Clinician Course Objectives

- Recognize the clinical utility of bone densitometry and other modalities to assess and monitor the fracture risk of your patients with low bone mass.

- Implement recommendations of the 2007 Official Positions to reduce DXA acquisition and interpretation errors.

- Recognize the utility and limitations of the WHO classification to diagnose osteoporosis.

- Conduct a precision assessment to ensure the accuracy and precision of the BMD testing done on your patients.

- Apply the recommendations of the ISCD Official Positions for interpreting and reporting DXA scan results to improve patient management for your patients with low bone mass.

Accreditation Statement

The International Society for Clinical Densitometry is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to offer continuing medical education for physicians.

Credit Designation

The International Society for Clinical Densitometry designates this educational activity for a maximum of *11.0 AMA PRA Category 1 Credit(s)*™. Physicians should only claim credits commensurate with the extent of their participation in the activity.

Clinician Course for Technologists*:* The course qualifies for 13.75 category A credits through the ASRT. Technologists must sign in and out each day at the ISCD registration desk to verify attendance and receive credit. Partial credit will not be given.

I. OVERVIEW OF OSTEOPOROSIS

A. Learning objectives

1) State definitions of osteoporosis
2) Summarize the pathophysiology of osteoporosis
3) Explain the prevalence and incidence of osteoporosis and fractures
4) Describe types of fractures and the morbidity and mortality related to osteoporotic fractures
5) List the economic costs of osteoporosis
6) Compare the incidence, prevalence, morbidity, mortality, and cost of osteoporosis with other chronic diseases
7) Explain the value of bone densitometry for diagnosis, fracture risk estimation and monitoring

B. Definitions of osteoporosis

1) Old definition: a reduced amount of bone that is qualitatively normal. (Albright F. *Ann Intern Med*. 1947; 27:861)
2) Modern definition: "A systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture." (Consensus Development Conference. (*Am J Med*. 1991;90:107-110.)
3) Newest definition: "Osteoporosis is a skeletal disorder characterized by compromised bone strength predisposing to an increased risk of fracture. Bone strength reflects the integration of two main features: bone density and bone quality." (NIH Consensus Development Panel. *JAMA*. 2001;285:785-795.)

C. Osteoporosis can also be defined based on the presence or history of a low-trauma or fragility fracture.

The definition of an osteoporotic fracture is not straightforward. Fragility and low trauma fracture is defined as a fracture resulting from the force of a fall from a standing height or less or a bone that breaks under conditions that would not cause a normal bone to break.

I. BASIC SCIENCE OF BONE DENSITOMETRY AND DEVICE OPERATING PRINCIPLES

A. Learning objectives

1) Describe basic DXA anatomy
2) Explain the principles of operation for
   - (i) DXA
     - (a) Central skeletal DXA
     - (b) Peripheral DXA (pDXA)
   - (ii) QCT and pQCT
   - (iii) Quantitative Ultrasound (QUS)
3) Compare and contrast the accuracy of the available bone densitometry devices

B. Basic DXA Anatomy: Central and peripheral skeleton

III. X-RAY SCIENCE, RADIATION SAFETY, AND QUALITY ASSURANCE

A. Learning objectives

1) List the properties of x-rays
2) State and define the units for expressing radiation dose
3) State the typical dose for densitometric examinations
4) Describe biologic effects of radiation
5) Discuss radiation safety and protection
6) State influences on quality originating with the equipment, the patient and the operator
7) Describe instrument quality control procedures for bone densitometers
8) Discuss the considerations and cautions when upgrading equipment hardware and software
9) Comparing results from different DXA devices

B. What is Radiation

1) Radiation is the flow of energy through space and matter.
   (i) Examples: visible light, radio waves, x-rays.
2) Radiation can be in the form of particles or waves.
   (i) Examples:
      (a) Electromagnetic waves such as X-rays and gamma rays
      (b) Particles such as neutrons, electrons, alpha particles
3) Radiation can penetrate matter to varying degrees (depends on type of radiation).

C. Ionizing Radiation and X-rays

1) Ionizing radiation produces ions (charged atomic particles) after penetrating into matter.
2) Ionizing radiation can damage cells by breaking chemical bonds, etc.
3) X-rays are a subset of ionizing radiation. They are waves of energy (electromagnetic) and are like radio waves, microwaves, light, etc., but of higher energy and capable of ionizing atoms.

(i) Short wavelength
(ii) Polyenergetic (multiple energy levels)
(iii) Emitted by electrical devices.
(iv) Activates DXA scanner detector(s)
(v) Can penetrate into tissues and cause ionization
(vi) Have many different energies, travel in straight lines in all directions, cannot be focused by a lens, cause certain crystals to glow, affect photographic film, and ionize certain gases and tissues. Tissue ionization, the interaction of radiation with atomic electrons, is what leads to the harmful effects of radiation, and must be detected by their effect on other media as they cannot be detected by human senses.

CLINICAL EVALUATION OF BONE HEALTH

A. Learning objectives

1) Describe relevant history and physical findings to identify patients at risk for fracture
2) List the clinical indications and contraindications for bone densitometry
3) Recognize secondary causes of osteoporosis and when laboratory testing is appropriate
4) Discuss the potential clinical uses for measurement of bone turnover markers
   Describe the radiologic findings in patients with osteoporosis including the utility of vertebral fracture assessment (VFA)

B. Clinical diagnosis of osteoporosis

1) The diagnosis of osteoporosis can be made by:
   (i) Fragility fracture (clinical) OR
   (ii) By sufficiently low bone density (densitometric)
2) Clinical history and physical examination
   (i) Osteoporosis has no symptoms and fracture symptoms are variable
   (ii) Able to diagnose osteoporosis in its advanced stages
      (a) Often the diagnosis is not made until the occurrence of a first fracture
      (b) Because the first fracture is a major risk factor for subsequent fractures, the goal should be to diagnose osteoporosis before the first fracture occurs
   (iii) Should be used to help assess fracture risk
      (a) In particular, it is important to differentiate risk factors for low bone mass (cannot be used instead of BMD testing) from risk factors for fracture and risk factors for falling
3) Clinical history and physical examination may reveal:
   (i) Increased fracture risk factors
      (a) Fragility fracture

(b) Reduced vision
(c) Orthostatic hypotension
(d) Pain
(e) Impaired ambulation and/or balance
(f) Muscle weakness
(g) Depression
(h) Long-term disability

(ii) Fracture related factors
(a) Loss of height
(b) Kyphosis
(c) Chest deformity
(d) Rib-pelvis overlap
(e) Respiratory difficulty (decrease in vital capacity)
(f) Protuberant abdomen and GI symptoms
(g) To determine whether there has been a significant loss of height, you must use a stadiometer based on units of centimeters. Degenerative disc disease and scoliosis and spine fractures result in height loss. Height loss begins in the mid 40s. Average cumulative height loss by age 80 in males is 5 cm and in females is 6.2 cm (Sorkin JD, et al. *Epidemiol Rev*. 1999;21:247-260.

