Update on DEXA/DXA scanning: what can you expect from a report?

PROFESSOR DAVID M REID

CONSULTANT RHEUMATOLOGIST AND OSTEOPOROSIS SPECIALIST

SENIOR MEDICAL ADVISOR, ROS Bone Research Academy

Royal Osteoporosis Society

Better bone health for everybody

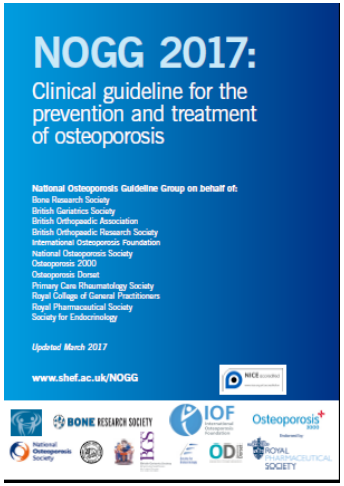
Osteoporosis 2019 - London

Objectives

- To examine the Principles of DXA scan Interpretation and reporting as laid out by International Guidelines
- To Outline the New Standards for DXA reporting to be launched by the Royal Osteoporosis Society.

Frequent Interruptions Welcome

The National Osteoporosis Guideline Group (NOGG) endorses the following:



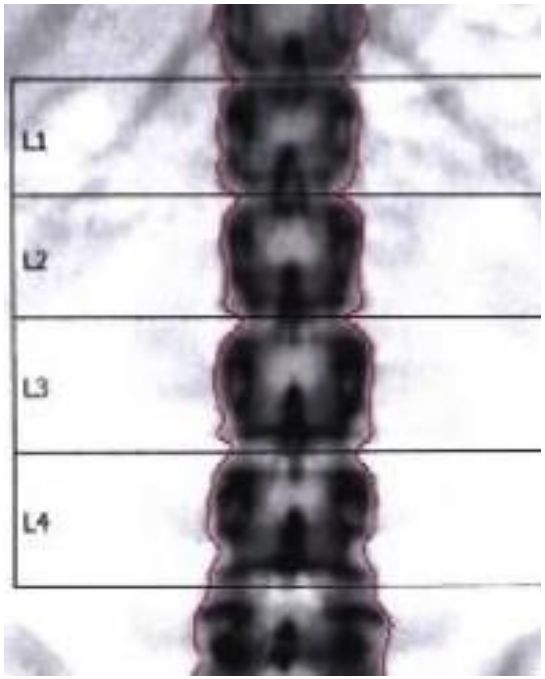
- The World Health Organization and the International Osteoporosis Foundation recommend that the reference technology for the diagnosis of osteoporosis is dual-energy X-ray absorptiometry (DXA) applied to the femoral neck.
- The femoral neck is the preferred site because of its higher predictive value for fracture risk [Kanis & Gluer 2000, Kanis et al 2008]; (Evidence level 1a).
- The spine is not a suitable site for diagnosis in older people because of the high prevalence of degenerative changes, which artefactually increase the BMD value; however,
- However the spine is the preferred site for assessing response to treatment [ISCD 2015].
- The normal reference range in men and women is that derived from the NHANES survey for Caucasian women age 20-29 years [Kanis et al 2008]

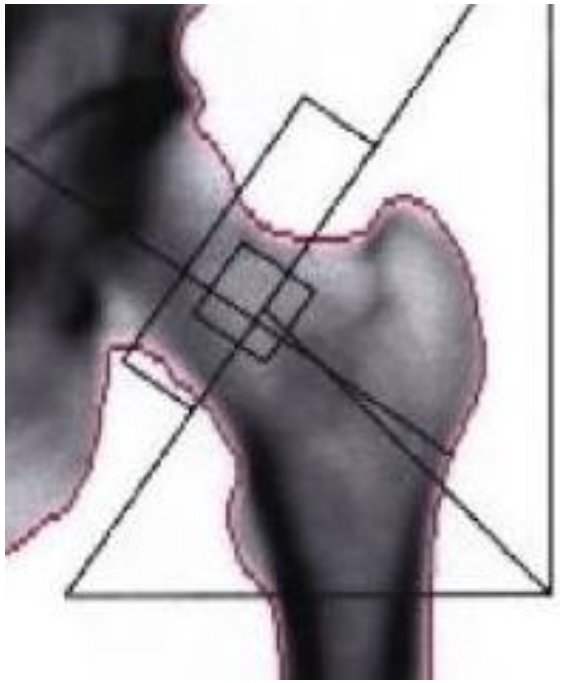
National Osteoporosis Society

Guidelines for the provision of a clinical bone densitometry service

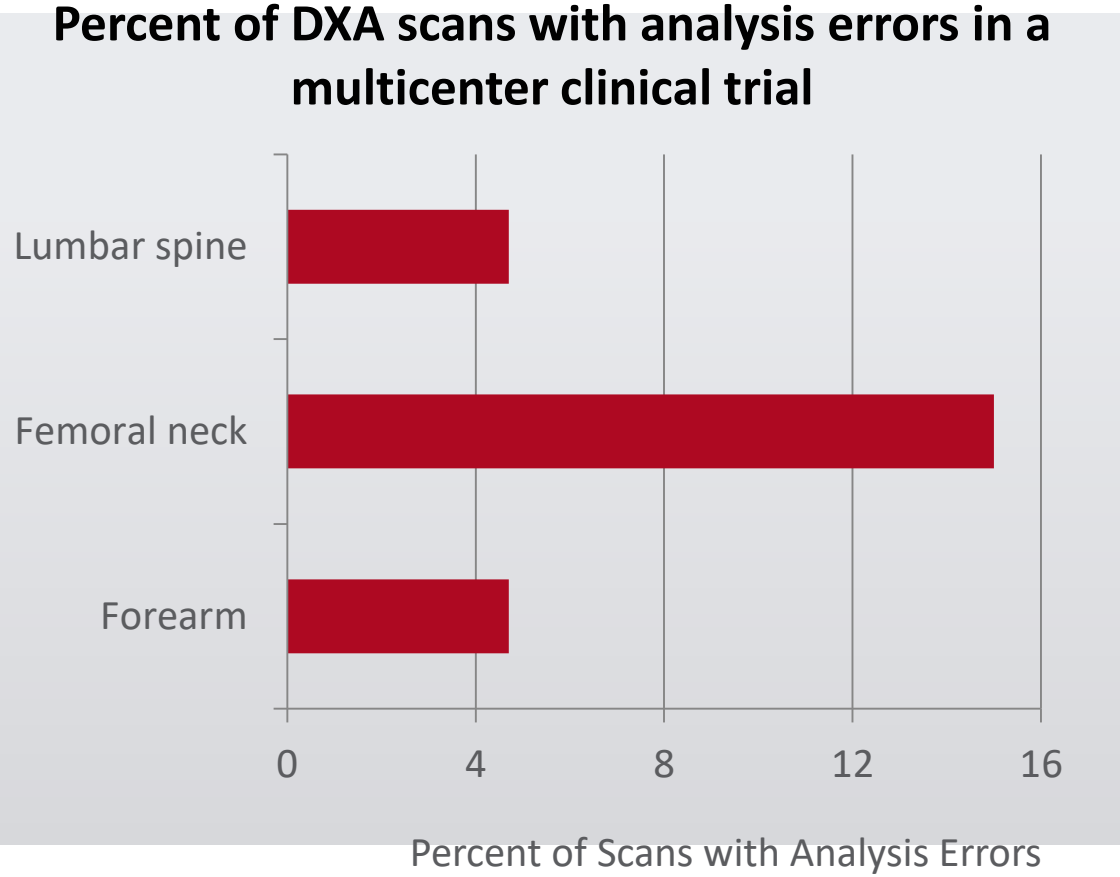
Publication Date: March 2015

Despite Technical Advances, Bone Densitometry will Continue to Require Technical Excellence



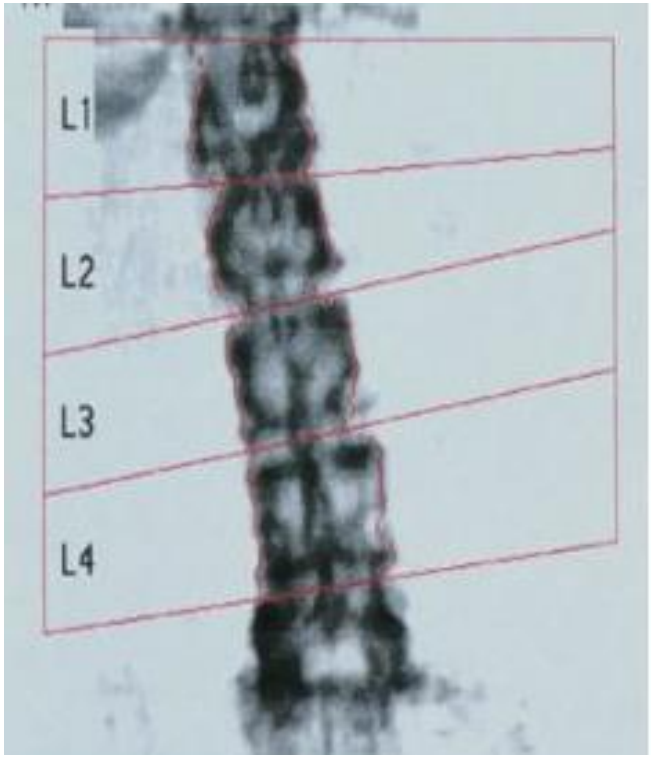


Always Evaluate the Scan Analysis: Errors Are Not Rare

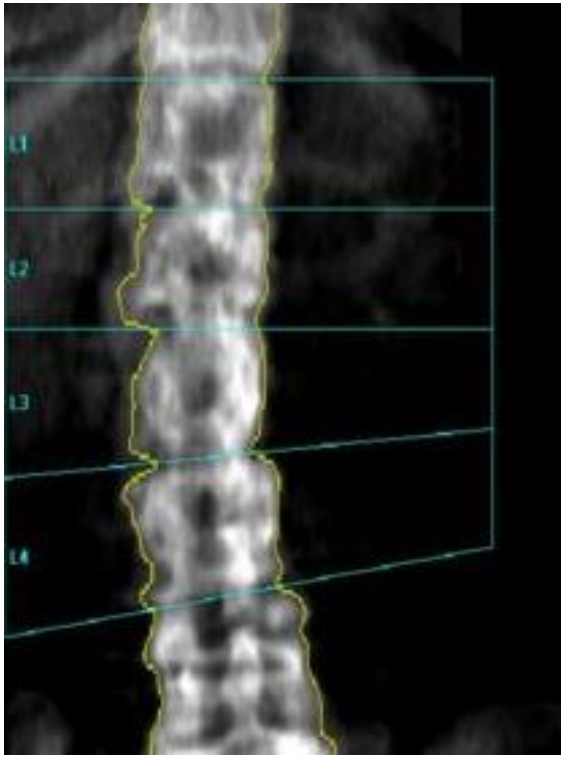


Adapted from Fuerst T, et al. In: Genant HK, et al. eds, Bone Densitometry. Springer-Verlag; 1998

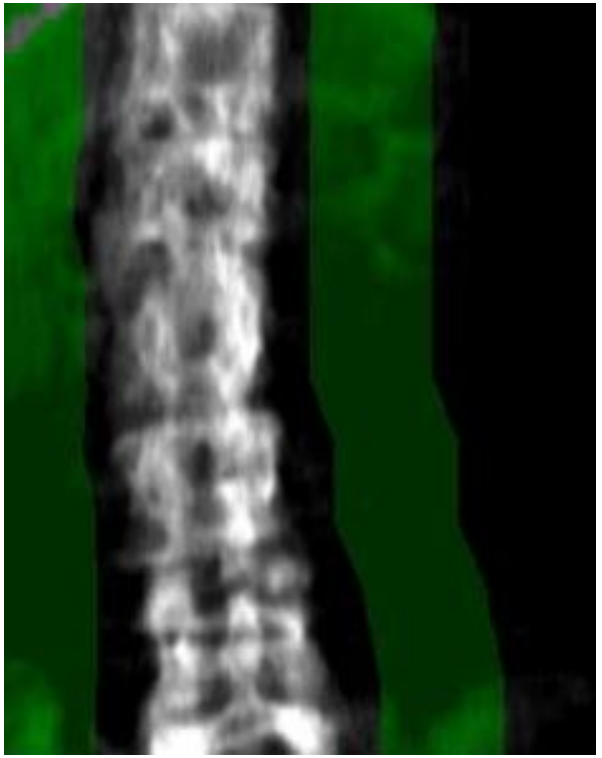
Positioning Pitfalls Examples:



Tilted

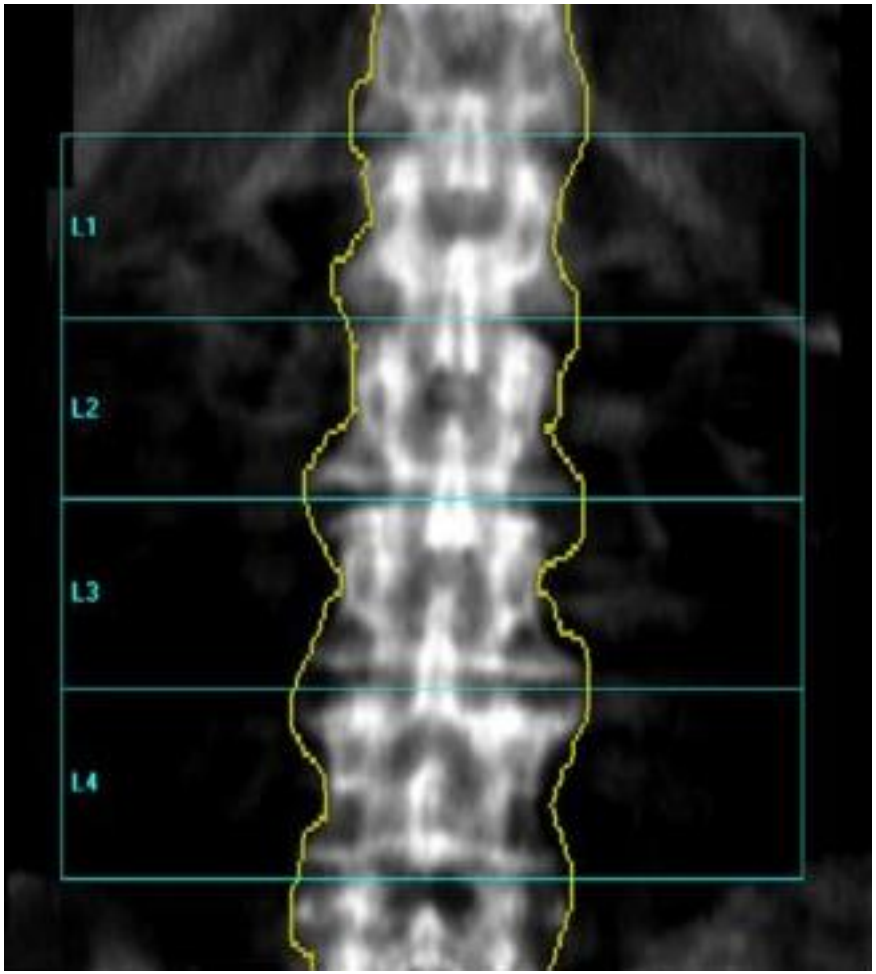


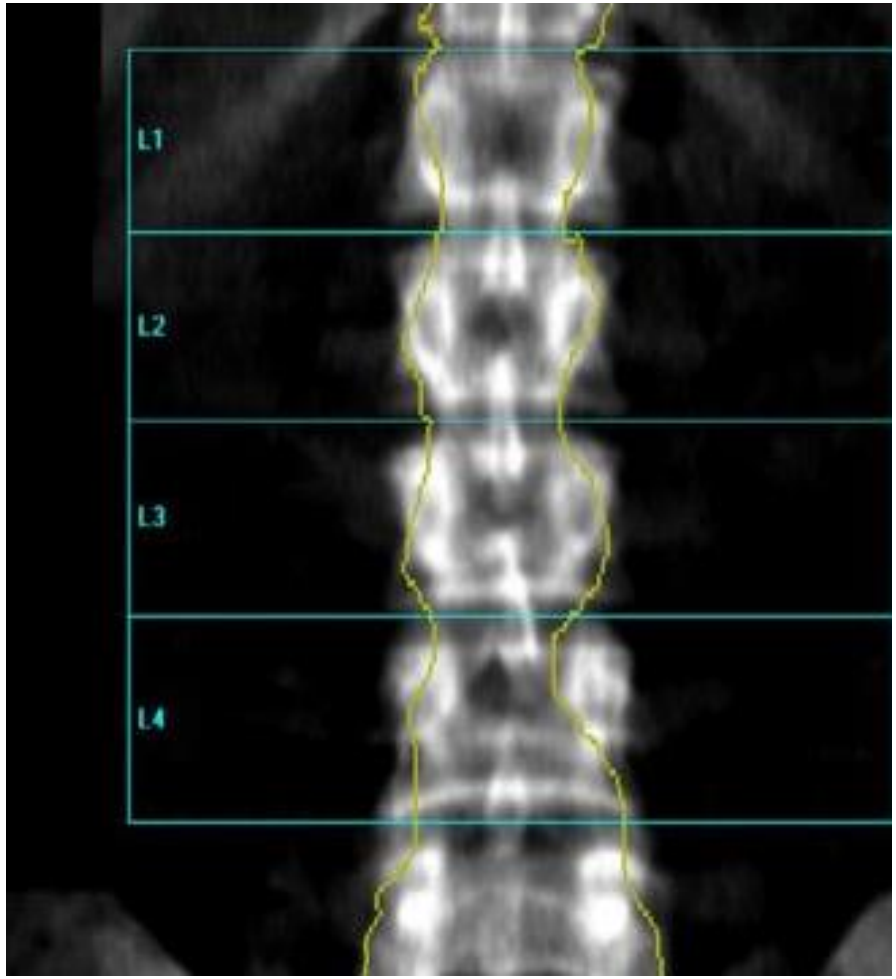
Off-Center

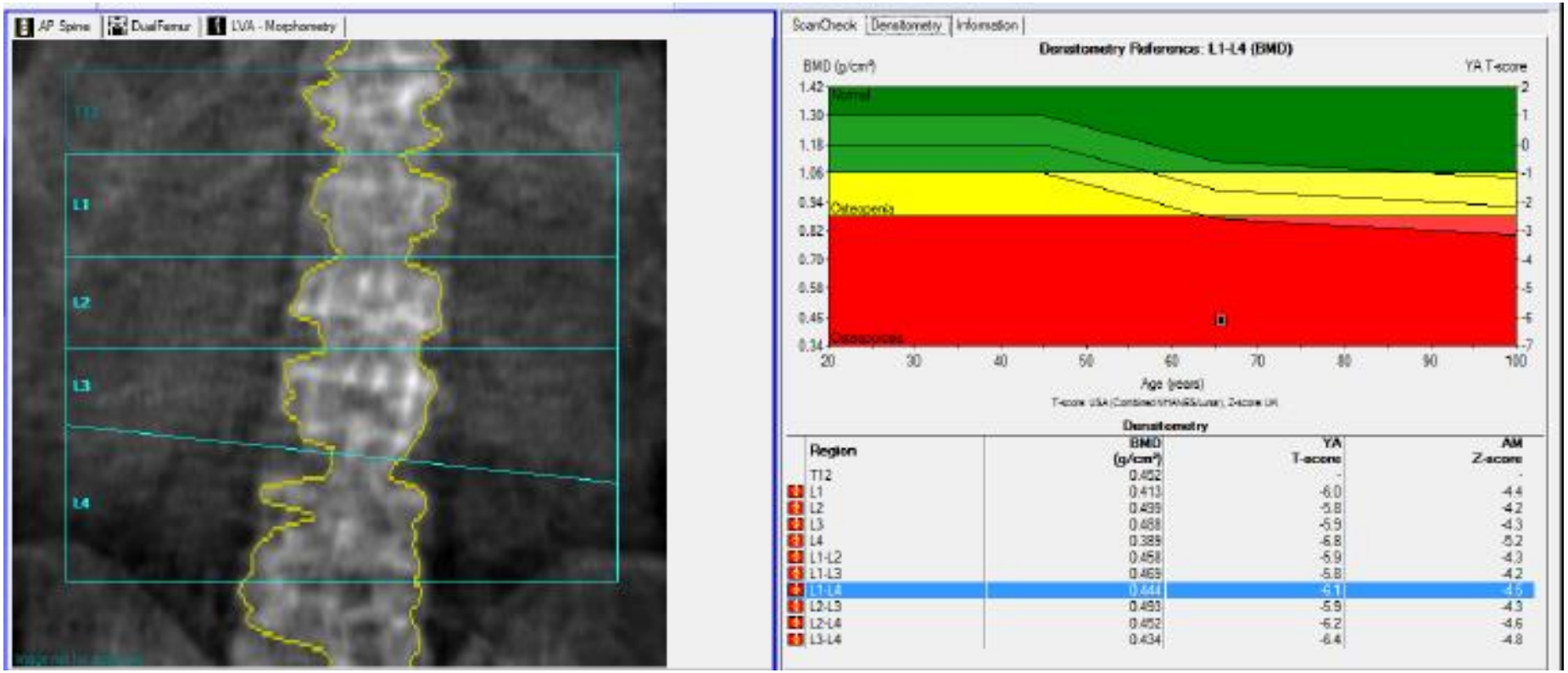


Point Typing (GE)
Green - soft tissue
Black - neutral

Poor Edge Detection

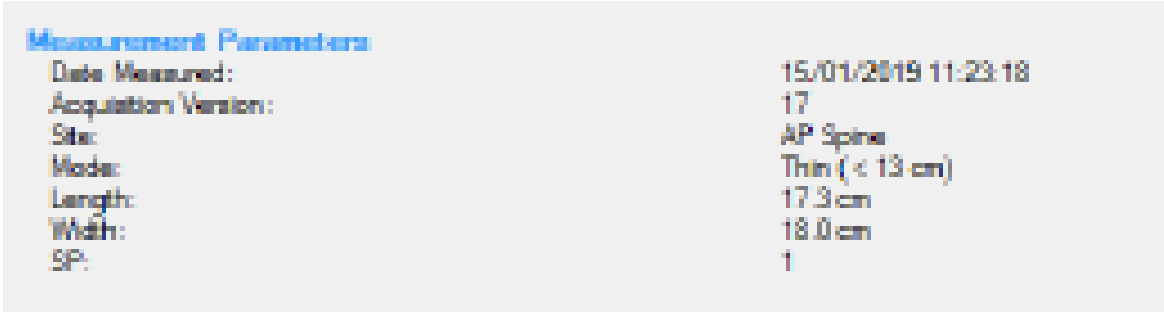




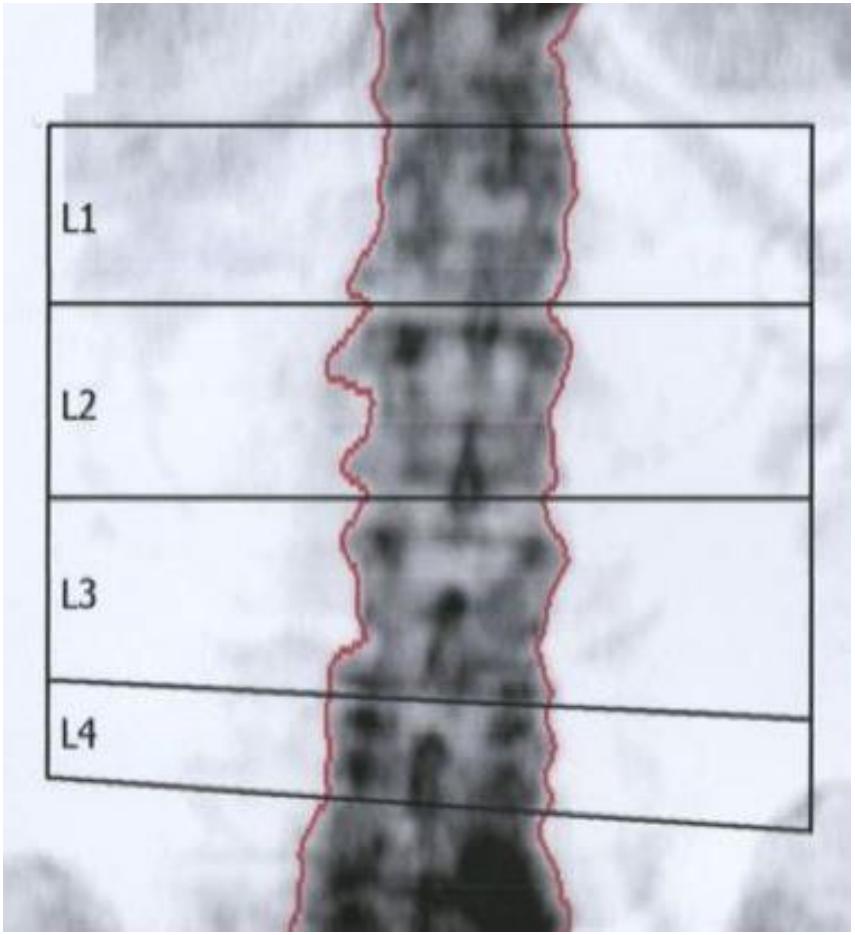


Poor Edge Detection due to (1) thinness of subject and (2) **extremely** low BMD

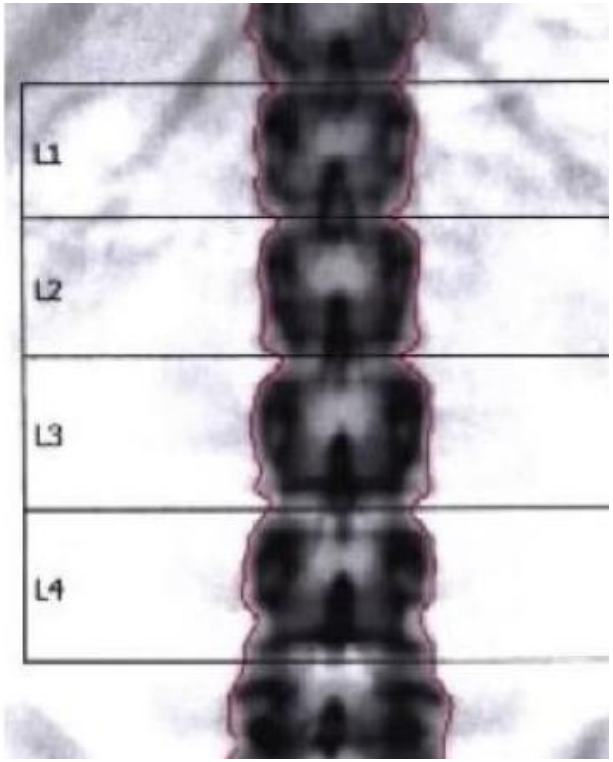
Always check correct mode of measurement has been used



