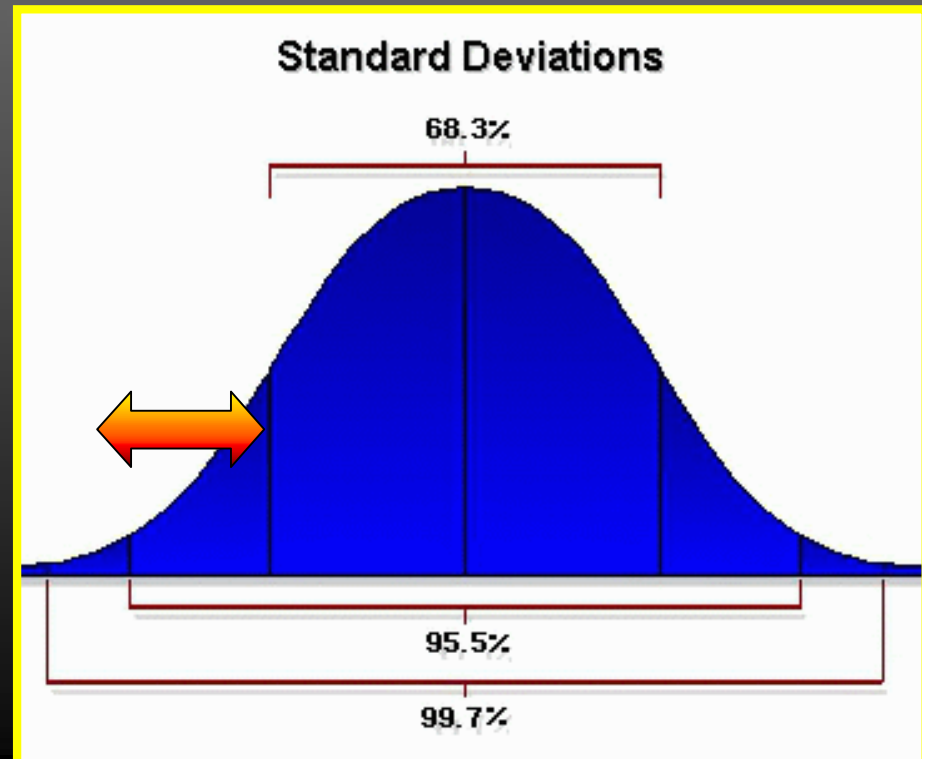
# Measurement of Bone Density

- (T score  $\geq -1$ )
  - Normal



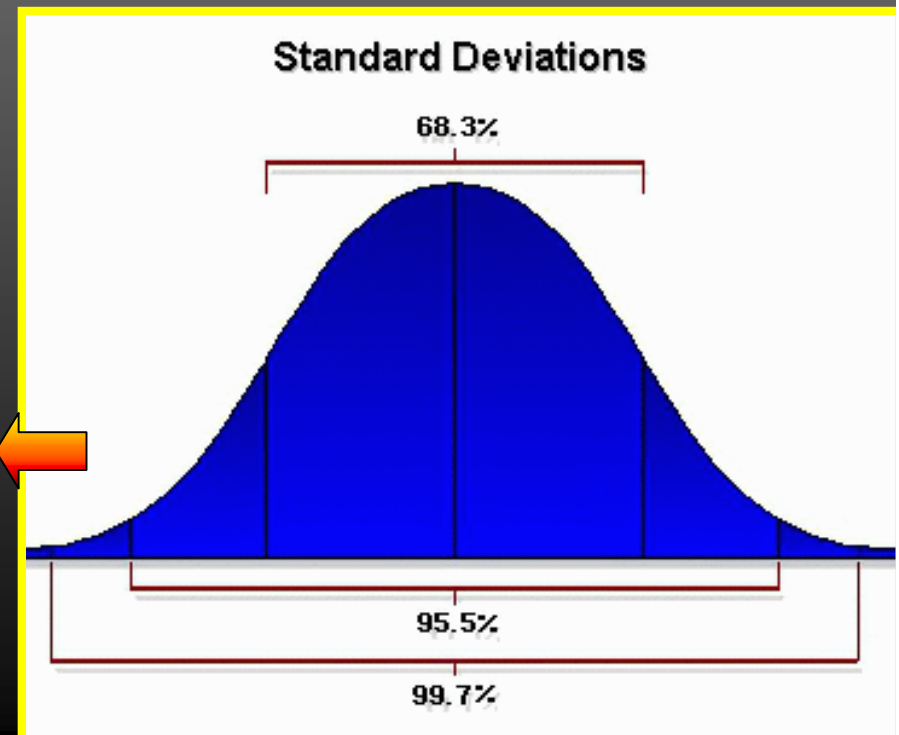
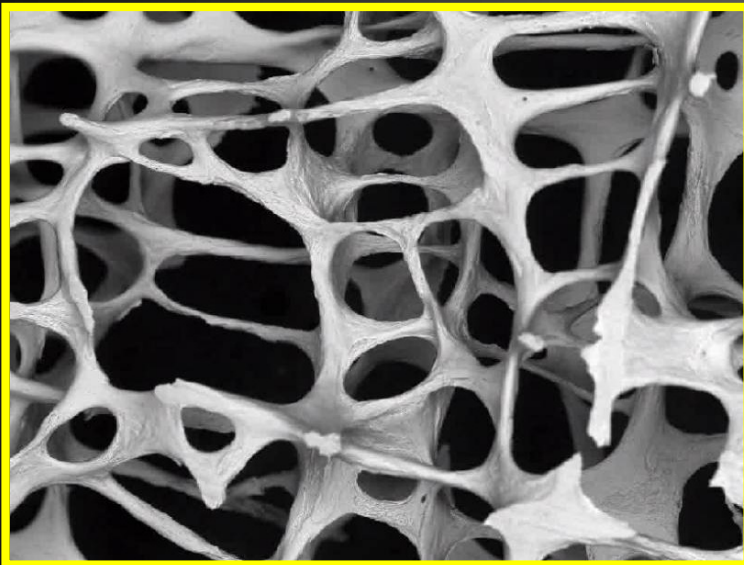
# Measurement of Bone Density

- (T score  $< -1$  &  $> -2.5$ )
  - Reduced
    - Osteopaenic *Osteo + penia (poverty)*