4) Clinical risk factors for low bone density (Riggs BL, Melton LJ, *New Engl J Med*. 1986;314:1676-1686.)
(i) Loss of height
(ii) Low body weight
(iii) Advanced age
(iv) Late age at menarche
(v) Menopausal
(vi) Time since menopause
(vii) Smoking
(viii) Dietary calcium
(ix) Alcohol intake
(x) Medications
(xi) Inflammatory conditions
(xii) Prior fragility fracture

(xiii) Review of 9 clinical studies to determine whether clinical risk factors for low BMD can predict low BMD (Ribot C, et al. *Am J Med*. 1995;98(suppl 2A): 52S-55S.):

(a) The total variance of vertebral bone mass could not be reliably predicted by assessment of clinical risk factors

(b) Correlation was poor and varied between 0.15-0.43

(c) Age and weight accounted for the greatest degree of the variance found

(d) Clinical risk factors are not a substitute for BMD testing

(xiv) IMPACT Trial (Delmas PD et al *J Bone Miner Res* 2005; 20:557-563.)

(a) Approximately 7,000 postmenopausal women without a previous diagnosis of osteoporosis had a BMD testing and risk factor assessment

(i) History of fracture

(ii) Family history of fracture

(iii) Low weight

(b) 50% of patients with osteoporosis were not found to have risk factors for osteoporosis

(c) 50% of patients with risk factors did not have osteoporosis by BMD determination

(d) Risk factors do not predict osteoporosis

V. USE OF BONE DENSITOMETRY FOR THE DIAGNOSIS OF OSTEOPOROSIS

A. Learning objectives

1) Explain how to use central DXA for the diagnosis of osteoporosis
2) State the WHO diagnostic classification for osteoporosis
3) State and explain the advantages and limitations of WHO classification for densitometric diagnosis
4) Define the standardized scores used in bone densitometry (T- and Z-score)
5) Compare and contrast use of different skeletal sites and regions of interest for diagnosis
6) Discuss the diagnosis of osteoporosis in pre-menopausal women, children, men and non-Caucasians
7) Review the use of technologies other than central DXA for diagnosis

B. Diagnosis of osteoporosis with central DXA

1) Diagnosis of osteoporosis with central DXA is most often based on T-score thresholds established by the World Health Organization (WHO) in postmenopausal Caucasian women

C. WHO Classification for Postmenopausal Osteoporosis

1) Published in 1994 by a working group of the WHO
2) Intended to assess the prevalence of the disease in a population
3) Results were expressed as a standard deviation from the mean predicted bone mass in young adult Caucasian females (which was later expressed as a T-score)

Normal	Bone density equal to –1.0 SD or higher (T-score ≥ -1,0)
Low Bone Mass (Osteopenia (low bone density))	Bone density between -1.0 and -2.5 SD (T-score > -2.5 and < -1.0)

Osteoporosis	Bone density equal to -2.5 SD or lower (T-score ≤ -2.5)
Severe (established) Osteoporosis	Bone density at least 2.5 SD below the mean for young-adult women, with history of fragility fracture (T-score ≤ -2.5)

(WHO Technical Report Series. Geneva: WHO, 1994)

NOTE: Although not part of the WHO classification, the presence of a fragility fracture, regardless of T-score, should be considered diagnostic of osteoporosis (provided other causes for the fracture have been excluded).

4) Osteoporotic fracture in the setting of normal BMD:

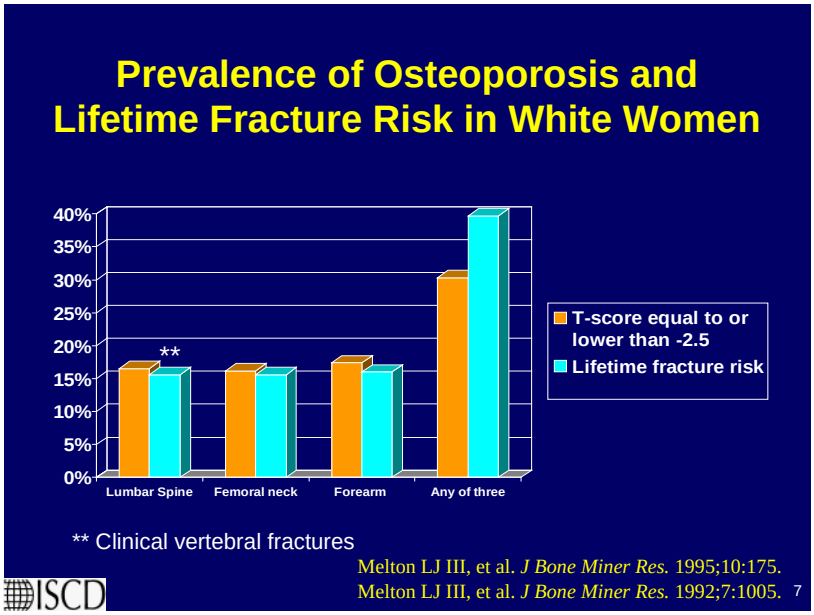
BMD may be abnormal at some other site than where it was measured (limitation of single site measurement)

The fracture may be a non-osteoporotic fracture (pathologic fracture, trauma, etc). If non-osteoporotic causes for fracture have been excluded, the individual should be categorized as having osteoporosis.

NOTE: that some patients will have an osteoporotic fracture and have normal BMD (even at site of fracture). This is analogous to patients who have normal cholesterol having heart attacks or patients with normal blood pressure having strokes.