Check Intervertebral Markers and Edges



Summary: Correct Spine Analysis

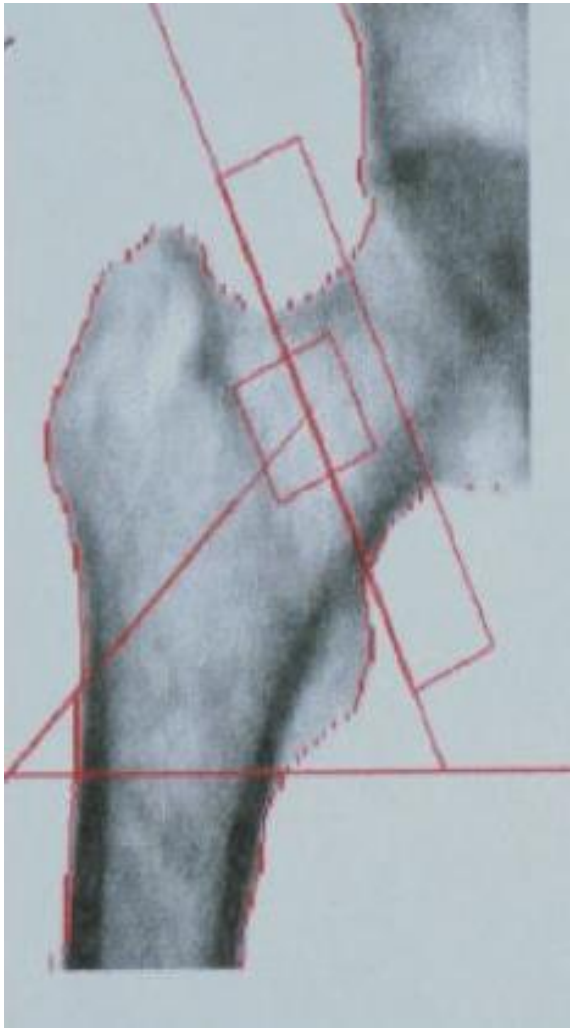


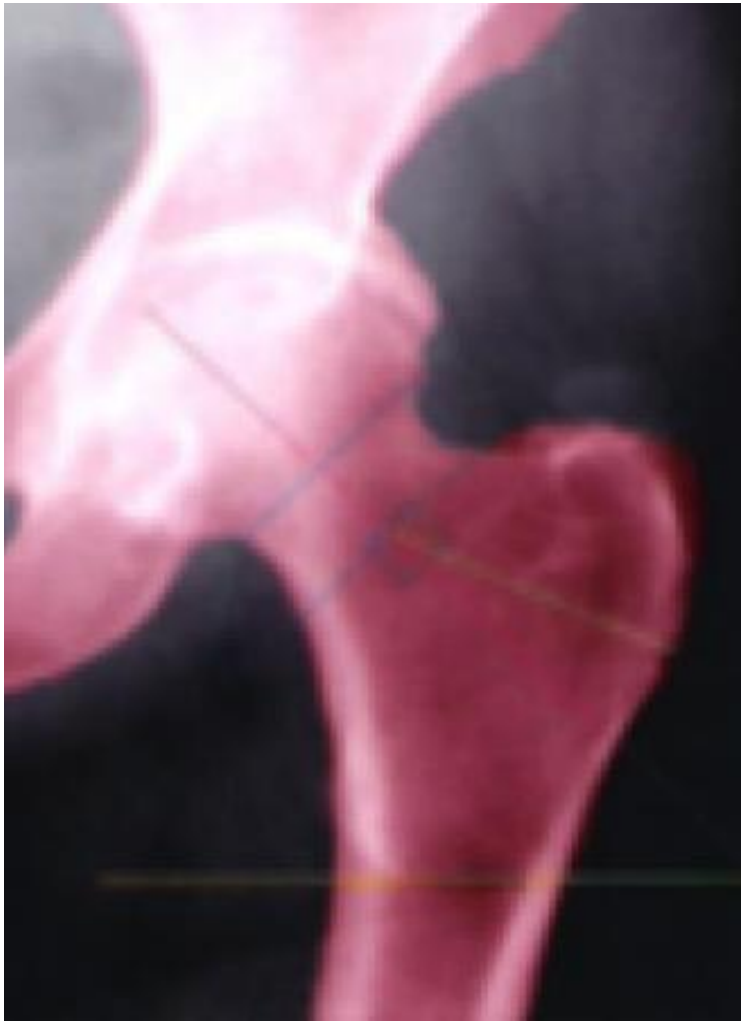
- Edges should include only bone that should be evaluated
- Intervertebral markers should be placed in the disc space
- Numbering should be correct

Proximal Femur: Positioning Pitfalls

- Femoral shaft is angled
  - Adducted
  - Abducted
- Leg is not internally rotated
  - Too much lesser trochanter

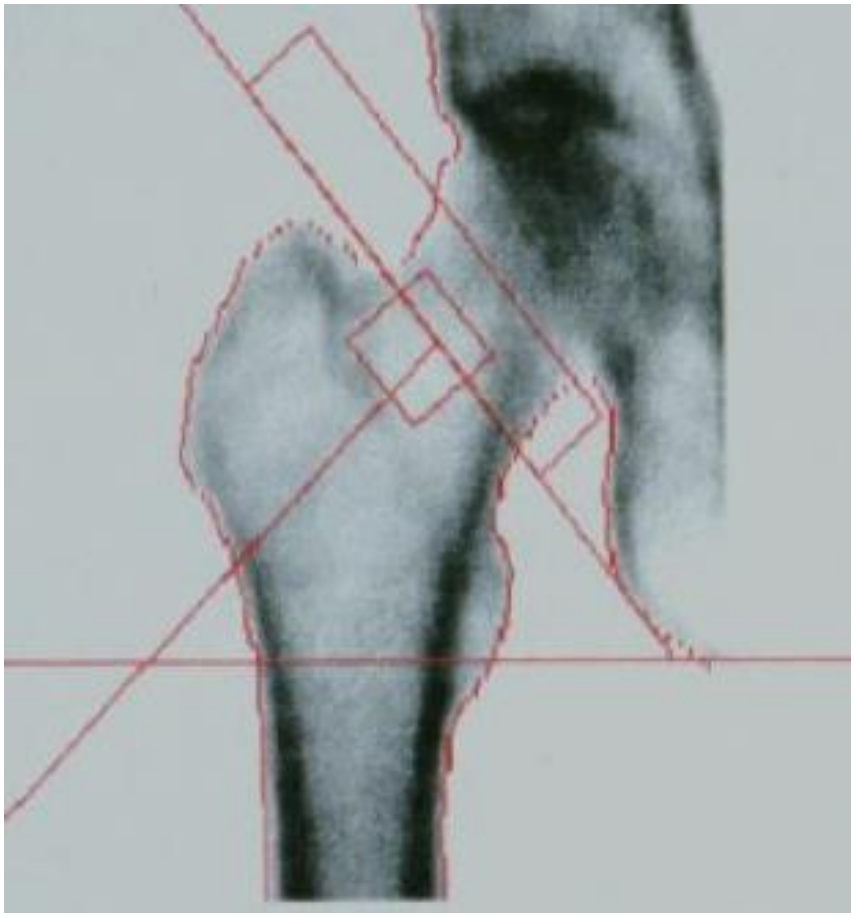
Positioning Pitfalls: Abduction/Adduction





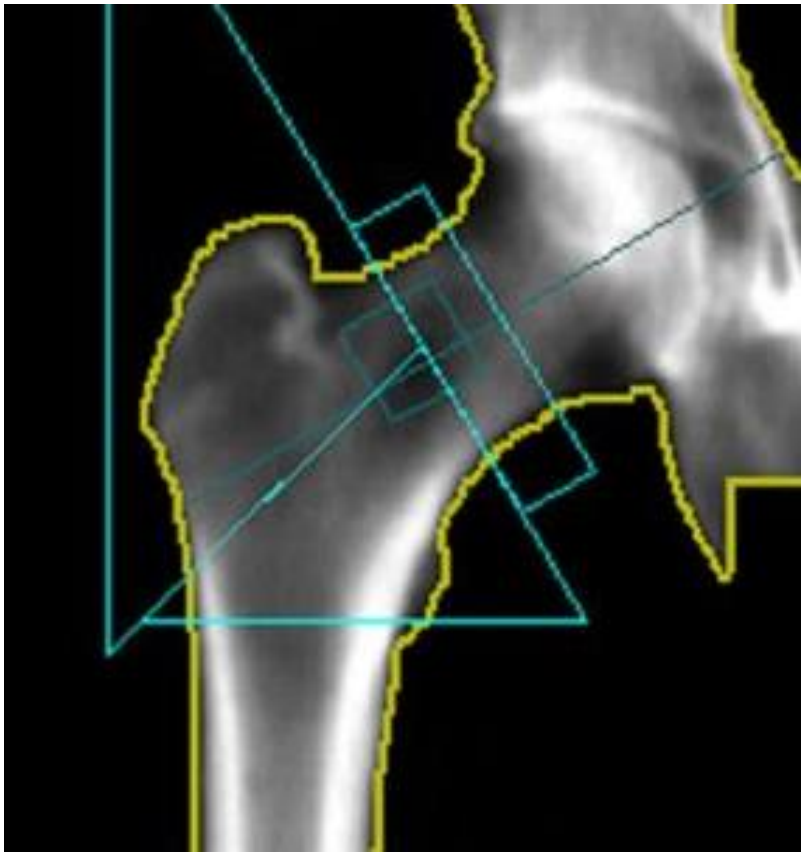
Positioning Pitfalls

Limited internal rotation due to hip osteoarthritis



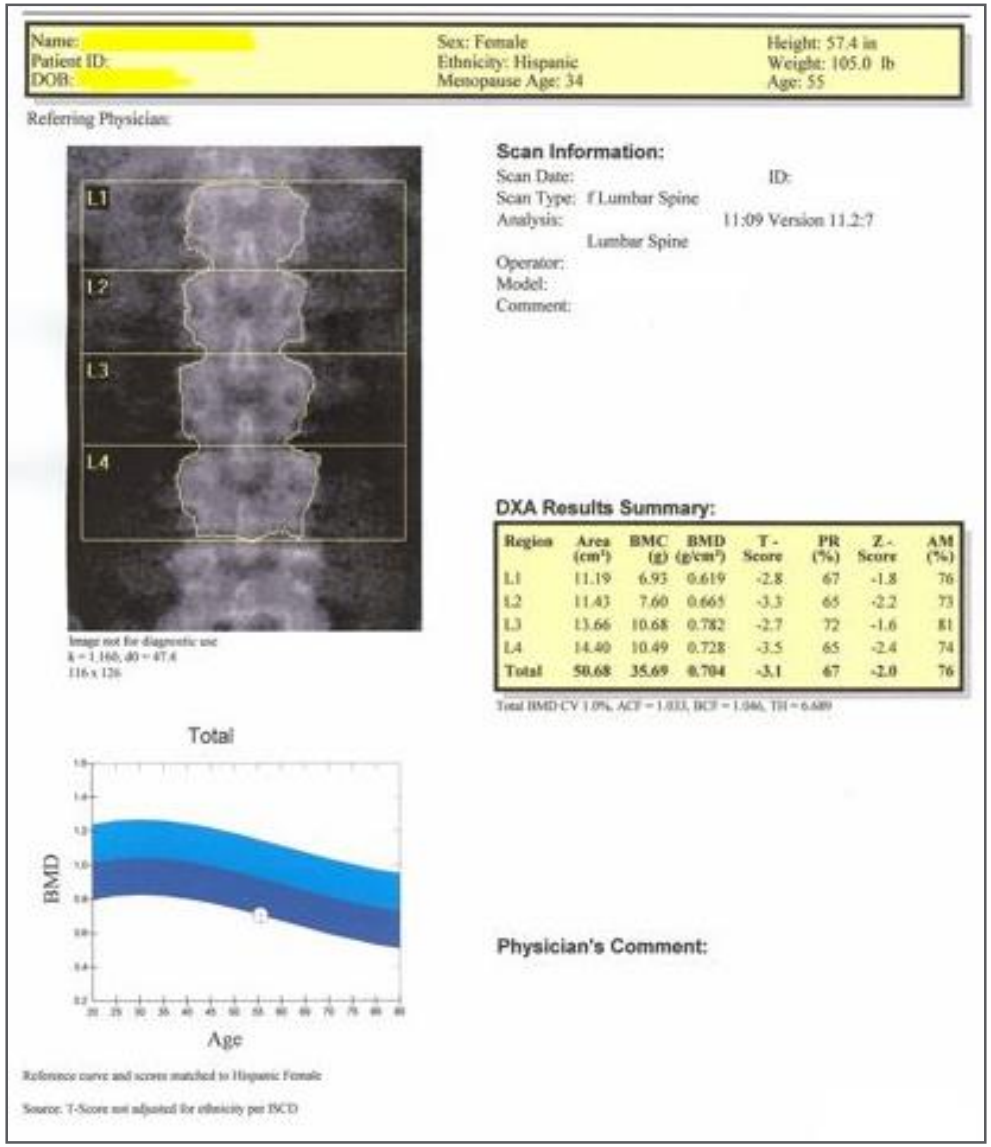
Proximal Femur Scan Analysis

- Check for proper positioning
- Check if hip is suited for measurement
  - Hardware, fusion, osteoarthritis, fractures
- Visually verify bone edges
- Neck ROI should not include greater trochanter
  - Avoid ischium if possible
- Exclude artifacts
  - If small, and do not overlay bone



Image

Graph

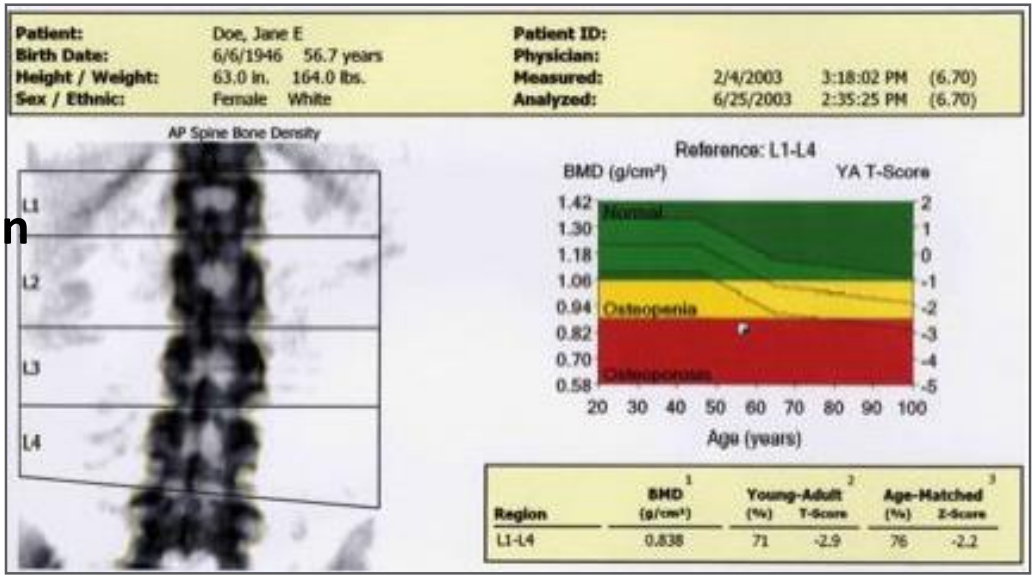


Basic information

Results
T- and
Z-scores

Basic information

Image



Graph

ANCILLARY RESULTS [AP Spine]

Region	BMD[1] (g/cm²)	Young-Adult[2] (%)	T-Score	Age-Matched[3] (%)	Z-Score	BMC (g)	Area (cm²)	Width (cm)	Height (cm)
L1	0.820	73	-2.6	78	-2.0	7.7	9.4	3.5	2.70
L2	0.806	67	-3.3	72	-2.7	10.8	13.4	3.6	3.71
L3	0.907	76	-2.4	80	-1.8	11.3	12.5	3.8	3.24
L4	0.820	68	-3.2	73	-2.6	12.0	14.6	4.1	3.53
L1-L2	0.812	71	-2.8	75	-2.2	18.5	22.8	3.5	6.41
L1-L3	0.845	72	-2.7	77	-2.1	29.8	35.3	3.6	9.65
L1-L4	0.838	71	-2.9	76	-2.2	41.8	49.9	3.8	13.18
L2-L3	0.855	71	-2.9	76	-2.3	22.1	25.8	3.7	6.95
L2-L4	0.842	70	-3.0	75	-2.4	34.1	40.5	3.9	10.48
L3-L4	0.860	72	-2.8	76	-2.2	23.3	27.1	4.0	6.77

