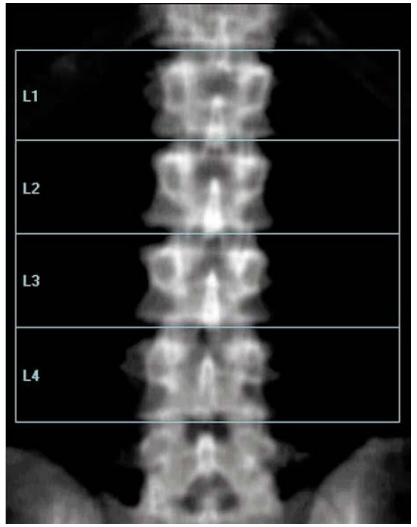
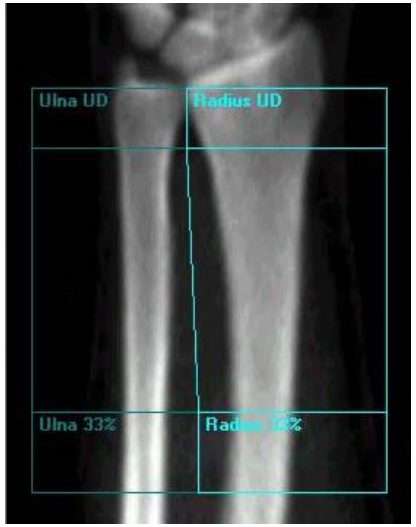
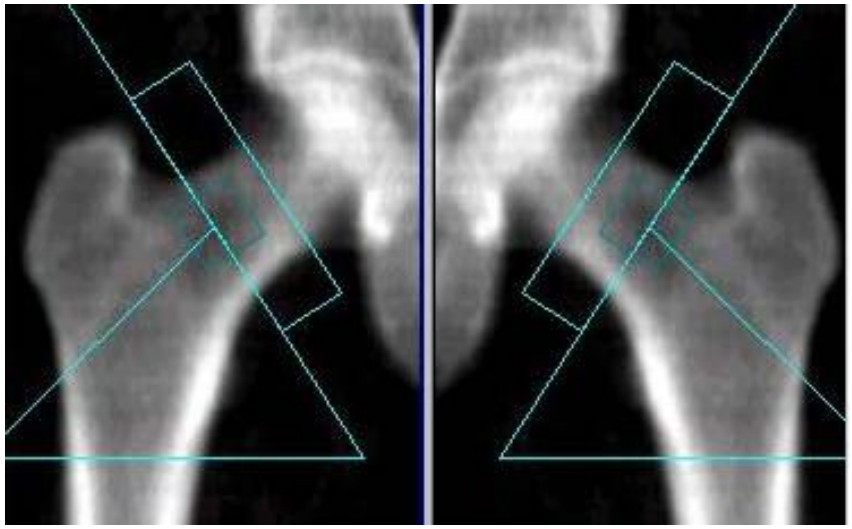
Common areas scanned for a DXA scan, Proper Patient Positioning and Analysis

LECTURE 6







What do we Measure?

PA Lumbar Spine

Proximal Femur

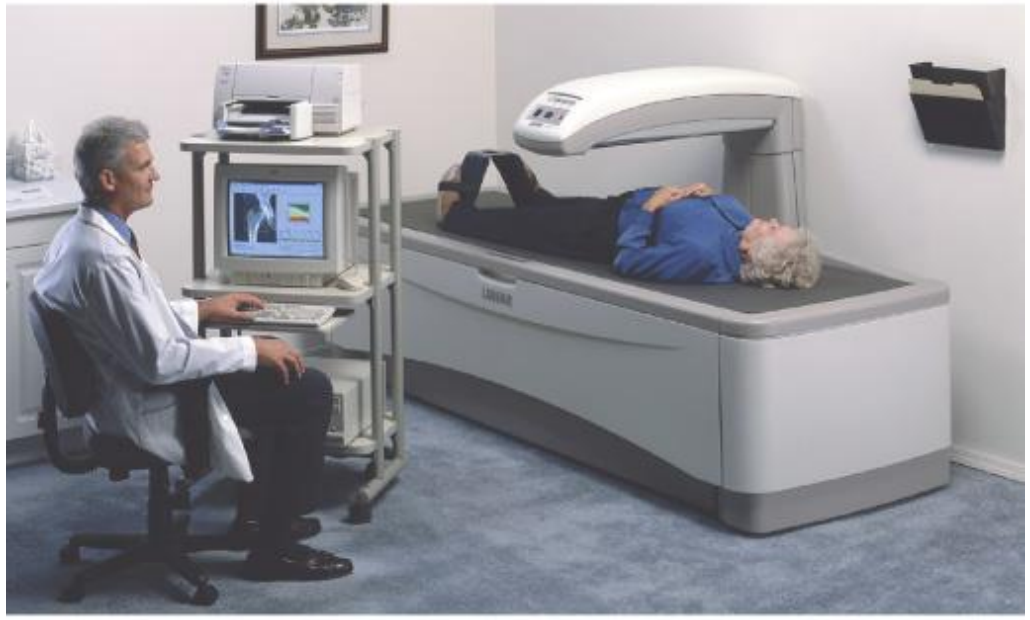
Distal Forearm

A

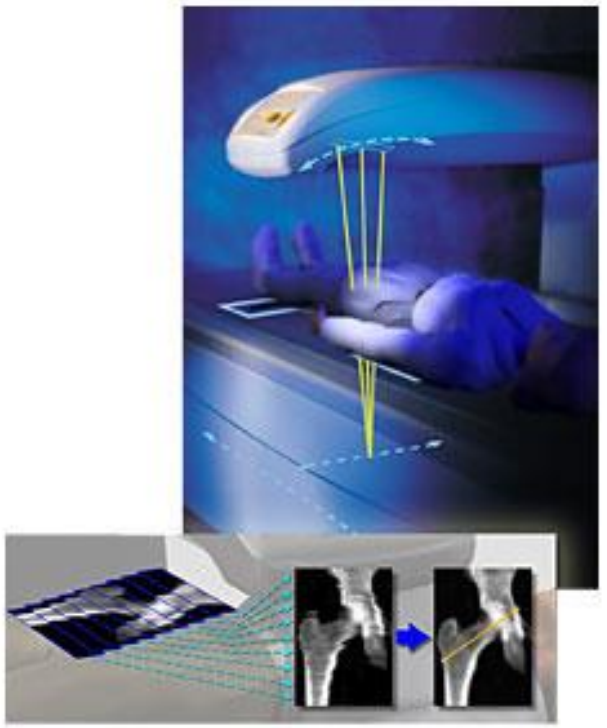
Courtesy Hologic, Inc., Bedford, Mass.

PA Lumbar Spine

B

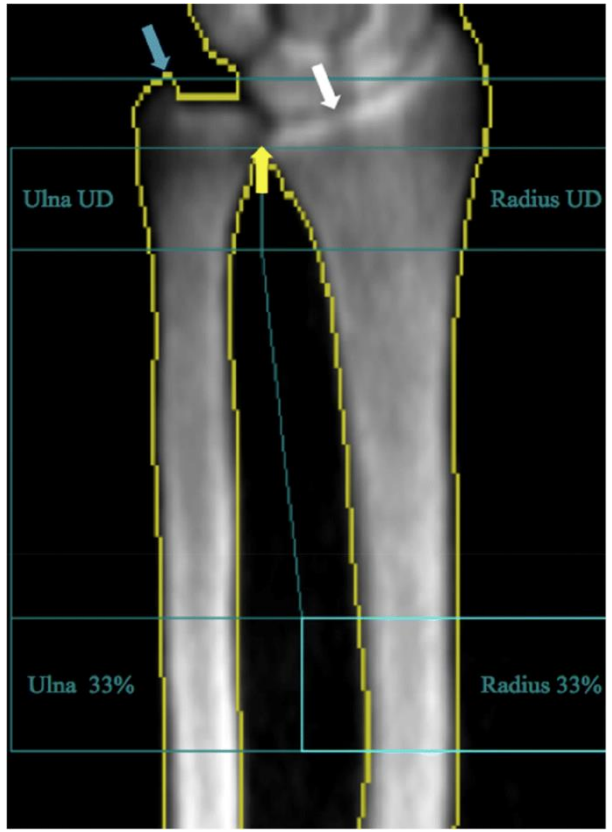


Courtesy GE-Lunar Corp., Madison, Wis.



Proximal Femur

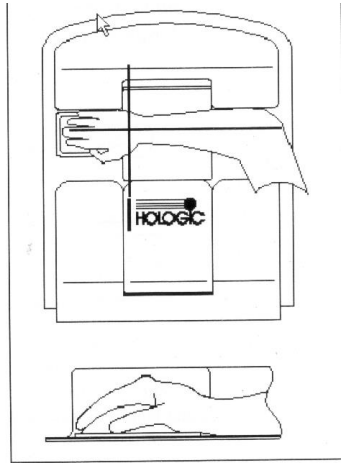
Forearm Measurement

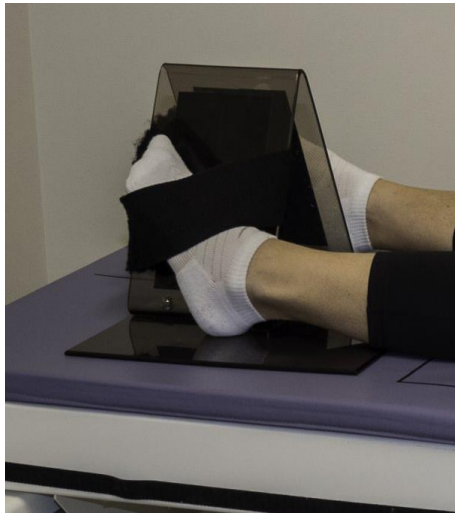


https://link.springer.com/article/10.1007/s11657-019-0658-2

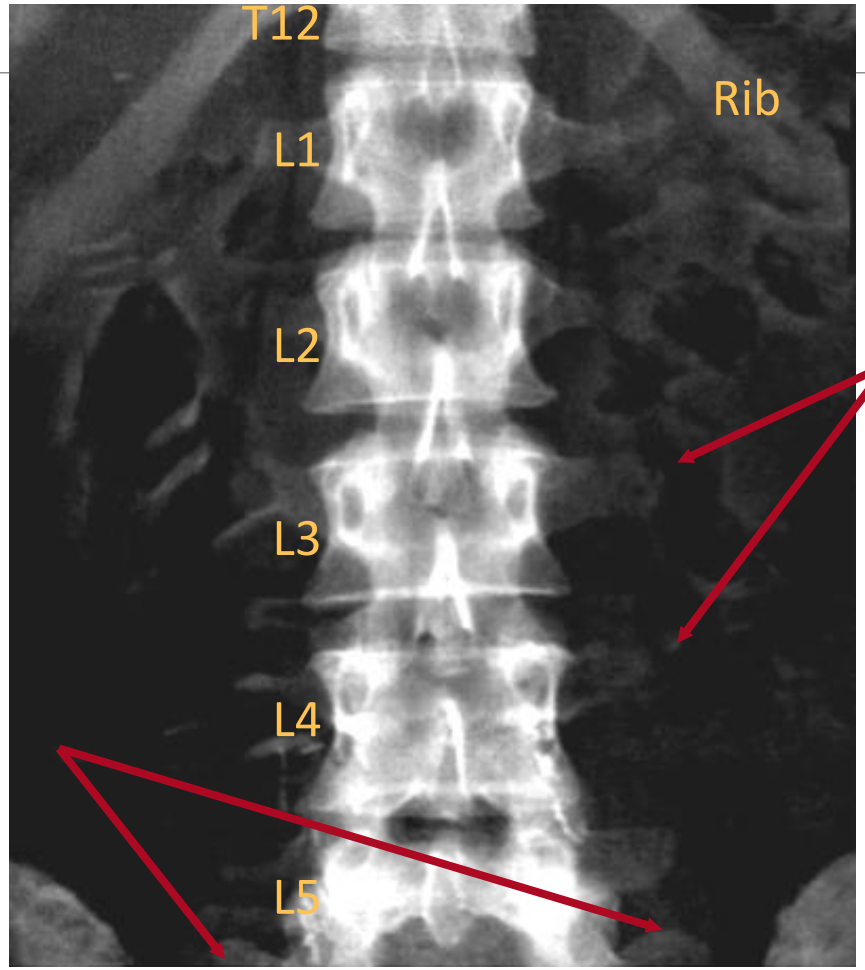
Horizon QDR Reference Manual

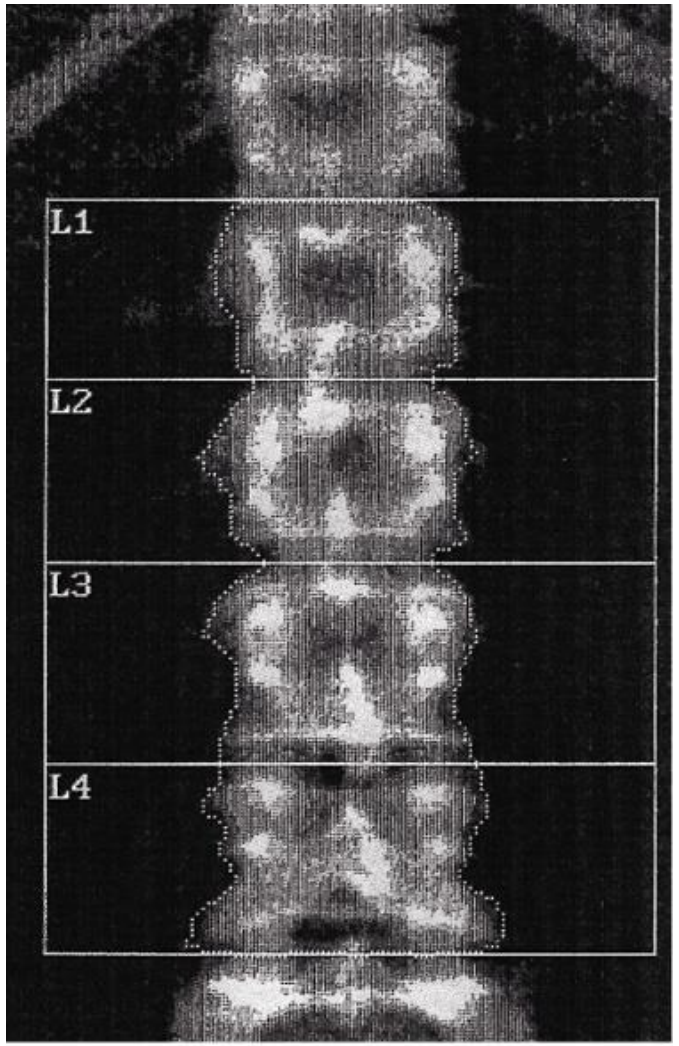
Positioning Devices





Lumbar Spine Anatomy





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A Question for you

What type of bone are you predominantly measuring in the DXA of the Lumbar Spine?

- Cortical?
- Trabecular?

Vertebral Fractures

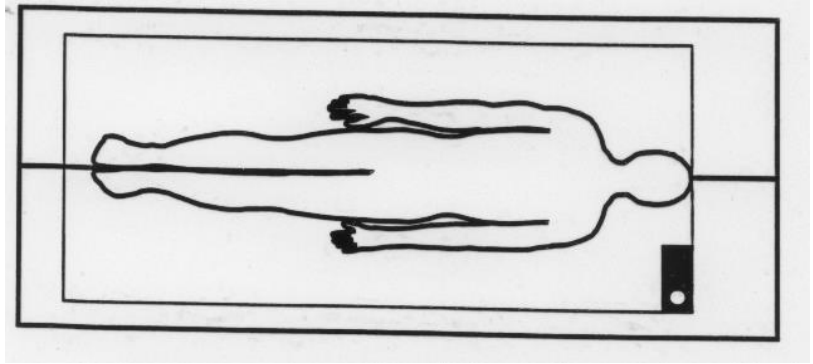
Can you diagnose vertebral fractures off of the DXA image?

- Yes
- No
- Maybe

PA Lumbar Spine

Have patient sit on table with legs extended straight out.

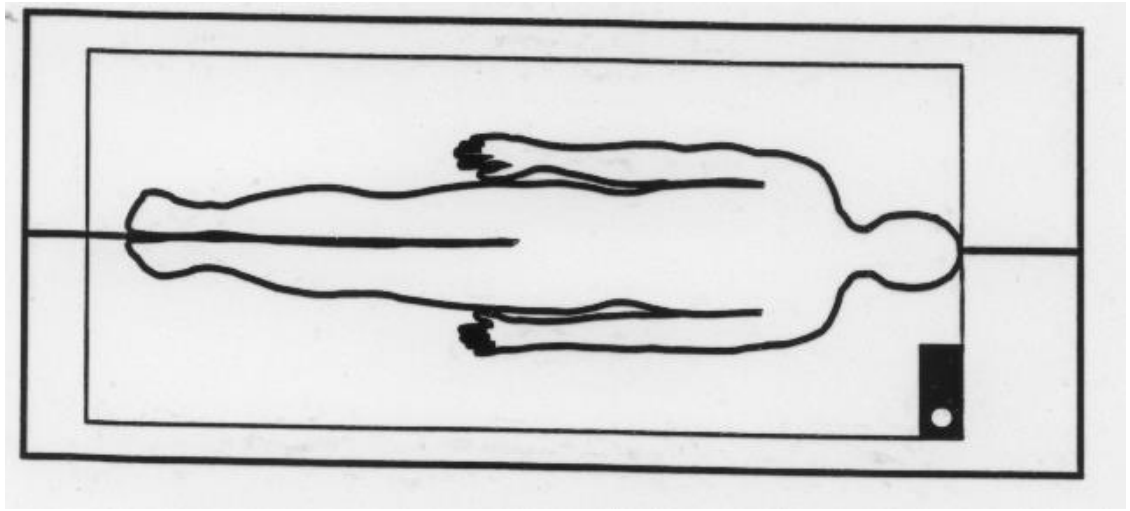
Using positioning line in center of table, have patient straddle this line to place spine in center of table.



PA Lumbar Spine

Have patient lay straight back without shifting position

Place arms by their sides



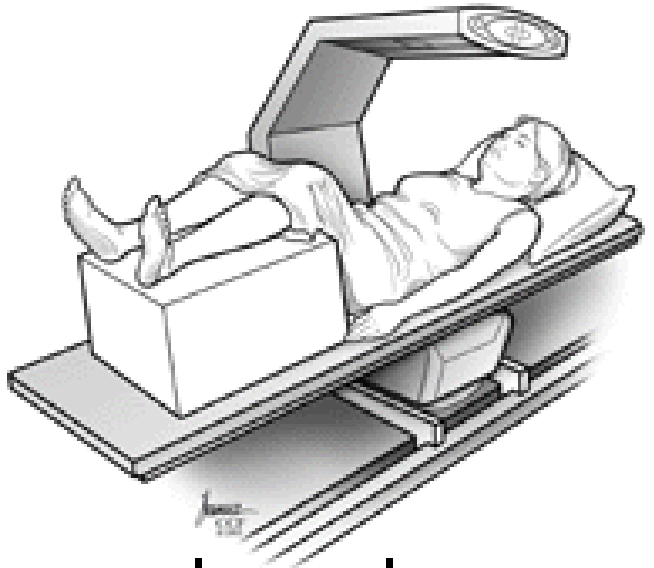
PA Lumbar Spine

Move scan arm into place

Place positioning block or bolster under legs of patient

- Femurs should be at approximately 45–90-degree angle to tabletop
- (Varies by manufacturer)
- Adjust side of block to accommodate patient anatomy

Have patient raise and lower hips to flatten spine



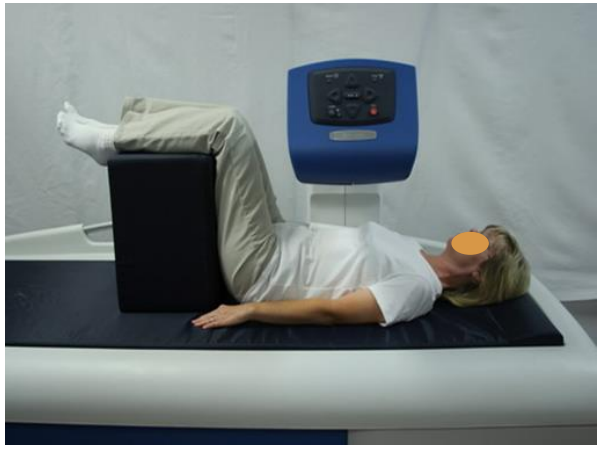
dexa procedure

Lumbar Spine Positioning

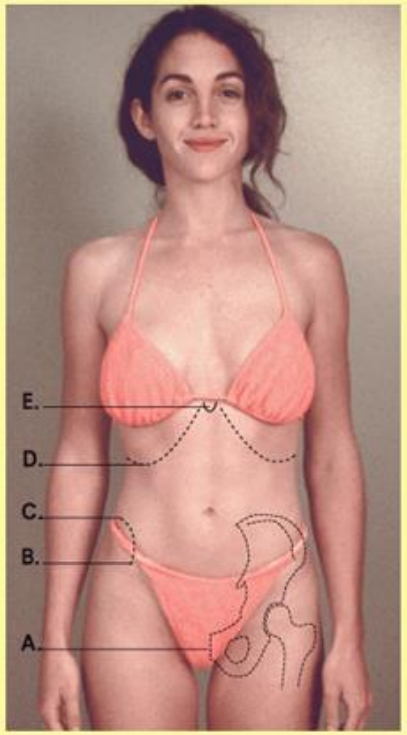
Inform patient of the following

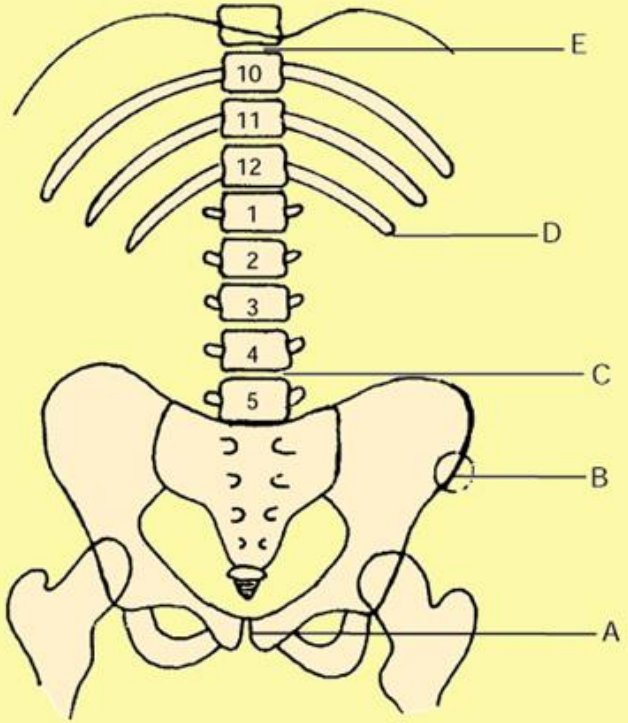
- Expected noises
- To remain still
- To breathe normally
- Estimated scan time
- When scan is completed