5) Why the WHO chose T = −2.5:

(i) "Such a cutoff value identifies approximately 30% of postmenopausal women as having osteoporosis using measurements made at the spine, hip, or forearm. This is approximately equivalent to the lifetime risk of fracture at these sites." (Kanis JA, et al. *J Bone Miner Res*. 1994;9:1137.)



6) Limitations of WHO

(i) Not intended as treatment guidelines

(ii) Definitions do not necessarily apply to other populations (e.g., men, non-Caucasians, premenopausal women)

(iii) Does not recognize that a presumptive diagnosis of osteoporosis can be made by a low-trauma (fragility) fracture regardless of the patient's BMD

(iv) Does not differentiate between osteoporosis and other causes of low BMD

NOTE: $T \leq -2.5$ is not always due to osteoporosis. (See Lecture 4).

VI. ASSESSMENT OF FRACTURE RISK

A. Learning objectives

1) Understand the use of central DXA for predicting fracture risk
2) Define different ways of expressing risk: absolute risk, relative risk, site-specific risk, global risk, current risk, lifetime risk
3) List clinical risk factors for fracture
4) Explain fracture risk assessment combining BMD with other risk factors (WHO fracture risk model)
5) Evaluate non-central DXA technologies for predicting fracture risk

B. BMD and fracture risk

1) General observations
   - (i) BMD is highly correlated with bone strength by biomechanical testing
   - (ii) In the absence of fracture and treatment, low BMD is the best predictor of fracture in prospective studies
   - (iii) Relationship between BMD and fracture risk is exponential.
   - (iv) Fracture risk is a gradient, not a threshold (there is no BMD cutoff below which all patients will fracture or above which no one will fracture)
     - (a) Fracture risk is similar in patients with T= −2.4 (osteopenia (low bone density)) and T= −2.6 (osteoporosis) despite different diagnostic categories
     - (b) Fracture risk is much higher in a patient with T-score of −5.0 compared with a T-score of −2.5 in spite of the same diagnostic categories (osteoporosis)
   - (v) BMD overlaps in patients with and without fractures
     - (a) There is a similar bell-shaped distribution of BMD in fracture and nonfracture populations but mean BMD is lower in the fracture

patients

(i) Not all patients with low BMD fracture, but all patients with low BMD, are at increased risk for fracture

(ii) A BMD measurement is not intended to diagnose fractures (x-rays can do that) but to determine risk of fracture (and need for therapy)

C. **Ways to express fracture risk**

1) Absolute risk

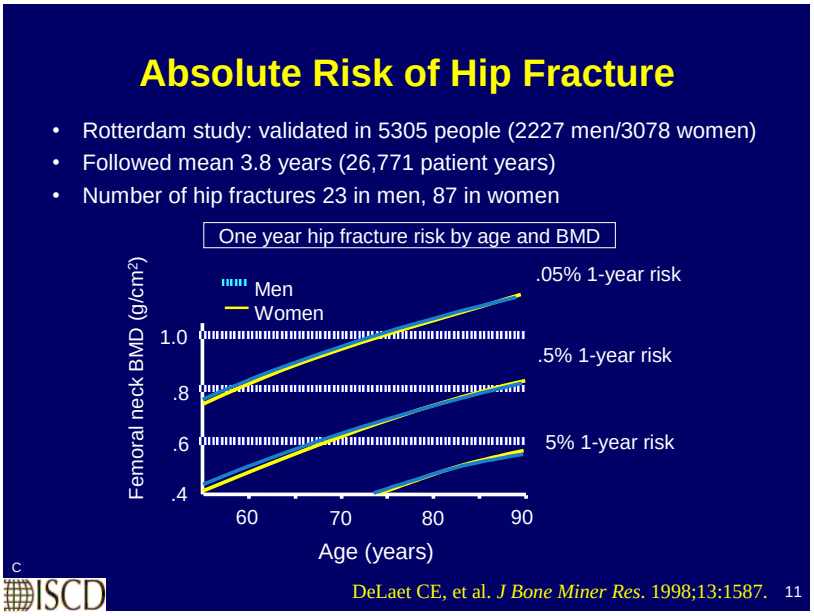
(i) Essentially identical to incidence of an event

(ii) Typically expressed number of events over a defined period of time, such as “absolute 10 year fracture risk” or “fracture risk per 1000 person years”

(iii) Describes the frequency of an event in at-risk population

(iv) For example, 100 smokers are followed for 1 year. If 6 of them fracture, the absolute fracture risk is 6 ÷ 100 = 6% per year

(v) See the Rotterdam study as an example of absolute fracture risk



Absolute 1-year risk for hip fracture for a 65-year-old woman with a BMD at the femoral neck of 0.6 g/cm^2 is 0.5%

(vi) Prevalence is the number of patients with the disease (e.g., osteoporosis) or event (e.g., fracture) divided by the number of persons at risk at a specific point in time. Usually expressed as a percentage e.g., 50% of women over the age of 80 have osteoporosis (T-score ≤ -2.5) at the hip (Rochester data).

2) Relative risk:

(i) Ratio of absolute risks for two different groups

(ii) Typically expressed in terms of relative risk of fracture for every standard deviation difference in BMD compared to a young-normal or an age-matched population with normal BMD

(iii) For example, if absolute risk of fracture is 6% in smokers and 2% in nonsmokers, the relative risk of fracturing is $6 \div 2 = 3$.