Results

Printouts Have Scanner ID

Allows documentation that the same instrument was used when monitoring

Name: BA0, C00
Patient ID: Removed
DOB: April 11, 1949

Sex: Female
Ethnicity: White
Menopause Age: 48

Height: 67.3 in
Weight: 167.0 lb
Age: 58

Referring Physician: Removed

k = 1.144, d0 = 49.5
97 x 106
NECK: 49 x 15
HAL: 105 mm

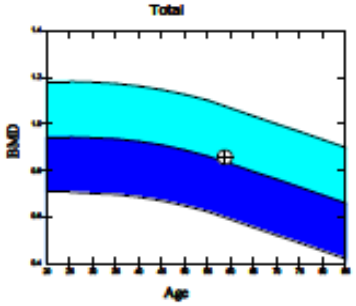
Scan Information:

Scan Date: January 23, 2008 ID: A01230809
Scan Type: a Right Hip
Analysis: January 23, 2008 09:54 Version 12.5:3
Operator: [redacted]
Model: Discovery A (S/N 45708)
Comment:

DXA Results Summary:

Region	Area (cm²)	BMC (g)	BMD (g/cm²)	T-score	PR (%)	Z-score	AM (%)
Neck	4.89	3.35	0.685	-1.5	81	-0.3	96
Troch	11.28	6.98	0.619	-0.8	88	0.0	100
Inter	19.09	19.78	1.036	-0.4	94	0.2	103
Total	**35.26**	**30.12**	**0.854**	**-0.7**	**91**	**0.2**	**102**
Ward's	1.03	0.51	0.493	-2.1	67	-0.1	97

Total BMD CV 1.0%, ACF = 1.026, BCF = 0.997, TH = 5.603



T-scores vs. White Female; Z-scores vs. White Female. Source:BMDCS/NHANES

Physician's Comment:

HOLOGIC

Patient:	253, JZS	**Facility ID:**	
Birth Date:	12/19/1939 66.0 years	**Referring Physician:**	
Height / Weight:	68.0 in. 269.0 lbs.	**Measured:**	1/4/2006 1:07:21 PM (9.30)
Sex / Ethnic:	Female White	**Analyzed:**	1/18/2010 2:52:09 PM (13.00)

DualFemur Bone Density

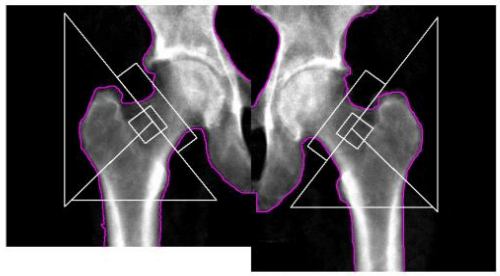
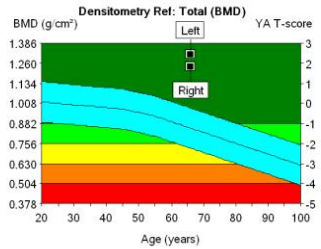


Image not for diagnosis



Region	BMD [1] (g/cm²)	Young-Adult [2,7] T-score	Age-Matched [3] Z-score
Total			
Left	1.313	2.4	3.7
Right	1.240	1.8	3.1
Mean	1.277	2.1	3.4
Difference	0.073	0.6	0.6

COMMENTS:

1 - Statistically 68% of repeat scans fall within 1SD (± 0.010 g/cm² for DualFemur Total)
2 - USA (Combined NHANES (ages 20-30) / Lunar (ages 20-40)) Femur Reference Population (v111)
3 - Matched for Age
7 - DualFemur Total T-score difference is 0.6. Asymmetry is Mild.
11 - World Health Organization - Definition of Osteoporosis and Osteopenia for Caucasian Women: Normal = T-score at or above -1.0 SD; Osteopenia = T-score between -1.0 and -2.5 SD; Osteoporosis = T-score at or below -2.5 SD; (WHO definitions only apply when a young healthy Caucasian Women reference database is used to determine T-scores.)

Printed: 1/18/2010 2:52:35 PM (13.00); Filename: 3y0lsi4abl.mee; Right Femur; 24.0:%Fat=40.7%; Neck Angle (deg)= 52; Scan Mode: Standard 146.0 µGy; Left Femur; 24.5:%Fat=42.0%; Neck Angle (deg)= 53; Scan Mode: Standard 146.0 µGy

GE Healthcare

Lunar iDXA
MA+200001

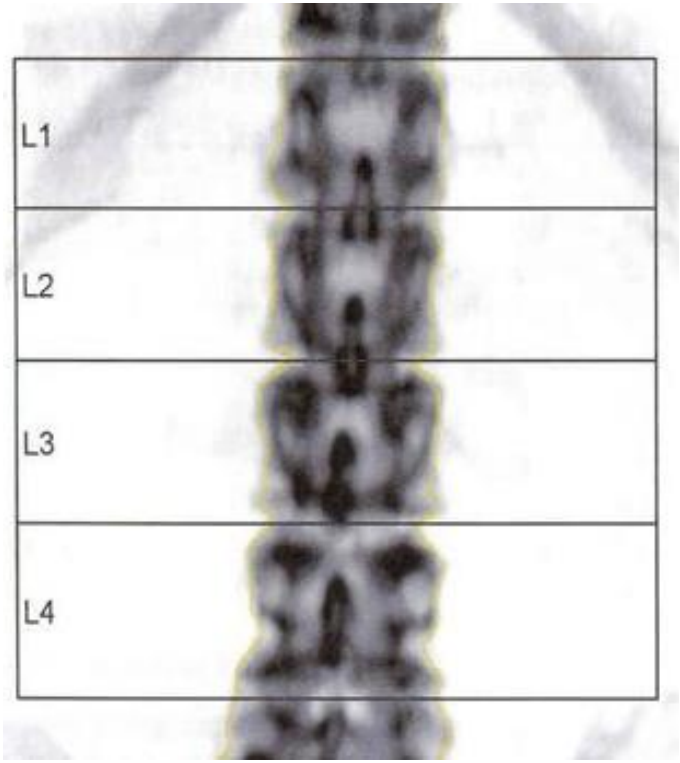
Central DXA Interpretation Principles

- Check demographics
- **Review the image**
  - Evaluate positioning, edge placement, labeling, artifacts
- Exclude vertebral bodies or regions/sites if artifacts
- Utilize the lowest T-score for diagnosis
  - Spine (L1-L4)
  - Hip (neck or total femur) not Ward's area or trochanter

DXA Image

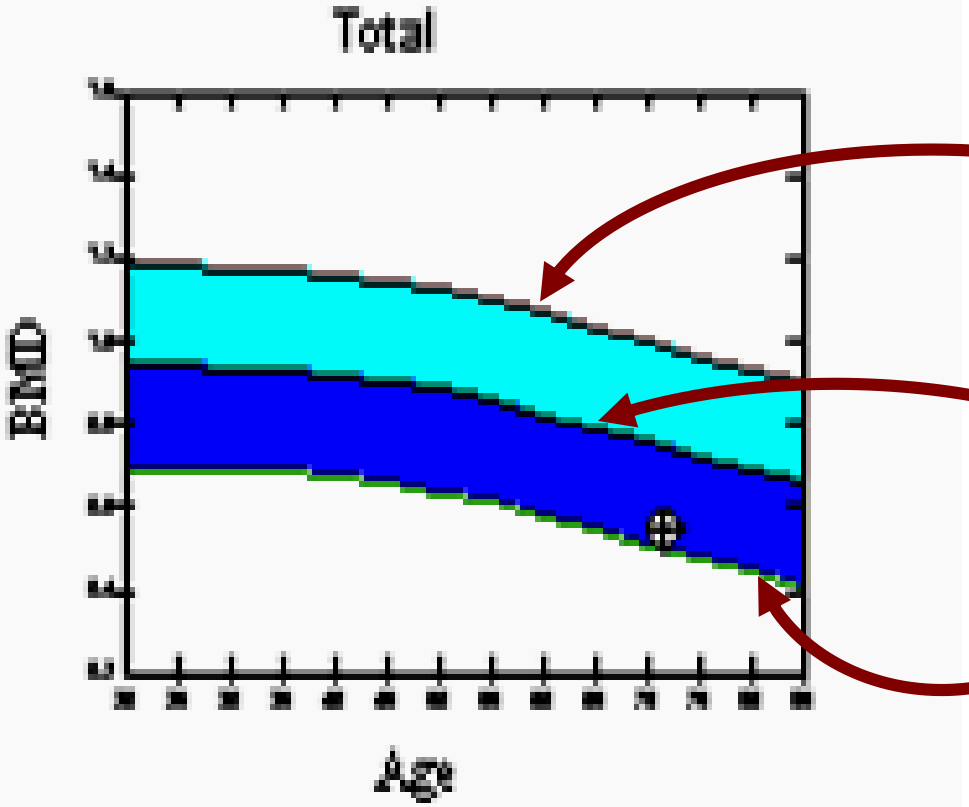
- Check patient positioning
- Check scan analysis
- Identify artifacts
- The disclaimer **“Image not for diagnosis”** is not a mandate to ignore the image

Review the Image



- Is positioning correct?
- Compare with prior study
- Are the proper regions identified?
- Are there other problems?
- Compression fractures?
- Degenerative changes?
- Get x-rays if not sure
- If possible, delete artifacts

Hologic Graph



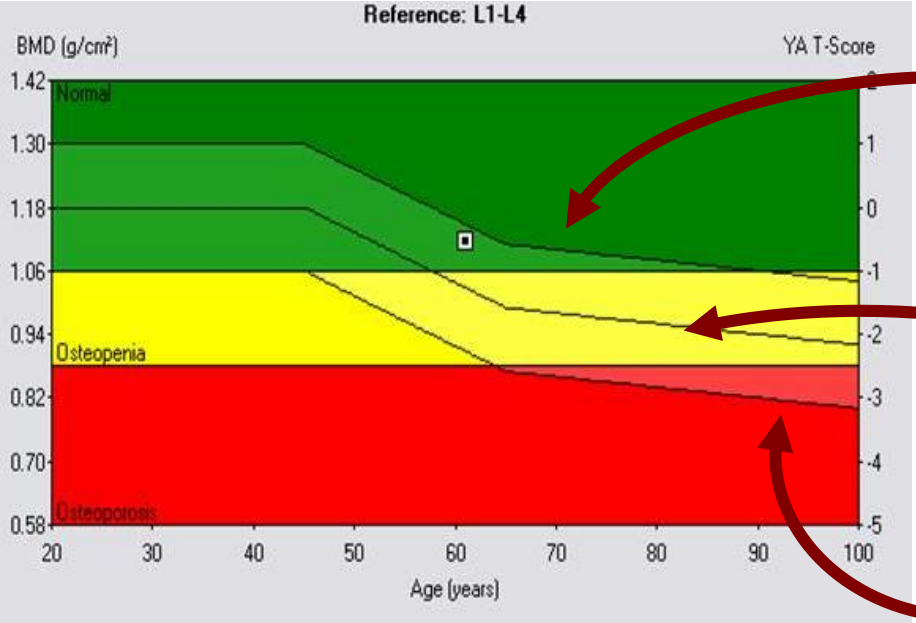
Lightly shaded area is above average for age; (top line = +2.0 SD)

Middle line is average for age

Darkly shaded area is below average for age; (bottom line = −2.0 SD)

The patient result is shown as a cross (or a half circle if result is off the scale)

GE-Healthcare Lunar Graph Default



Top line = +1.0 SD

Middle line is average for age

Darkly shaded area is below average for age; (bottom line = −1.0 SD)

The patient result is shown as a white box

Numerical Results: Spine Look for Progression

- BMD should increase from L1 to L4
- Sometimes L4 ≤ L3
- BMC and area should also increase L1 to L4

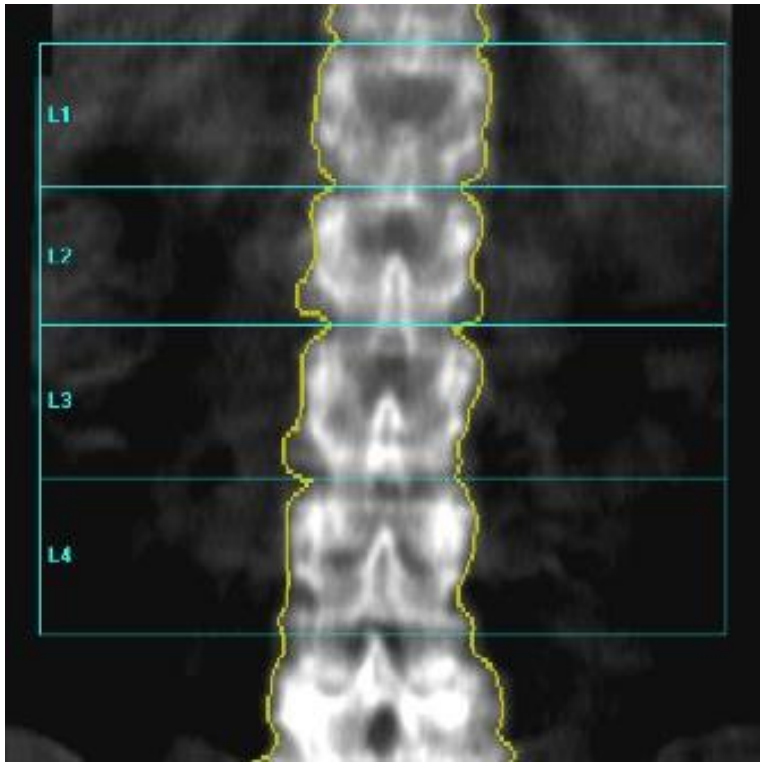
Region	Est.Area (cm^2)	Est.BMC (grams)	BMD (gms/cm^2)
L1	11.81	6.95	0.589
L2	13.10	8.62	0.658
L3	14.10	9.81	0.695
L4	16.30	11.82	0.725
TOTAL	55.31	37.21	0.673

Numerical Results: Spine

- Individual vertebral T-scores should be within 1 SD
- Do not report individual T-scores
- Instead, report T-score of L1-L4 if no exclusions

Reference					
Region	BMD (g/cm^2)	YA (%)	YA T-Score	AM (%)	AM Z-Score
L1	0.909	80	-1.8	96	-0.3
L2	0.914	76	-2.4	90	-0.8
L3	0.959	80	-2.0	95	-0.4
L4	0.927	77	-2.3	92	-0.7
L1-L2	0.911	78	-2.1	93	-0.5
L1-L3	0.928	79	-2.0	95	-0.4
L1-L4	0.928	79	-2.1	93	-0.5

