Bone Densitometry Update:
DXA Quality Matters
Live Webinar
October 2, 2019

Bone Densitometry Update
DXA Quality Matters

October 2, 2019
E. Michael Lewiecki, MD, FACP, FACE, CCD
Director, New Mexico Clinical Research & Osteoporosis Center
University of New Mexico Health Sciences Center
Albuquerque, NM, USA

Disclosure
• No direct compensation from potentially conflicting entities
• Employed by New Mexico Clinical Research & Osteoporosis Center, which has received the following in the past one year:
  – Research grant support from Amgen, Radius, Mereo
  – Consulting and scientific advisory board fees from Amgen, Radius, Alexion, Sandoz, Samsung Bios, Takeda
  – Honoraria for speakers’ bureau of Alexion, Radius
  – Support for project development with University of New Mexico
  – Royalties from UpToDate for sections on DXA, fracture risk assessment, and prevention of osteoporosis
• Board positions with the ISCD, NOF, OFNM
• Guideline committees with ISCD, NOF, AACE

Objectives
• Explain the public health importance of osteoporosis
• Compare dual-energy X-ray absorptiometry (DXA) with other technologies for assessing musculoskeletal health
• Demonstrate the importance of precision assessment for serial bone density tests
• Describe the clinical applications of DXA
• Review common pitfalls in DXA interpretation

Osteoporosis
• 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 (e.g., architecture, turnover, damage accumulation, mineralization)

Osteoporosis is a Major Public Health Concern
• 54 million Americans with osteoporosis or osteopenia
• 2 million fractures per year
• Morbidity, mortality, loss of independence
• High cost

Treatment Gap Getting Worse

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DXA Medicare Payments
- $139: Osteoporosis Diagnosis
- $252: DXA Testing

$568 million additional expenses
11,464 additional hip fractures
2,293 additional deaths
17.9% 14.8% 13.2% 11.3%

Fractures per 100,000 Women Age 65+
Age-adjusted to the 2014 Age Distribution

Bone Density Testing Technologies

Adapted from Lewiecki EM et al. Osteoporos Int. 2018;29:717-722.

DXA Information Sources

To learn more and stay informed, visit the ISCD website, become an ISCD member, take the course(s), get certified, consider facility accreditation, read the journal, and come to the annual meeting

www.iscd.org

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DXA (not DEXA)

Dual-energy X-ray Absorptiometry
Introduced for clinical use in 1987

Why not DEXA?

DXA Applications

- Bone Mineral Density (BMD)
  - Diagnosis (T-score)
  - Fracture Risk Assessment
    - BMD alone, FN BMD input for FRAX, LS TBS input for FRAX
    - Monitor (quantitative BMD comparison)
- Vertebral Fracture Assessment (VFA)
- Trabecular Bone Score (TBS)
- Hip geometry
- Body Composition (Body Comp)
- Extended femur view (diagnosis of AFF)

Role of DXA in the Management of Osteoporosis

Dx and Fx Risk Assessment
Intervention Thresholds
Evaluation / Discussion
Treatment
Follow-up: response, target

Diagnosis of Osteoporosis

WHO Classification of BMD

<table>
<thead>
<tr>
<th>T-score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ -1.0</td>
<td>Normal</td>
</tr>
<tr>
<td>-1.0 &lt; T-score &lt; -2.5</td>
<td>Osteopenia</td>
</tr>
<tr>
<td>≤ -2.5</td>
<td>Osteoporosis</td>
</tr>
<tr>
<td>≤ -2.5 + fragility fracture</td>
<td>Severe Osteoporosis</td>
</tr>
</tbody>
</table>

Use lowest T-score of LS, TH, FN, or 33%R (if measured).
Applies to peri- and postmenopausal women, and men age 50 and older.
Cannot be used in premenopausal women and men under age 50.
Should never be used in children (under age 20).
T-score ≤ -2.5 is not always osteoporosis.
A patient may have osteoporosis with a T-score > -2.5.