(iv) Relative risk requires knowledge of absolute risk of the event or disease. An odds ratio (OR) is similar but easier to calculate as it does not require prospective data – retrospective data can be used to compare the prevalence in 2 populations

(v) Marshall's meta-analysis: an example of relative fracture risk (table below)

(a) 11 prospective cohort studies

(b) 90,000 person-years observation

(c) >2,000 fractures

MONITORING WITH BONE DENSITOMETRY

A. Learning objectives

1) Describe approach to monitoring with DXA
2) State how to calculate precision error and least significant change
3) Discuss which skeletal site to measure, which densitometric method to use, and how often to test
4) Explain clinical relevance of changes in BMD

B. Approach to monitoring with DXA

1) ISCD position on serial monitoring
   (i) In untreated patients, significant loss may be an indication for treatment and is associated with an increased fracture risk.
   (ii) In treated patients, DXA is used to monitor response to therapy. An increase in BMD or stable BMD is encouraging and is associated with fracture risk reduction. Consider further evaluation (adherence, secondary causes) for those who are losing BMD. (*J Clin Densitom* 2003;6(4):307)
2) Comparing “apples” with “apples”
   (i) Compare the BMD, not the T-score
   (ii) How much of a difference is real?
   (iii) If there is a difference, what does it mean?
   (iv) Look at the DXA images on the 2 comparison studies
   (v) The region of interest (ROI) must be the same
   (vi) The measured area should be comparable
   (vii) If the ROI appears the same but the area is different, look for improper positioning, incorrect scan analysis, and/or artifacts (fractures, degenerative changes, etc)
   (viii) When possible, use the compare feature of your software

3) Compare BMD values, not T-scores
   (i) T-scores depend on normative database, which may change with software upgrades, and so should not be compared on serial studies
   (ii) Compare BMD (g/cm^2) between 2 studies
   (iii) Software may calculate: change in BMD, percent change in BMD (from initial or previous), or annualized rate of change in BMD

C. **Calculating precision error and least significant change (LSC)**

1) Precision
   (i) Expresses reproducibility or consistency of repeat measurements
   (ii) Precision error (RMS-%CV) helps determine how much of a change in BMD is required to know that the difference is real
   (iii) Significant bone loss increases fracture risk regardless of the BMD (Nguyen TV et al *J Bone Miner Res* 2005; 20:1195-1201 and Sornay-Rendu E et al *J Bone Miner Res* 2005; 20:1929-1935)

	Manufacturers range	Clinical Centers
PA spine	0.5% to 1.5%	1.0% to 2.5%
Total hip	0.5% to 1.5%	1.5% to 2.5%
Femoral neck	1.0% to 2.5%	2.0% to 3.5%

2) ISCD Official Position: Precision
   (i) Each center should determine its precision error and LSC
      (a) The precision error supplied by the manufacturer should not be used
   (ii) For more than 1 technologist: use average precision from all technologists by combining data provided the precision error for each is within a pre-establish range of acceptable performance
   (iii) Each technologist should perform an in vivo

precision assessment using patient's representative of the clinic's patient population

(iv) Each technologist should do 1 complete precision assessment after learning basic skills (such as manufacturer's training) and after having performing about 100 scans

(v) Repeat precision study if new system installed or if technologist has reached a new level of skill

(vi) To perform a precision analysis:

(a) Measure 15 patients 3 times, or 30 patients 2 times, repositioning the patients after each scan

(b) Calculate precision as the root mean square standard deviation (RMS-SD) or RMS-%CV for the group

(c) Calculate LSC for the group at 95% confidence interval

(vii) Precision studies should be standard clinical practice

(viii) Precision assessment is not research and may potentially benefit patients

(ix) Adhere to local radiologic safety standards and regulatory agencies

(x) Performance of a precision assessment requires the consent of participating patients.

(xi) It generally should not require approval by an IRB.

3) How to calculate precision for your center

(i) For statistical power, at least 15 individuals can be scanned 3 times each or at least 30 individuals can be scanned 2 times each

(ii) Use patients representative of your typical patient population

(iii) Reposition patient between scans (off the table in between scans)

(iv) Calculate the mean BMD, SD and %CV of each patient.

(v) Calculate the root mean square standard deviation (RMS-SD) for entire group (RMS-SD) or the

RMS-%CV for the entire group (Bonnick SL, et al. *J Clin Densitom*. 2001;4:105.)

4) Calculate SD for each subject:
   (i) Subtract each BMD from mean BMD
   (ii) Square each difference
   (iii) Add them
   (iv) Divide by number of scans minus 1
   (v) Take the square root
5) Calculate RMS-SD for entire group:
   (i) Square SD for each patient
   (ii) Add them
   (iii) Divide by number of patients
   (iv) Take the square root

NOTE: Spreadsheet for calculation of precision error available on www.iscd.org

Example: BMD Measurements
(3 scans/patient)

Subject	Scan 1	Scan 2	Scan 3
1	1.005	1.010	0.990
2	0.985	1.010	0.990
3	0.880	0.900	0.890
4	0.920	0.900	0.910
5	0.920	0.900	0.915
6	0.845	0.870	0.850
7	0.983	0.970	0.990
8	1.100	1.107	1.098
9	0.960	0.972	0.980
10	0.913	0.920	0.930
11	1.010	1.020	1.000
12	0.917	0.900	0.920
13	0.892	0.900	0.880
14	0.970	0.982	0.965
15	0.950	0.953	0.969