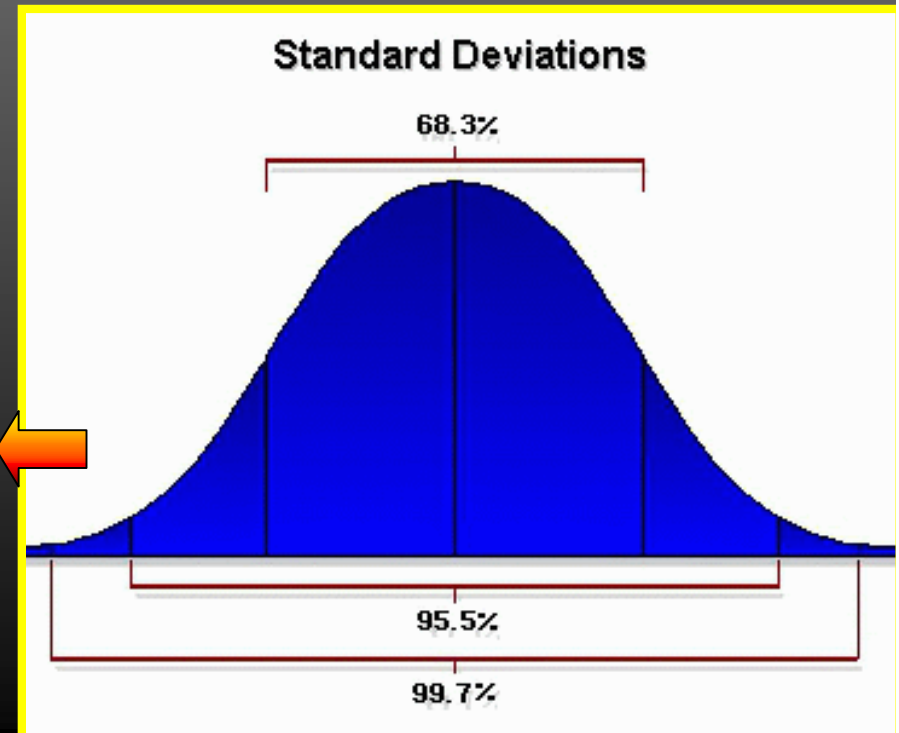
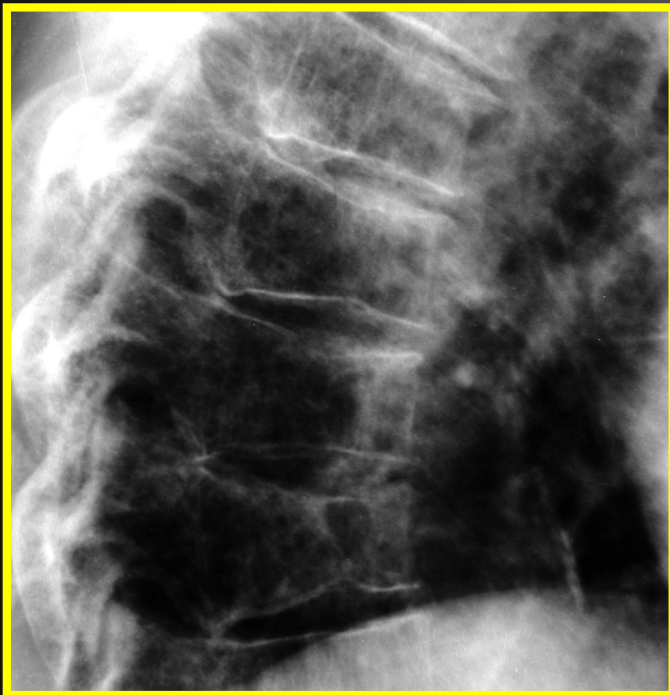
# Measurement of Bone Density

- (T score  $\leq -2.5$ )
  - Reduced
    - **Osteoporotic** Osteo + poros(pore) +  
osis(condition)

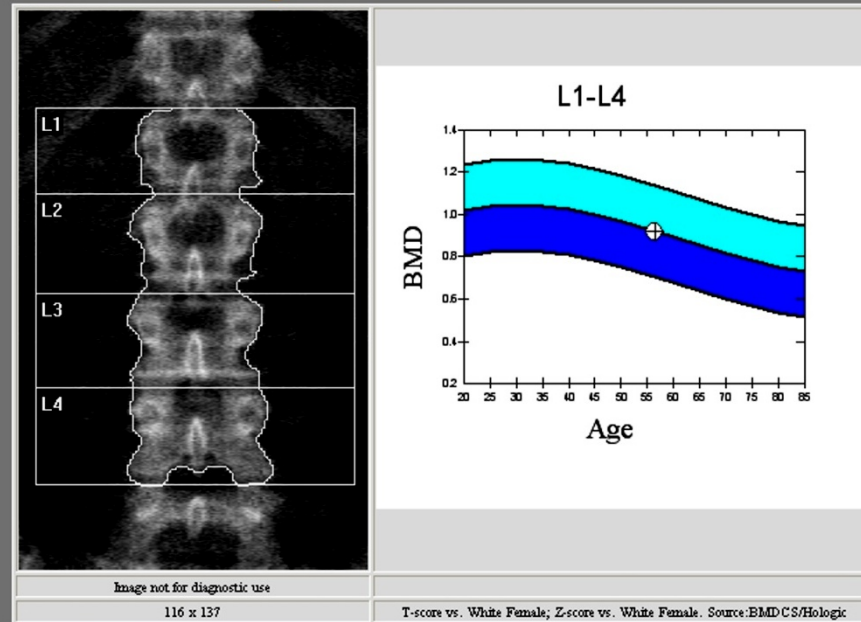


# Measurement of Bone Density

- (T score  $\leq -2.5$  & osteoporotic fracture)
  - Reduced
    - Established Osteoporosis