ISCD Official Positions. 2015.
More About T-scores

- T-score ≤ -2.5 is not always osteoporosis
  - Osteomalacia
  - Invalid measurement (e.g., laminecetomy)
- T-score > -2.5 may be osteoporosis
  - Fracture
  - High fracture probability (FRAX)
- Many risk factors for fracture other than T-score
  - Especially advancing age and previous fracture
  - Also family history, smoking, glucocorticoids, falling, DM, RA, AA, ADT, etc.
- Correlation between T-score and fracture risk is a gradient, not a threshold

3 Ways to Diagnose Osteoporosis

- BMD testing (WHO, ISCD)
  - T-score ≤ -2.5 at LS, TH, FN, or 33%R
- Fragility fracture (NBHA)
  - Low trauma hip fracture regardless of BMD
  - Low trauma vertebral, proximal humerus, pelvis or some distal forearm fractures with T-score between -1.0 and -2.5
- FRAX (NBHA, USA only)
  - MOF risk ≥ 20% or HF risk ≥ 3%

Indications for Bone Density Testing

<table>
<thead>
<tr>
<th>Indication</th>
<th>LS Score ≤ -2.5</th>
<th>TH Score ≤ -2.5</th>
<th>FN Score ≤ -2.5</th>
<th>BMD Score ≤ -2.5</th>
<th>33%R Score ≤ -2.5</th>
<th>FRAX MOF Risk ≥ 20%</th>
<th>FRAX HF Risk ≥ 3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women aged 65</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Younger postmenopausal women</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>with risk factors</td>
<td></td>
<td></td>
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<tr>
<td>Men aged 70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Younger male with risk factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Adults with fragility fractures</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Adults with end-stage renal disease</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Monitor treatment</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* FRAX MOF risk ≥ 9.3%

Ann is a healthy 65 year-old woman is physically active with healthy lifestyle and good nutrition. She has had no fracture and has no family history of osteoporosis.

She asks you if she should have a bone density test.

Your answer is ...

A. Yes
B. No
C. Maybe
D. You need more information

Ann now has DXA:

Is this report correct?

<table>
<thead>
<tr>
<th>Area Examined</th>
<th>T-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar spine</td>
<td>-2.68</td>
</tr>
<tr>
<td>Left femoral neck</td>
<td>-3.11</td>
</tr>
</tbody>
</table>

Report: (1) Osteoporosis of the lumbar spine. Fracture risk is high. (2) Osteopenia of the femoral neck. Fracture risk is moderate.

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Another Patient: Is this report correct?

<table>
<thead>
<tr>
<th>Area Examined</th>
<th>T-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine (L1)</td>
<td>-2.42</td>
</tr>
<tr>
<td>Hip (right)</td>
<td>-2.63</td>
</tr>
<tr>
<td>Femoral Neck</td>
<td>-2.67</td>
</tr>
<tr>
<td>Wrist Triangle</td>
<td>-1.27</td>
</tr>
<tr>
<td>Greater Trochanter</td>
<td>-1.70</td>
</tr>
</tbody>
</table>

Impression: Osteopenia is marked.

• "Marked osteopenia" is not a diagnostic classification
• Correct diagnosis is osteoporosis (FN T-score -2.5)
• T-scores should be reported with one decimal place
• Never use Ward's area (it is actually a square with DXA), trochanter, or single vertebra body for diagnostic classification

Fracture Risk Assessment

Prior Fracture Predicts Future Fractures

<table>
<thead>
<tr>
<th>Prior Fracture</th>
<th>Future Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wrist</td>
</tr>
<tr>
<td>Wrist</td>
<td>3.3</td>
</tr>
<tr>
<td>Vertebra</td>
<td>1.4</td>
</tr>
<tr>
<td>Hip</td>
<td>NA</td>
</tr>
</tbody>
</table>

Most Women with Hip Fracture have T-score > -2.5

Rationale
• Osteoporosis is a lifelong disease that warrants lifelong attention
• Retaining the diagnosis is consistent with other chronic diseases
• Adverse consequences of changing diagnosis to osteopenia include ...
  - False sense of security
  - Loss of insurance coverage for medication
  - Stopping medication that is still needed
  - Change in allowable frequency of BMD testing


Ten Year Fracture Probability (%)

<table>
<thead>
<tr>
<th>Age</th>
<th>BMD and Age are Independent Risk Factors for Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>50</td>
<td>80</td>
</tr>
</tbody>
</table>

Adapted from Kanis JA et al. Osteoporosis Int. 2001;12:989-995


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FRAX
Fracture Risk Algorithm developed at University of Sheffield, launched in 2008

NOF Treatment Guidelines
For postmenopausal women and men age 50 and older, after appropriate evaluation for secondary causes

Osteoporosis by T-score
- T-score -2.5 or less at FN, TH, or LS, or . . .
Clinical Osteoporosis
- Hip or vertebral (clinical or morphometric) fracture, or . . .