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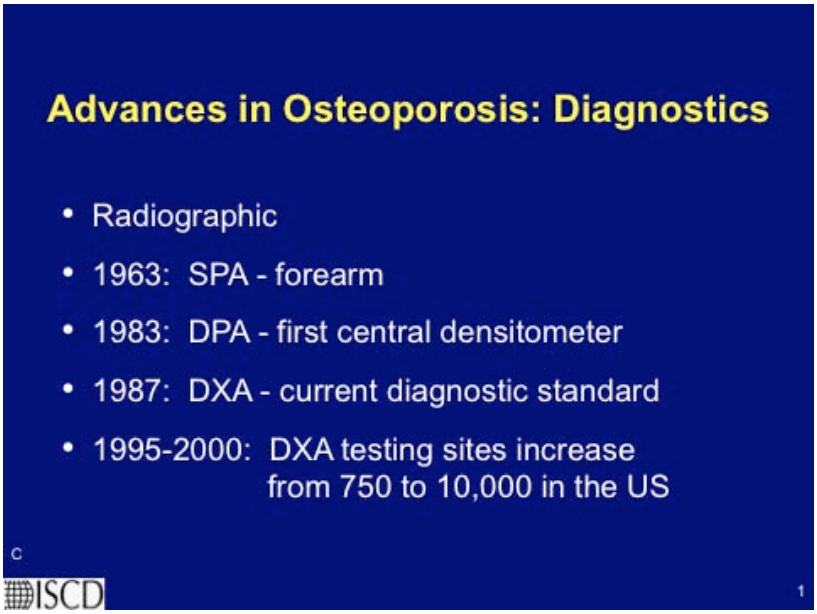
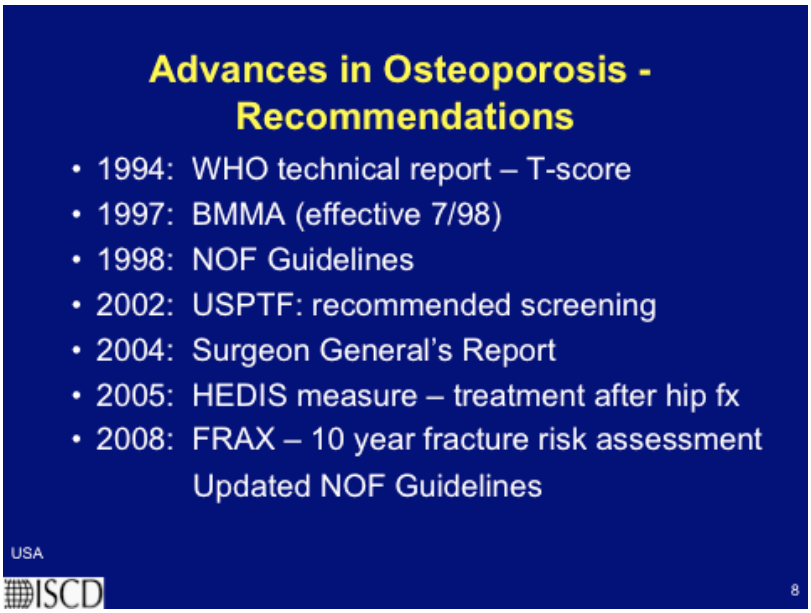
VIII. CLINICAL MANAGEMENT OF OSTEOPOROSIS

A. Learning objectives

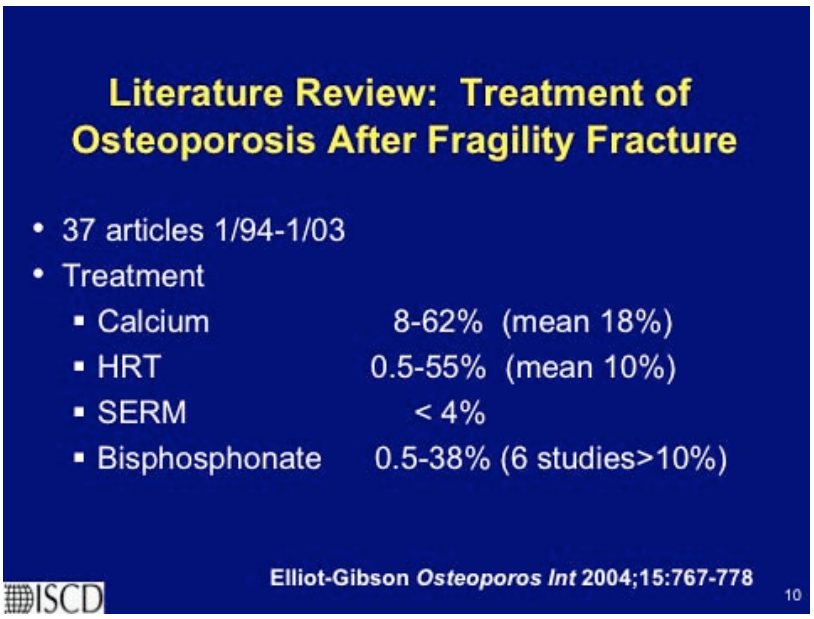
1) Recognize major advances in osteoporosis diagnosis and treatment but persistence of undertreatment
2) Describe the use of nonpharmacological therapy in the management of patients at risk for osteoporosis
3) Describe pharmacological agents used for prevention and therapy of osteoporosis

B. Major advances





C. **Undertreatment:** Despite Major Advances in Diagnosis and Therapy, Most Patients with Osteoporosis Receive No Evaluation or Treatment: Even Patients Who Have Had a Fragility Fracture



D. **Nonpharmacologic therapy**

1) Bone health recommendations (National Osteoporosis Foundation. *Physicians Guide to Prevention and Treatment of Osteoporosis*.)
   (i) Adequate intake of dietary calcium and vitamin D
      (a) Calcium: at least 1200 mg/day in divided doses
      (b) Vitamin D: 800-1000 IU/day
   (ii) Regular weight-bearing and muscle-strengthening exercise
   (iii) Avoidance of smoking and excess alcohol
   (iv) Fall prevention
2) Calcium and vitamin D
   (i) Essential for prevention and treatment regimens
   (ii) Shown in some studies to slow bone loss, enhance the effect of pharmacologic therapy (Nieves JW, et al. *Am J Clin Nutr*. 1998;67:18-24.), and reduce fracture risk (Recker RR, et al. *J Bone Miner Res*.

1996;11:1961-1966; Chapuy MC, et al. *BMJ*. 1994;308:1081-1082.)

(v) Especially important adjuvant with osteoporosis pharmacologic therapies

(vi) Dietary sources as effective as supplements

(b) Calcium and cardiovascular risk

(i) A recent meta-analysis suggested that calcium supplements, in the absence of vitamin D supplementation, may be associated with a modest increased risk of myocardial infarction (hazard ratio 1.31 with 95% confidence interval 1.02 to 1.67 p of 0.035) (Bolland MJ et al *BMJ* 2010;341:c3691)

(ii) WHI did not show increased cardiovascular risk in women taking calcium with vitamin D supplementation (Hsia J et al *Circulation* 2007;115:846-54)

(iii) Vitamin D deficiency is common in the elderly because:

(a) Reduced exposure to the sun

(b) The skin is less effective as a source

(c) Dietary intake is reduced

(d) Decrease GI absorption

(e) Activation in the kidney is impaired

(iv) The best reflection of vitamin D status is the serum level of 25-hydroxyvitamin D. The desirable level of serum 25-hydroxyvitamin D is 30-60 ng/mL (for maximum suppression of PTH and maximum intestinal absorption of calcium).