Place positioning block under the patient's legs with hands down at the side



Lumbar Spine Topographic Landmarks
(Frontal View)





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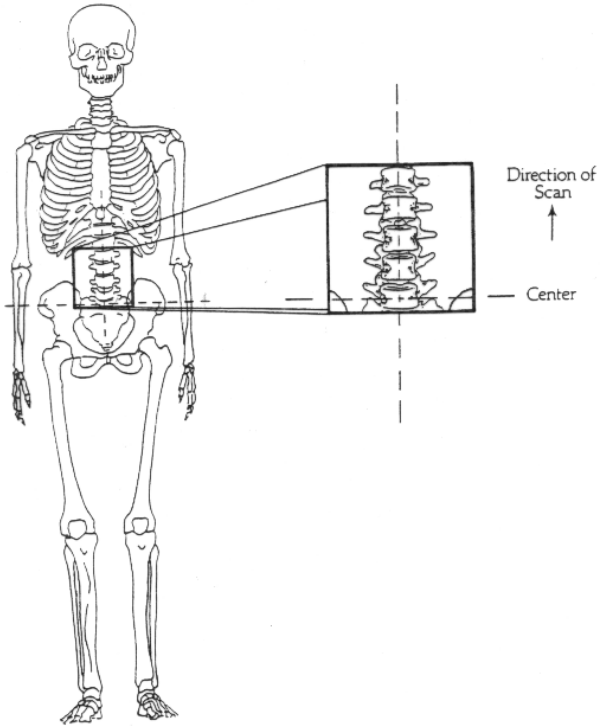
PA Lumbar Spine

Using laser light align scan arm to patient

Center transversely down Mid Sagittal Plane

Locate ASIS for vertical centering

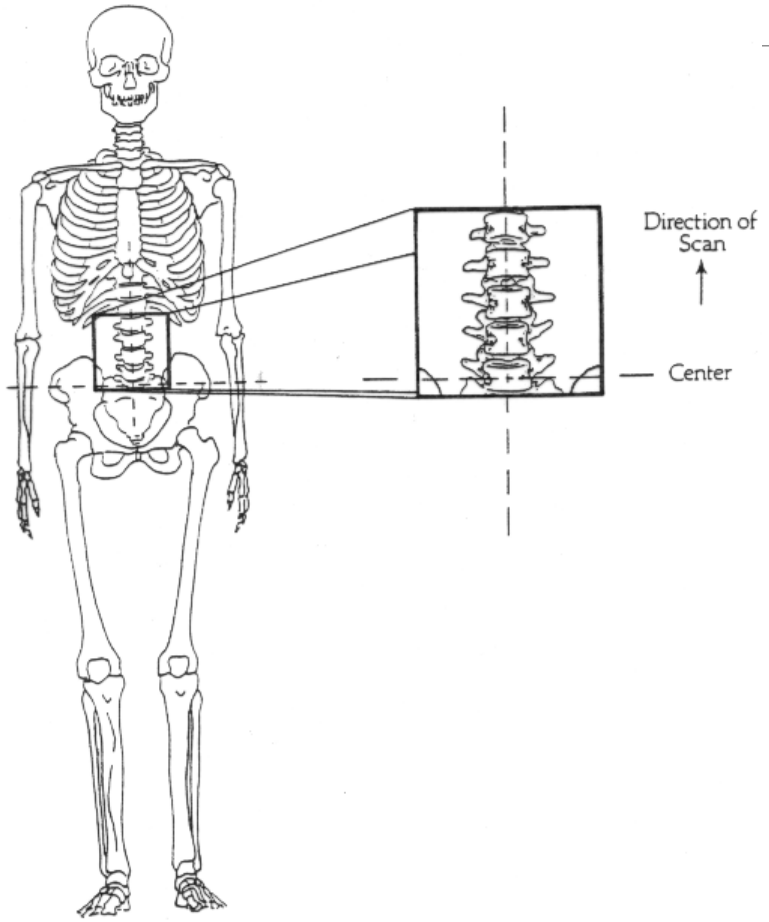


PA Lumbar Spine

Place laser light at approximately 1-2 inches below level of ASIS

- You will start in the middle of L-5

Start scan process



PA Lumbar Spine

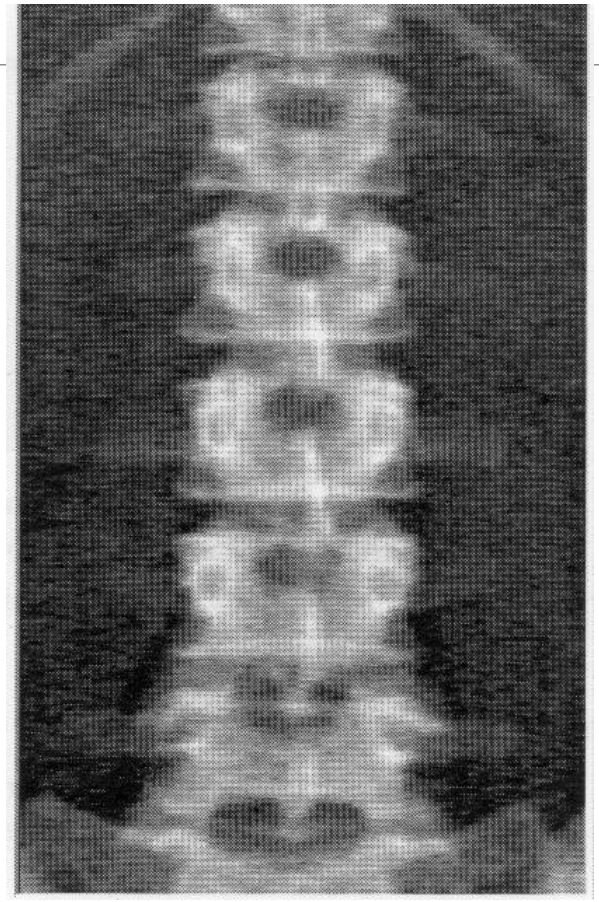
Image Evaluation:

Begin scan in middle of L-5

Spine is straight in scan field

Iliac crest evenly displayed in lower corners of image

- Crest will not always be visible on analysis screen



PA Lumbar Spine

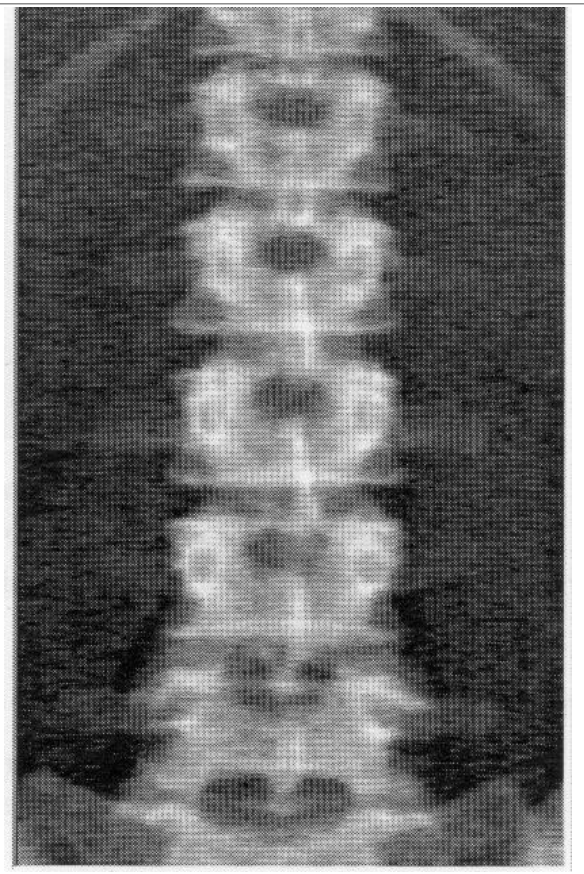
Image Evaluation:

Spine centered to scan window

Even amounts of soft tissue on each side of spine

End scan where top of ribs attach to T-12

- Be sure to follow through to top of rib attachment

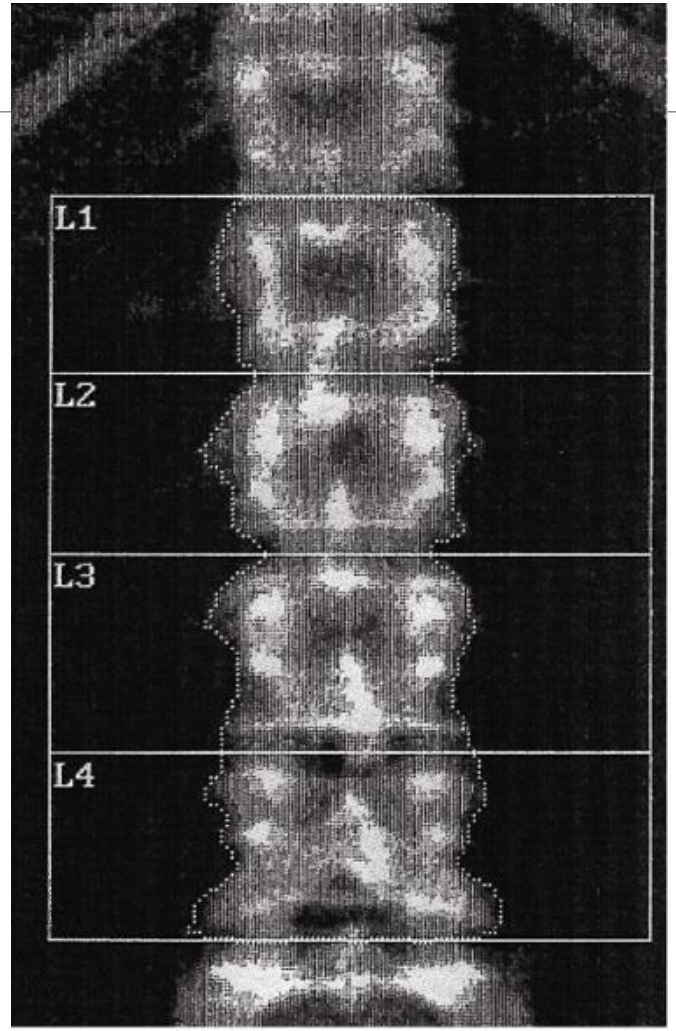


PA Lumbar Spine

Analysis:

(Manufacturer specific)

- Label vertebrae correctly
- Place intervertebral (IV) lines correctly
- Delete vertebrae with anatomical variations, pathology, artifacts, fractures



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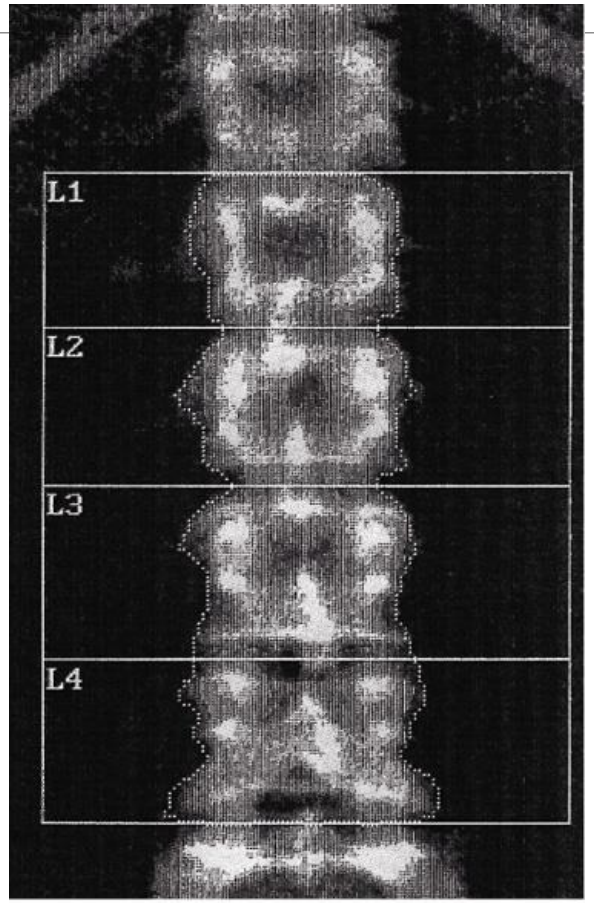
PA Lumbar Spine

Analysis:

(Manufacturer specific)

- Fill in bone map correctly
- Align profile lines
- Finalize vertebrae to be analyzed



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How do you count Lumbar Vertebrae?

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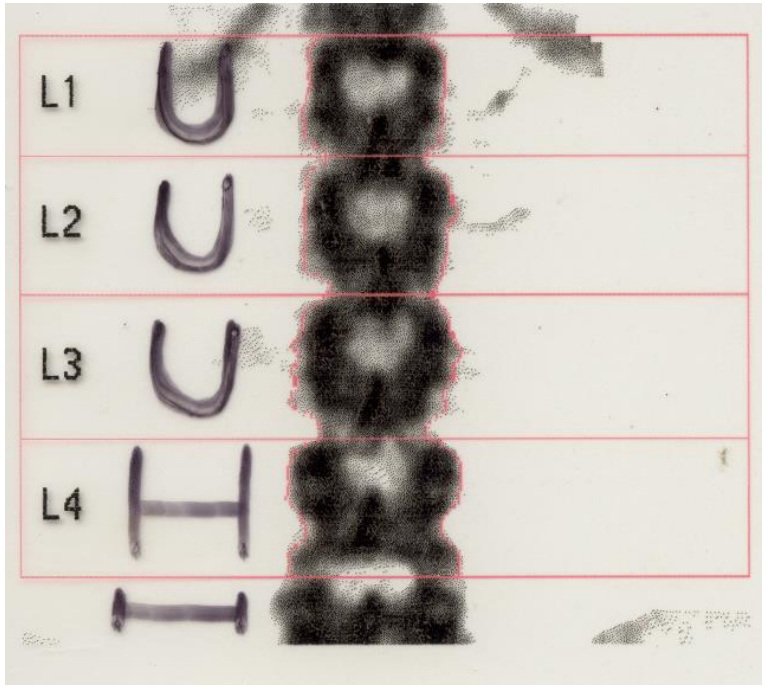
Numbering Vertebrae

Count from bottom up

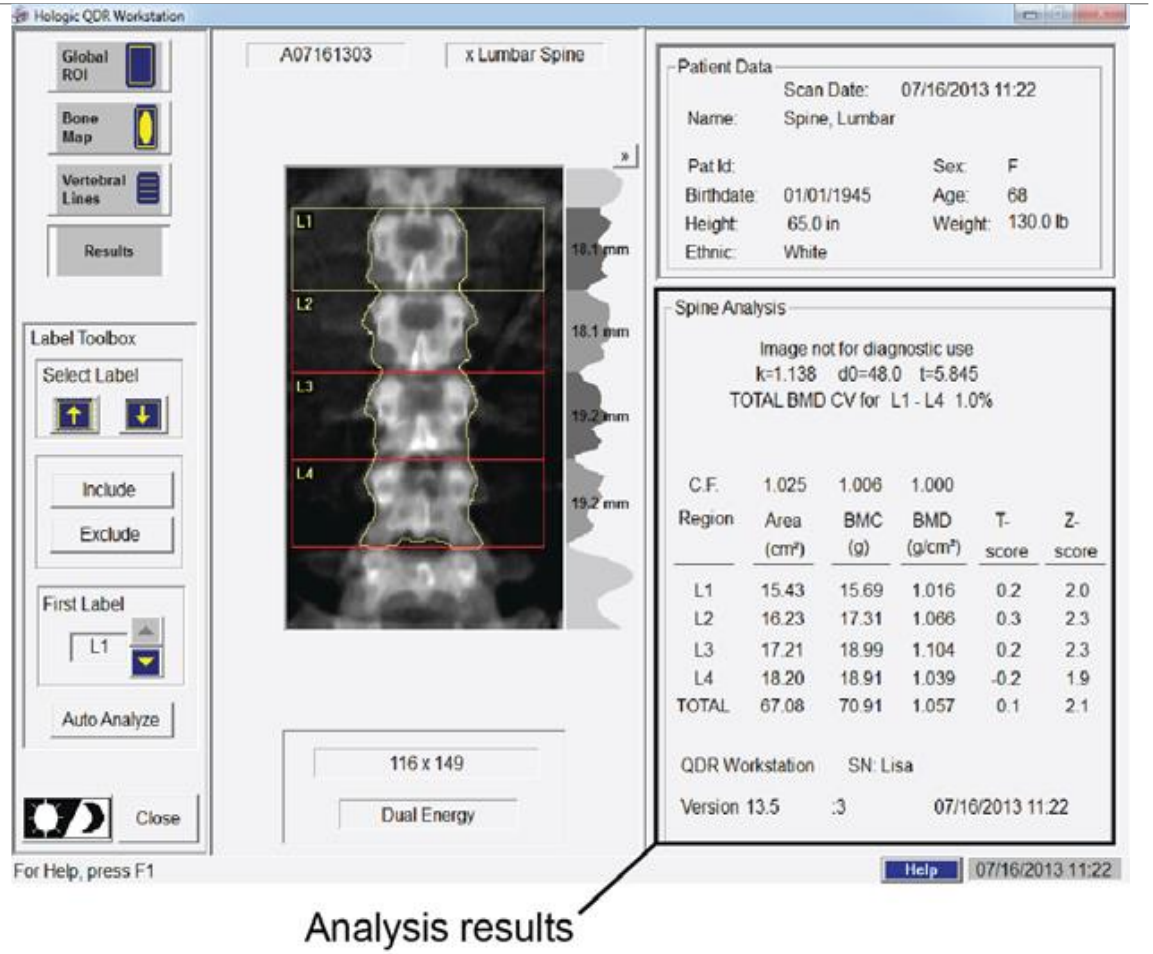
Look for distinct shapes of vertebrae

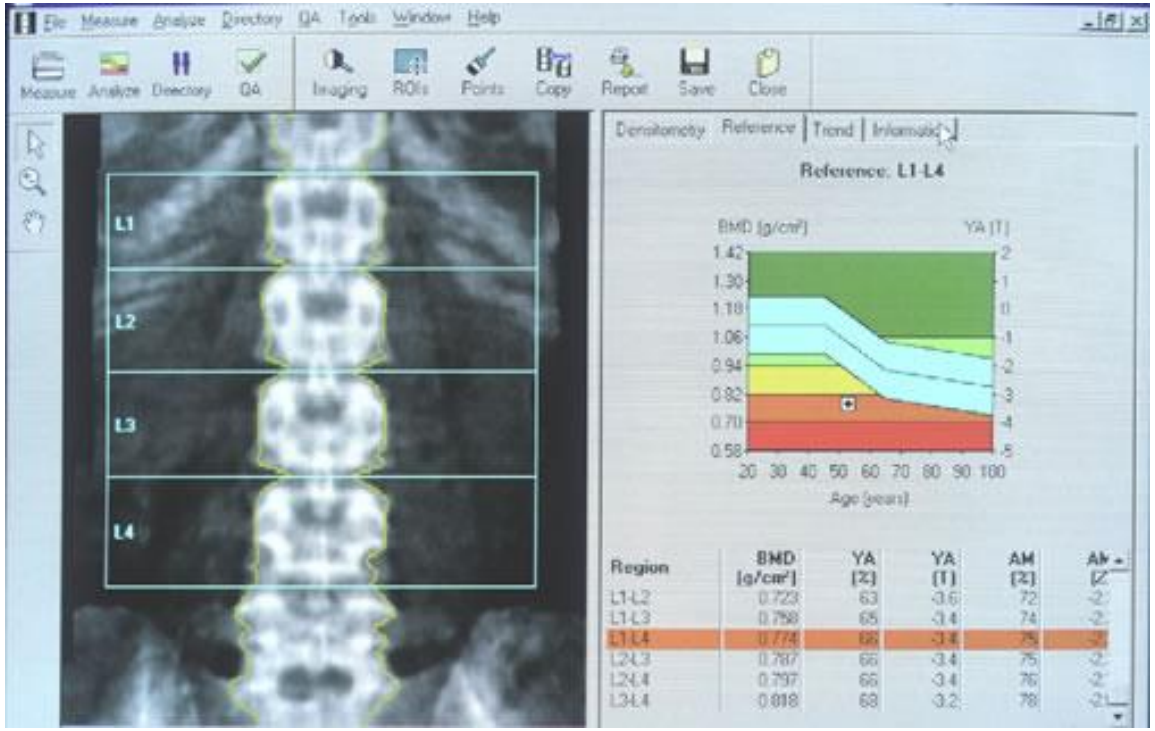


L-Spine L1-L4 Final Analysis Page

Anatomy you want to see:

- Part of T-12 and T-12 Ribs
- L1-L4
- Part of L5
- May see top of iliac crest





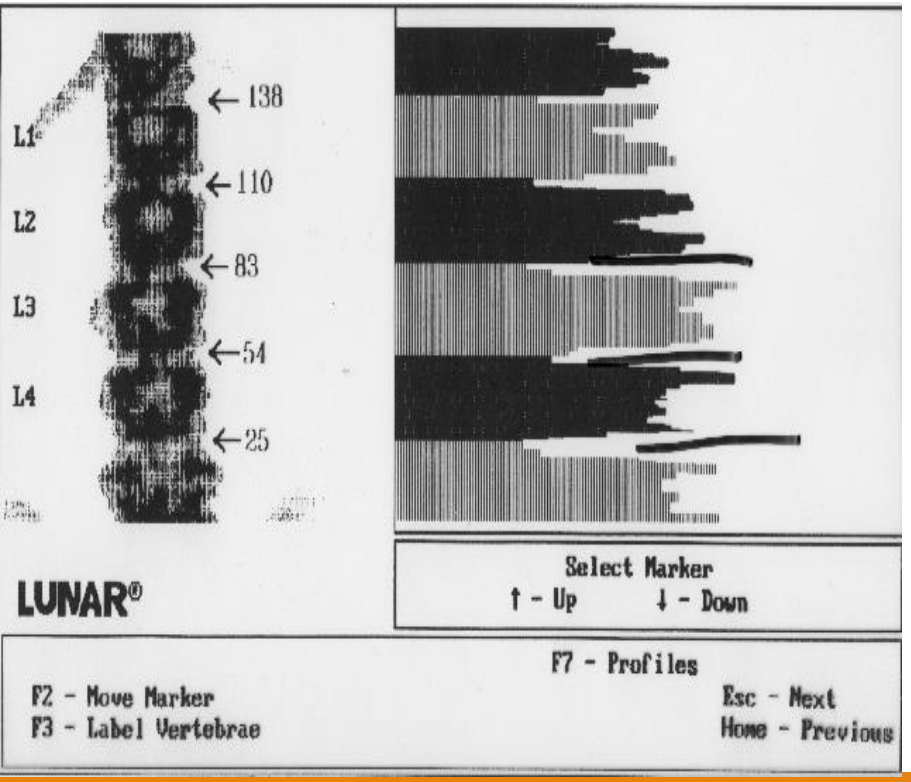
Placing Intervertebral Lines

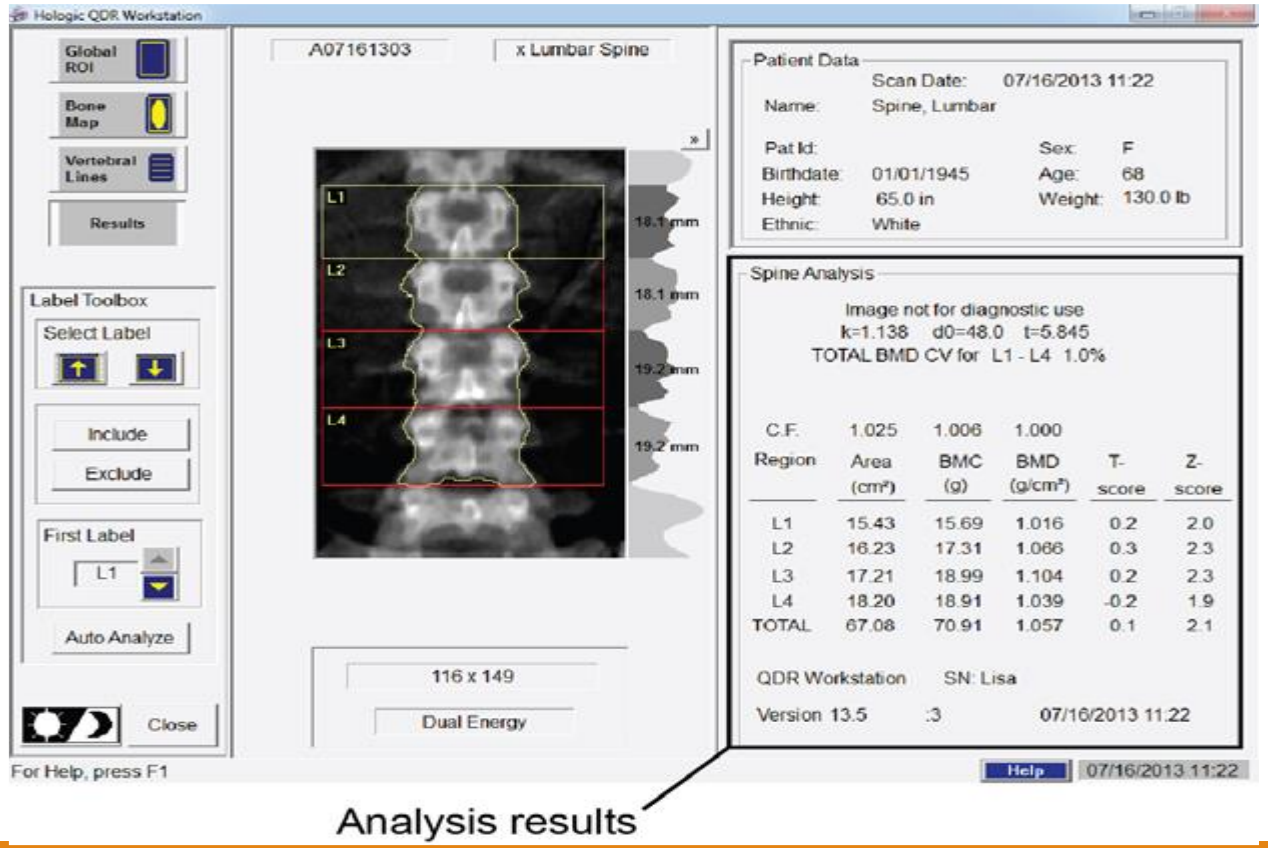
Some are visually placed (Hologic)

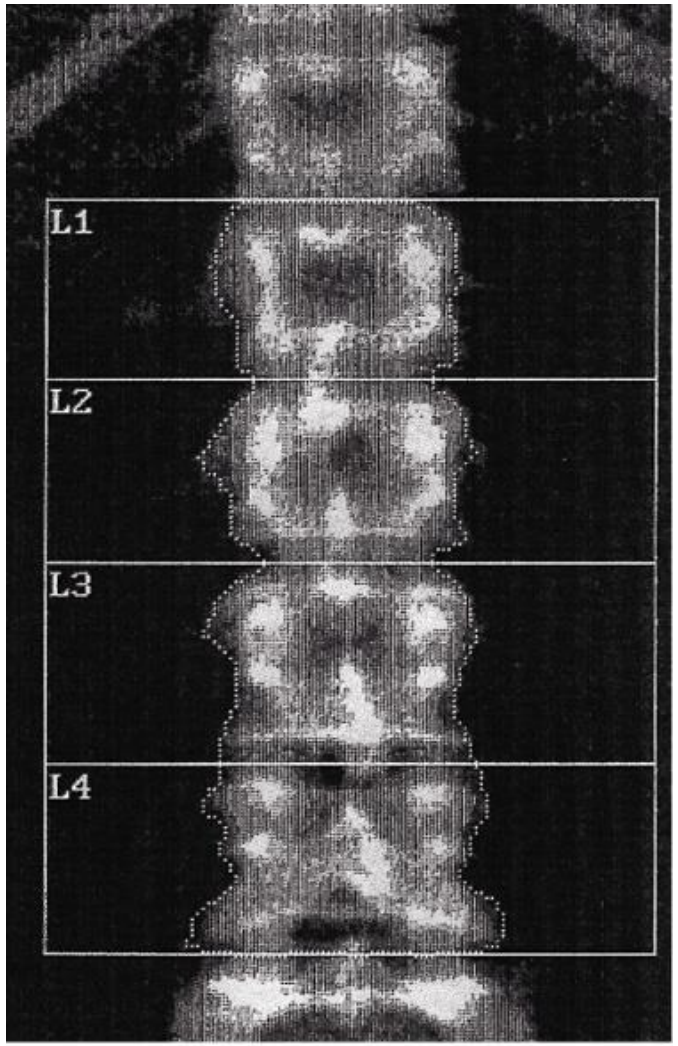
- Global ROI
- Individual ROIs

Placing Intervertebral Lines

Some utilize a hologram to measure intensity of radiation for IV line placement (GE Lunar/Norland)







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What happens if IV lines are improperly placed?

Will affect vertebral height

Will affect area measured on scan

Will affect BMD of patient

Might not match last year's area measured

For Analysis

Analyze L1-L4 if possible	The more bone you analyze, the more accurate your scans	What if I can only use one or two vertebrae?
		• Is this an accurate measurement?

Profile Lines

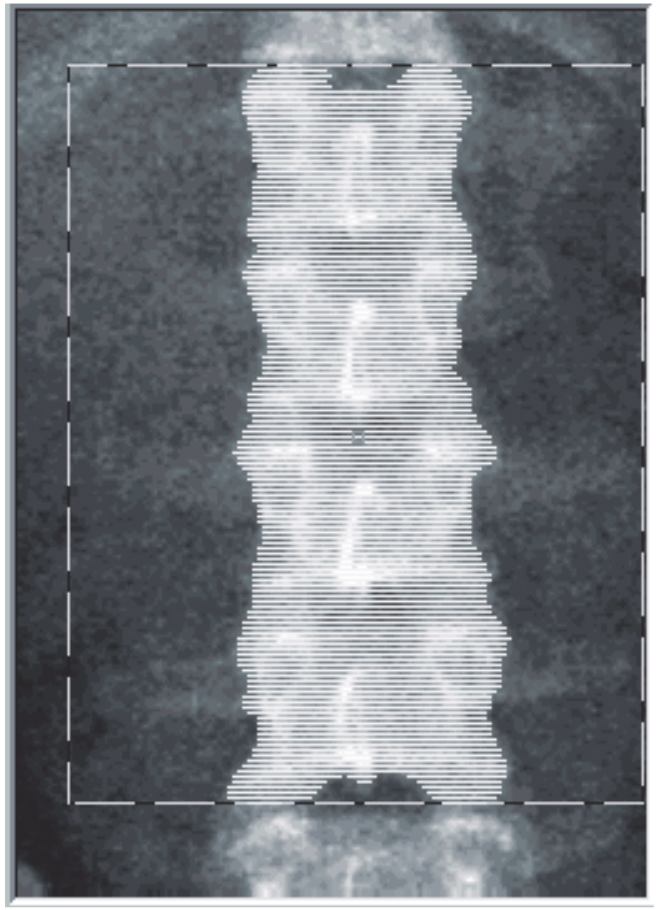
Trace along edges of vertebrae

Determine filling of bone map

- Hologic

Define lateral edges of vertebral body

- GE Lunar



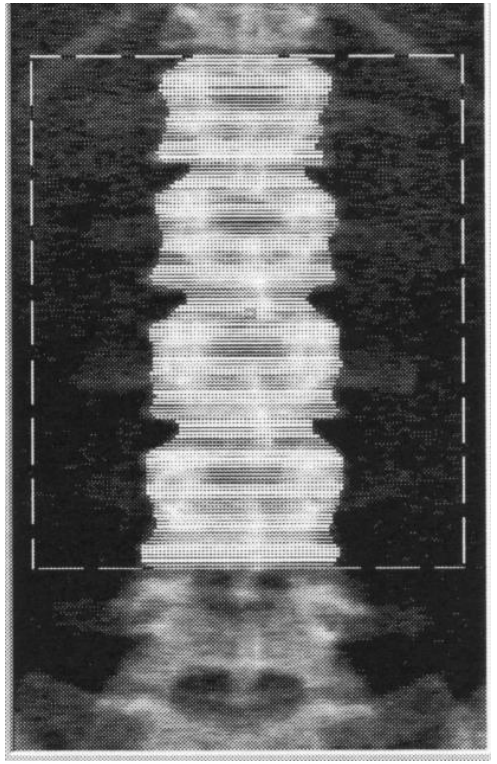
Bone Mapping

A bony map of region to be analyzed.

Should fill in completely with no gaps.

Do not alter lateral borders of bone map by moving global ROI in (collimation?).

Bone map should be duplicated on serial measurements.



Bone Mapping

Can be used to add or delete bone

Delete **(be careful)**

- Osteophytes
- Artifacts

To fill in bone map

- Move global ROI out
- Close profile line down

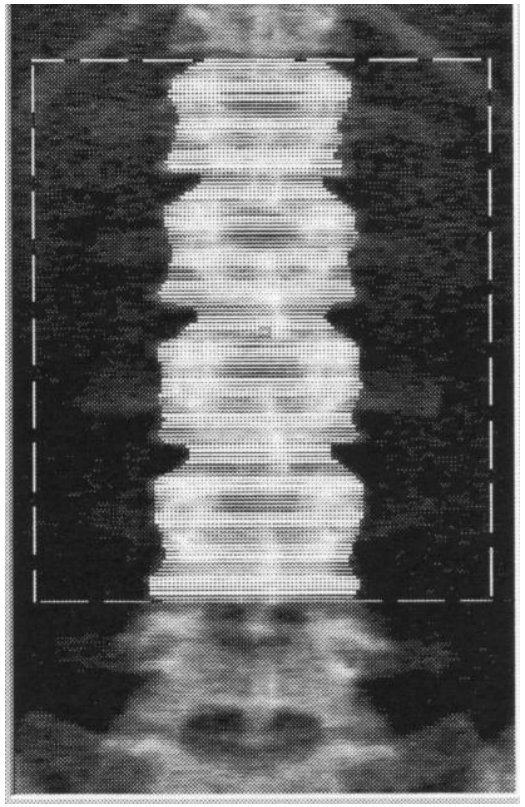
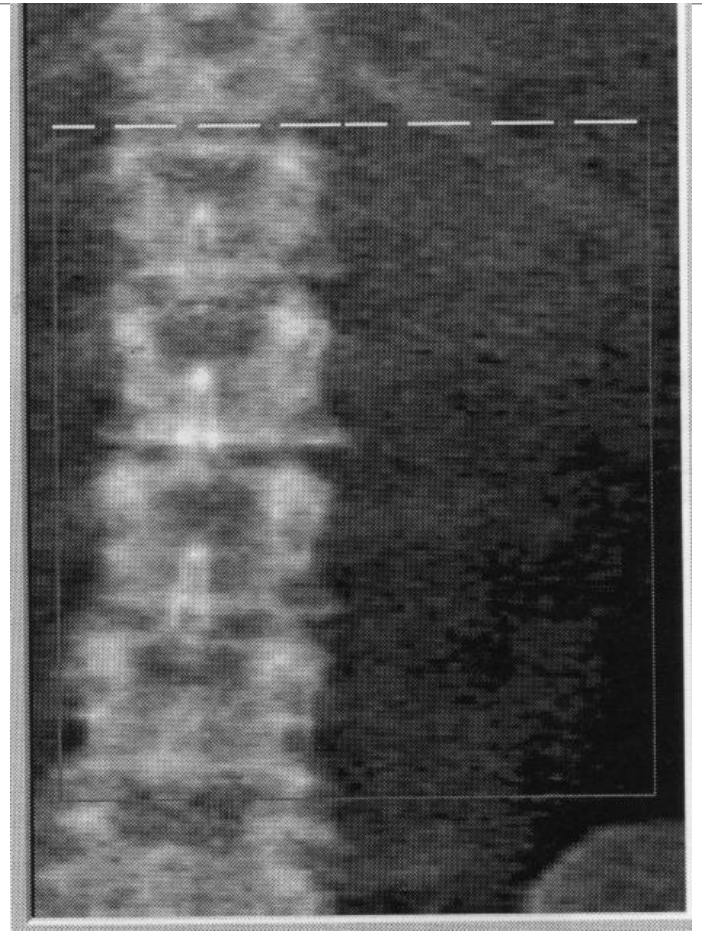


Image Evaluation



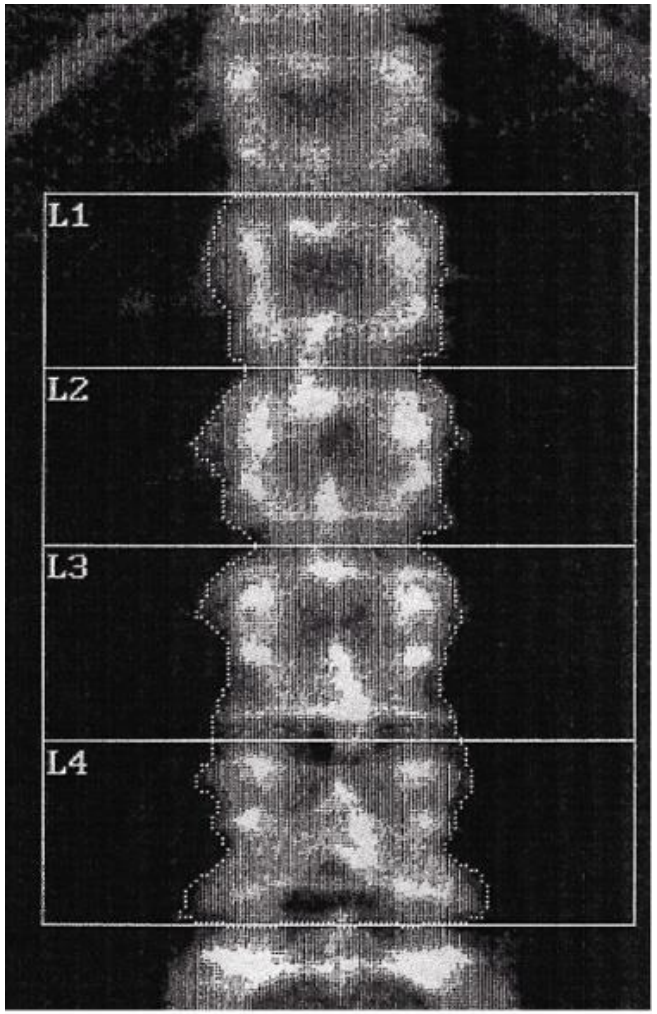


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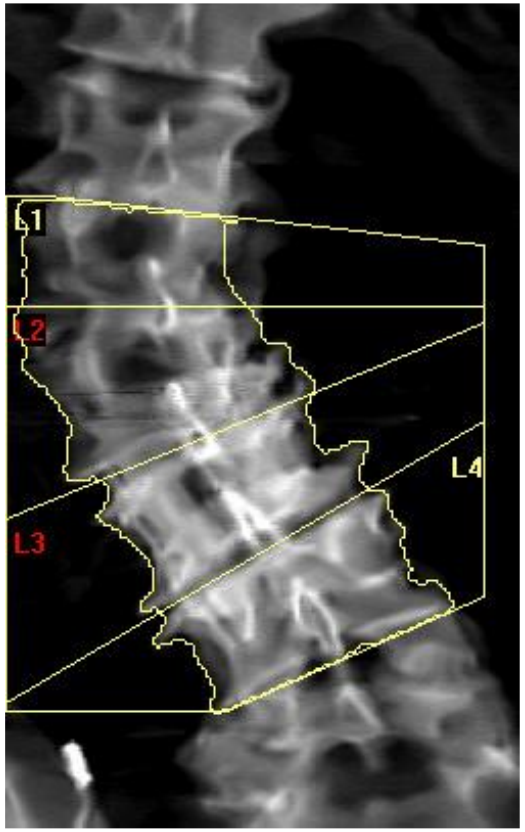
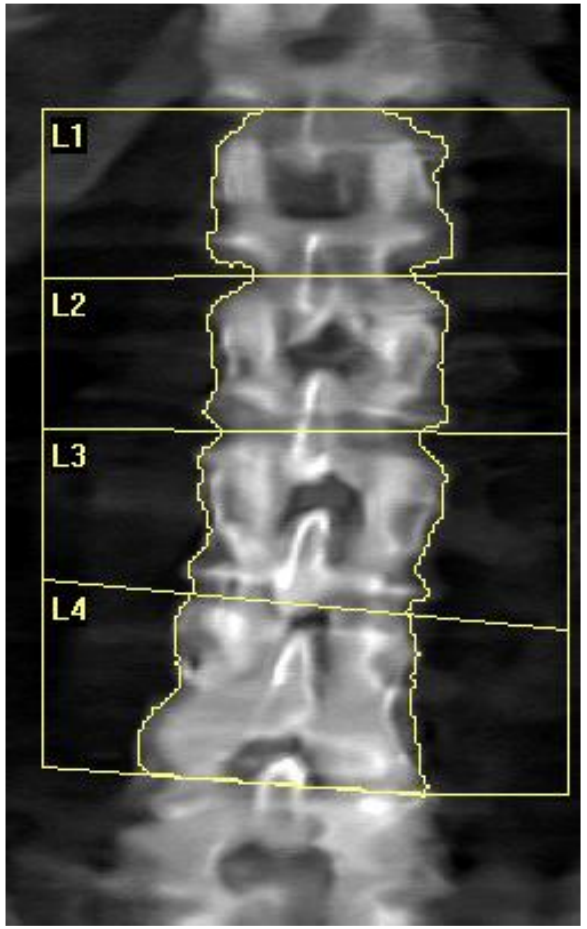
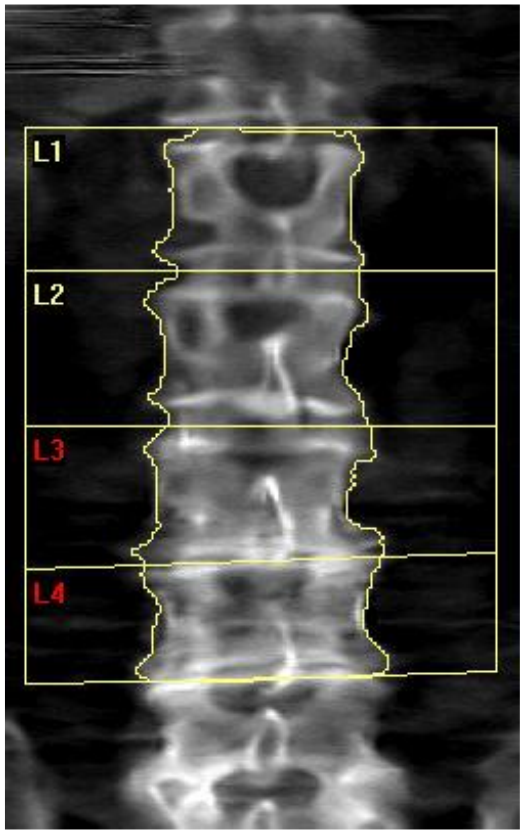
Image Evaluation



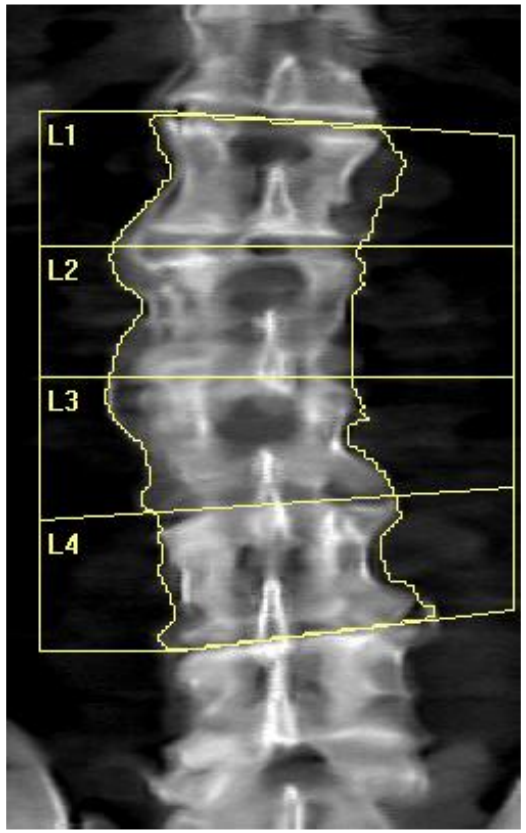
Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	12.46	16.24	1.304	2.7	3.9
L4	19.93	37.72	1.893	6.8	8.2
Total	**32.39**	**53.96**	**1.666**	**5.3**	**6.6**



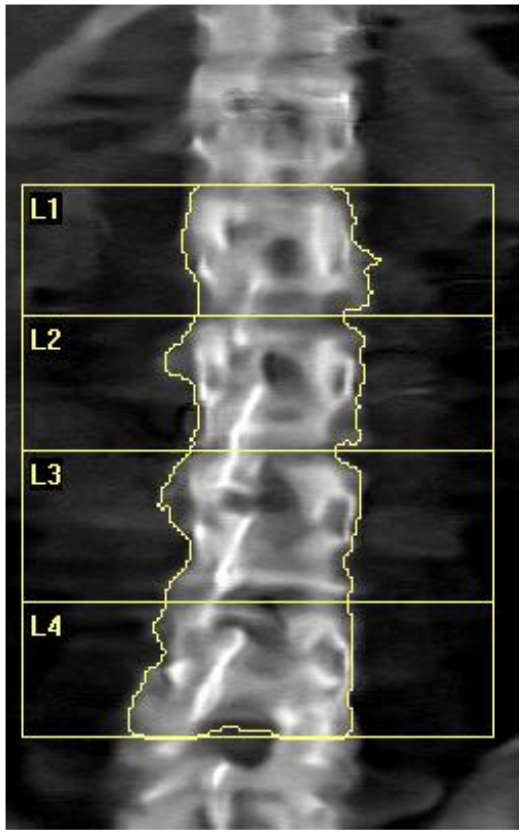
Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	17.92	18.28	1.020	0.1	1.3
L2	17.33	22.42	1.294	1.8	3.1
L3	19.73	27.59	1.399	2.7	4.0
L4	22.58	34.42	1.525	3.5	4.8
Total	**77.55**	**102.72**	**1.325**	**2.1**	**3.4**