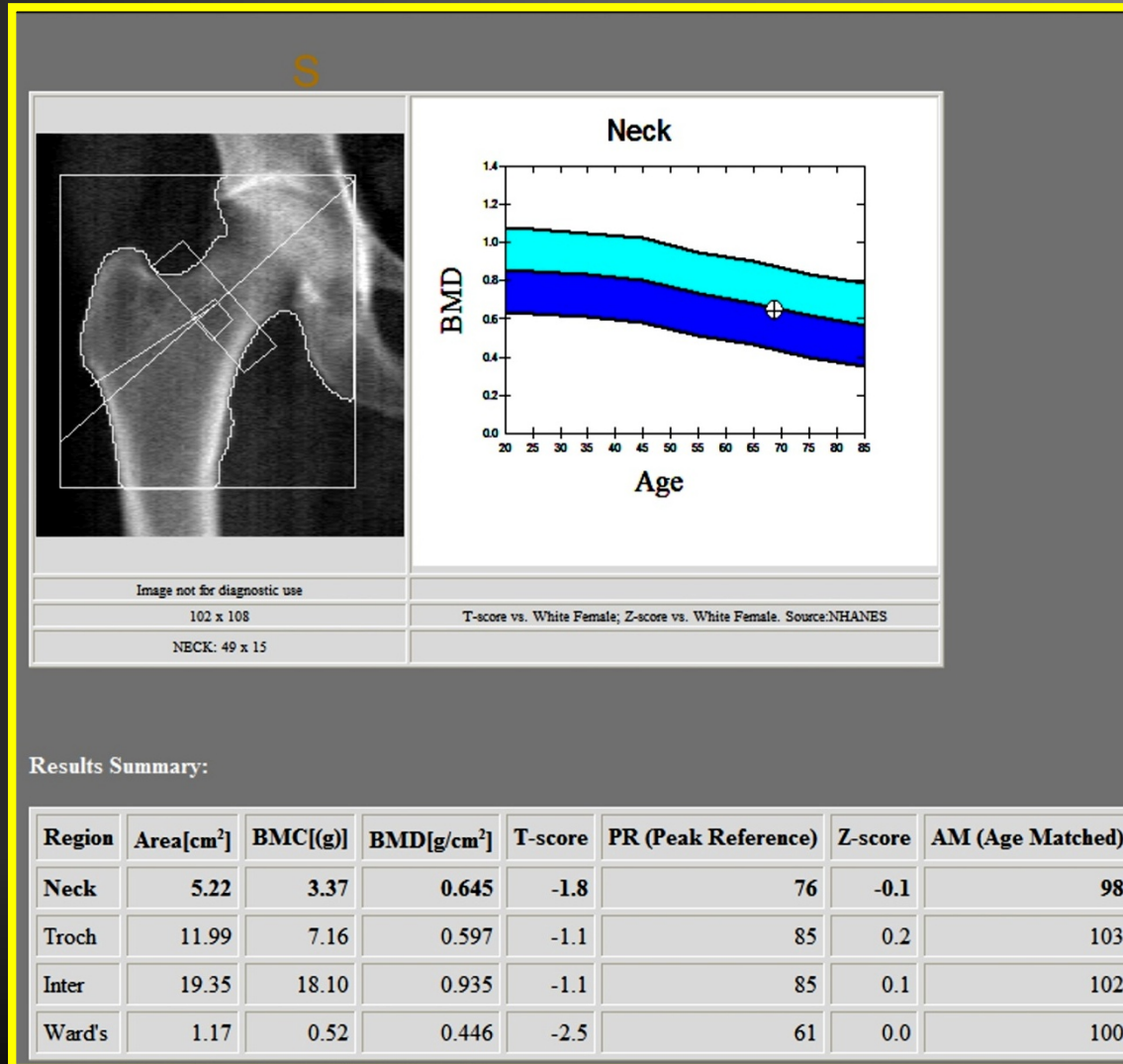
# Measurement of Bone Density



## Results Summary:

| Region       | Area[cm <sup>2</sup> ] | BMC[(g)]     | BMD[g/cm <sup>2</sup> ] | T-score     | PR (Peak Reference) | Z-score    | AM (Age Matched) |
|--------------|------------------------|--------------|-------------------------|-------------|---------------------|------------|------------------|
| L1           | 12.56                  | 10.14        | 0.808                   | -1.7        | 82                  | -0.6       | 92               |
| L2           | 14.73                  | 13.76        | 0.935                   | -0.8        | 91                  | 0.3        | 103              |
| L3           | 14.99                  | 14.47        | 0.965                   | -1.1        | 89                  | 0.1        | 101              |
| L4           | 15.83                  | 15.01        | 0.948                   | -1.0        | 89                  | 0.2        | 102              |
| <b>Total</b> | <b>58.10</b>           | <b>53.38</b> | <b>0.919</b>            | <b>-1.2</b> | <b>88</b>           | <b>0.0</b> | <b>100</b>       |

# Measurement of Bone Density



- Measure the bone density.
- Provide information on the probability of future fractures.

# Probability of Future Fractures

## – Normal

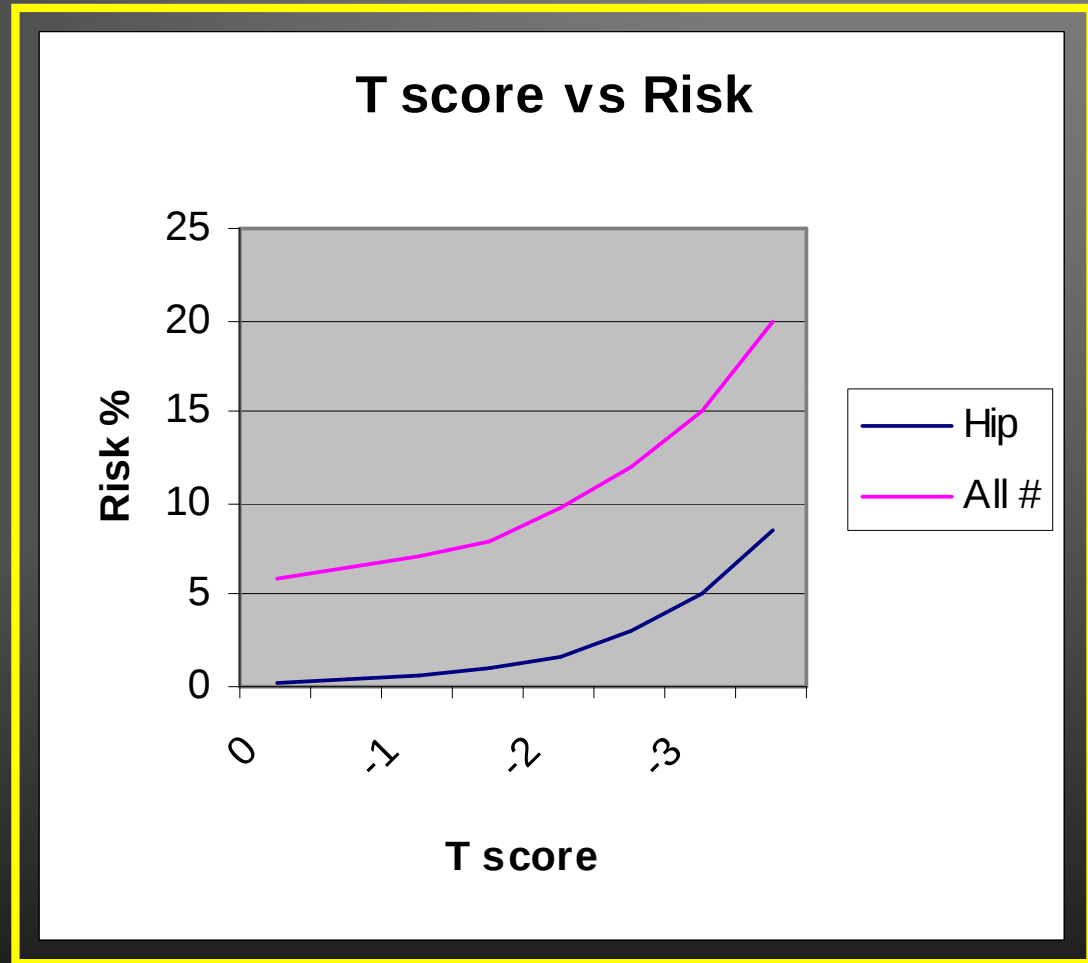
- Does not mean that a fracture will not occur but is less likely.