(Holick MF *NEJM* 2007; 357:266-281)

(v) Vitamin D Reduces Fracture Risk

(a) Meta-analysis of 12 randomized control trials (RCTs) using vitamin D3 (Bischoff-Ferrari H. et al. *JAMA*. 2005;293(18):2257-2264)

(b) Approximately 19,000 elderly people

(c) Vitamin D3 dose of 700-800 IU daily

(i) Reduced hip fracture by 26%

(ii) Reduced non-vertebral fracture by 23% (95th percentile CI 0.68-0.87)

(vi) Vitamin D deficiency may result in muscle weakness, increased body sway, and falls; treatment with vitamin D in these patients has been associated with increased muscle strength, reduced body sway, fewer falls and hip fractures (Janssen HCJP, et al. *Am J Clin Nutr*. 2002;75:611-615. [review article])

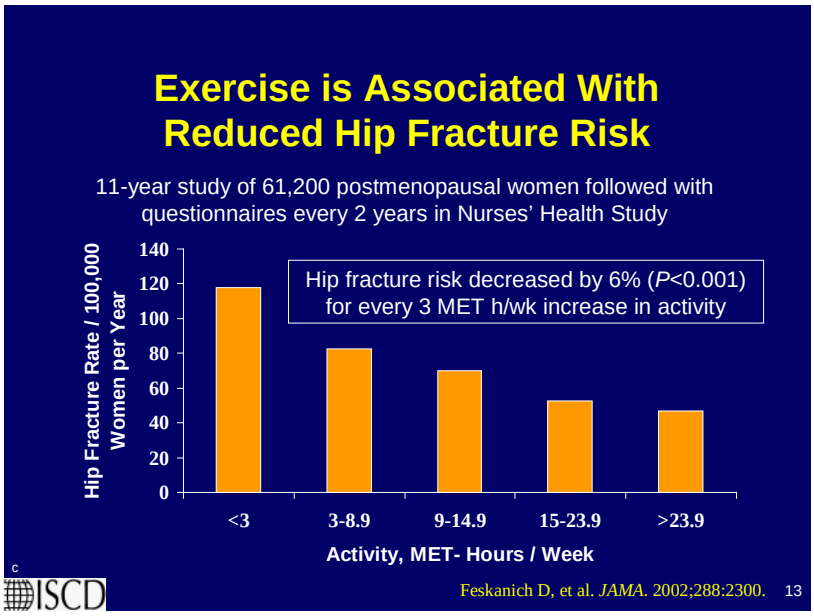
3) Exercise

(i) Systematic review of 18 RCTs

(a) Aerobics, weight-bearing and resistance exercises may increase BMD at the spine

(b) Walking improved BMD at the hip (Bonaiuti D, et al. *Cochrane Database of Systematic Reviews* 2002;(2):CD000333.)

(ii) May be associated with reduced hip fracture risk in postmenopausal women (Feskanich D, et al. *JAMA*. 2002;288:2300-2306.)

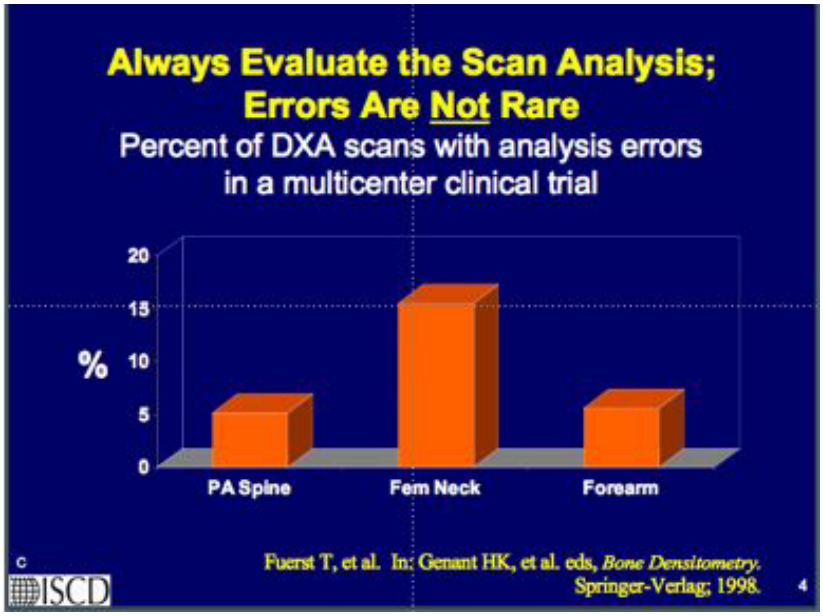


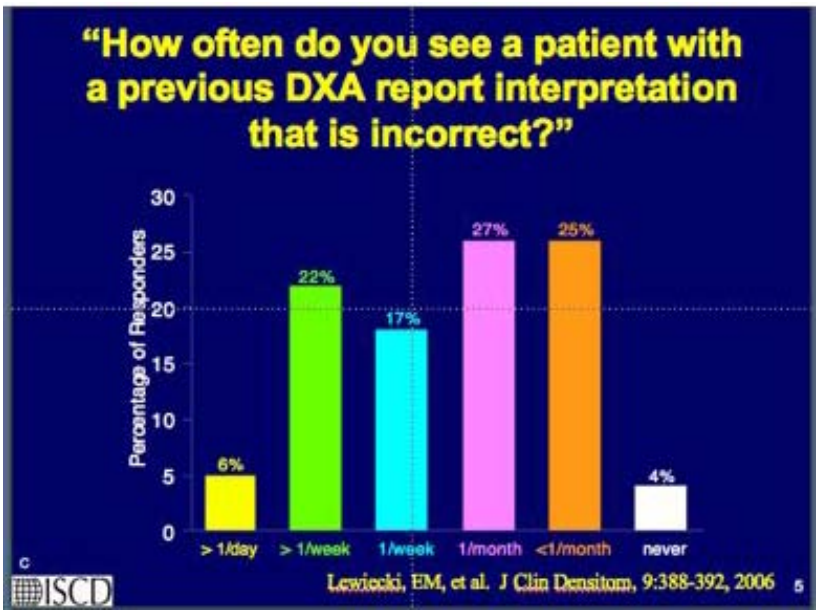
IX. PRINCIPLES OF DXA SCAN INTERPRETATION

A. Learning objectives

1) Discuss patient positioning and scan analysis (PA spine, hip, forearm, total body) and recognize common errors in DXA analysis
2) Review skeletal anatomy relevant to DXA
3) Describe principles for interpreting central DXA scans
4) Recognize common artifacts on DXA scan images

Densitometry continues to require technical excellence. Be sure that the scan is technically valid before interpretation. Analysis errors are common, even in clinical trials.