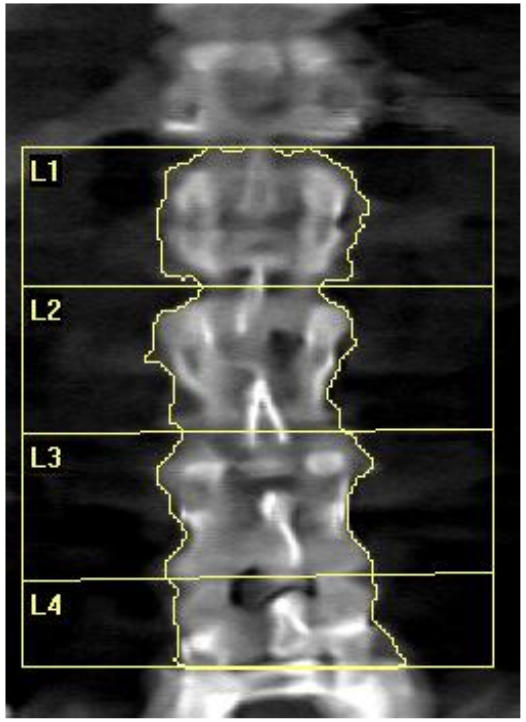
Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	16.33	13.49	0.826	-1.7	-0.4
L2	19.19	18.50	0.964	-1.2	0.1
Total	**35.52**	**31.98**	**0.901**	**-1.4**	**-0.1**



Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	18.57	26.19	1.410	3.7	4.7
L2	19.15	25.34	1.323	2.1	3.3
L3	19.32	27.18	1.407	2.8	3.9
L4	19.88	30.02	1.510	3.3	4.5
Total	**76.92**	**108.73**	**1.413**	**2.9**	**4.1**



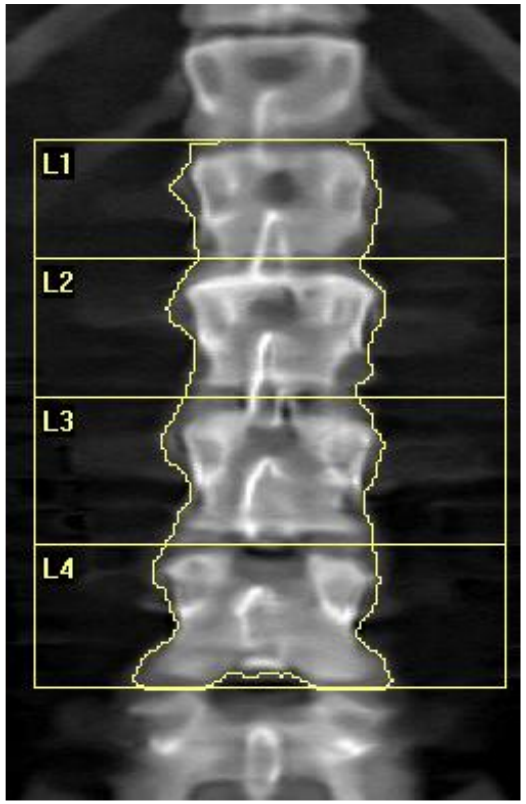
Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	13.66	14.55	1.065	0.7	1.0
L2	14.28	15.41	1.080	0.5	0.8
L3	16.59	17.09	1.030	-0.5	-0.1
L4	17.05	18.24	1.070	0.1	0.5
Total	**61.57**	**65.29**	**1.060**	**0.1**	**0.5**



Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	15.80	13.71	0.868	-1.9	-1.6
L2	15.84	14.81	0.935	-1.4	-1.1
L3	17.14	15.94	0.930	-1.6	-1.3
L4	12.05	13.19	1.095	0.0	0.4
Total	**60.82**	**57.65**	**0.948**	**-1.3**	**-1.0**

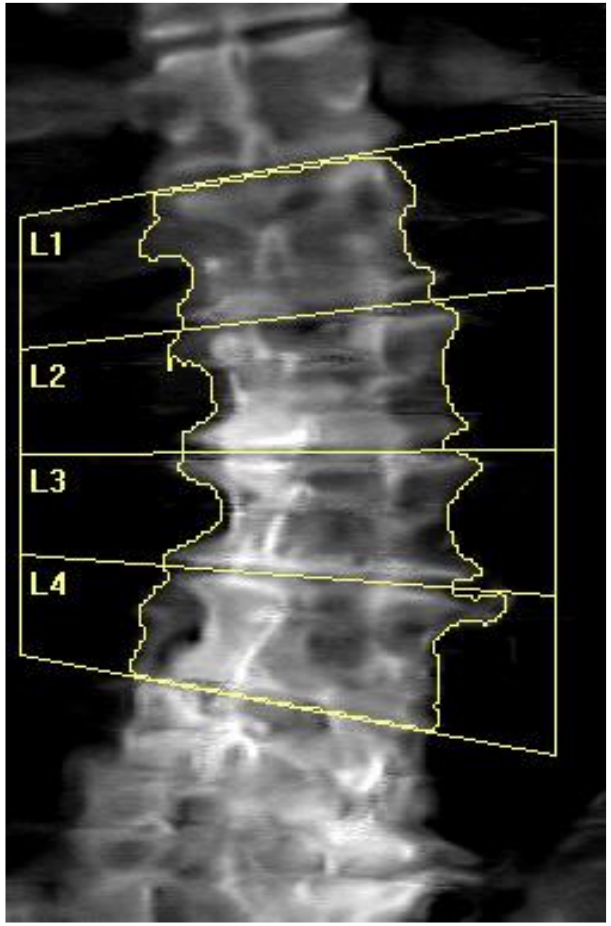
DXA Results Summary:

Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	15.80	13.71	0.868	-1.9	-1.6
L2	15.84	14.81	0.935	-1.4	-1.1
L3	17.14	15.94	0.930	-1.6	-1.3
L4	12.05	13.19	1.095	0.0	0.4
L1-L2	31.63	28.51	0.901	-1.4	-1.1
L1,L3	32.93	29.65	0.900	-1.4	-1.1
L1,L4	27.85	26.90	0.966	-1.1	-0.8
L2-L3	32.98	30.75	0.932	-1.5	-1.2
L2,L4	27.89	28.00	1.004	-1.1	-0.7
L3-L4	29.19	29.13	0.998	-1.1	-0.8
L1-L3	48.77	44.45	0.911	-1.4	-1.1
L1-L2,L4	43.68	41.71	0.955	-1.2	-0.9
L1,L3-L4	44.98	42.84	0.952	-1.3	-0.9
L2-L4	45.03	43.94	0.976	-1.3	-0.9
L1-L4	**60.82**	**57.65**	**0.948**	**-1.3**	**-1.0**

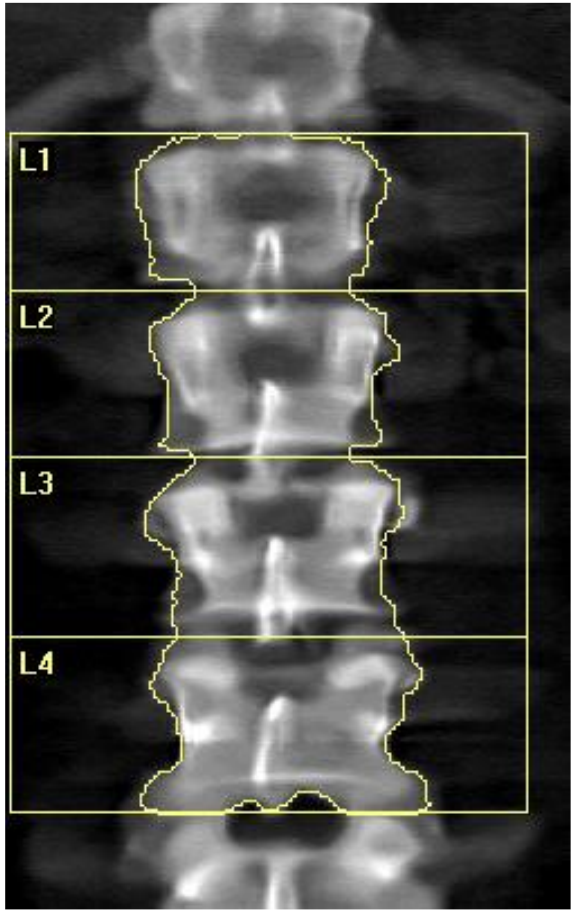


Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
L1	13.49	17.12	1.269	2.5	2.8
L2	16.11	23.09	1.434	3.7	4.0
L3	17.84	23.42	1.313	2.1	2.4
L4	18.94	23.72	1.253	1.7	2.1
Total	**66.38**	**87.35**	**1.316**	**2.4**	**2.7**

What do you think?



What do you think?



Femur Positioning

Patient should be in center of table

Place hands on chest to remove from image field

Shoes should be removed for measurements

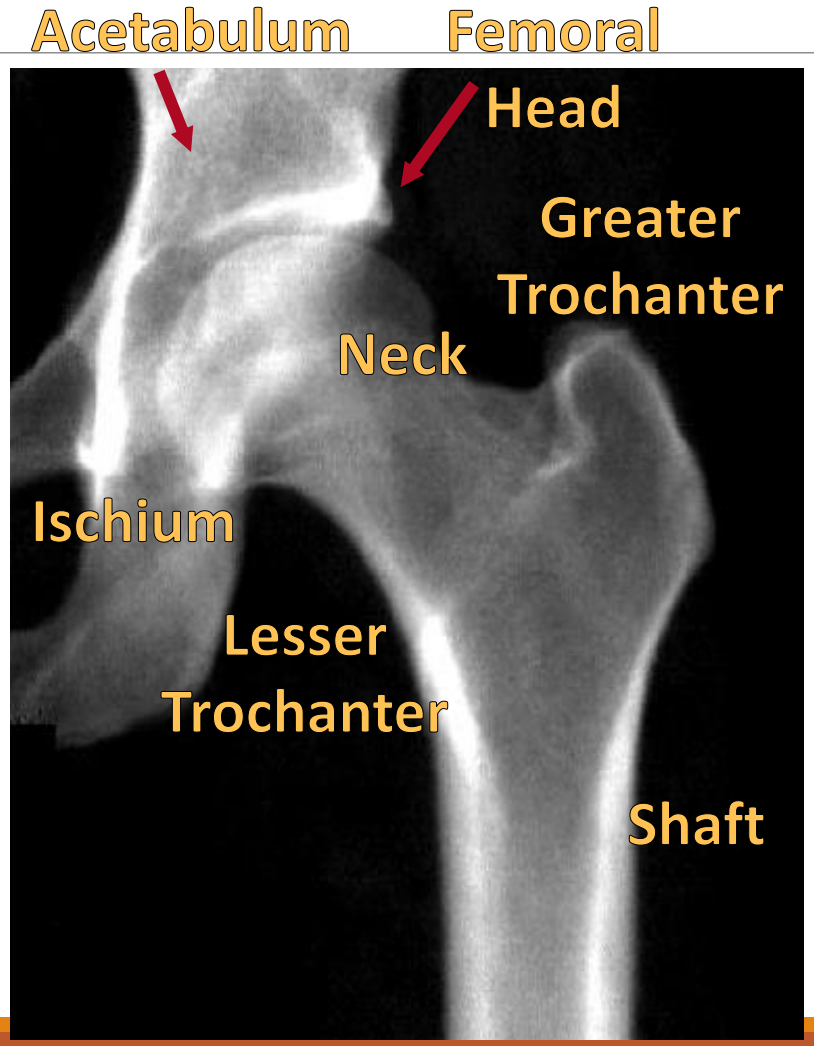
Watch those hands!!!

Patients will place hands in your area of interest

Carefully verify where the hands go even after you've placed them out of your field

If using a sheet on your patient be especially careful

Proximal Femur Anatomy/ Left and Right



Femur Positioning

Place positioning device on table between feet (yes, remove shoes-this is an advertisement)

Patient Positioning: Proximal Femur

Verify and adjust patient alignment

- Straight
- Centered to table
- Pelvis level
- Leg extended and slightly abducted

Femur Positioning

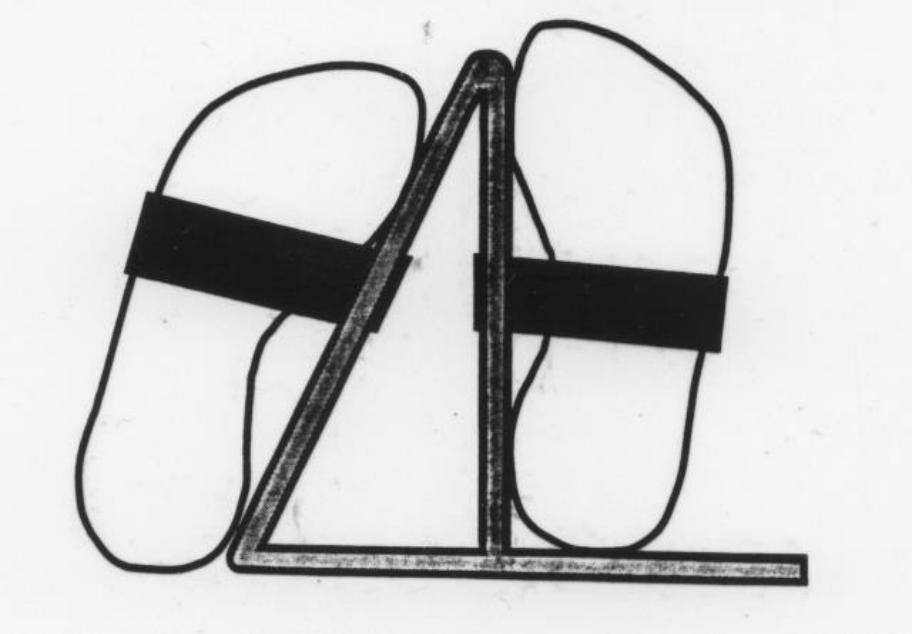
Invert entire leg to be scanned 15 degrees

- Brings femoral neck parallel to tabletop.
- Best sampling of bone for accurate BMD.
- Prevents rotation of lesser trochanter into femoral neck and shaft.
  - This will increase BMD of those areas.
  - And extends the length of the femoral neck.

Femur Positioning

Place Velcro straps around patient's foot.

Align femoral shaft to long axis of table.



Femur Positioning

Start software to move scan arm into place

If system uses rice bags (Lunar)(Do not use on newer systems)

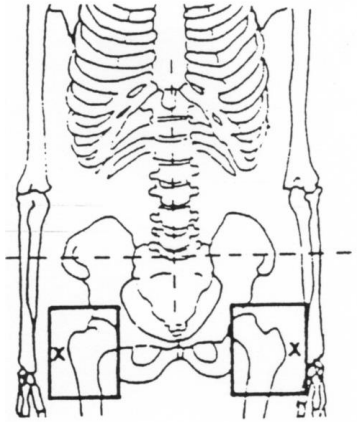
- Place them right next to patient to eliminate air artifacts
- Will also increase tissue thickness for better scan on thin patient

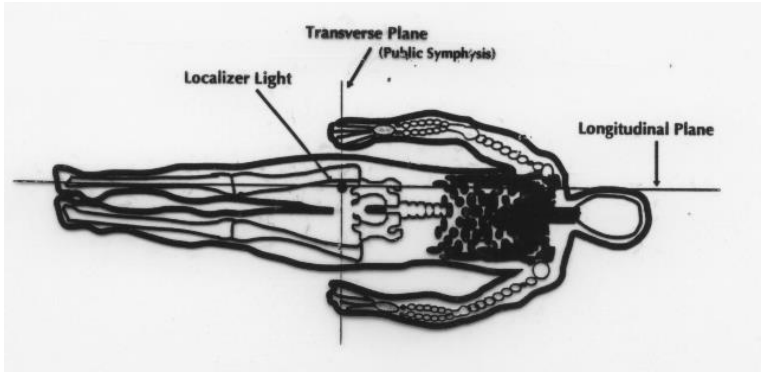
Femur Positioning

Center laser longitudinally to center of femoral shaft

You may also locate bend of hip and center 1-2” inferior

Do not start at hip joint but below the ischium





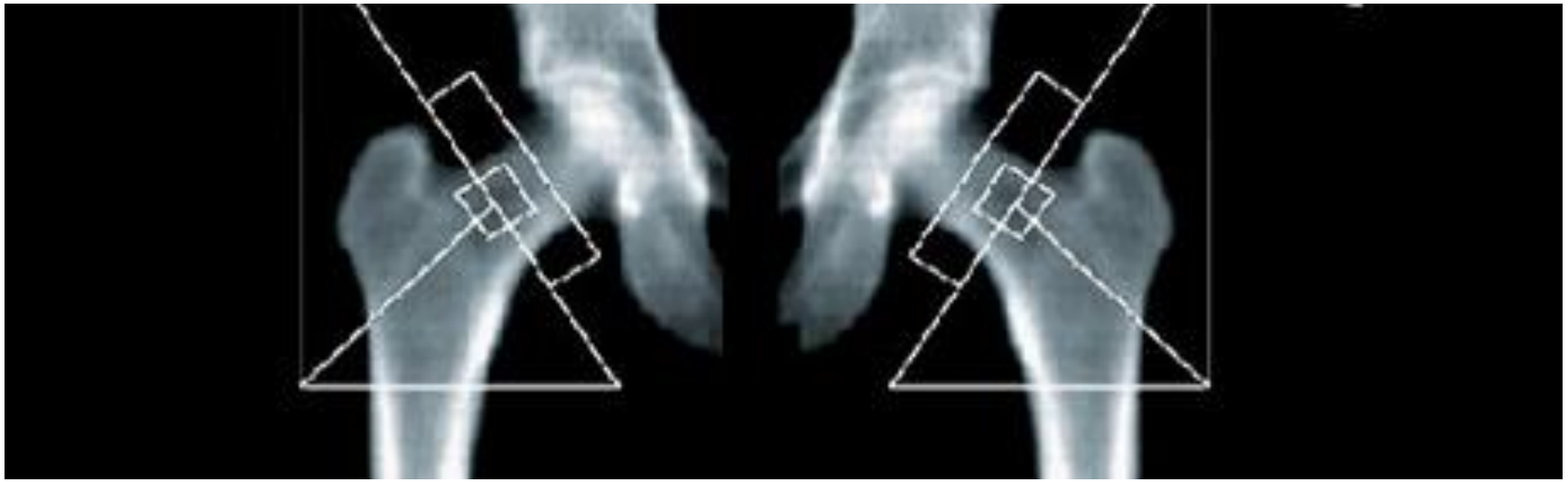


Image Evaluation

Image Evaluation

Use your manufacturer as your guide

Scan includes appropriate amounts of:

- Soft tissue below lesser trochanter and/or ischium
- Soft tissue above acetabular rim
- Bone medial to acetabulum

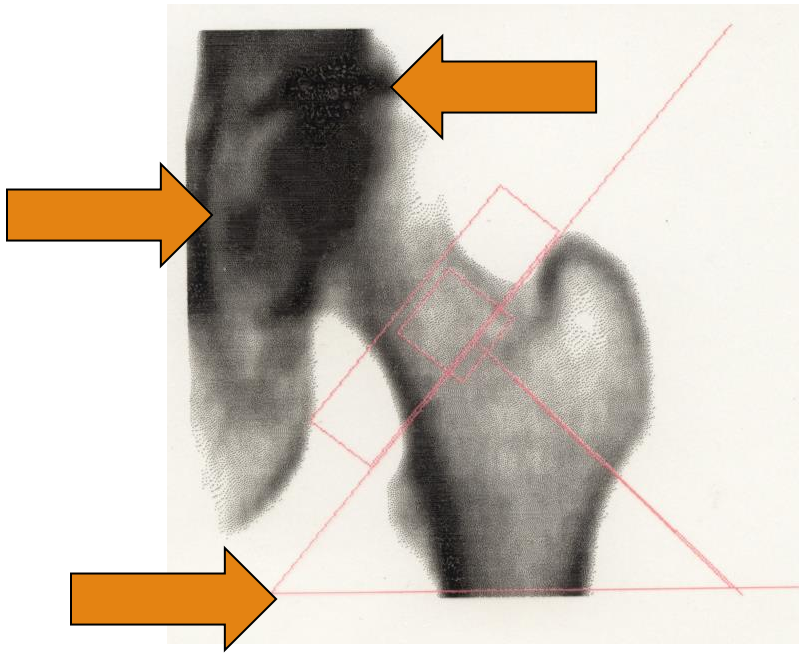
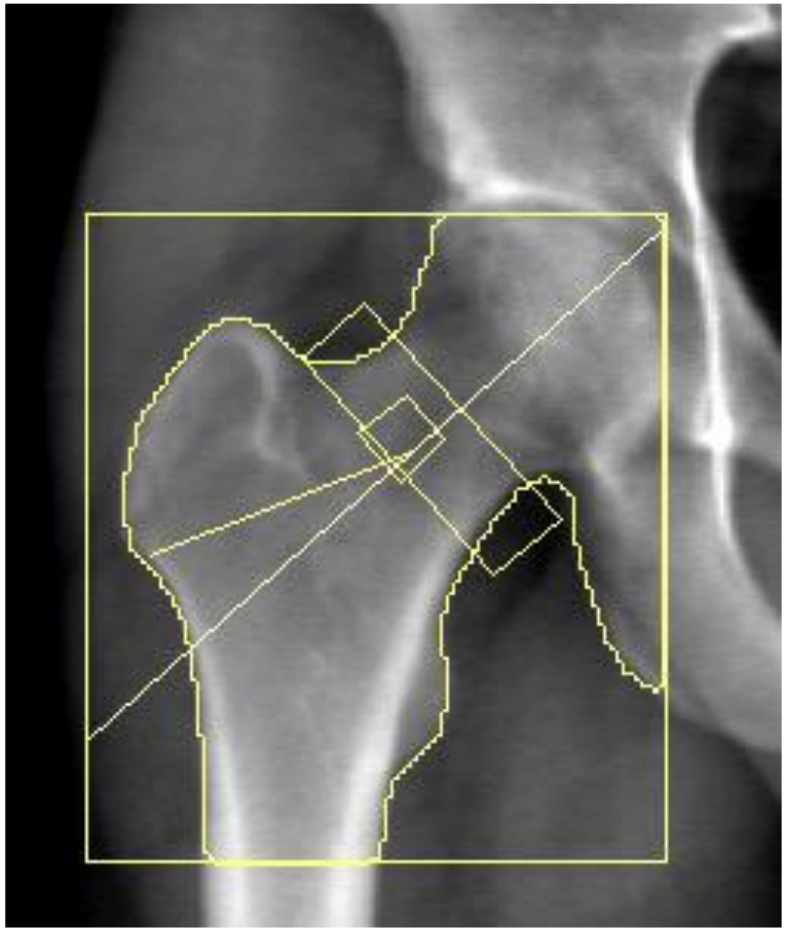


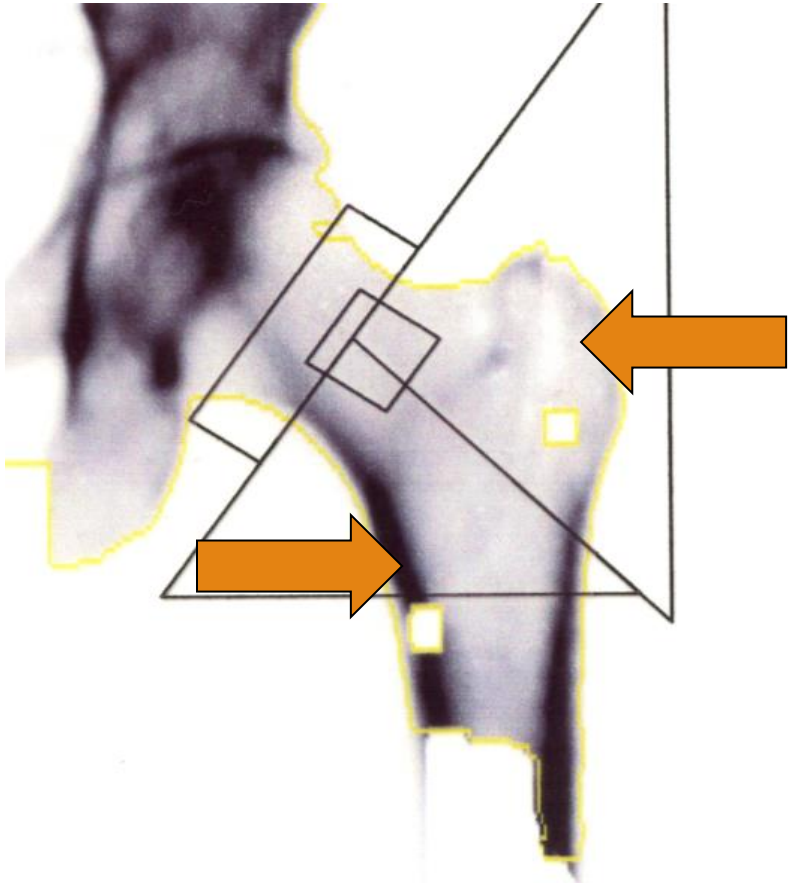
Image Evaluation

If you do not cover appropriate anatomy, you may have gaps in your bone map

- Open global ROI larger to fill in
- If not, rescan patient



Gaps in bone map?