## – Osteoporosis

- Does not mean that a fracture will occur but is more likely.

# Probability of Future Fractures

- When moving between T scores the risk is not linear.



# Probability of Future Fractures

- Individuals with T scores of  $< 2.5$  have the greatest fracture risk.

# Probability of Future Fractures

- Individuals with T scores of  $< -2.5$  have the greatest fracture risk.
- But most fractures occur in individuals with T scores  $> -2.5$

# Probability of Future Fractures

- Individuals with T scores of  $< -2.5$  have the greatest fracture risk.
- But most fractures occur in individuals with T scores  $> -2.5$
- Reliance on BMD alone will miss at risk individuals.

# Probability of Future Fractures

- Clinical risk factors that are independent of BMD need to be incorporated into the risk assessment
  - Age
  - Fracture History
  - Steroid use
  - Smoking / Alcohol
  - Parental Hx. of hip fracture
  - Rheumatoid Arthritis
  - BMI
- Use the International Osteoporosis Foundations one minute test.



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#### ABOUT IOF

The International Osteoporosis Foundation (IOF) is the largest global non-governmental organization dedicated to the prevention, diagnosis and treatment of osteoporosis...

[Read about IOF](#)

#### ABOUT OSTEOPOROSIS

Osteoporosis is a disease in which the density and quality of bone is reduced, increasing the risk of fracture. It affects around one in three women and one in five men around the world...

[Find out about osteoporosis](#)

#### Patients & Public

Complete information about osteoporosis and what you can do. Find an osteoporosis society in your country or region. Take the risk assessment test.  
[Visit: Patients & Public](#)

#### Health Professionals

Useful information about osteoporosis and related topics. Educational materials, training courses.  
[Visit: Health Professionals](#)



Are you at risk of osteoporosis?

**Take the IOF One-Minute  
Osteoporosis Risk Test**

Want more Info? Contact an





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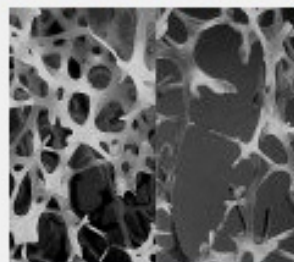
World Osteoporosis Day

IOF World Congress on  
Osteoporosis 2008

Are you among the one in three women, and the one in five men who will be affected by osteoporosis?

**Are you among the one in three women,  
and the one in five men who will  
be affected by osteoporosis?**

### What is osteoporosis?



Osteoporosis is a disease in which the density and quality of bone is reduced, increasing the risk of fracture. It affects around one in three women and one in five men around the world...

[Read more](#)



## The NEW Interactive IOF One-Minute Osteoporosis Risk Test

### Your family history

Have either of your parents been diagnosed with osteoporosis or broken a bone after a minor fall (a fall from standing height or less)?

☐ yes ☐ no

Did either of your parents have a "dowager's hump"?

☐ yes ☐ no

### Your personal clinical factors

These are fixed risk factors that one is born with or cannot alter. But that is not to say that they should be ignored. It is important to be aware of fixed risks so that steps can be taken to reduce loss of bone mineral.

Are you 40 years old or older?

☐ yes ☐ no

# Probability of Future Fractures

How do we to combine the risks conferred by:

BMD

Age

Sex

BMI

Clinical risk factors

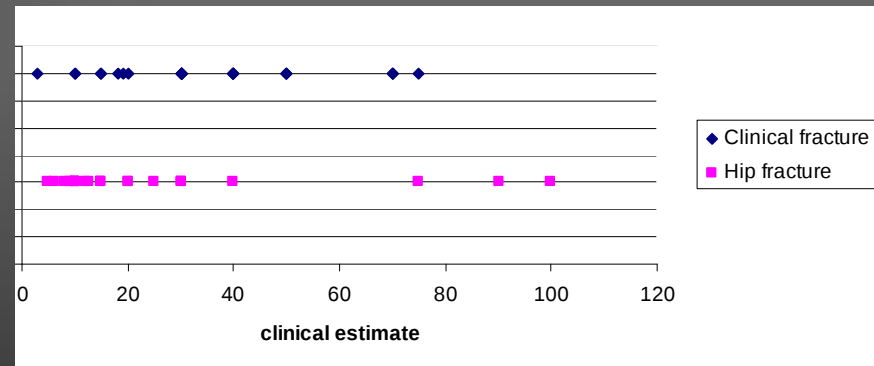
In a reliable and reproducible way ?