Low BMD + High Fx Risk
- T-score between -1.0 and -2.5 at FN, TH, or LS, and . . .
- FRAX 10-year probability of hip fracture ≥ 3% or major osteoporotic fracture ≥ 20%


FRAX
Benefits
- Quantitative assessment of fracture risk
- Algorithm supported by robust data
- Included in many treatment guidelines
- Can be used without BMD when DXA not available

Limitations
- FN BMD only (do not use T-score)
- Many risk factors not included (eg, falls, bone turnover)
- Dichotomous input for factors with a range of risk (eg, fractures, glucocorticoids)
- Limited to 4 ethnicities in US (Caucasian, Hispanic, Black, Asian)
- Range of uncertainty not known
- Applies to only untreated patients age 40-90

FRAX Adjustments
- T2D: RA, FN T-score -0.5, TBS
- Spine-Hip BMD Discordance: Increase MOF risk by 15% for every T-score unit LS is less than FN
- High Dose Glucocorticoids: Increase MOF risk by 15% and HF risk by 20% for prednisone > 7.5 mg/day
- TBS: included in FRAX algorithm
- Parental Hip Fracture Over Age 80: not a risk factor in Manitoba study

Bone Loser
- 65 year-old retired male university professor has a densitometric diagnosis of osteoporosis (L1-L4 T-score = -3.3) associated with hypogonadism and idiopathic hypercalciuria.
- Treatment with alendronate and HCTZ resulted in a significant BMD increase at L1-L4, but a subsequent DXA showed a significant BMD loss.
- He is referred for evaluation of non-response to therapy. What do you do?

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**Look at the Images!**

- **Baseline**
  - L1-L4 = 0.729 g/cm²
- **Follow-up #1**
  - +0.038 (+5.3%) BMD Increase
- **Follow-up #2**
  - -0.037 (-5.1%) Mislabeled, Invalid

---

**How can poor quality BMD testing harm patients?**

<table>
<thead>
<tr>
<th>Harm</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Unnecessary treatment, change in treatment, fracture</td>
</tr>
<tr>
<td>Side effects</td>
<td>Unnecessary or wrong treatment</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Wrong diagnosis of osteoporosis</td>
</tr>
<tr>
<td>False measurement</td>
<td>Wrong diagnosis of normal</td>
</tr>
<tr>
<td>Denial of insurance</td>
<td>Wrong diagnosis of osteoporosis</td>
</tr>
<tr>
<td>Disability/Death</td>
<td>Effective treatment not given</td>
</tr>
</tbody>
</table>

---

**Precision Assessment and LSC**

- Required for quantitative comparison of serial BMD measurements
- Standard practice, not research
- Measure 15 patients 3 times or 30 patients 2 times
- Calculate least significant change (LSC) with 95% level of confidence with ISCD precision calculating tool
- Always compare BMD, not T-scores

[https://www.iscd.org/resources/calculators/precision-calculator/](https://www.iscd.org/resources/calculators/precision-calculator/)

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**Responders and Non-responders**

- **Cross-calibration**
  - Adding or replacing DXA with same manufacturer and model
    - Cross-calibration with phantom scans on both systems
  - Adding or replacing DXA using different technology by same or different manufacturer
    - Scan at least 30 patients on index system and on new system within 60 days
    - Use ISCD cross-calibration tool (for ISCD members only)
  - If cross-calibration is not done, quantitative comparison with prior measurements cannot be made

- **Responders and Non-responders**
  - Stability or a significant increase in BMD is often considered to be an acceptable response to therapy
  - Total hip may be the best skeletal site to monitor, especially in older patients (LS BMD increase may be due to OA)
  - Significant loss of BMD or failure of bone turnover marker to respond as expected may represent a suboptimal response to therapy, warrants further evaluation, and possibly a change in therapy
  - Fracture(s) on therapy may or may not represent treatment failure but certainly suggests that fracture risk is higher than previously estimated and the need for further evaluation
  - Larger BMD increases with treatment are associated with greater reduction in fractures

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**Precision Assessment and LSC**