More information?

GE Lunar

Height- 62”

Weight-95.0 lbs.

Thin patient will be difficult to get full bone map at times

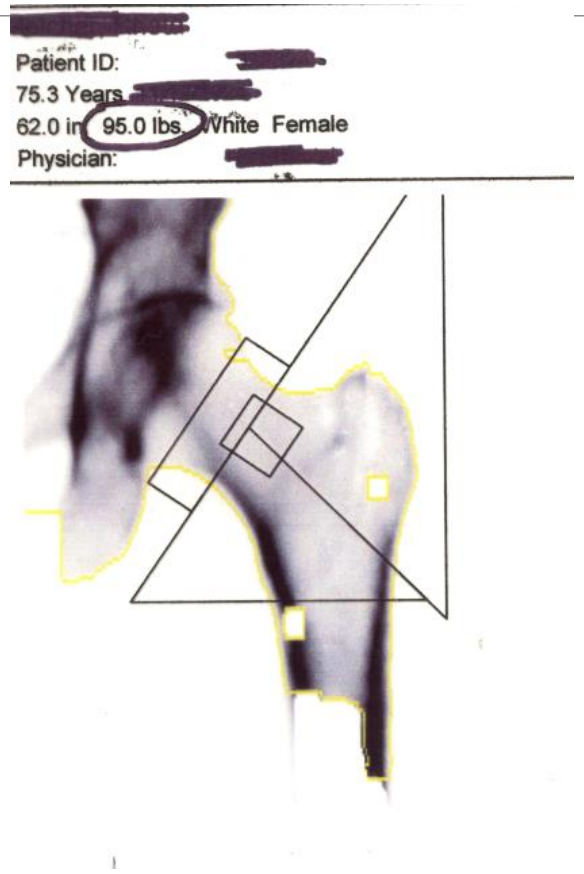


Image Evaluation

Femoral shaft parallel to tabletop

Proper rotation of leg

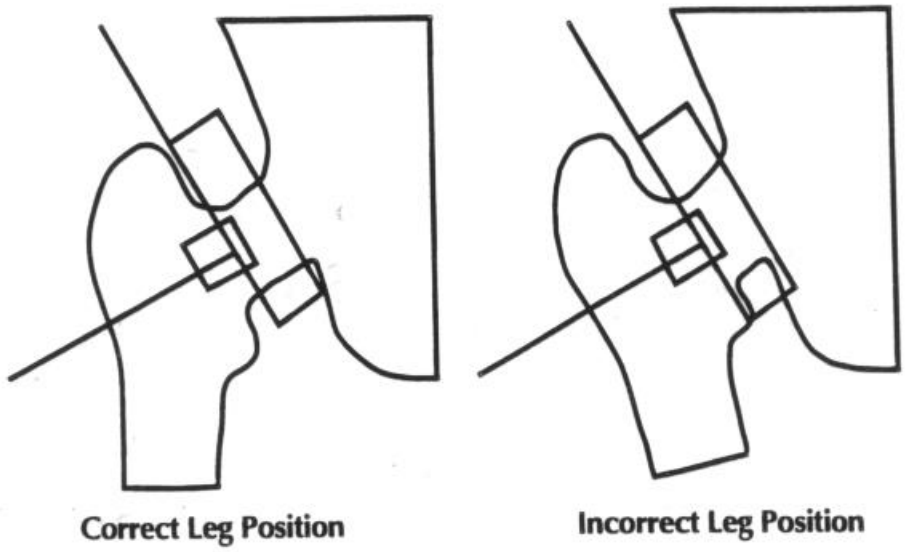
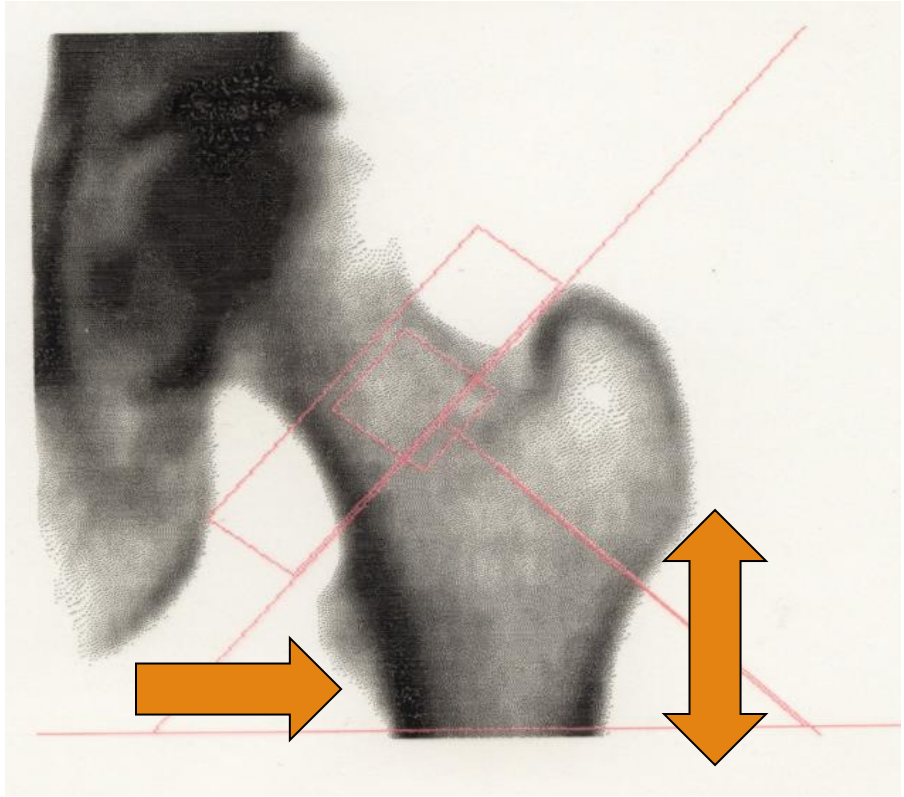


Figure B-7. Correct and Incorrect Leg Position

Image Evaluation

Some lesser trochanter should be visible

Shaft parallel to long axis of table



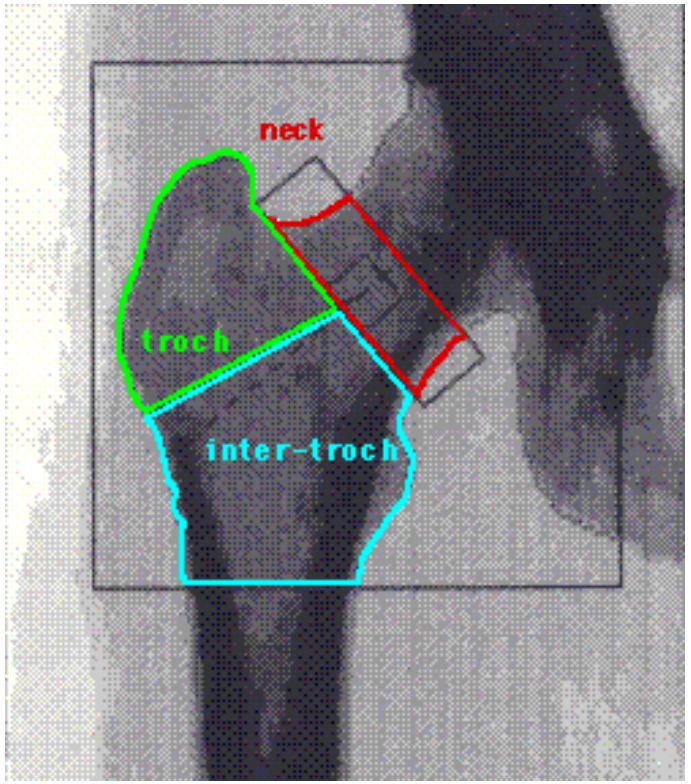
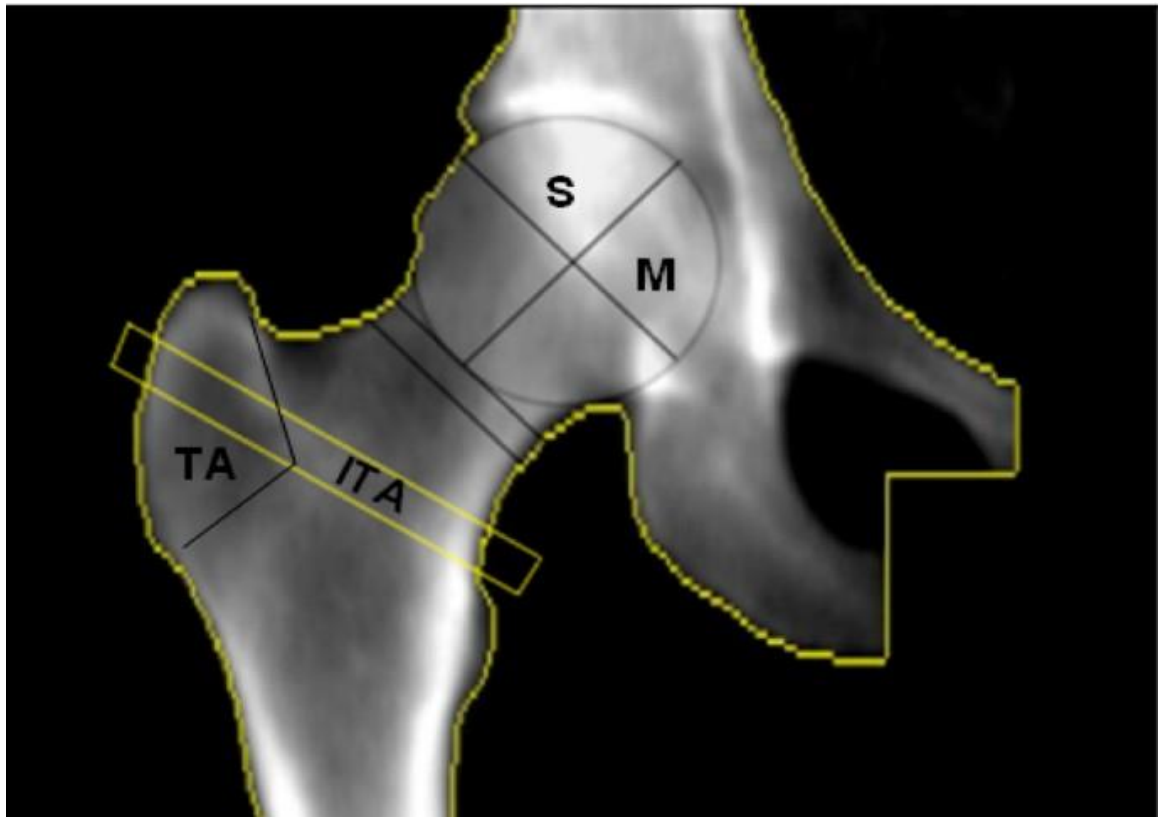


Image Evaluation

How do you fix this mistake?

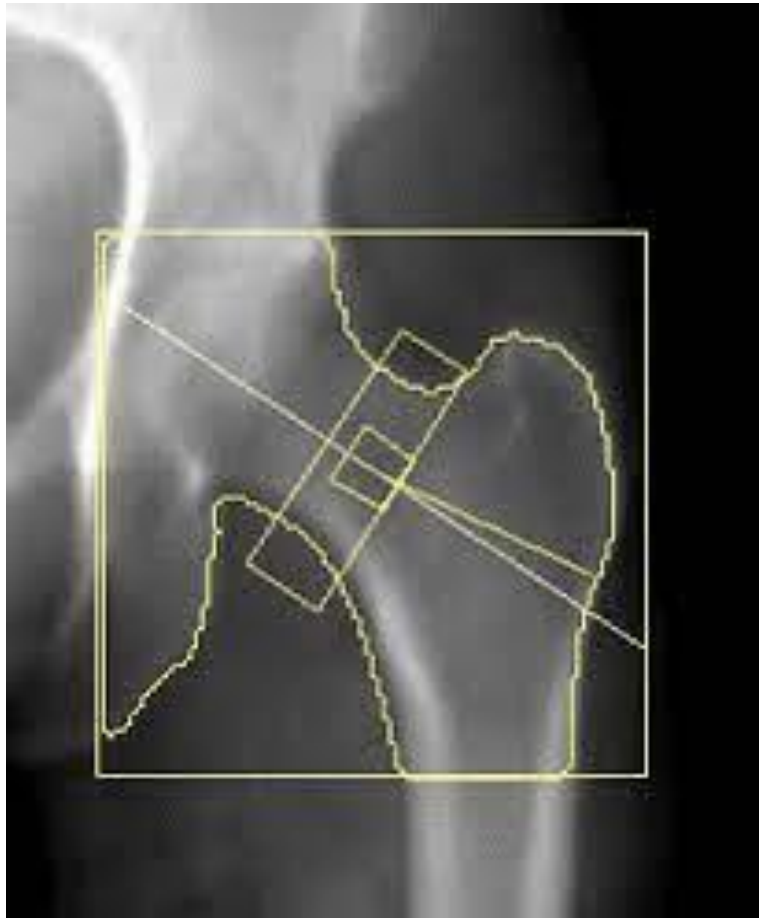


Ward's Area

Measurement of trabecular bone.

Selected by software-not operator.

Affected by rotation of femur.



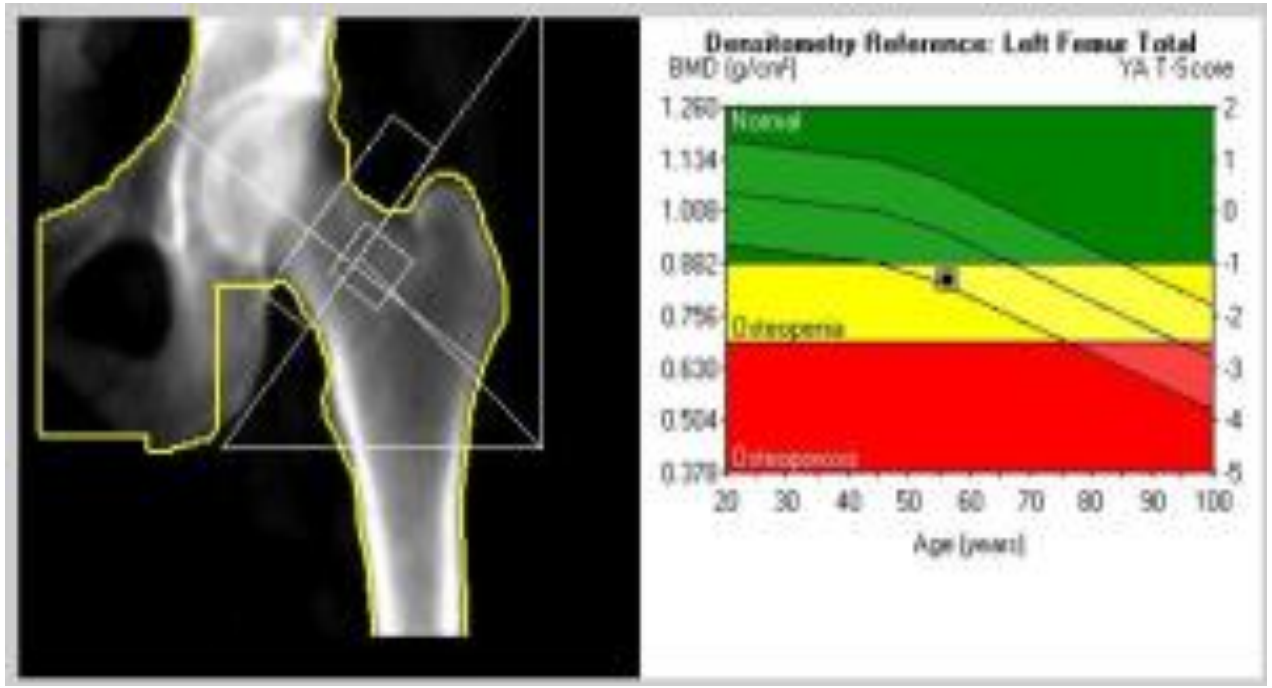
Problem???

Ward’s area is placed by software

Software seeks area of lowest BMD on femoral neck region

Rod in femur is displacing Ward’s to move away from dense object

Ward's area is no longer used for diagnosis Per ISCD!!!



Neck ROI

Where does it go?

It is preferable to have soft tissue in all four corner of ROI

Multiple schools of thought

- Park it high
- Park it low
- Do the same every time
- Match the baseline scan

Hologic

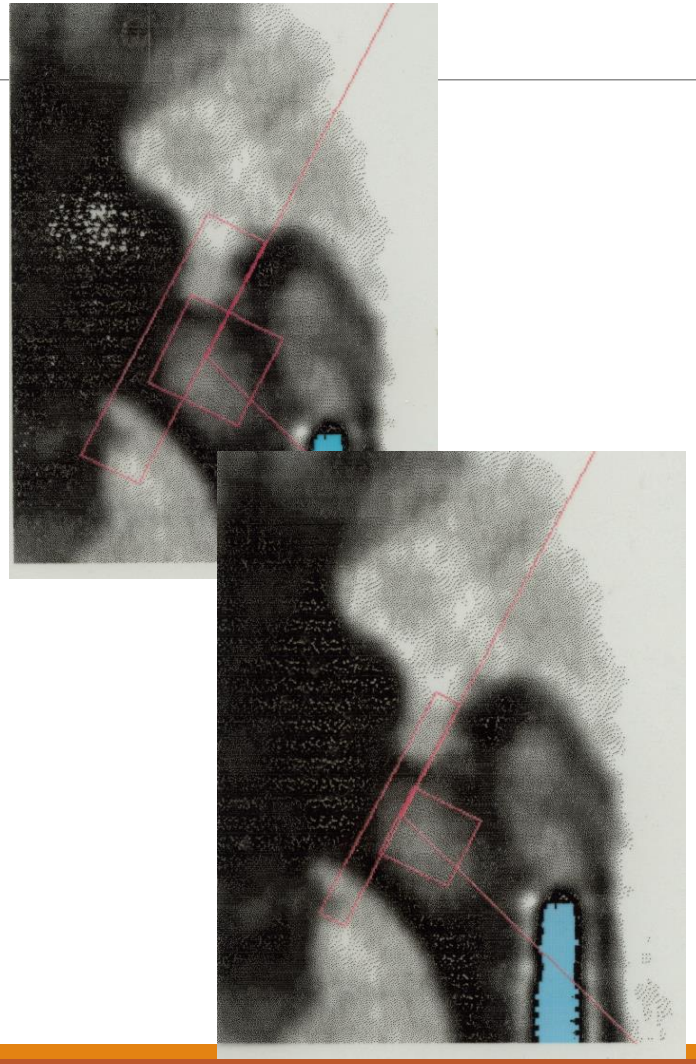
GE Lunar

Neck ROI

Never change the width of the ROI Box.

You can change the length.