# Probability of Future Fractures

- 71 year old woman
- Xrays show vertebral crush fracture
- 1.59 meters tall, 64.7 kg
- Non smoker, no steroids, little alcohol
- Describes good health (no past history)
- remains active
- No hx of parental hip fracture
- Her femoral neck T score -3.5

# Probability of Future Fractures

- 71 year old woman
- Xrays show vertebral crush fracture
- 1.59 meters tall, 64.7 kg
- Non smoker, no steroids, little alcohol
- Describes good health (no past history)
- remains active
- No hx of parental hip fracture
- Her femoral neck T score -3.5



# Probability of Future Fractures

- 2008 WHO collaborating with the Centre for Metabolic Bone Diseases introduced the Fracture Risk Assessment Tool
- FRAX
  - Combines BMD and Clinical risk factors.
  - Computes the 10 year probability of a hip fracture or of a major osteoporotic fracture (spine, hip, humerus or forearm)



# FRAX™ WHO Fracture Risk Assessment Tool

[HOME](#)[CALCULATION TOOL](#)[PAPER CHARTS](#)[FAQ](#)[REFERENCES](#)[Select a Language](#)

## Welcome

The FRAX™ tool has been developed by WHO to evaluate fracture risk of patients. It is based on individual patient models that integrate the risks associated with clinical risk factors as well as bone mineral density (BMD) at the femoral neck.

The FRAX™ models have 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).

This is a beta version



**Dr. John A Kanis**

Professor Emeritus, University of Sheffield

### Links :

International Osteoporosis Foundation : <http://www.iofbonehealth.org/>

National Osteoporosis Foundation : <http://www.nof.org/>

Japan Osteoporosis Foundation : <http://www.jpof.or.jp/>



## Questionnaire:

1. Age (between 40-90 years) or Date of birth

Age:

Date of birth:

Y:

M:

D:

2. Sex

☐ Male

☐ Female

3. Weight (kg)

4. Height (cm)

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/cm<sup>2</sup>)

Select DXA



Clear

Calculate

## 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)

170

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/cm<sup>2</sup>)

T-Score



-2.1

Clear

Calculate

**BMI 24.2**

**The ten year probability of fracture (%)**



**with BMD**



Major osteoporotic

**10**



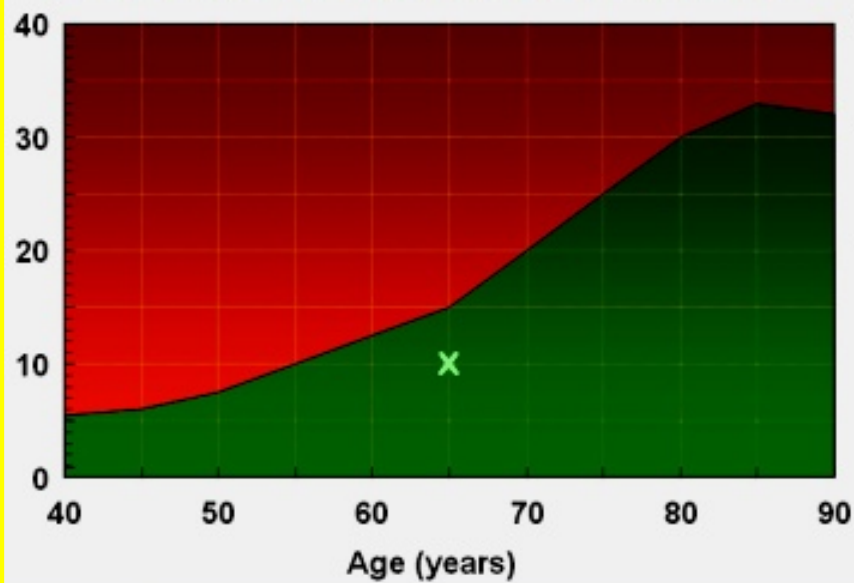
Hip fracture

**1.9**

View NOGG Guidance

## Intervention Threshold

Major Fracture - 10 year fracture probability



Hip - 10 year hip fracture probability



Country : **UK**

Name / ID :

About the risk factors



## Questionnaire:

1. Age (between 40-90 years) or Date of birth

Age:

Date of birth:

Y:

M:

D:

2. Sex

☐

Male

☒

Female

3. Weight (kg)

70

4. Height (cm)

170

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/cm<sup>2</sup>)