- Precision error / LSC supplied by manufacturer should not be used
- Should be done by every technologist after performing at least 100 scans
- Should be repeated if new DXA system is installed or skill level of technologist has changed
- For DXA facility with more than 1 technologist, average precision error for all technologists should be used to establish the facility LSC

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Target T-score

- Target is T-score at least > -2.5
  - Rationale: T-score ≤ -2.5 is an indication for treatment
  - Consistent with ASBMR Task Force report on duration of treatment with bisphosphonates
- Higher level of confidence with T-score > -2.0 (or -1.5?)
  - Rationale: based on ISCD Official Positions regarding least significant change with DXA measurements
  - Consistent with data showing that greater increases in BMD are associated with greater reductions in fracture risk

DXA Quality


Christopher R. Shuhart,1,2 Swan Yin Yau,1 Paul A. Anderson,2 Lawrence G. Junkowski,1 E. Michael Lewiecki,1 Leslie R. Marx,1 Harold N. Rosen,3 David R. Weber,2 Babette S. Zemel,4 and John A. Shepherd5

Open access: download FREE at www.iscd.org

DXA Best Practices

Open access: download FREE at www.iscd.org
How to use DXA Best Practices if you are a bone densitometrist

- Download DXA Best Practices
- Be familiar with it
- Follow the recommendations
- Be trained and stay updated
- Get certified (if not already)
- Facility accreditation is the best way to demonstrate that high quality DXA is being performed

How to use DXA Best Practices if you are NOT a bone densitometrist

- Ask about the following
  - Certification for DXA tech and interpreter
  - Facility accreditation
  - Precision assessment has been done and least significant change is known
- Look at the report
  - Make and model of DXA instrument are identified
  - One diagnosis per patient, not different diagnosis for each skeletal site
  - One fracture risk assessment per patient, not different one for each skeletal site
- Look at the images
  - Spine positioning and vertebral body labeling
  - Hip positioning
  - Comparing "apples with apples"

Non-BMD DXA Measurements

- HAL is associated with hip fracture risk in postmenopausal women (longer HAL = greater hip fracture risk)
- Other hip geometry parameters (CSA, OD, SM, BR, CSMI, NSA) should not be used to assess hip fracture risk, initiate treatment, or monitoring

Full-length Femur Imaging (FFI) by DXA for Detection of Atypical Femur Fracture (AFF)

- Femur DXA images should be reviewed for localized cortical abnormalities in spectrum of AFF
- When using DXA to detect AFF, bilateral AFF is preferred
- Consider for patients with at least 3 years cumulative exposure to bisphosphonate or denosumab

Body Composition by DXA

- Indications
  - Patients with HIV
  - Patients having bariatric surgery
  - Patients with muscle weakness or poor physical function
- Reporting: include total body values for BMI, BMD, BMC, total mass, total lean mass, total fat mass, and percent fat mass
Vertebral Fracture Assessment (VFA) by DXA

- Recognition of a VF may change diagnostic classification, assessment of fracture risk, and treatment decisions
- VFA is more convenient, less radiation, and less expensive than standard spine X-rays
- Spine imaging (VFA, X-ray) is indicated when T-score is < -1.0 and 1 or more of the following is present:
  - Women ≥ age 70 and men ≥ age 80
  - HtH ≥ 1.5 m.
  - Self-reported but undocumented VF
  - Glucocorticoid therapy ≥ 5 mg prednisone per day for ≥ 3 mo.


Trabecular Bone Score (TBS) is an Independent Risk Factor for Fracture

Gray-level textural measure derived from LS image by DXA


Ongoing Osteoporosis and DXA Education

Sharing knowledge through ongoing videoconferences with interactive case-based learning to expand capacity to deliver best practice medical care in underserved communities at lower cost and greater convenience than referral to a specialty center.

ECHO is not a Webinar

ECHO is not Telemedicine
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UNM Bone Health TeleECHO

To Learn More About ECHO

- echo.unm.edu/bone-health
  - Links for all bone ECHO programs worldwide
  - Curriculum (free CME)
  - Information for starting bone ECHO

- Google: bone ECHO

To Learn More About DXA

- www.iscd.org
  - Official Positions and Best Practices
  - Courses
  - Journal
  - Newsletter
  - Annual meeting
  - Certification for techs and clinicians
  - Facility accreditation

- Google: ISCD

DXA References

- DXA Quality

- ISCD Official Positions

- DXA Best Practices