BE CONSISTENT



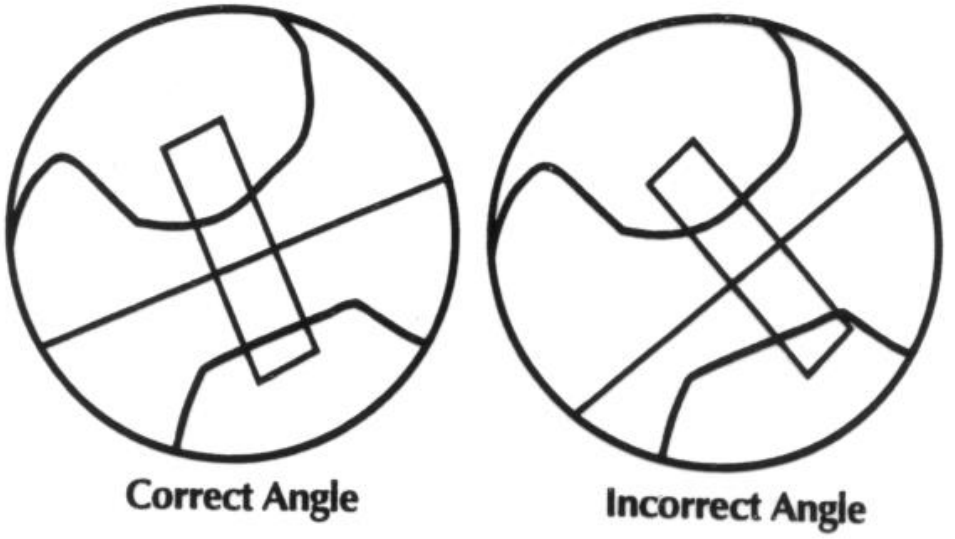
GE Lunar Neck ROI

Measurement of cortical bone

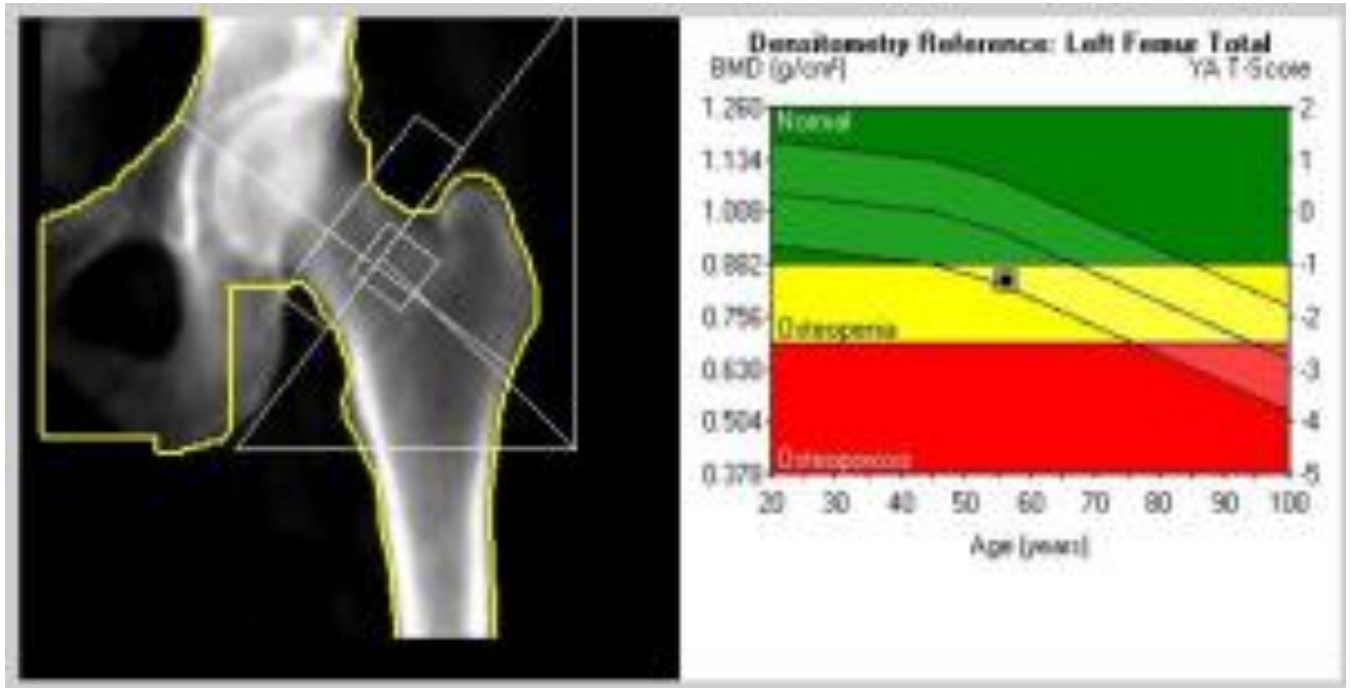
Angle of ROI for neck

Angle of mid neckline

Center line to midline of neck

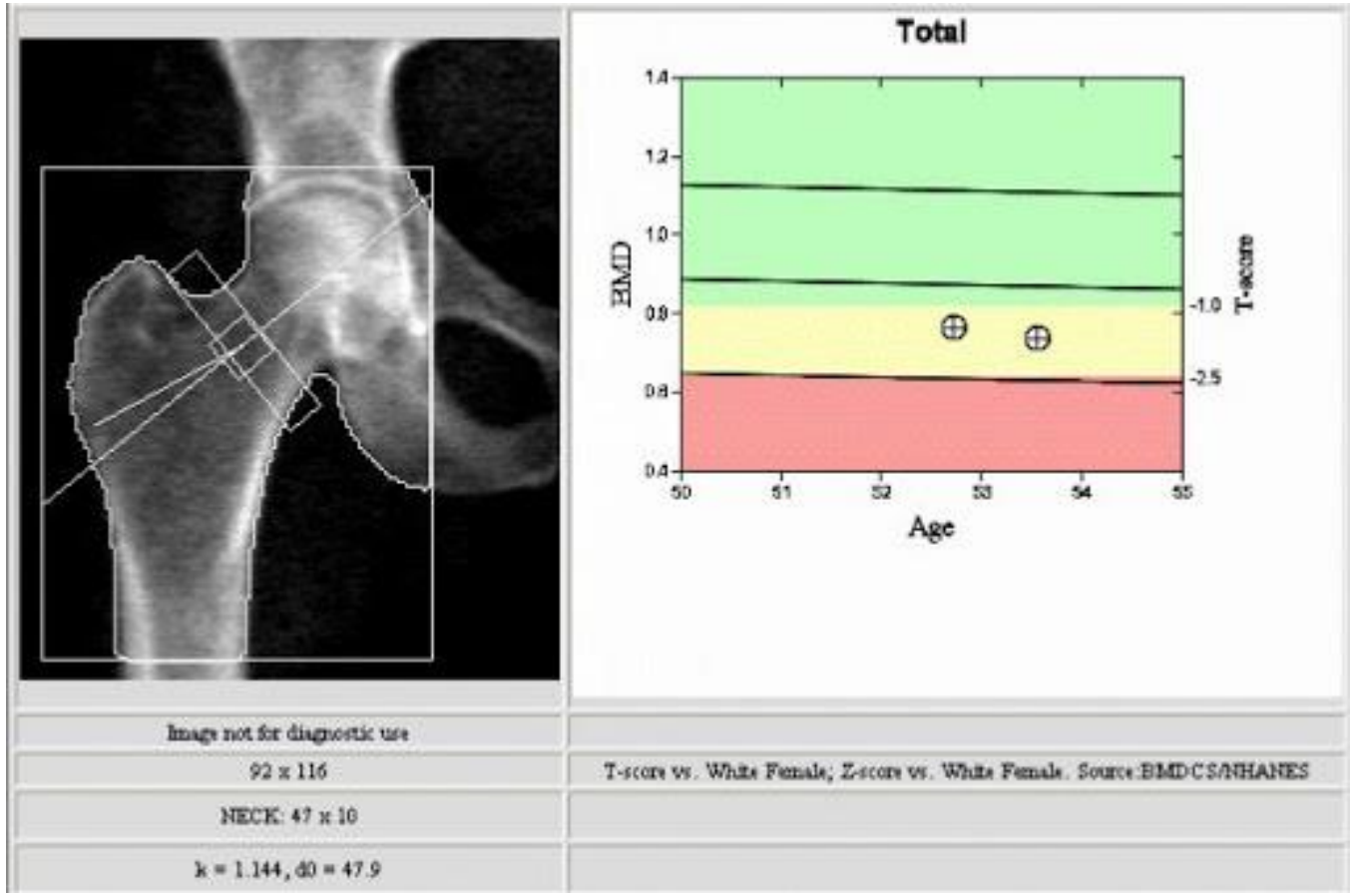


GE Lunar

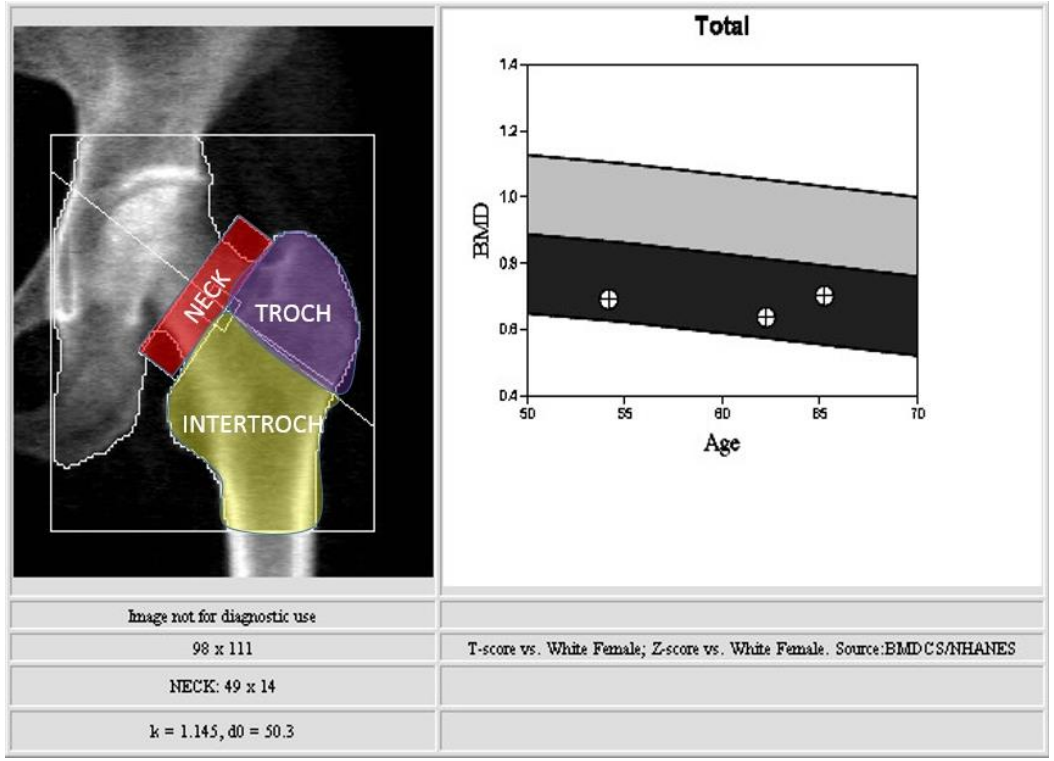

Densitometry Reference: Left Femur Total
BMD (g/cm²)
YA T-Score
1.260
1.134
1.008
0.882
0.756
0.630
0.504
0.378
2
1
0
-1
-2
-3
-4
-5
Normal
Osteopenia
Osteoporosis
20
30
40
50
60
70
80
90
100
Age (years)

Hologic

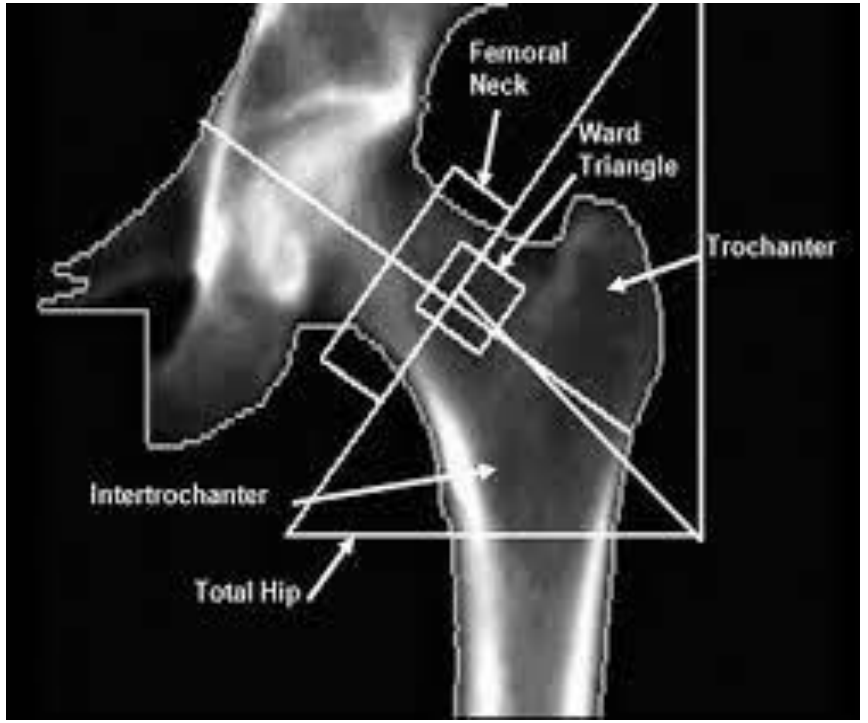
Anchor neck box to the femoral Neck



Total Hip



Hologic



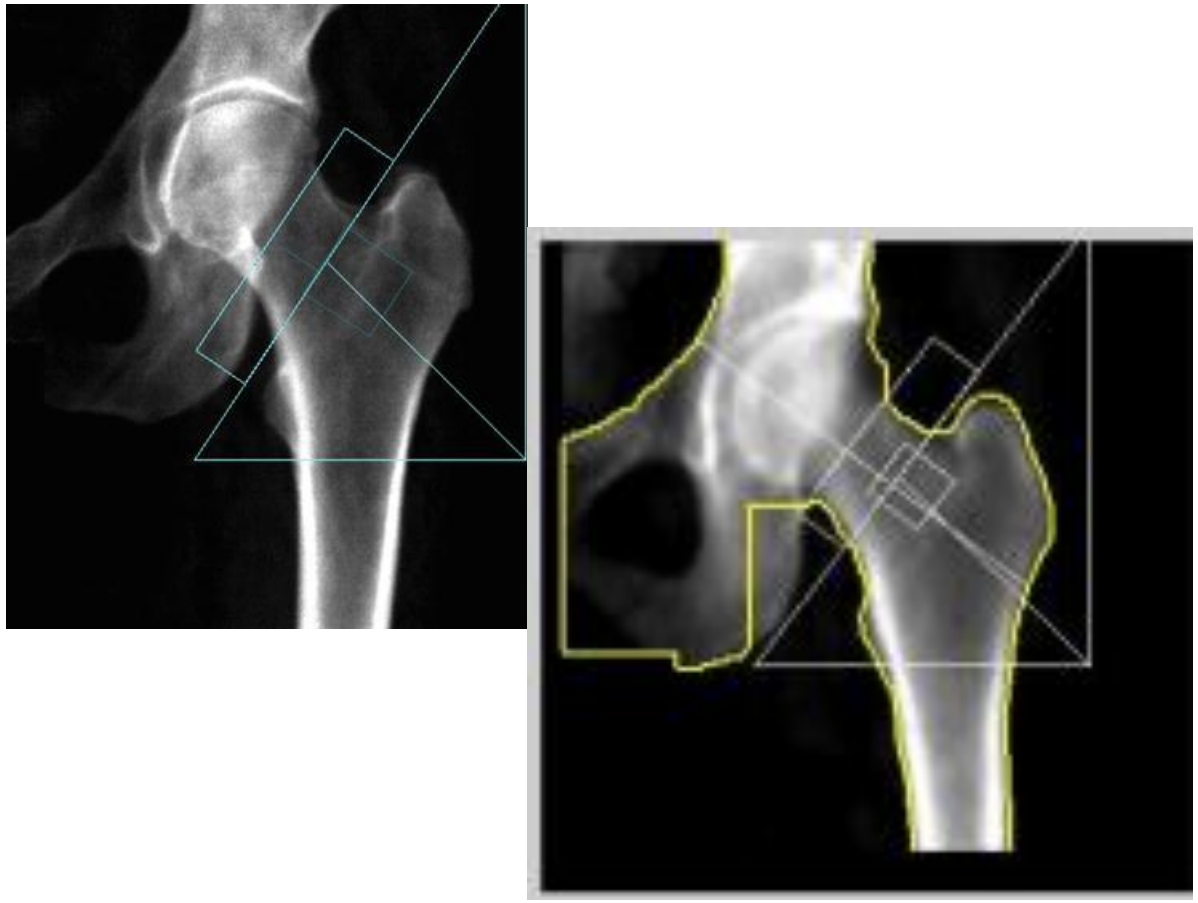
GE Lunar

Deleting Bone

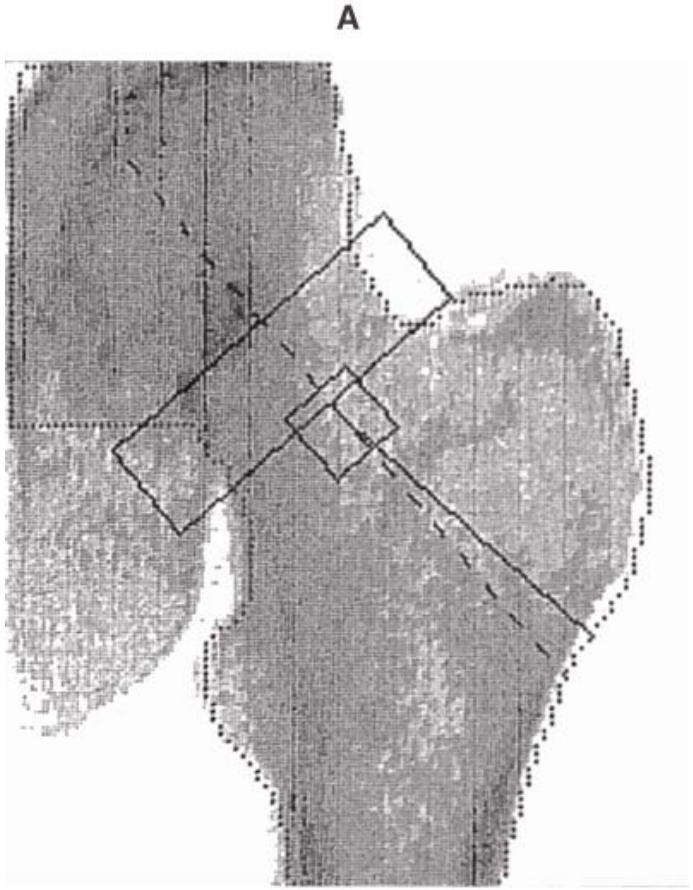
Your software might do this

Allows you to remove the ischium from the neck ROI

Be consistent on serial measurements



How about this one?



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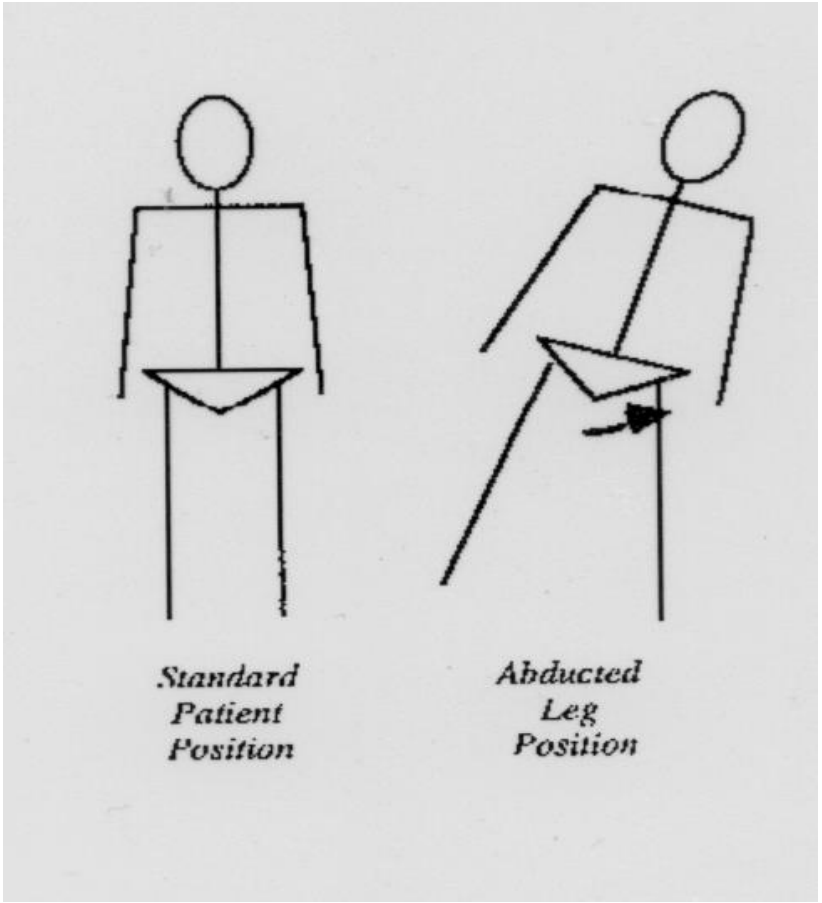
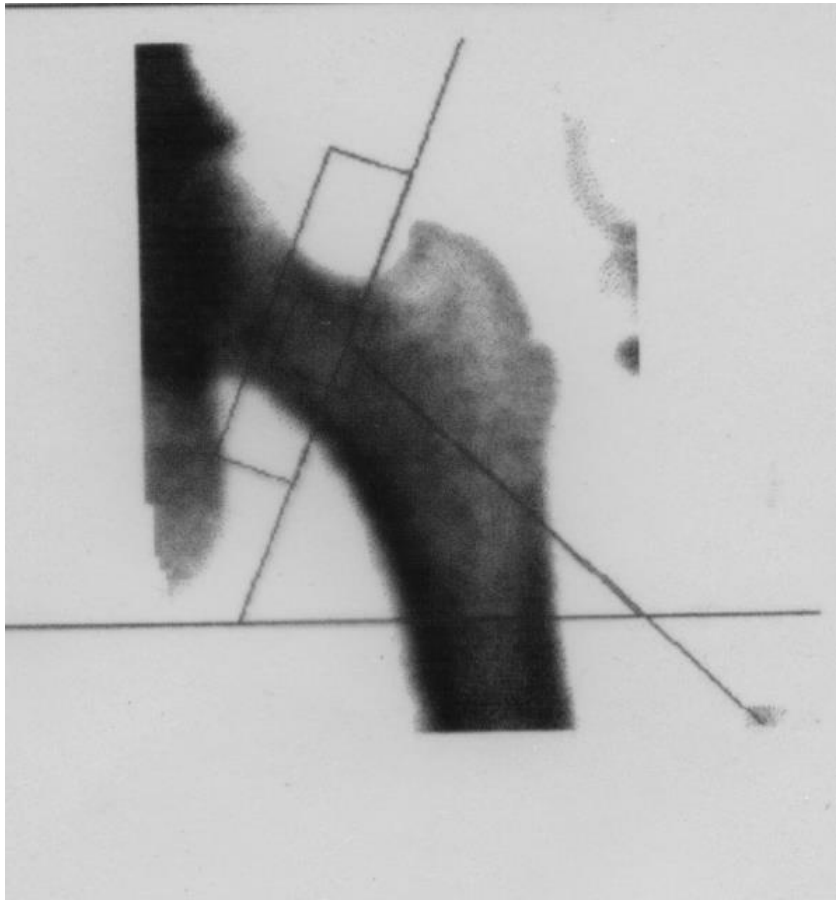
No room for Neck ROI?