T-Score



-2.1

Clear

Calculate

**BMI 24.2**

**The ten year probability of fracture (%)**



**with BMD**

Major osteoporotic

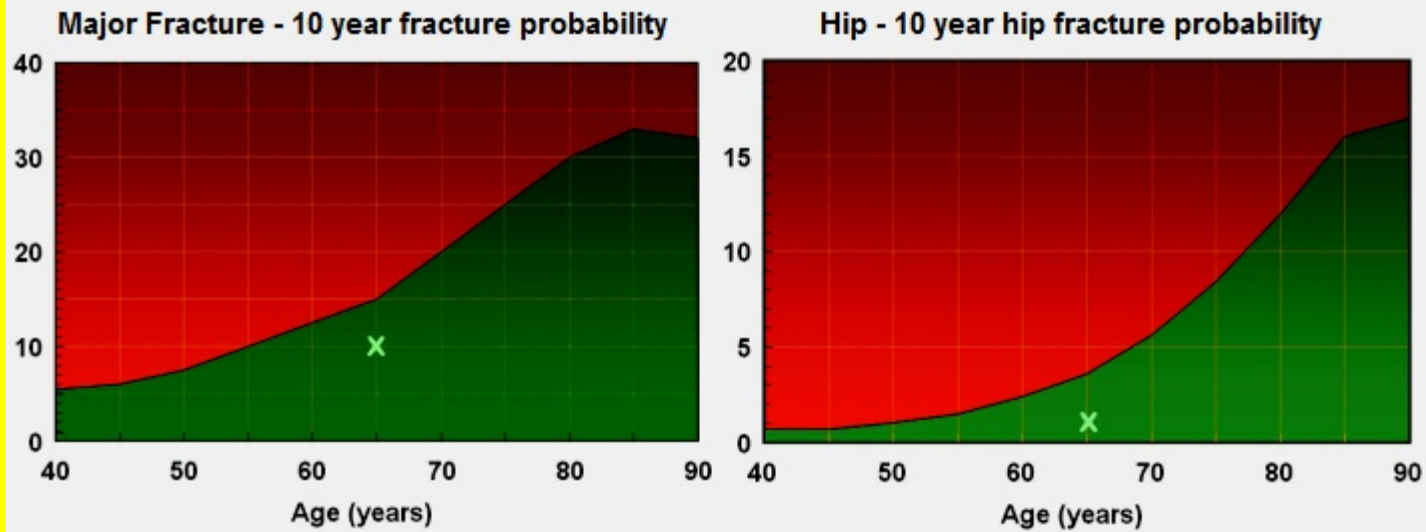
**17**

Hip fracture

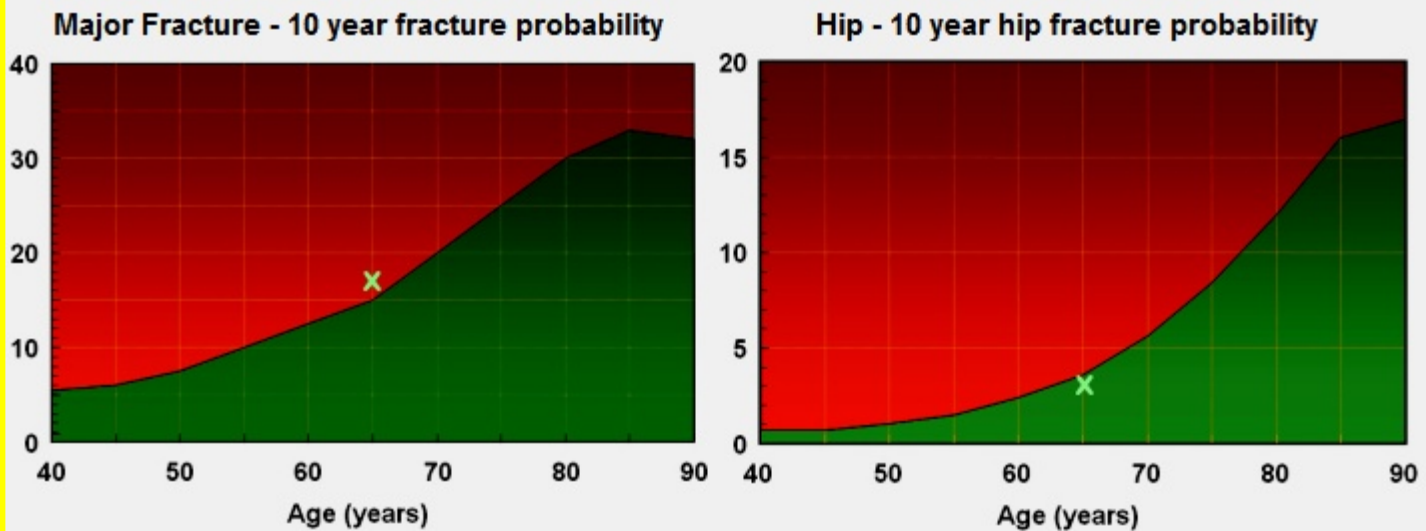
**3.2**

View NOGG Guidance

## Intervention Threshold



## Intervention Threshold



+ #

## 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)

170

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/cm<sup>2</sup>)