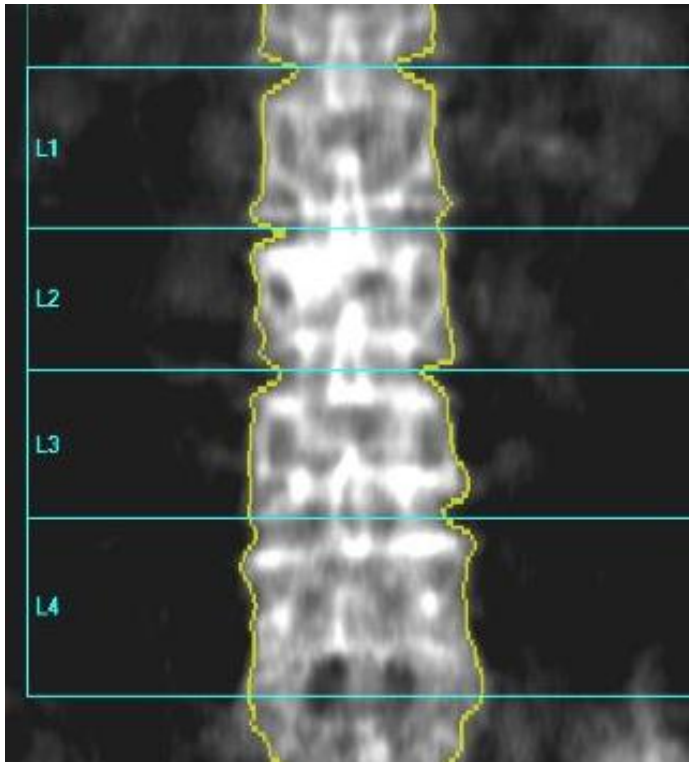
Agreement of Individual Vertebrae



Normal Progression and T-Score Variation

Region	BMD (g/cm^2)	T-score
L1	0.832	-2.5
L2	0.919	-2.3
L3	0.984	-1.8
L4	0.998	-1.7

Discrepancy of Individual Vertebrae



Region	BMD (g/cm^2)	T-score
L1	0.755	-3.1
L2	0.972	-1.9
L3	0.970	-1.9
L4	0.768	-3.6

L1, L4 BMD reported
(excluding L2 and L3)

L1-L4 Is Preferred for Diagnostic Purposes

Criteria for Exclusion of Vertebrae from Analysis

- Anatomically abnormal vertebrae may be excluded from analysis if:
  - They are clearly abnormal and non-assessable within the resolution of the system; or
  - There is more than a 1.0 T-score difference between the vertebra in question and adjacent vertebrae
- When vertebrae are excluded, the BMD of the remaining vertebrae is used to derive the T-score

Hans D, et. al. J Clin Densitom 2006, 9;15-21.

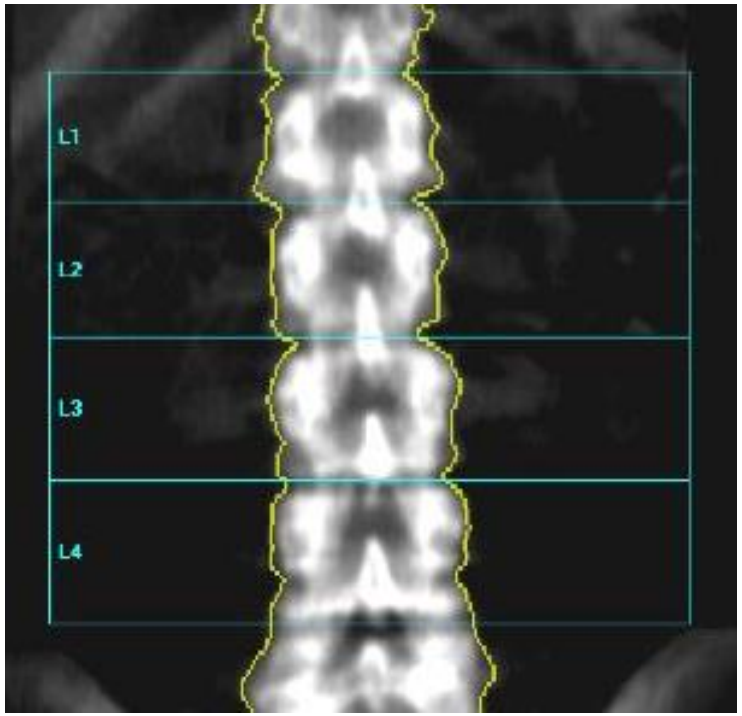
Follow-Up Scans

- Consistent patient positioning
- Consistent scan analysis
- Scan area should be similar

Scan date	Region	BMD (g/cm^2)	BMC (g)	Area (cm^2)
11/16/01	L1-L4	0.924	49.26	53.31
02/07/03	L1-L4	0.997	53.66	53.81
11/16/01	Neck - L	0.835	3.79	4.53
02/07/03	Neck - L	0.880	3.99	4.53