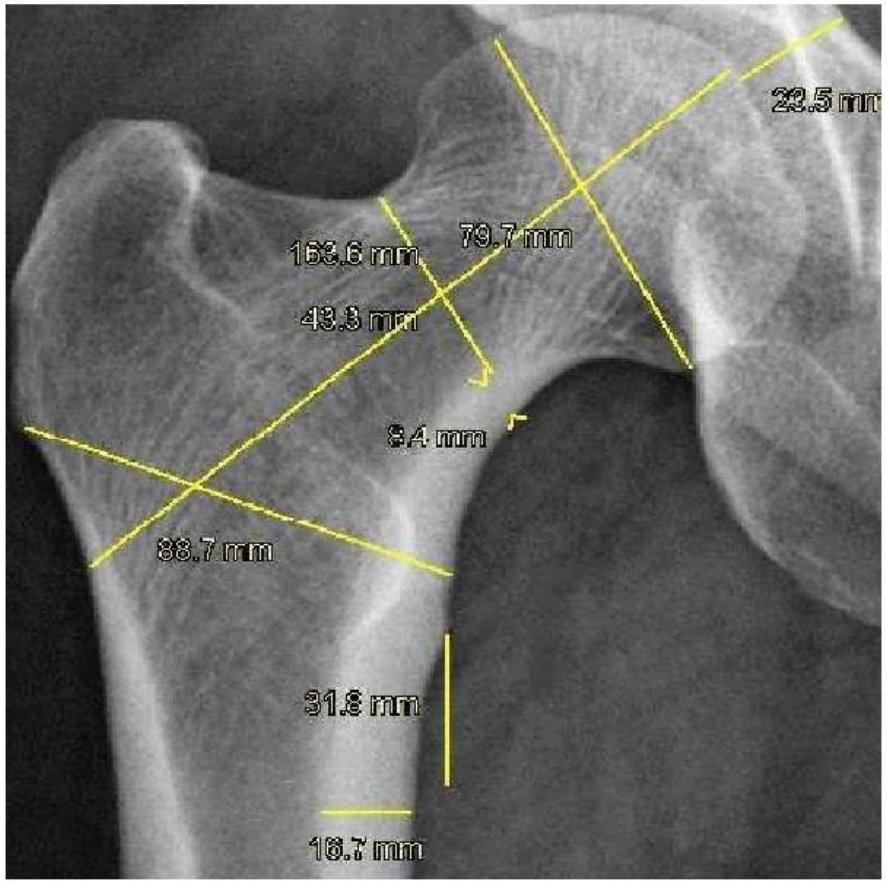
Evaluate this image



Evaluate this image

Femoral shaft not parallel to table

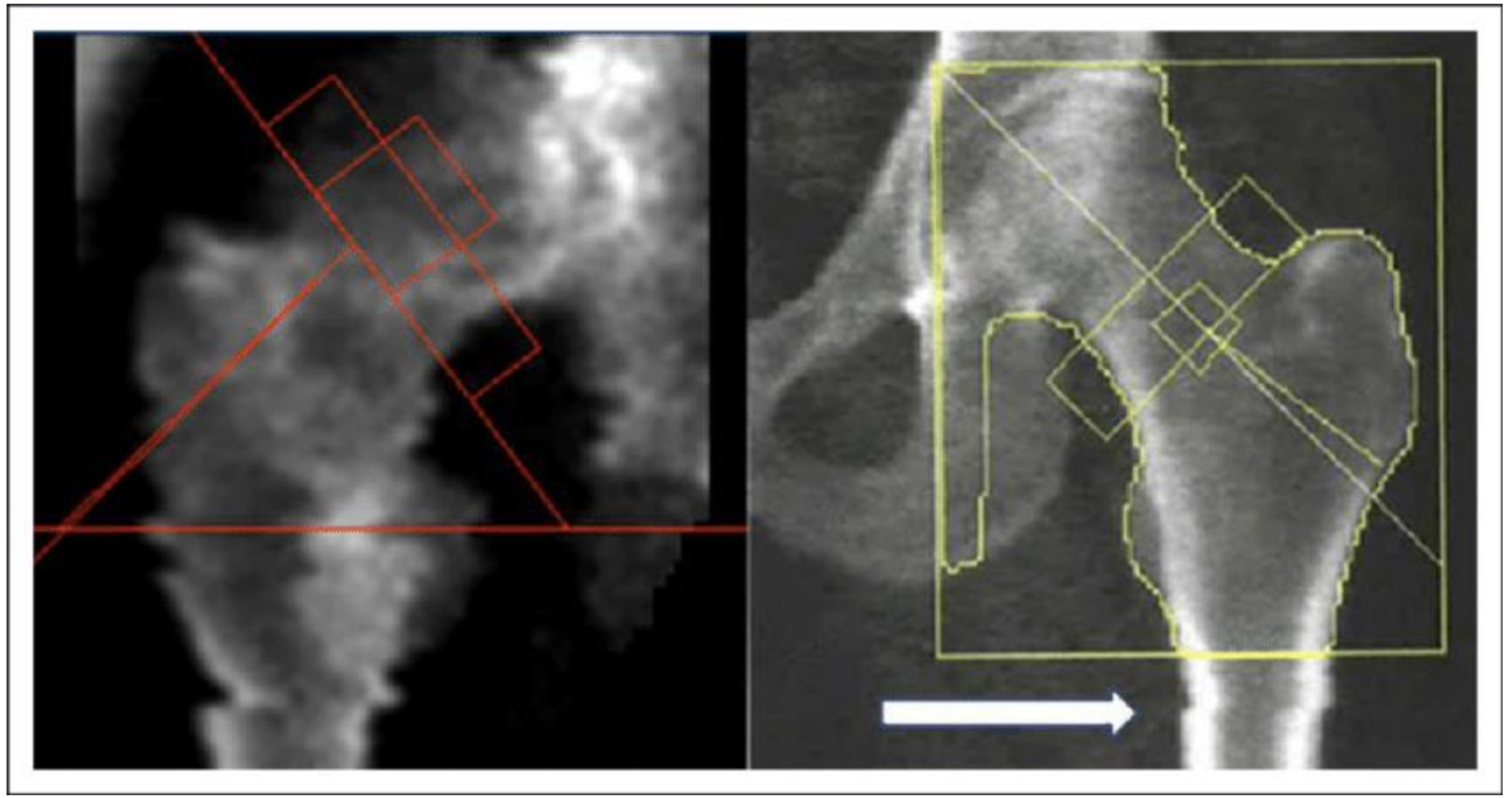
Over-rotation of femur



ig. 2 (c) Hip geometrical measurements on a digital radiograph of 28 year

Evaluate image

Motion from patient



What do you do about this?

Well?

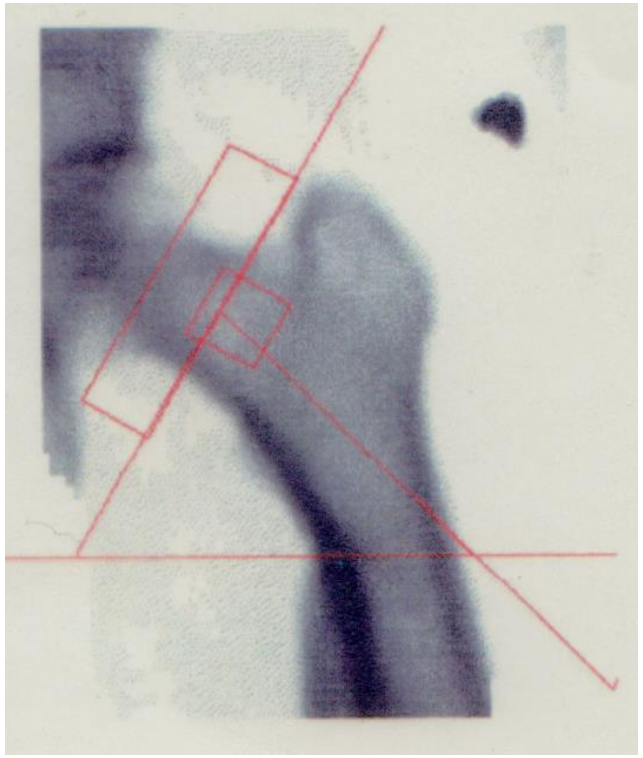
Shaft not parallel to tabletop

Femur abducted

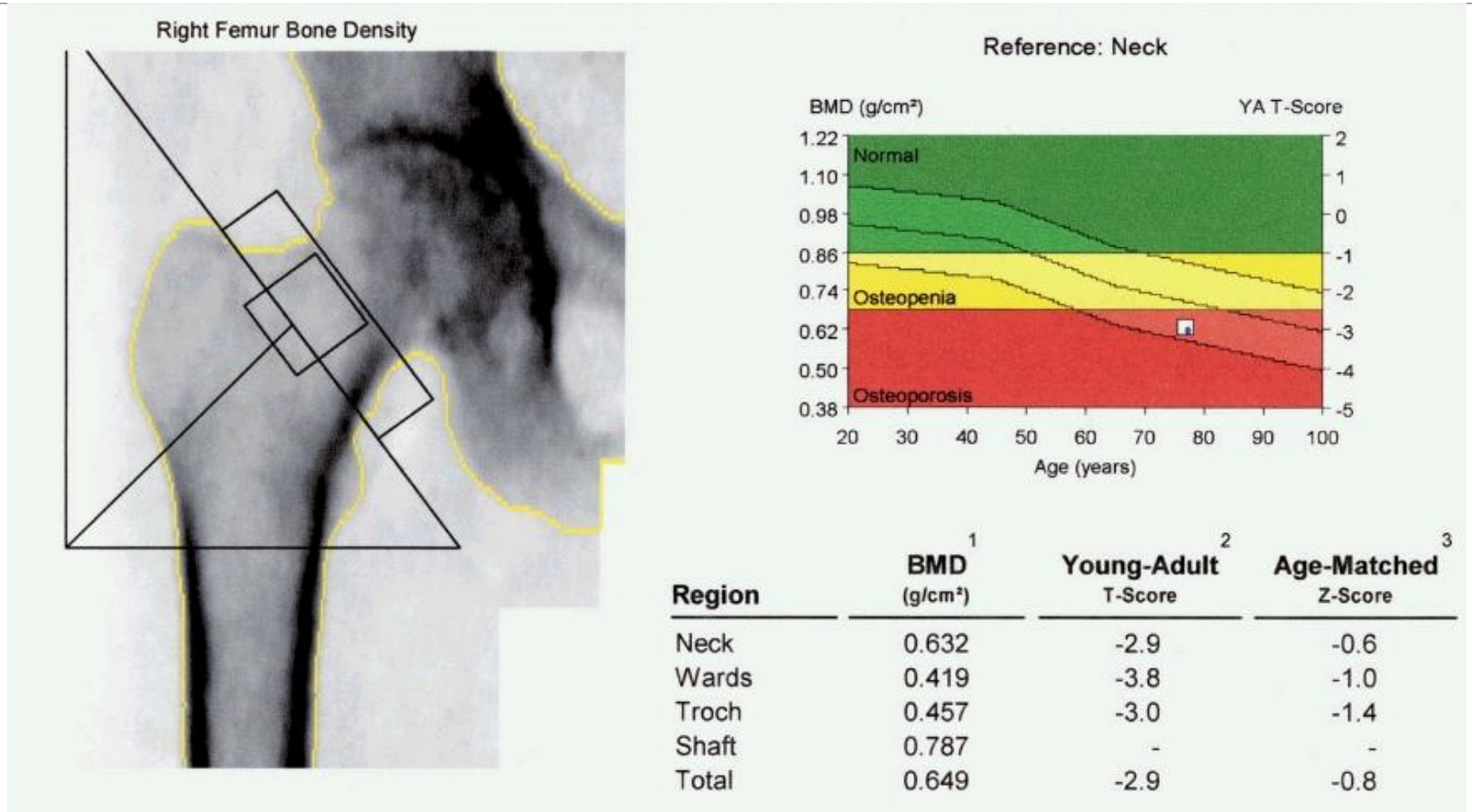
Not enough medial acetabular bone

Artifact in soft tissue

- Pill in patient's pocket

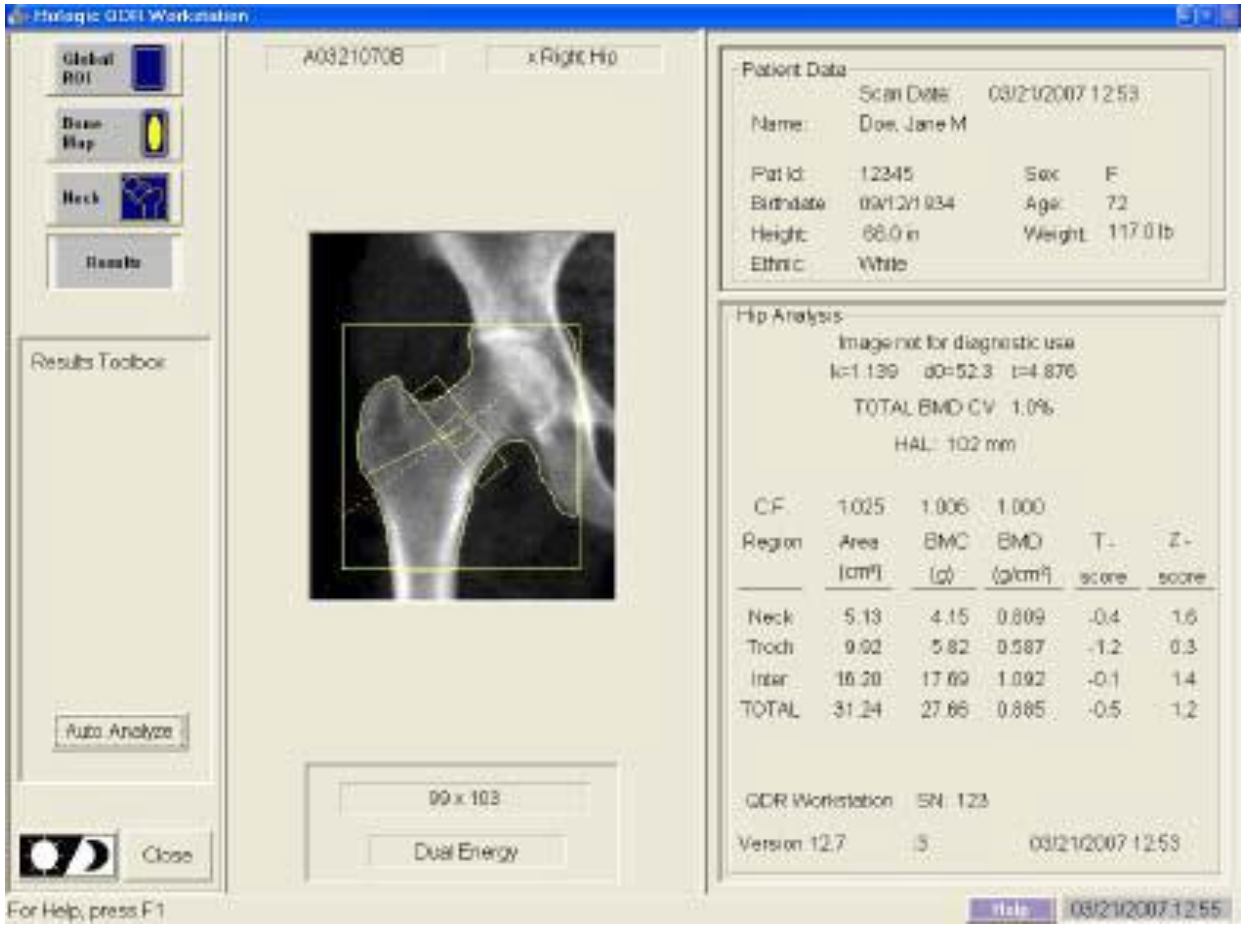


Evaluate this Image



Region	BMD [1] (g/cm²)	Young-Adult [2] T-Score	Age-Matched [3] Z-Score
Neck	0.632	-2.9	-0.6
Wards	0.419	-3.8	-1.0
Troch	0.457	-3.0	-1.4
Shaft	0.787	-	-
Total	0.649	-2.9	-0.8

Left and Right Hips Final Analysis Page



A Question for you

What type of bone are you measuring in:

- Femoral neck?
- Ward's area?
- Trochanteric area?
- Total hip?

More questions

How much do you invert the femur for the proximal hip scan?

Why do you invert the femur in the first place?

How do you know if you've over-rotated the femur?

Another Question

What will happen to the patient's BMD measurement if you over-rotate the femur?

- Increase
- Decrease
- No effect

Dual Femur Software

Will start with left femur and when complete software will move to approximate start of right femur

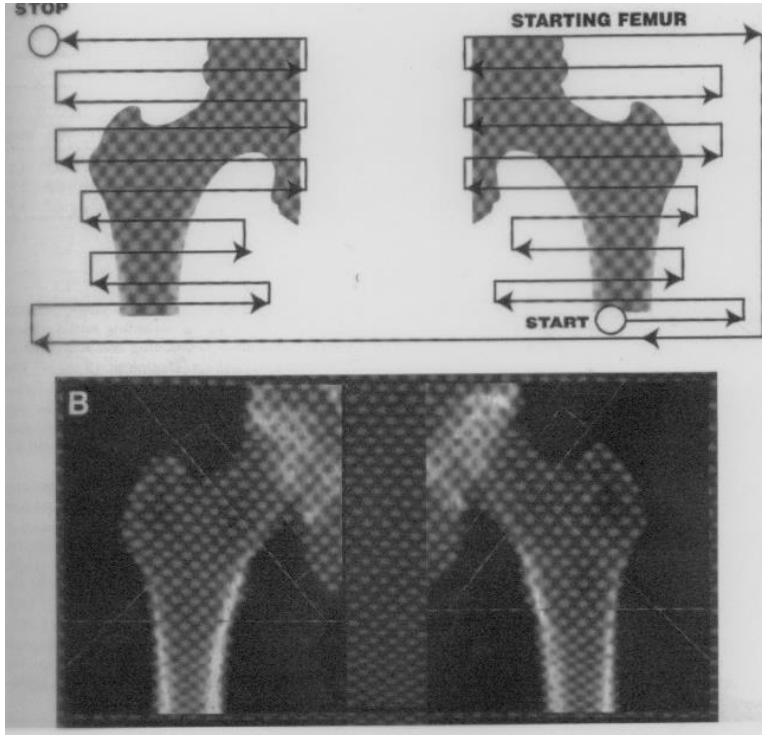
These will be compared by the software in the analysis process

Be careful with Dual Femurs

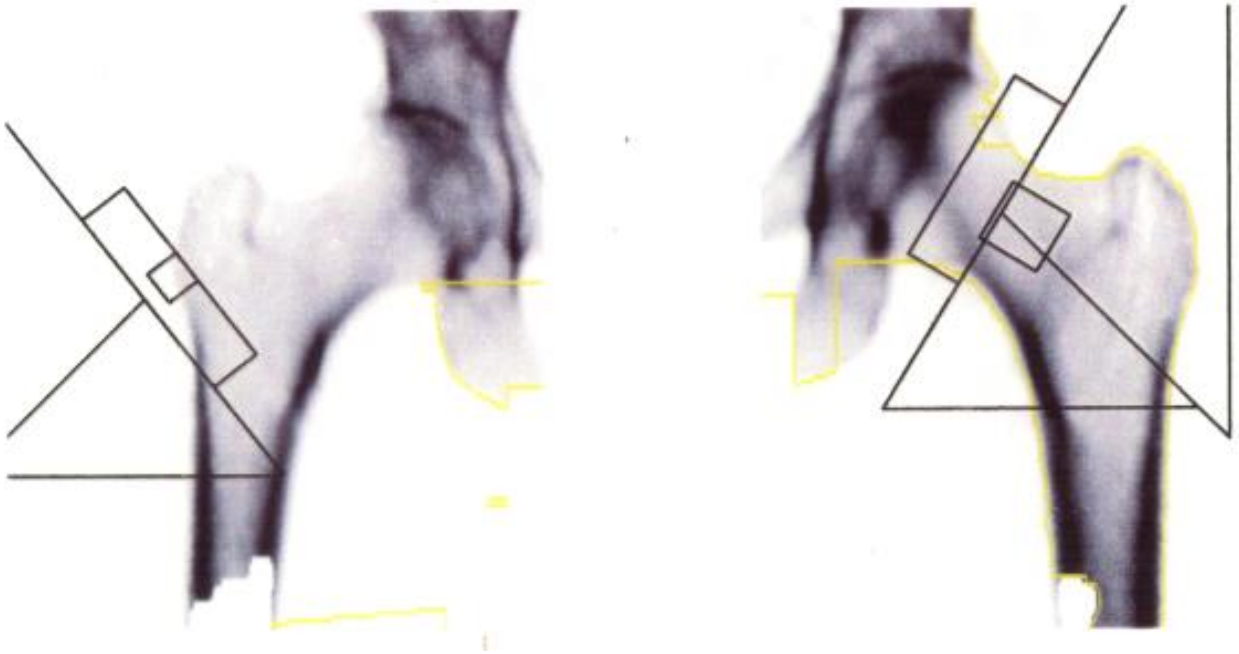
Both femurs should be properly positioned

Do not have an excellent left hip and a crooked right hip

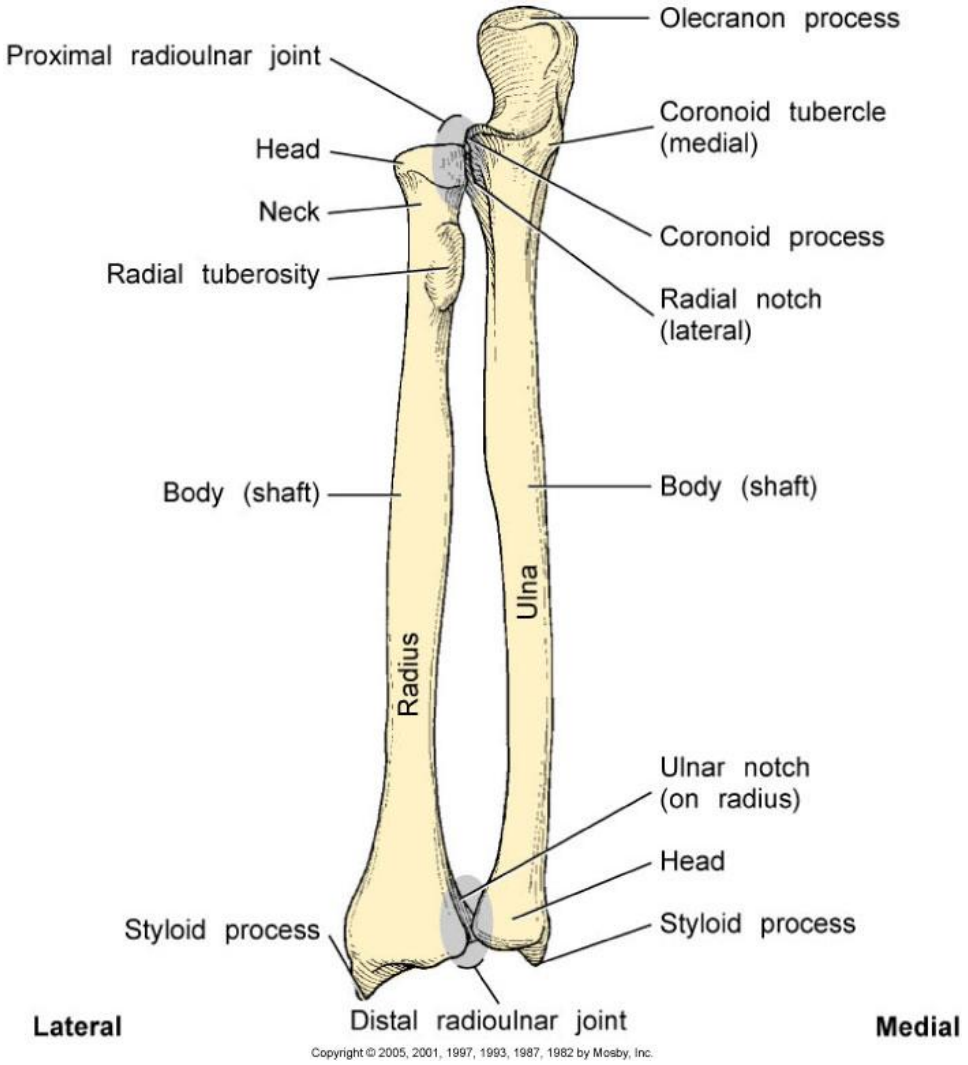
Restart measurement as needed for proper positioning



Assess separately,
they will be compared to each other

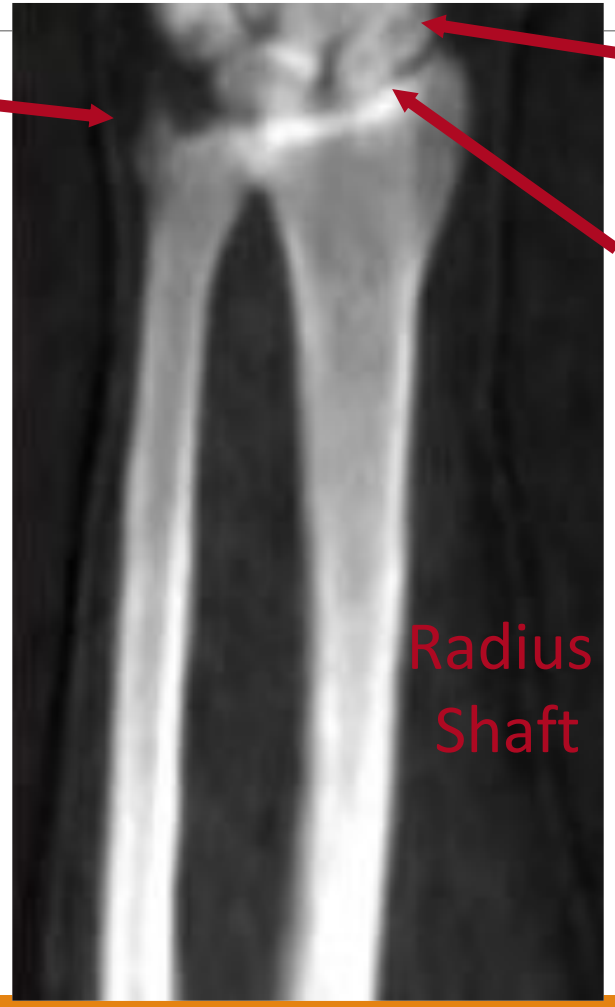


DXA Scanning of Forearm



Forearm Anatomy

Forearm Anatomy



DXA of Forearm

This positioning varies from positioning for a radiograph of the forearm.