T-Score



-2.1

Clear

Calculate

**BMI 24.2**

**The ten year probability of fracture (%)**



**with BMD**



Major osteoporotic

**30**

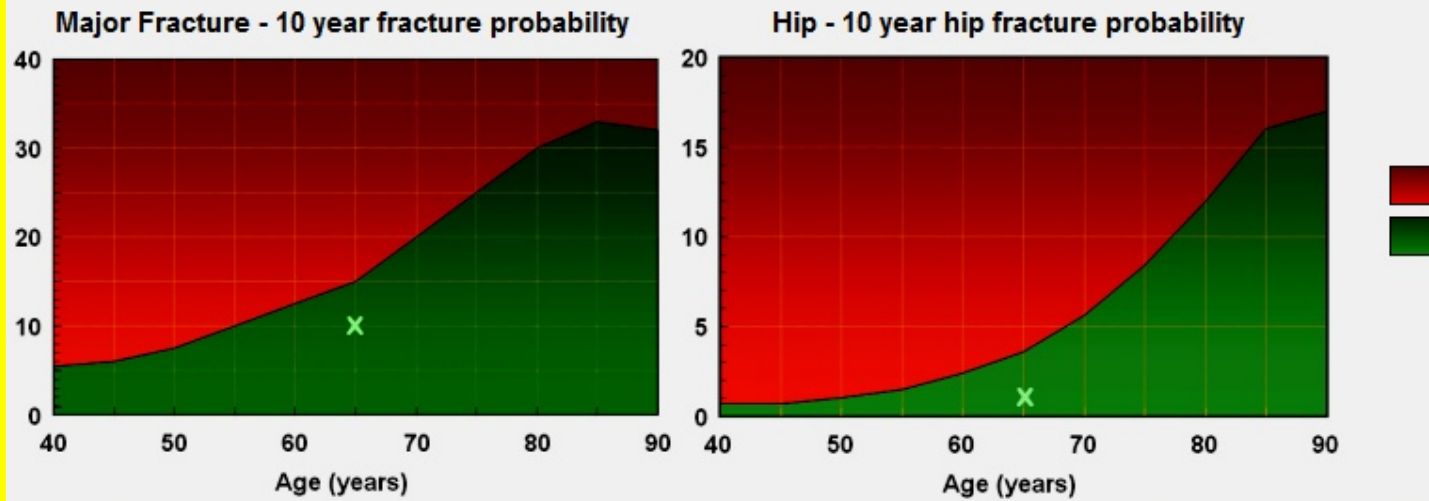


Hip fracture

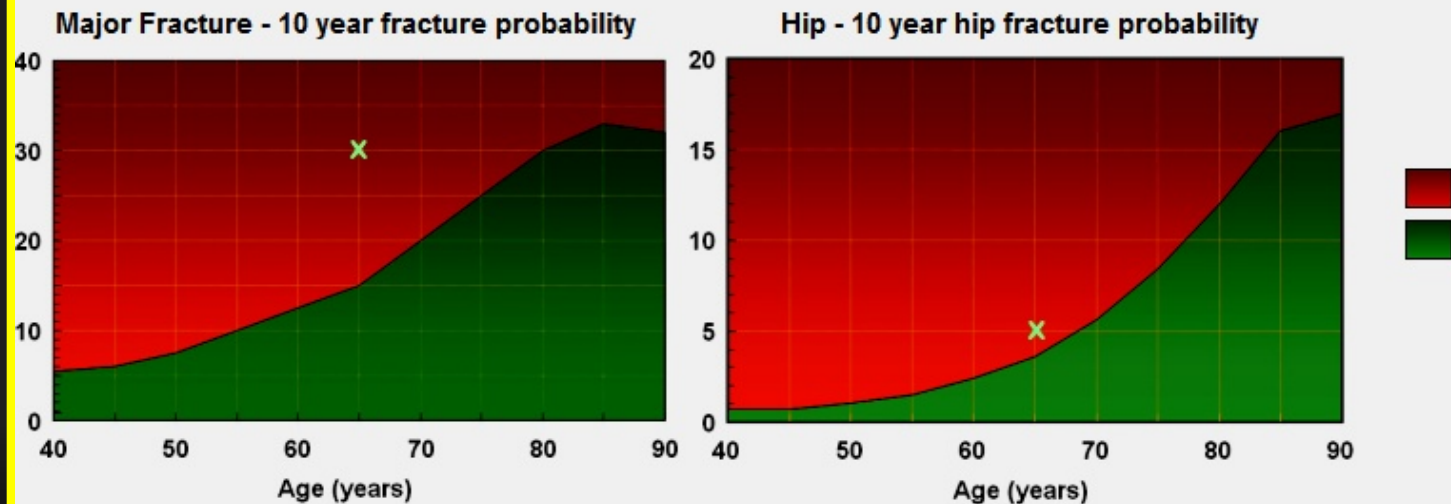
**5.6**

View NOGG Guidance

### Intervention Threshold



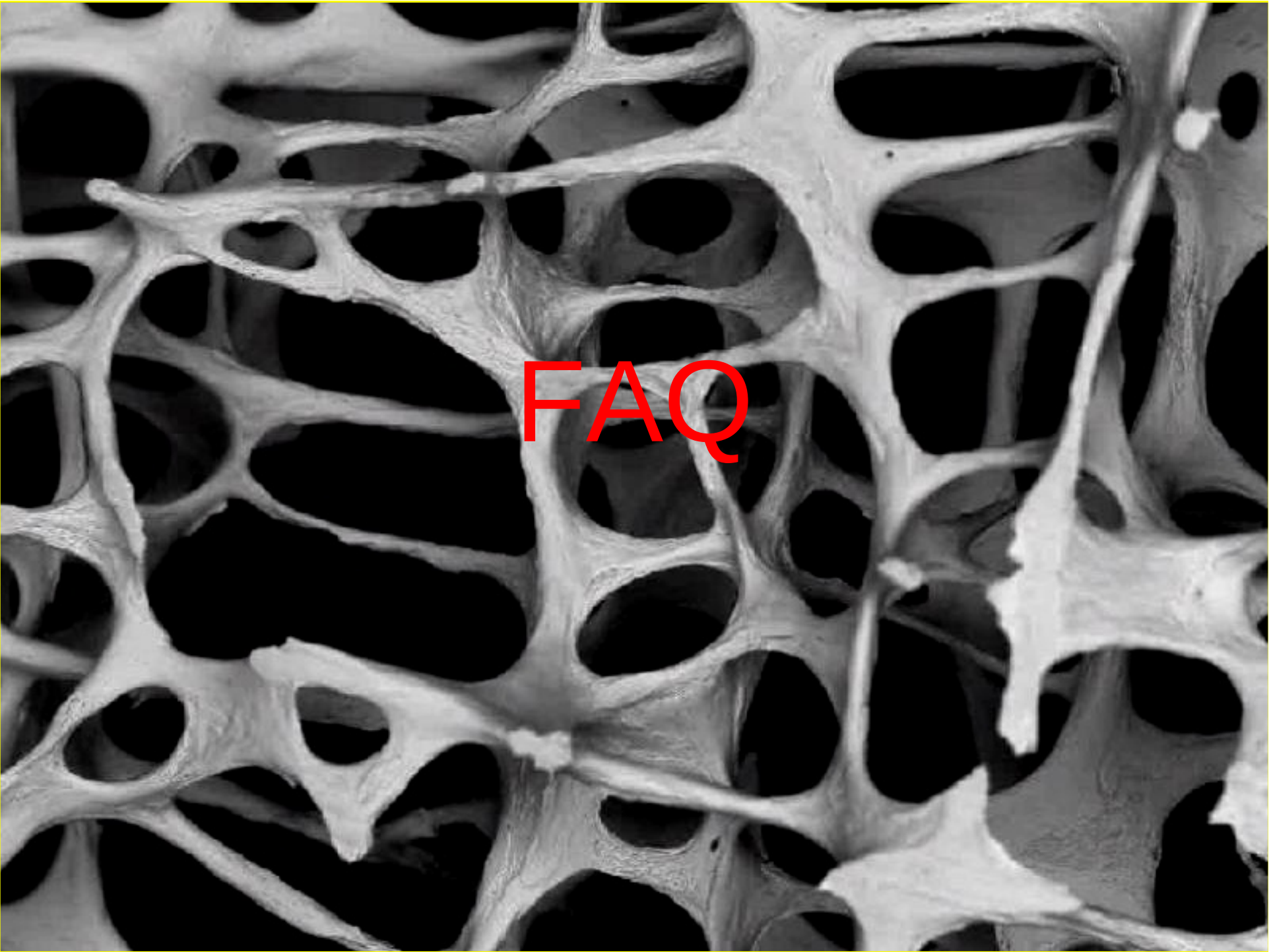
### Intervention Threshold



# Summary

- Osteoporosis is a common condition.
- Develop a culture of bone health.
- Identify people at risk before they fracture.
- Treat / preserve bone mineral where appropriate.





FAQ

Is there a tool to help me decide  
which patients need assessment?