Good Follow-Up Scan

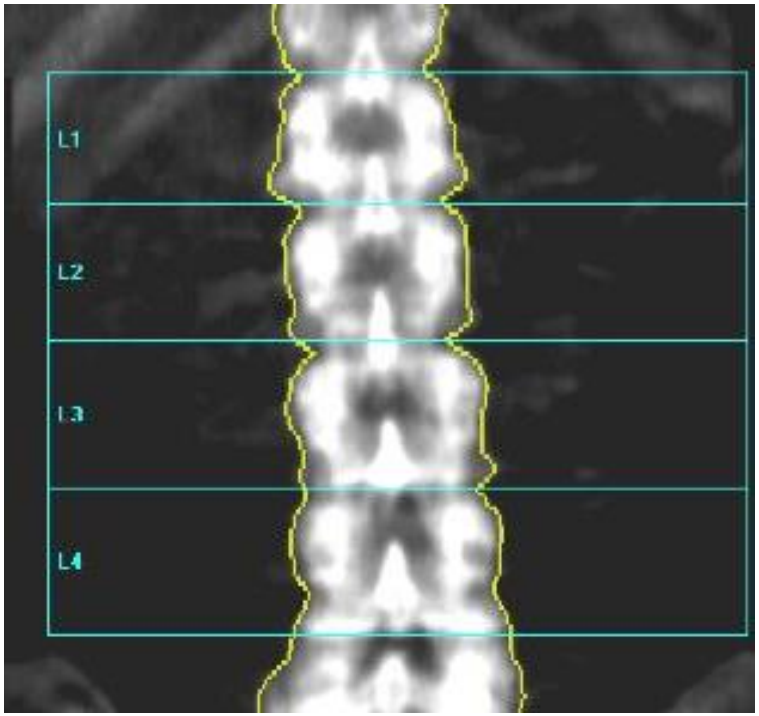
Baseline



L1: 1.312
L2: 1.324
L3: 1.448
L4: 1.411

L1-L4
BMD = 1.389
T-score = 1.7

Follow-up

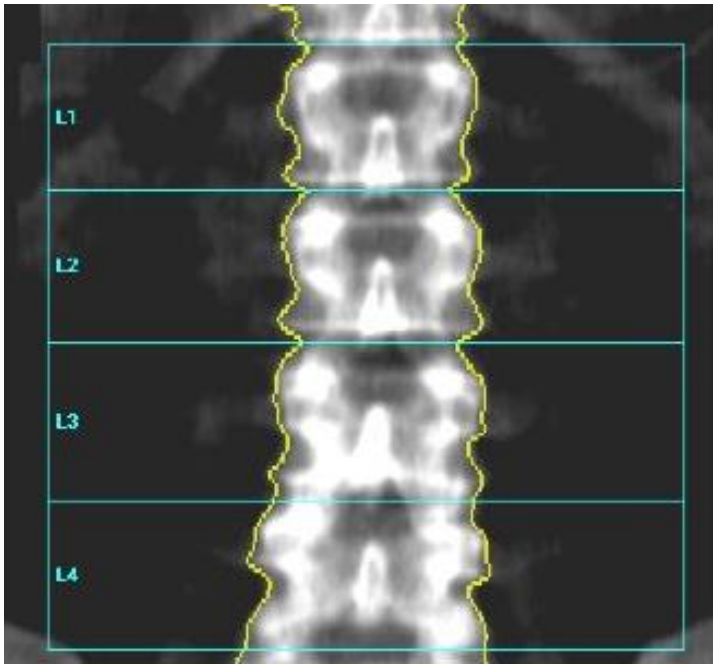


L1: 1.302
L2: 1.337
L3: 1.435
L4: 1.399

L1-L4
BMD = 1.372
T-score = 1.6

Poor Follow-Up Scan

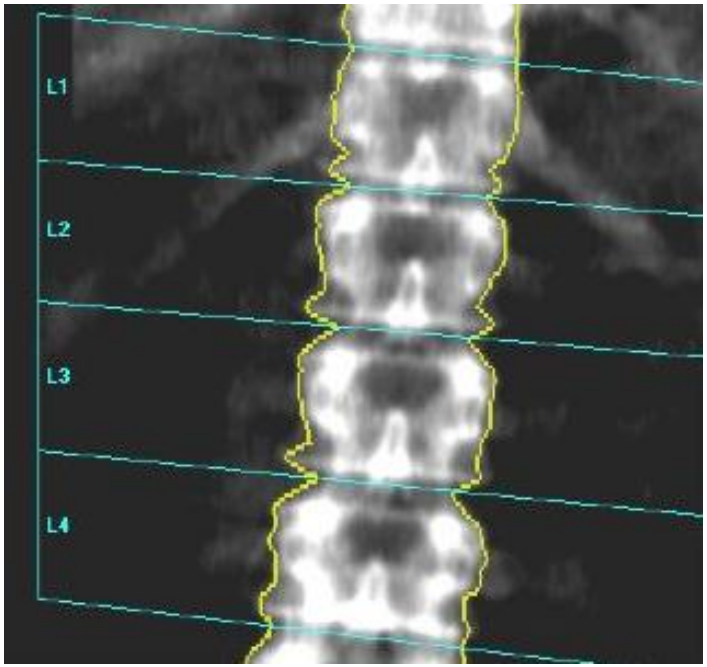
Baseline



L1: 0.992
L2: 1.103
L3: 1.237
L4: 1.254

L1-L4
BMD = 1.157
T-score = −0.5

Follow-up

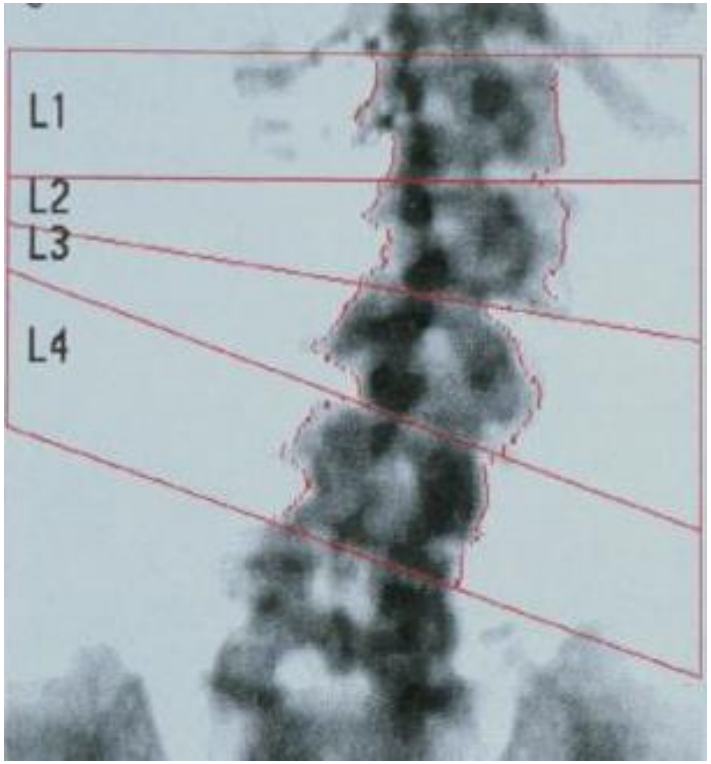


L1: 1.003
L2: 0.930
L3: 1.057
L4: 1.150

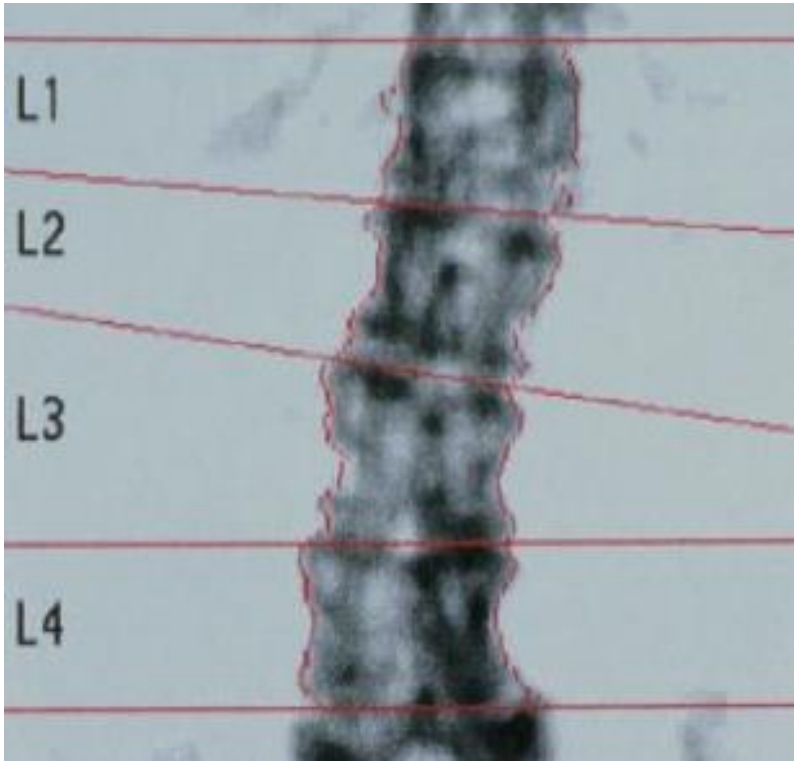
"L1-L4"
BMD = 1.043
T-score = −1.5

Watch for Artifacts

Spine Artifact: Degenerative Disease



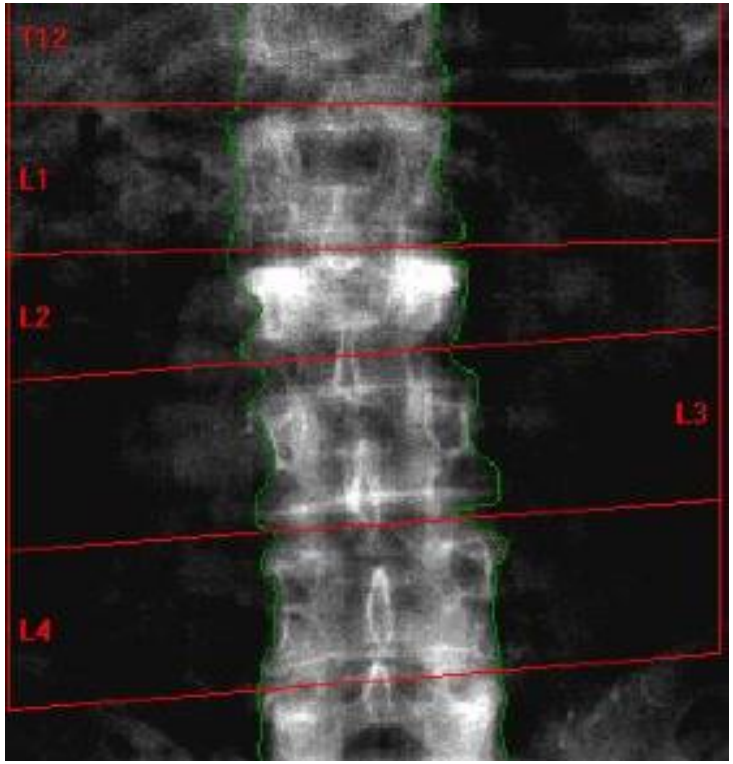
Case 1



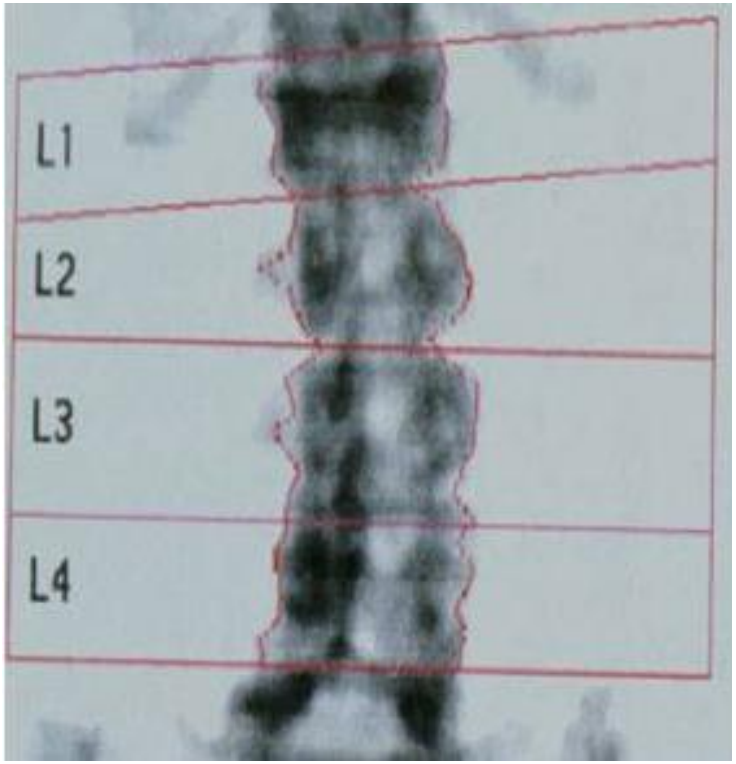
Case 2

Spine Artifact

Compression fractures



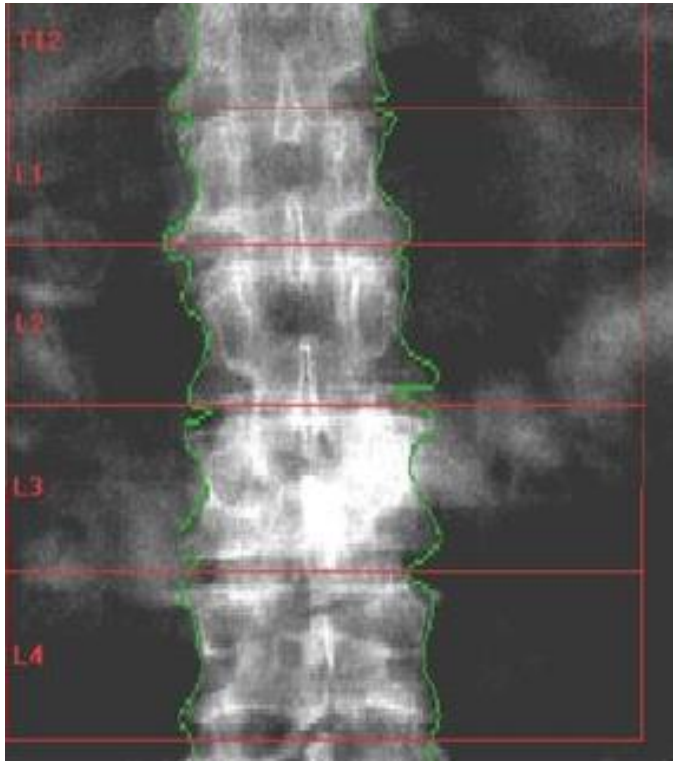
Case 1



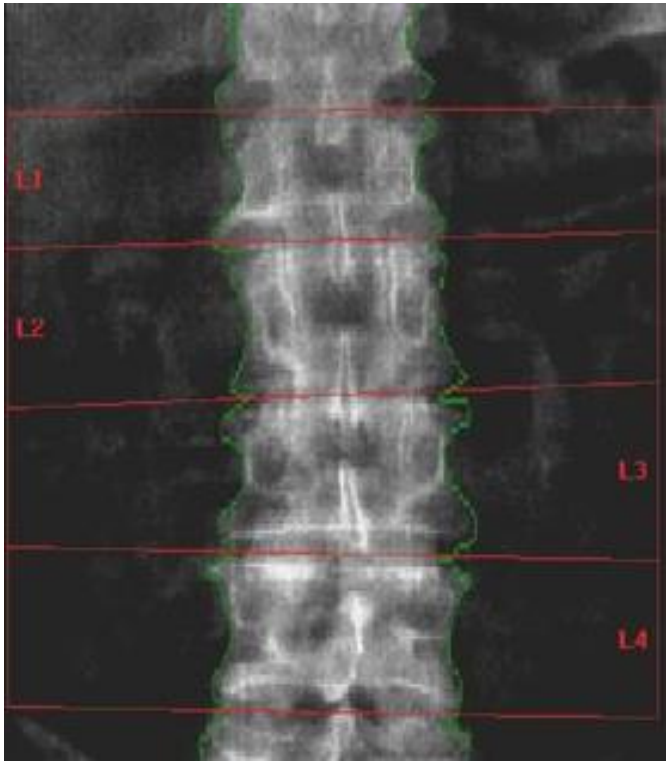
Case 2

Spine Artifact

GI contrast material



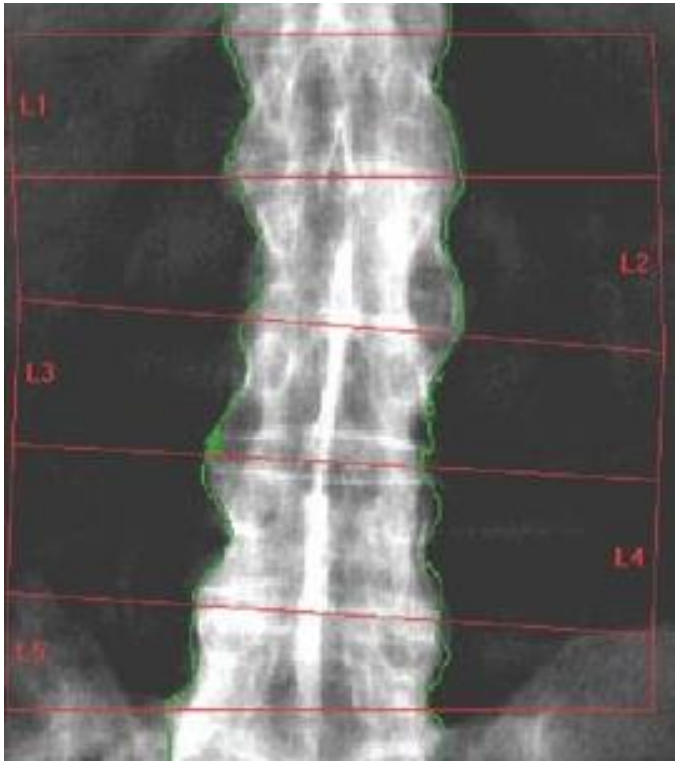
Initial scan
L1-L4 BMD = 1.268 g/cm^2



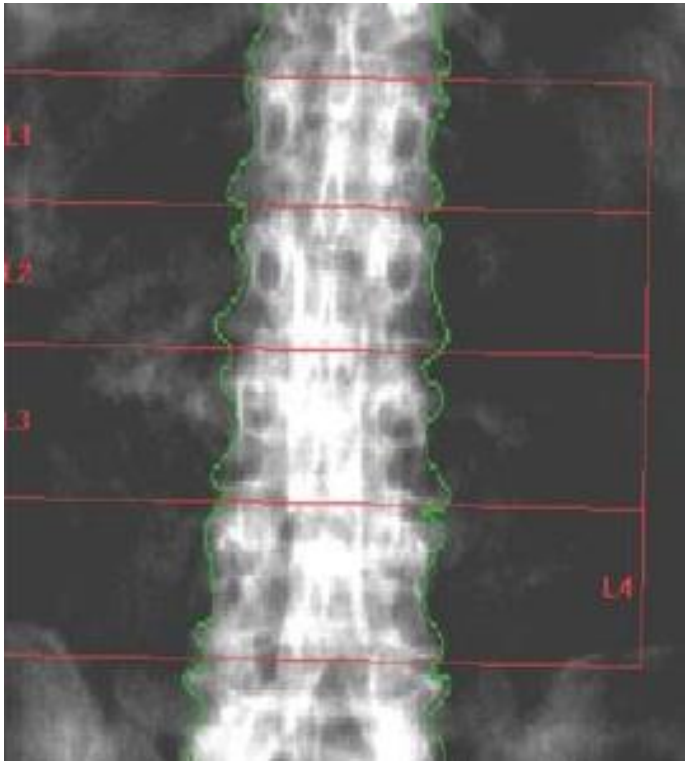
2 weeks Later
L1-L4 BMD = .929 g/cm^2

Spine Artifacts

Ankylosing spondylitis/calcified aorta



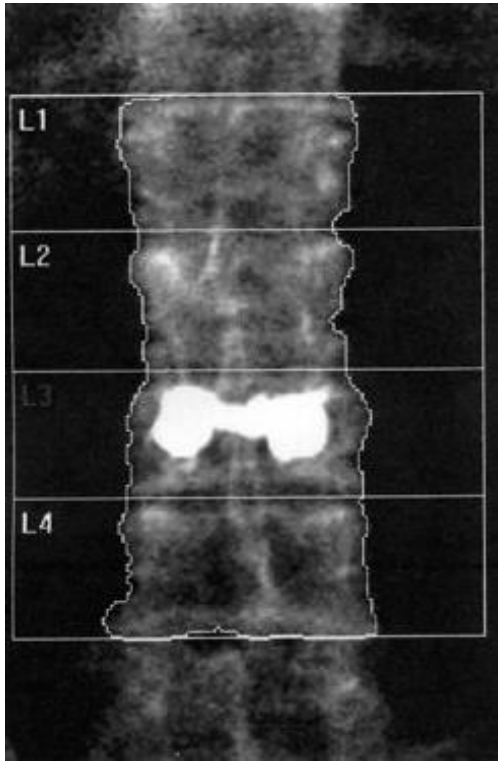
Case 1



Case 2

Spine Artifact

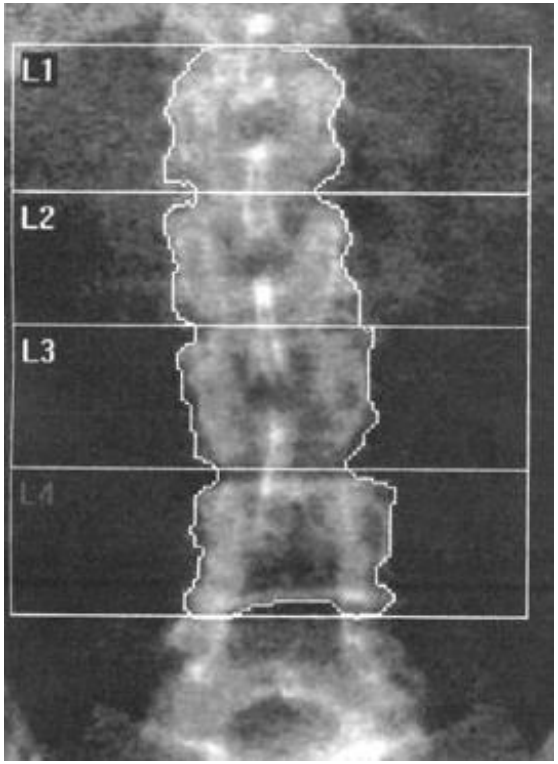
Vertebral augmentation, L3



Region	T-score
L1	0.3
L2	0.6
L3	14.7
L4	-2.6
L1, 2, 4	-0.7

Spine Artifact

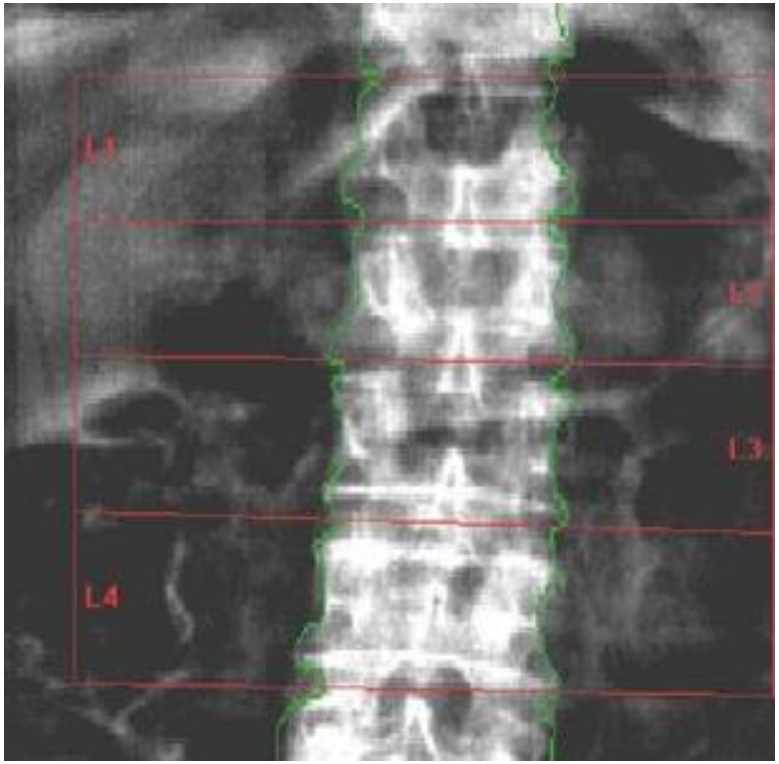
Laminectomy L4



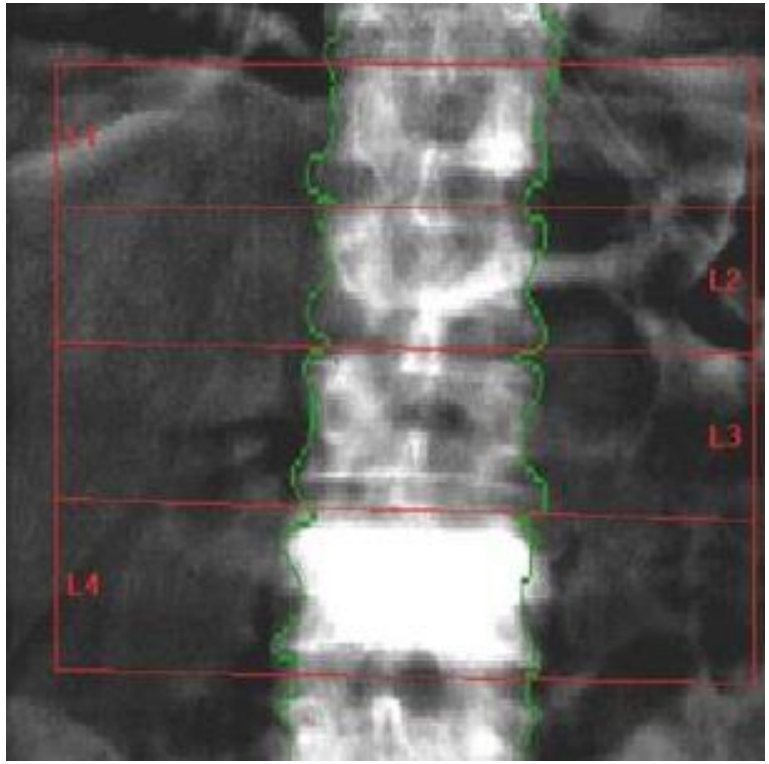
Region	T-score
L1	-1.6
L2	-1.6
L3	-2.0
L4	-3.1
L1-L3	-1.8

Spine Artifact

Prostate cancer



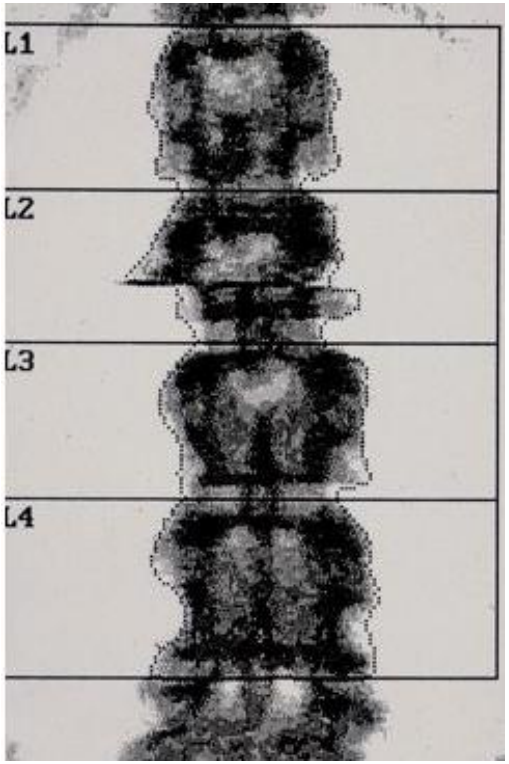
Baseline

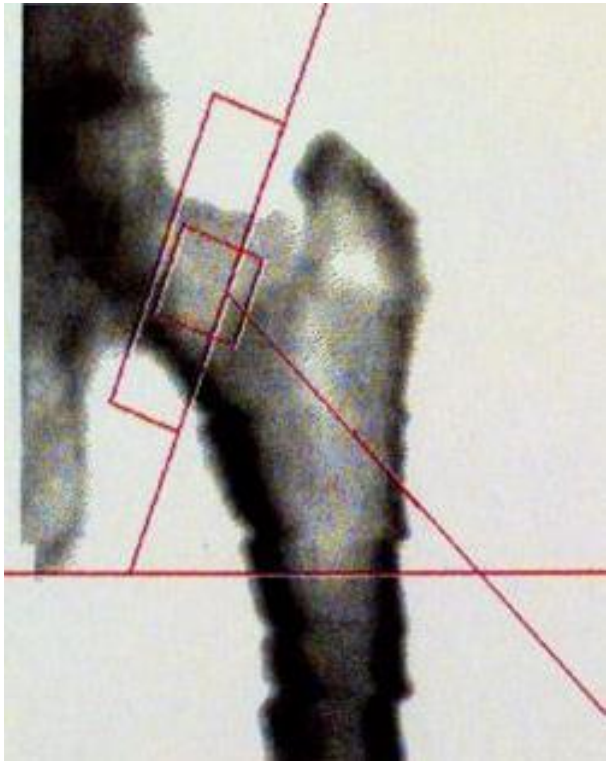


2 years Later

Spine/Femur Artifacts

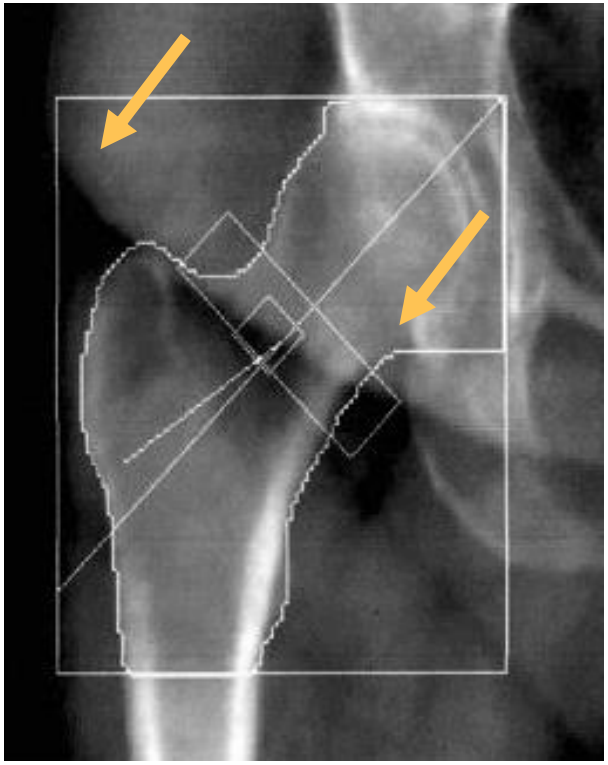
Patient motion



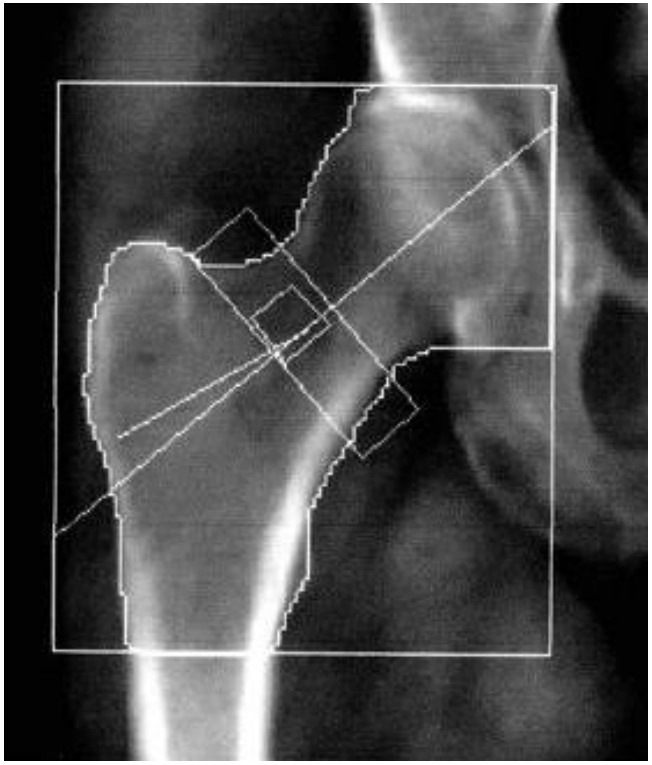


Femur Artifact

Fat panniculus



Total femur BMD Pre:
0.899 g/cm^2



Total femur BMD Post:
0.794 g/cm^2

~12% difference between scans

Jankowski, LG et al. J. Clin Densitom 2002; 5 (Suppl):S57;
Binkley N et al. J Clin Densitom. 2003;6:199-204

Royal Osteoporosis Society

Better bone health for everybody

Royal Osteoporosis Society

Reporting dual energy X-ray absorptiometry scans in adult fracture risk assessment: Standards for quality.

Replaces{ *Position Statement on the reporting of dual energy X-ray Absorptiometry (DXA) bone mineral density scans*, published June 2011 and *A structure for reporting dual energy X-ray absorptiometry scans at the hip and spine in adults*, published October 2012).

Publication Date: Quarter 3, 2019

DXA Nomenclature