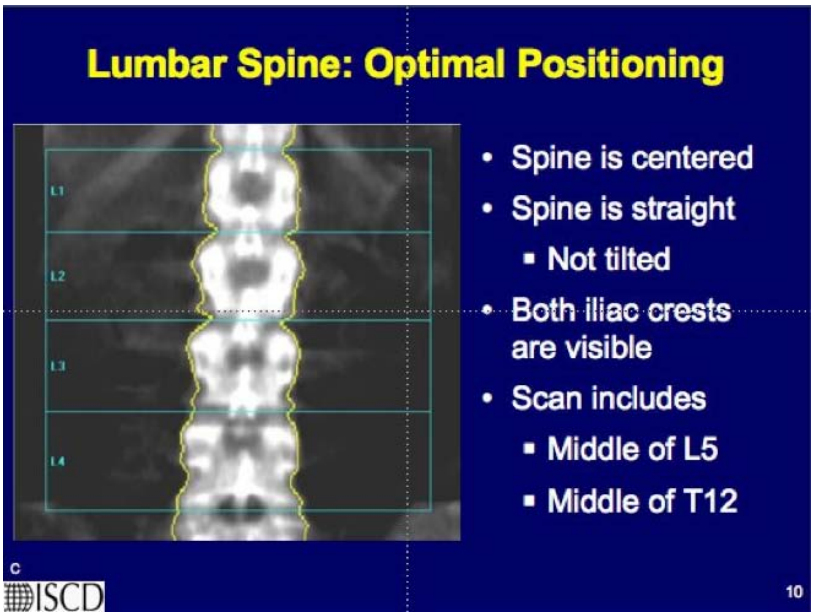



"How often do you see a patient with a previous DXA report interpretation that is incorrect?"
Percentage of Responders
30
25
20
15
10
5
0
6%
22%
17%
27%
25%
4%
> 1/day
> 1/week
1/week
1/month
<1/month
never
c
ISCD
Lewiecki, EM, et al. J Clin Densitom, 9:388-392, 2006
5

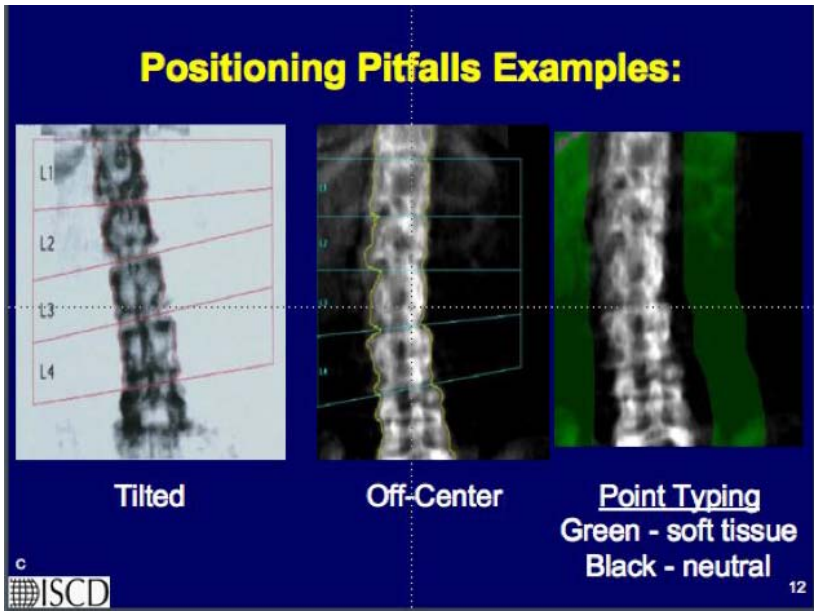
C. **Patient positioning and scan analysis**

1) Positioning for PA spine
   (i) Center patient on scanner table
   (ii) Align patient with scanner axis
   (iii) Raise legs with positioning block
   (iv) GE-Lunar has a One-Scan option that uses a correction factor to compensate for the change in position.

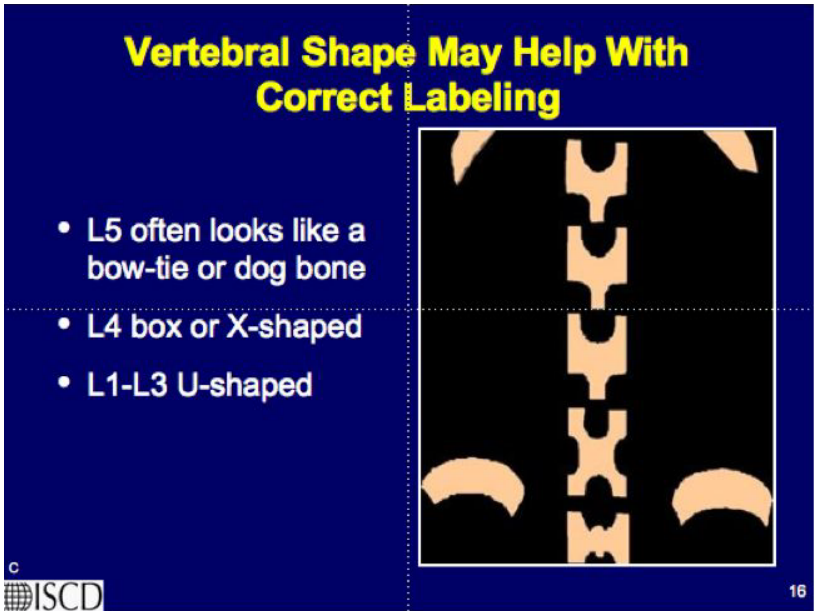
2) PA spine, optimal positioning
   (i) Spine is centered
   (ii) Spine is straight (not tilted)
   (iii) Both iliac crests are visible
   (iv) Scan includes (middle of L5 and middle of T12)