## 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)

170

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/cm<sup>2</sup>)

Select DXA



Clear

Calculate

**BMI 24.2**

**The ten year probability of fracture (%)**



**without BMD**

Major osteoporotic

**16**

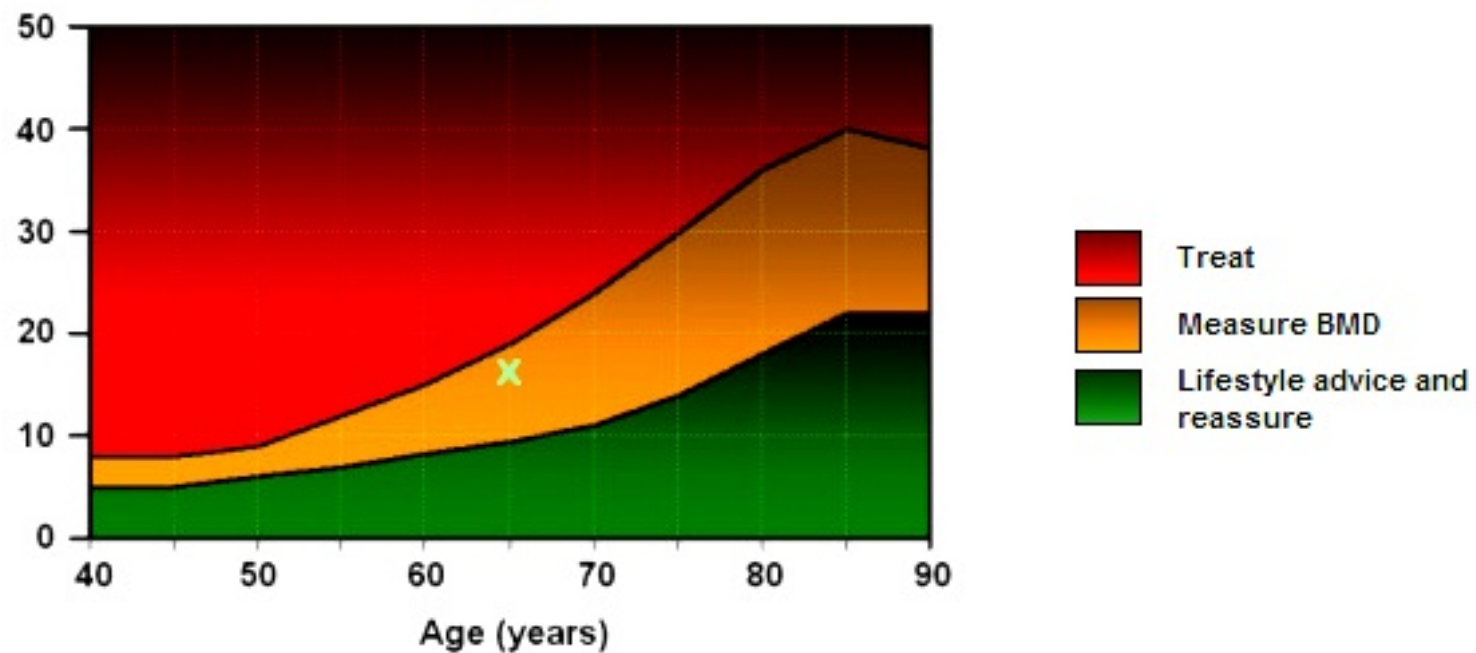
Hip fracture

**3.4**

[View NOGG Guidance](#)

## Assessment threshold - Major fracture

10 year probability of major osteoporotic fracture  
(%)



Who gets funding for Alendronate  
or MSD DEXA scans?

# MSD DXA funding criteria



## FOSAMAX PLUS® funding & MSD DXA criteria



Merck Sharp & Dohme fund DXA scans to assist patients to access treatment for osteoporosis. (The funding is ONLY for patients who would not otherwise be able to have a DXA.)

Select patient category and follow process:

### STERIOD INDUCED OSTEOPOROSIS

#### Patient Prescribed Steroids

- For at least 3 months
- $\geq 5$  mg/day prednisone equivalents

Has fracture\*

No fracture

↓

MSD DXA

↓

T-score  $\leq -1.5$

↓

Apply for FOSAMAX PLUS®

Apply for FOSAMAX PLUS®

### OSTEOPOROSIS

Patient <75 years

Patient has T-score  $\leq -3.0$

Patient  $\geq 75$  years\*

Has 1 fracture

Has had 2 or more fractures

↓

MSD DXA

↓

T-score  $\leq -2.5$

↓

Apply for FOSAMAX PLUS®

Apply for FOSAMAX PLUS®

Apply for FOSAMAX PLUS®

Apply for FOSAMAX PLUS®

Has fracture

↓

↓

↓

↓

↓

THE ONLY PATIENT GROUPS THAT QUALIFY FOR AN MSD FUNDED DXA SCAN

- FOSAMAX PLUS® can be purchased privately for patients who do not meet the funding criteria
- MSD is not able to fund DXA scans for patients >75 years who DO NOT have an osteoporotic fracture
- MSD is not able to fund repeat DXA scans

# MSD DXA Voucher

The patient must meet ALL criteria in EITHER box below  
(for Merck Sharp & Dohme to fund the scan)

## STEROID INDUCED OSTEOPOROSIS

Patient has been prescribed steroids  
For at least 3 months and is receiving  $\geq 5$  mg/day  
prednisone equivalent ☐

Patient has not had an osteoporotic fracture  
If the patient has had a fracture they  
do not need a DXA to access treatment ☐

Patient does not have medical insurance  
that covers DXAs ☐

OR

## OSTEOPOROSIS

Patient is <75 years ☐

Patient has 1 osteoporotic fracture  
If the patient has 2 or more fractures they do not need  
a DXA scan to access treatment ☐

Patient does not have medical insurance  
that covers DXAs ☐

In alignment with PHARMAC criteria (based on WHO guidelines),  
should the patient be eligible for treatment I wish to commence this patient  
on FOSAMAX PLUS\* (alendronate 70mg/colecalciferol 2800IU, MSD).

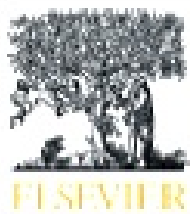
Patient must meet ALL criteria in  
either box to be eligible for MSD  
funded DXA.

Section 1  
Steroid Induced Osteoporosis

Section 2  
Osteoporosis

FRAX is Binary.

- FRAX does not take into account dose / number of fractures etc.
  - » FRAX is a guide and does not replace clinical judgement.



Contents lists available at [ScienceDirect](#)

Bone

Journal homepage: [www.elsevier.com/locate/bone](http://www.elsevier.com/locate/bone)



Review

FRAX® and its applications to clinical practice

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The Future?

- Increased range of drugs for OP in NZ.
- Use of fracture probability rather than T score to assess eligibility for funding.
- Micro CT.