Terminology

- DXA: not DEXA
- T-score: not T score, t-score, or t score
- Z-score: not Z score, z-score, or z score
- VFA – Vertebral Fracture Assessment

The Writing Group for the ISCD Position Development Conference. J Clin Densitom. 2004;7:45.

Baseline DXA Report
Minimum Requirements — Results

- Diagnosis based on lowest T-score of spine, total hip or femoral neck; if hip or spine not interpretable, use the 33% site of the radius
  - Report only one diagnosis
    - Don't say: "osteoporosis at spine, osteopenia at hip"
- Use T-scores for diagnosis in postmenopausal women and men age 50+
  - Use Z–scores in children, premenopausal women, and men younger than age 50

The Writing Group for the ISCD Position Development Conference. J Clin Densitom. 2004;7:45.

Items That Should Not be Included in a DXA Report

- A statement that there is bone loss; unless a comparison is available that shows significant loss
- Mention of "mild," "moderate," or "marked" osteopenia, or osteoporosis
  - Note: "Severe" or "established" osteoporosis is acceptable to describe postmenopausal women with T-scores at or below -2.5 with a history of fragility fracture

The Writing Group for the ISCD Position Development Conference. J Clin Densitom. 2004;7:45.

Items That Should Not be Included in a DXA Report

- Separate diagnoses for different regions of interest (e.g., osteopenia at the hip and osteoporosis at the spine)
- Expressions such as, "She has the bones of an 80-year-old," if the patient is not 80-years-old
- Results from skeletal sites that are not technically valid
- The change in BMD, if it is not a significant change based on the precision error and LSC

The Writing Group for the ISCD Position Development Conference. J Clin Densitom. 2004;7:45.

Reporting dual energy X-ray absorptiometry scans in adult fracture risk assessment: Standards for quality.

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Address of DXA Scanning Service
Date of report
Referrer name/address
Patient details: Name, address, Date of birth, unique identifier, ethnicity
Introduction: The above patient attended for a bone mineral density (BMD) assessment by DXA (equipment make) on dd/mm/yyyy.
Primary reason for referral:
Indications including BMI; Fractures; Current osteoporosis treatments etc
Results table

Site	Area	Date of measurement	BMD g/cm^2	T-score	Z-score or % (age matched)	Change since baseline (%)
Spine	L1-L4					
Hip*	Total hip					

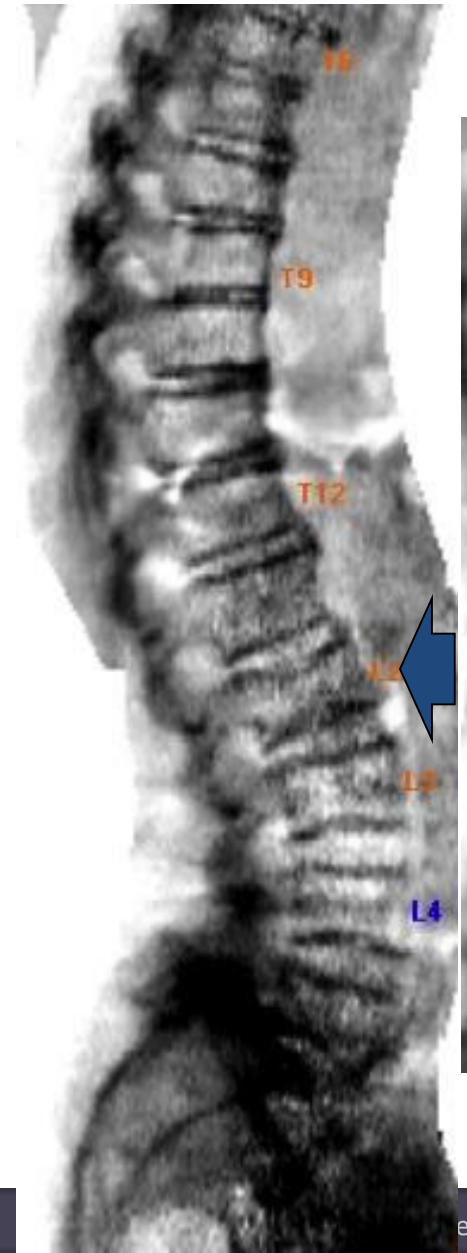
*Either total hip or femoral neck may be used depending on local protocol.