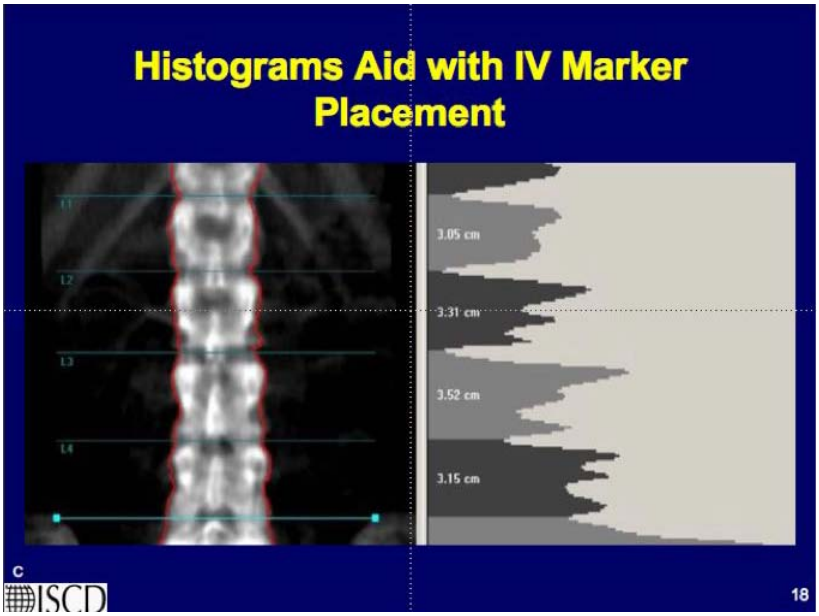
3) PA spine, positioning pitfalls
   (i) Spine is off center (may change the BMD result)
   (ii) Spine is tilted (changes the result)
   (iii) Only one iliac crest is visible
   (iv) Neither iliac crest is visible
   (v) Does not include T12 or L5



4) PA spine scan analysis
    (i) Verify
        (a) Lateral vertebral margins
        (b) Intervertebral markers
    (ii) Consistent numbering for patients with segmentation anomalies
        (a) Count from the iliac crest up
    (iii) Neutralize artifacts
5) Spine segmentation
    (i) Approximately 84% of the population have 5 lumbar vertebrae with the lowest set of ribs on T12
    (ii) An additional ~8% have 4 lumbar vertebrae with the lowest set of ribs on T11 or T12
    (iii) About 7% have 5 lumbar vertebrae with the lowest ribs on T11
    (iv) About 2% have 6 lumbar vertebrae with lowest ribs on T12 or L1 (Peel NFA, et al. *J Bone Miner Res*. 1993;8:719-723.)
6) Approach to vertebral numbering
    (i) In patients with 6 non rib-bearing lumbar vertebrae, label from bottom up using the superior margin of iliac crest to designate the level of L4-L5 disk



7) Correct spine analysis
   (i) Intervertebral markers should be placed in the disc space
   (ii) Edges should only include bone that should be evaluated
   (iii) Histograms may aid with intervertebral marker placement
   (iv) Adjusting intervertebral markers can impact the BMD



X. PRINCIPLES OF REPORTING OF DXA SCANS

A. Learning objectives

1) Recognize the standard nomenclature for use in bone densitometry reports
2) Identify the ISCD basic recommendations for reporting densitometry results
3) Identify the ISCD optional recommendations for reporting densitometry results
4) Recognize errors in DXA reporting (PowerPoint only)
5) Apply the ISCD recommendations using case examples (separate handout)

B. ISCD Official Positions with annotations – Appendix A

The Writing Group for the ISCD Position Development Conference.
(*J Clin Densitom*. 2004; 7 (1):37-44. Available at: www.ISCD.org)

C. Standard Nomenclature for use in bone densitometry reports

1) Terminology
   (i) DXA – not DEXA
   (ii) T-score – not T score, t-score, or t score
   (iii) Z-score – not Z score, z-score, or z score
   (iv) VFA – Vertebral Fracture Assessment
2) DXA nomenclature: decimal digits

	Digits	**Example**
BMD	3	0.927 g/sq cm
T-Score	1	−2.3
Z-Score	1	1.7
BMC	2	31.76 gm
Area	2	43.25 sq cm
% reference database	integer	82%

D. Clinical reporting to primary care physicians

1) Clinical Reporting

(i) Manufacturer generated
(ii) Customized software packages
(iii) Do it your self
(iv) Include a copy of the machine generated images with your report
(v) Always perform a methodical analysis of the DXA study your self

2) Short report: Minimum standard to clinical reporting
(i) LS and hip BMD
(ii) T-score
(iii) Z-score
(iv) Comments about artifacts

3) Long Report
(i) Data in short report
(ii) Diagnosis by WHO classification
(iii) Clinical risk factors for fracture
(iv) Specific suggestions for non-pharmacologic and pharmacologic treatment and follow-up DXA (Stock JL, et al. *Ann Intern Med*. 1998:128:996-999.)

E. **Advantage of the clinical bone density report**

1) Detailed reports are found to be more useful than shorter reports by referring physicians
2) Detailed reports increase use and understanding of bone densitometry
3) Detailed reports are more likely to influence patient management

F. **Baseline DXA report**

1) Demographics (does **not** impact interpretation)
(a) Name, medical record number
(b) Age
(c) Race or ethnicity
(i) May be difficult to determine
(ii) USA – Caucasian database should be used regardless of race and a male reference population should be used for men

(d) Sex
(e) Height
(i) Stadiometer preferable
(f) Weight
(i) Can affect results especially in older densitometers
(ii) Optional use as factor in Z-scores in some machines

2) Other
(i) Indications for the test
(a) Reason test was requested
(ii) Additional information (Syllabus appendix B)
(a) Prior fracture
(b) Family history
(c) Glucocorticoid use
(d) Rheumatoid arthritis
(e) Smoking
(f) Alcohol
(iii) Manufacturer and model of instrument used
(a) Especially to help determine comparability in absence of a printout
(b) Mode, automatic/manual

3) Technique/limitations
(i) Technical quality and limitations of the study
(a) Regions of interest (ROI): included or excluded
(b) Other factors: prior back surgery, hip replacement, arthritis, prior known fracture should be noted
(c) Poor hip rotation (may be limited by arthritis), scoliosis, prior surgery may limit interpretation