BMD Interpretation: WHO diagnostic category (where appropriate), commentary on reliability of measurements, commentary on rate of change and statistical and clinical significance.
Other investigations: Comment on VFA if performed, other imaging or lab tests where appropriate
Summary of risk factors: Clinical risk factors for fracture and falls
Clinical Interpretation of fracture risk: Either as a 10-year fracture probability (FRAX) or High/moderate/low.
Referrer actions:
Provide treatment recommendations, lifestyle modification, falls risk assessment, additional investigations, onward referral.
Provide a recommendation for follow-up
Reported by:
Name Title Signature GMC/HCPC/NMC number Date

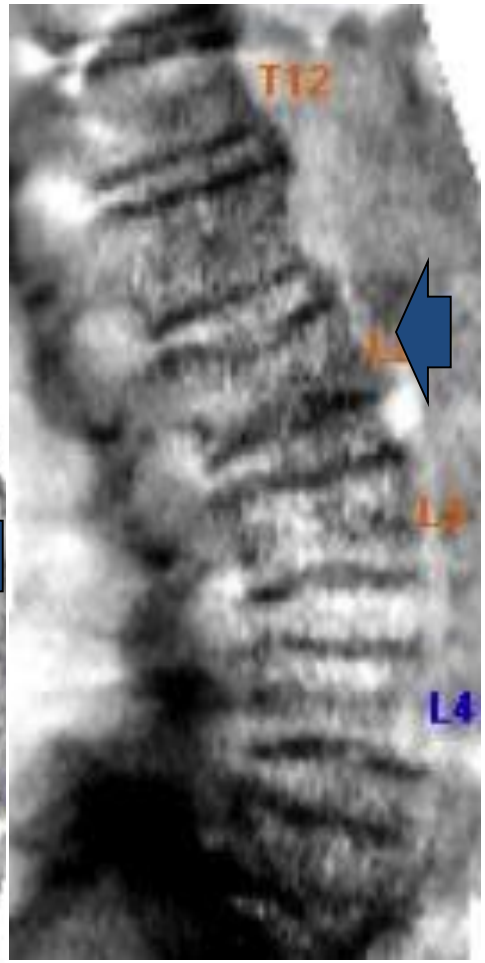
Components of DXA Report: Follow-up

1. Statement regarding which previous or baseline study and ROI is being used for comparison
2. Statement about the LSC at your facility and the statistical significance of the comparison
3. Report significant change, if any, between the current and previous study or studies in g/cm^2 and percentage
4. Comments on any outside study including manufacturer and model on which previous studies were performed and the appropriateness of the comparison
5. Recommendations for the necessity and timing of the next BMD study

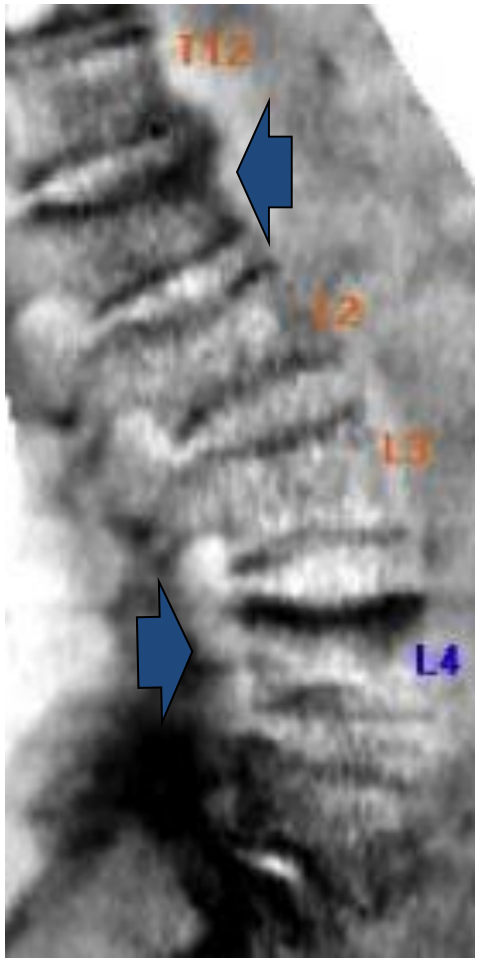
Case 8



Baseline



1Yr Follow-up



How do we use DXA results in Clinical Practice?

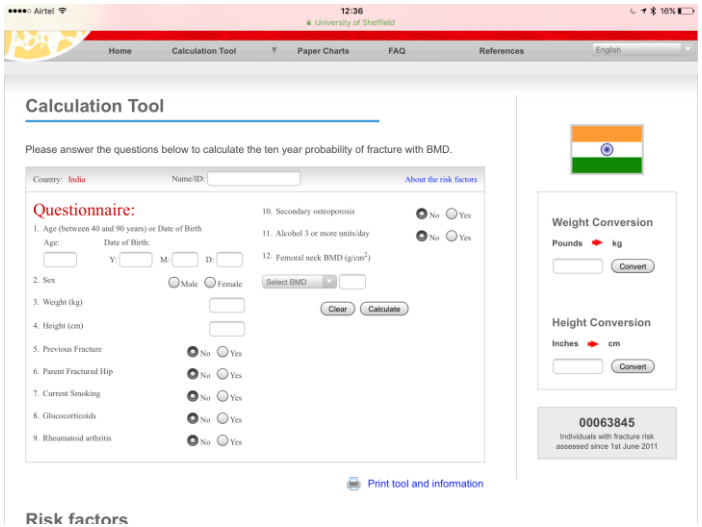
As Part of Fracture Risk Assessment

NOGG Approach

- In addition to its diagnostic use, the **assessment of BMD** provides information on the likelihood of future fractures. The risk of fracture increases approximately twofold for each SD decrease in BMD, but the gradient of risk (relative risk/standard deviation; RR/SD) varies according to the site and technique used, the patient's age and the fracture outcome [Johnell et al 2005]; (Evidence level Ia).
- The performance characteristics of BMD assessment can be improved by the concurrent **consideration of risk factors** that operate independently of BMD. Of particular importance is age, which contributes to risk independently of BMD [Kanis et al 2007, Kanis et al 2008]; (Evidence level Ia).
- **Vertebral fracture assessment** should be considered in postmenopausal women and older men if there is a history of ≥4cm height loss, kyphosis, recent or current long-term oral glucocorticoid therapy, or a BMD T-score ≤-2.5 (Grade C recommendation). It should also be considered in individuals with a history of non-vertebral fracture after the age of 50 years [Gallacher et al, 2007].

https://www.sheffield.ac.uk/NOGG/NOGG%20Guideline%202017.pdf

The NOGG approach to Fracture Risk Assessment and Treatment



Risk factors:

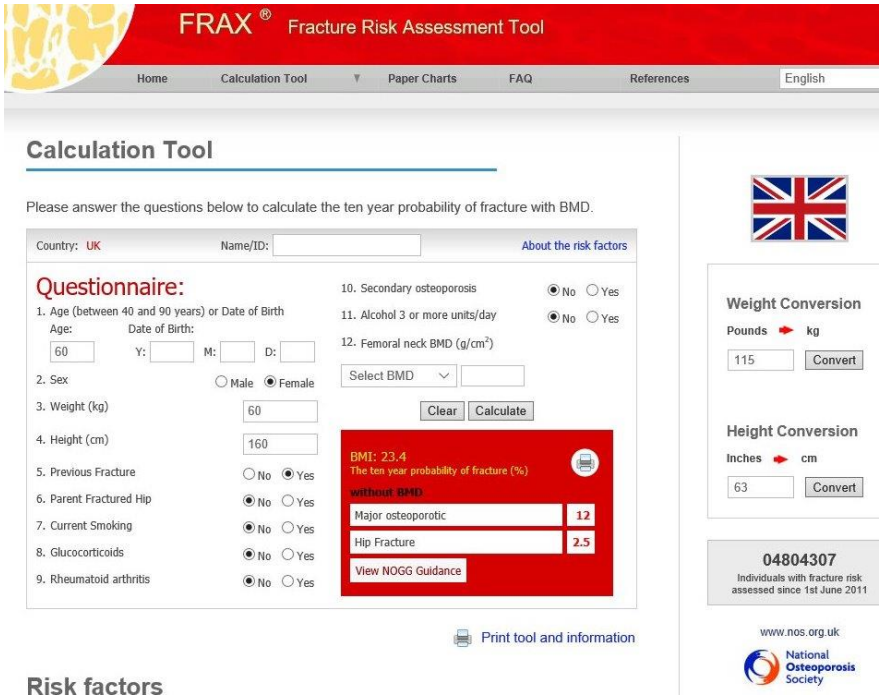
- Age
- Low BMD
- Previous fractures
- Low BMI
- Prior history of fracture
- Family history of hip fracture
- Current smoking
- High intake of alcohol
- Secondary Osteoporosis
- Rheumatoid arthritis
- Glucocorticoid therapy

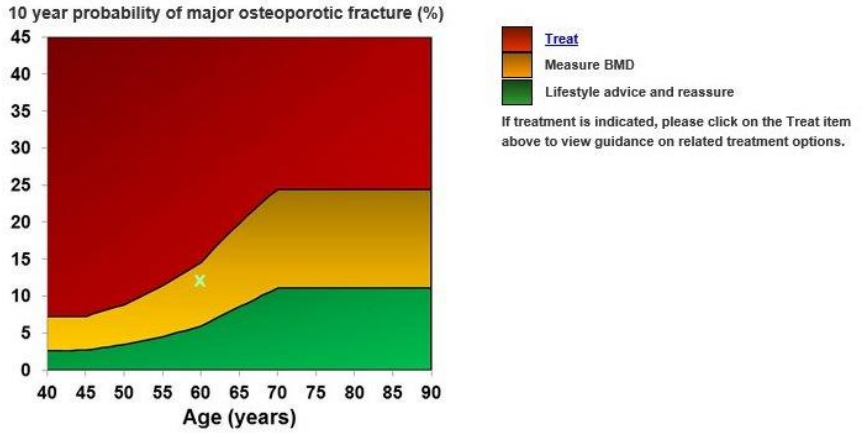
All risk factors add up to the 10-year probability of fracture

Secondary Osteoporosis Disorders

- type I (insulin dependent) diabetes,
- osteogenesis imperfecta in adults,
- long-standing hyperthyroidism
- hypogonadism or premature menopause
- chronic malnutrition
- malabsorption and chronic liver disease

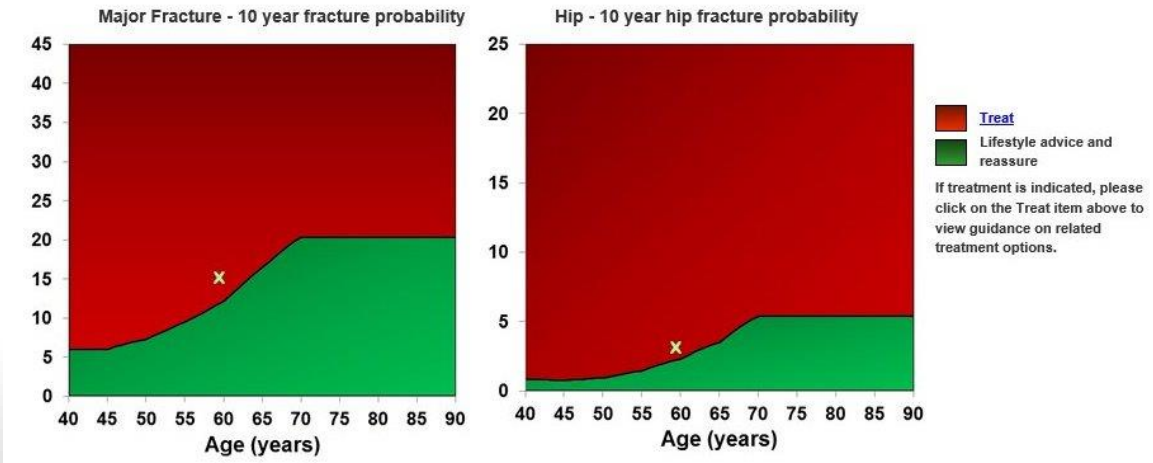
Fracture Risk Assessment & Intervention Thresholds





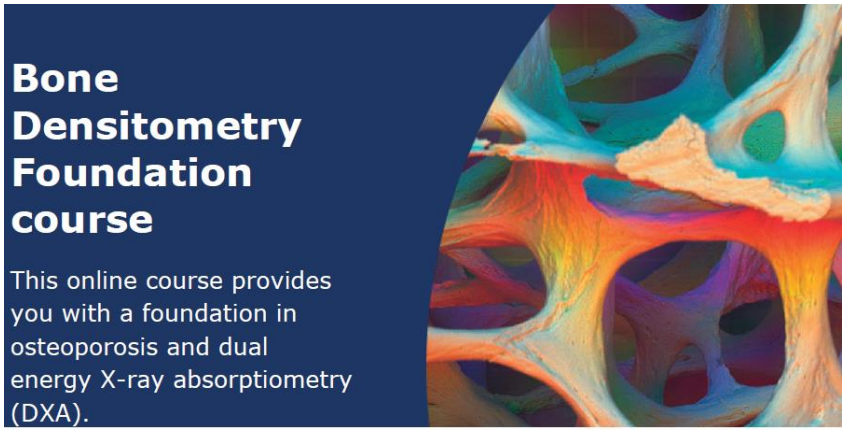
NOGG Guidance **without** BMD

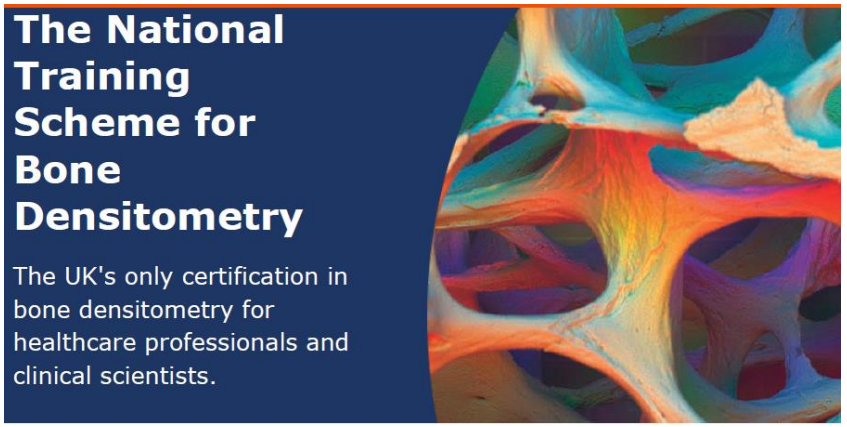
NOGG Guidance **with** BMD



Conclusions

- DXA plus Clinical Risk factor analysis is the key to targeting therapy in osteoporosis
- Good positioning and quality interpretation is essential as part of a **Technical Report.**
- A useful **Clinical Report** should include any technical issues, Clinical Interpretation of the BMD results, the FRAX score, any Treatment Recommendations and any Follow-up required.





https://theros.org.uk/healthcare-professionals/courses-and-cpd/