Value of the Forearm

Tends to have less artifacts/architectural changes than spine and proximal femur.

Can be used to detect primary and secondary hyperparathyroidism.

Can be used for heavier patients who the table may not accommodate.

Used when one or more standard deviation between the spine or hips.

Used when spine or hips must be excluded due to hardware.

ROIs of Forearm DXA

ROI	% Trabecular	% Cortical
Midradius	1	99
Distal Radius	20	80
8-mm Radius	25	75
5-mm Radius	40	60
Ultradistal Radius	66	34

Which do we scan?

Nondominant arm

- Could be a 6-9% variation in BMC

Arm with no previous fracture history

DXA of the Forearm

Some systems require measurement of the Ulna for scanning

- The ulna is used to set the % based measurements for analysis
- You may physically measure ulna
- Software will perform measurement during scan

Measuring the Ulna

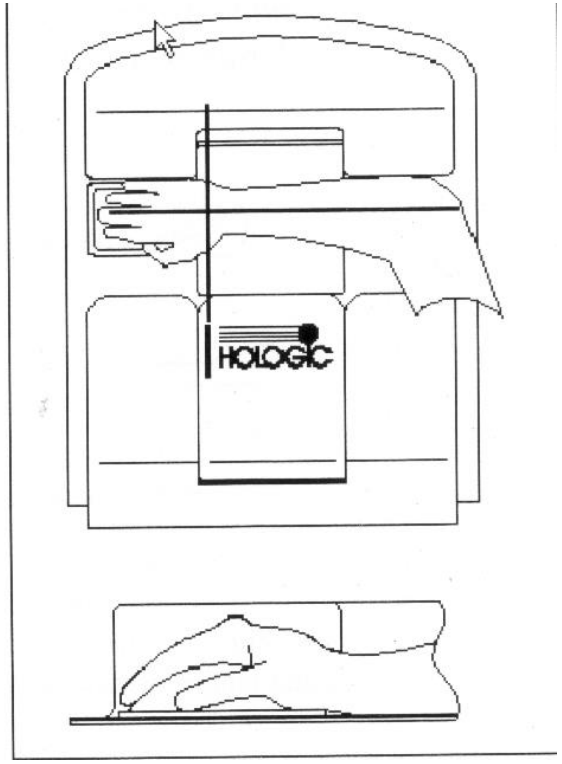
Place patient ’s elbow on a flat surface

Extend forearm vertically with 5th digit toward their face

Place ruler on flat surface and measure up to the ULNAR styloid

Record measurement in cms for use in analysis

Hologic Positioning Device



NO Longer need Positioning device for Newer Hologic Systems.

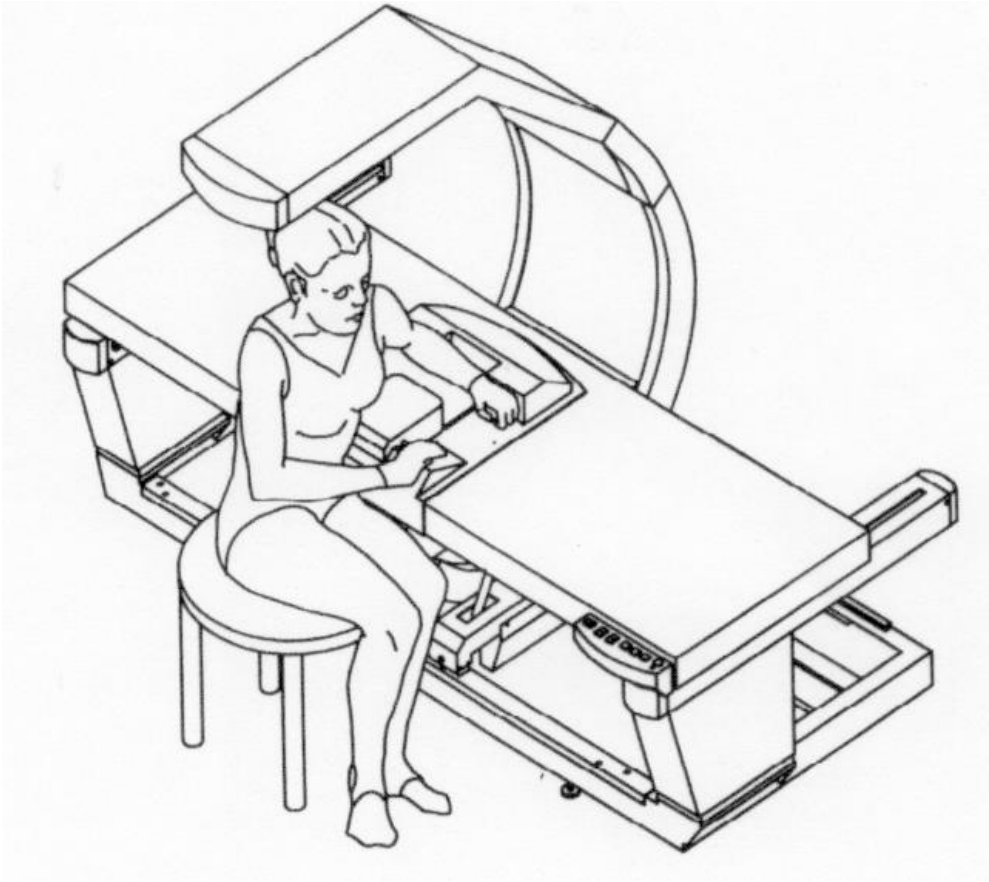
Positioning of Measurement With Device

Place patient with legs parallel to long axis of table

Place forearm prone on positioning device with support under cupped hand

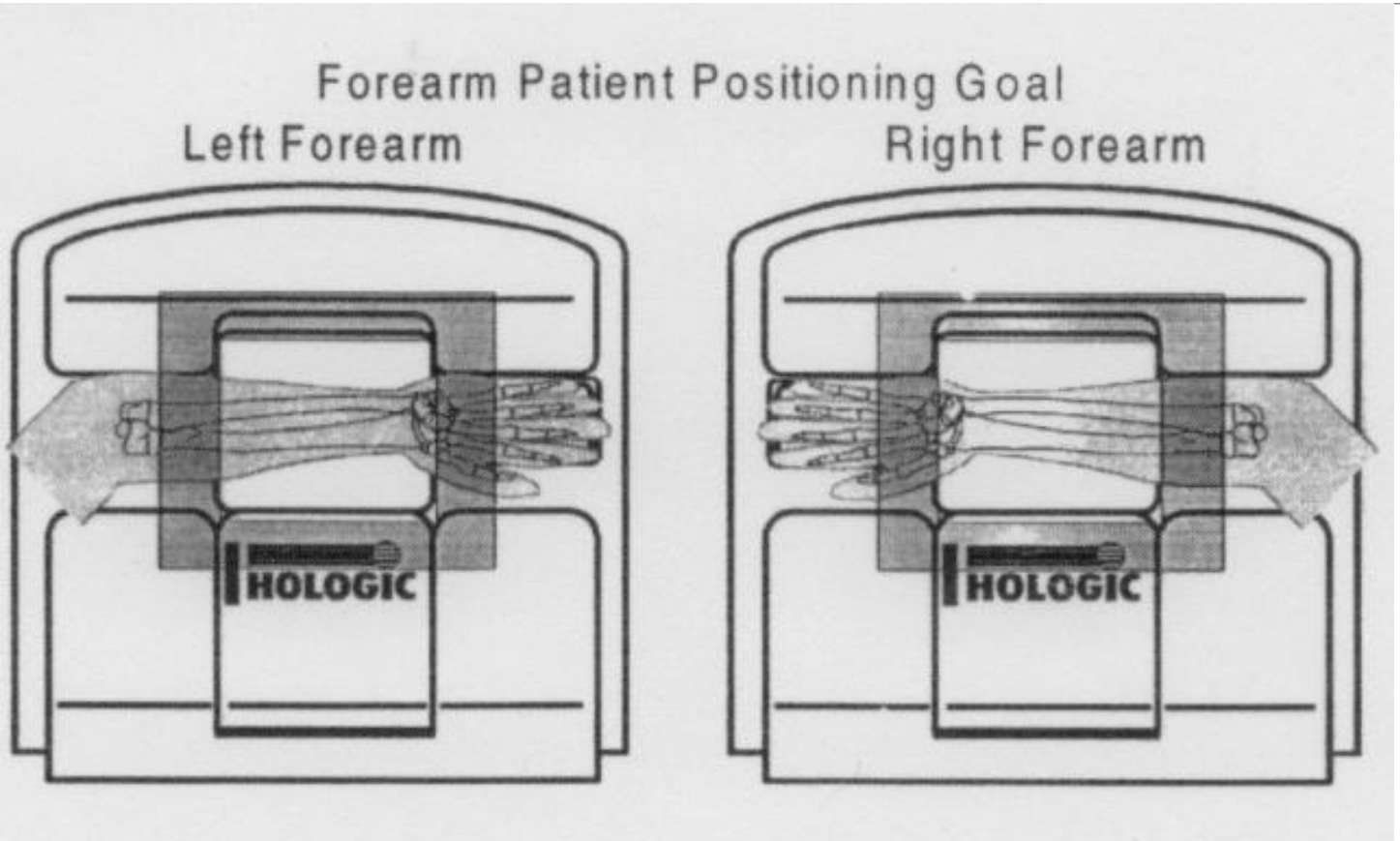
Long axis of forearm should be parallel to long axis of table

Forearm Positioning



with newer systems position patient the same way without the device.

Right vs. Left Forearm



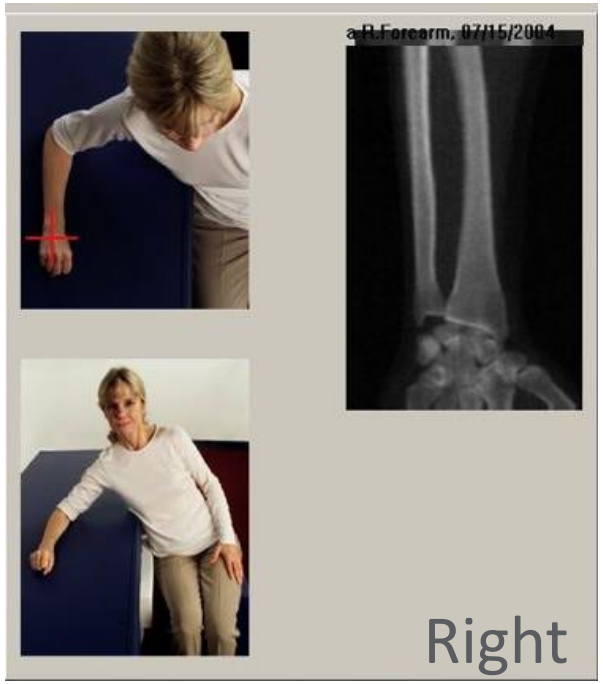
GE Lunar positioner

Must USE for Lunar!!!

See Reference Manual for use.
Must use correctly.

Forearm Start Point

Start distal to radius on right side, start near proximal radius for left.



What about the Chair!!!

- When Scanning the forearm, for precision purposes, use the same chair every time.
  - Chair should not have wheels.
  - Chair should sit flat.
  - Chair should not have arm rests.

Positioning of Measurement

Laser positioning

Left forearm: scan starts in mid-forearm

- 1st row of carpal bones should be within 15 cm of start

Right forearm: scan starts at 1st row of carpal bones

Forearm DXA Image Criteria

Forearm must be straight and centered in the scan image

- Long axis of forearm parallel to long axis of scan field

Image includes at least one row of carpal bones

Ulnar side of image contains at least enough air to equal the shaft width of ulna

Analysis of Forearm DXA

Many systems will auto-analyze your data

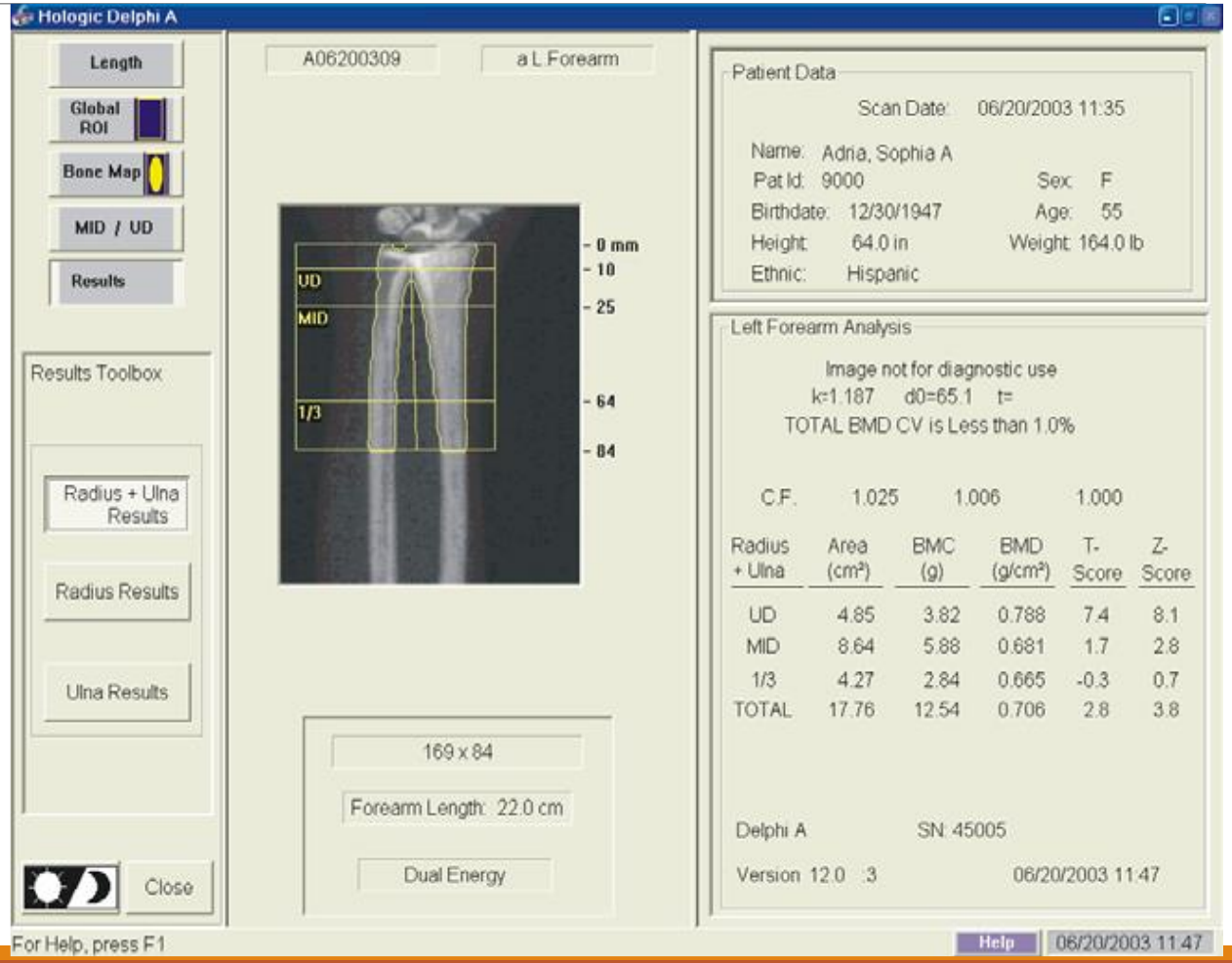
If not:

- Review image for appropriate criteria
- Position top of ROI to tip of styloid process
- ROI outside ulna including soft tissue
- Radius ROI border should be 10 lines lateral to bone edge

Left Forearm Final Analysis

Regions analyzed

- Distal radius, 33% or 1/3 site
- 1/3 site use for diagnosis*
  - Almost 100% cortical bone

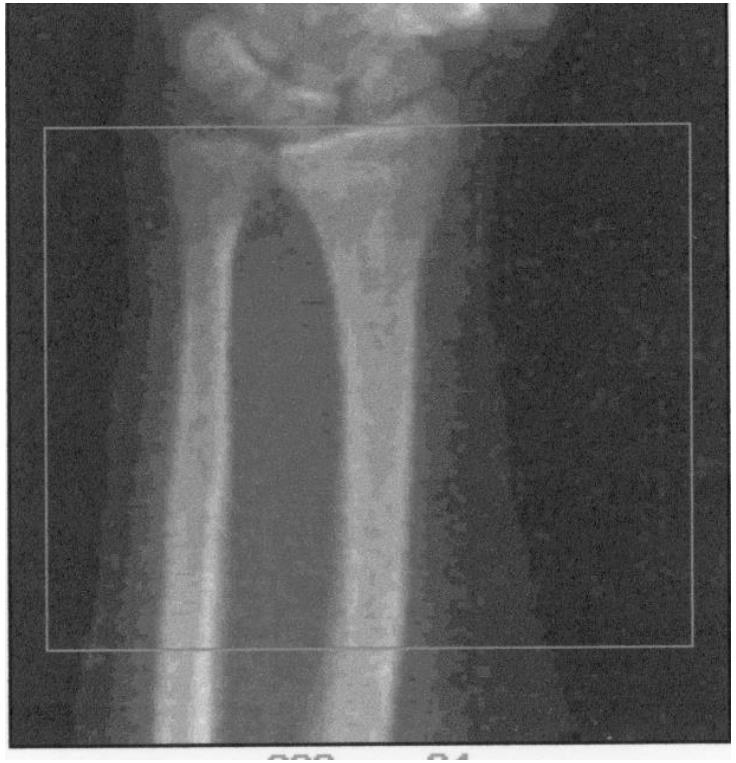


ROI Placement

Top of ROI at tip of ulnar styloid

ROI outside ulna including soft tissue

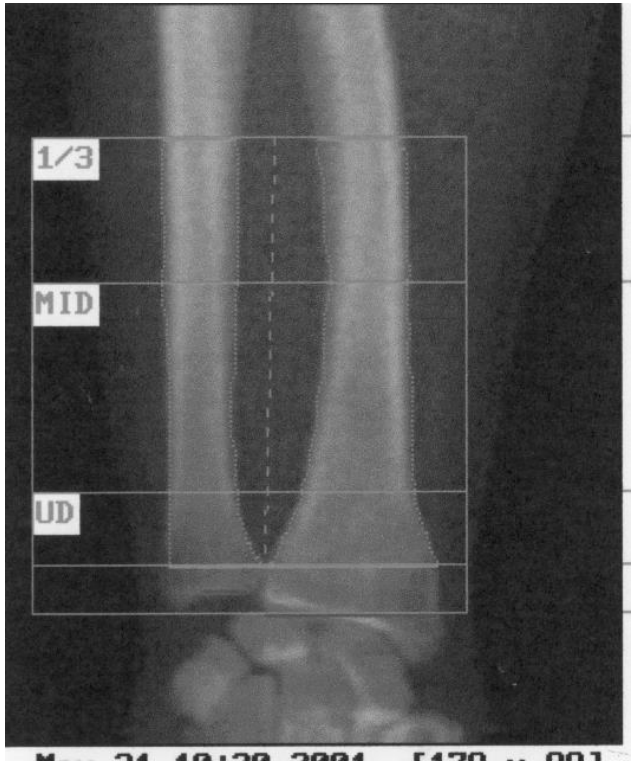
Radius ROI border should be 10 lines lateral to bone edge



ROI Placement

Drop perpendicular line between radius and ulna

This is used for mm measurements if your software uses them



Completed Forearm Analysis

Name: FOREARM #3 25.5 C.M.
Patient ID: NORM
DOB:

Sex: Female
Ethnicity:

Height:
Weight:
Age:

Referring Physician:

Image not for diagnostic use
k = 1.227, d0 = 62.1
228 x 95, Forearm Length: 25.5 cm

Total (Radius + Ulna)

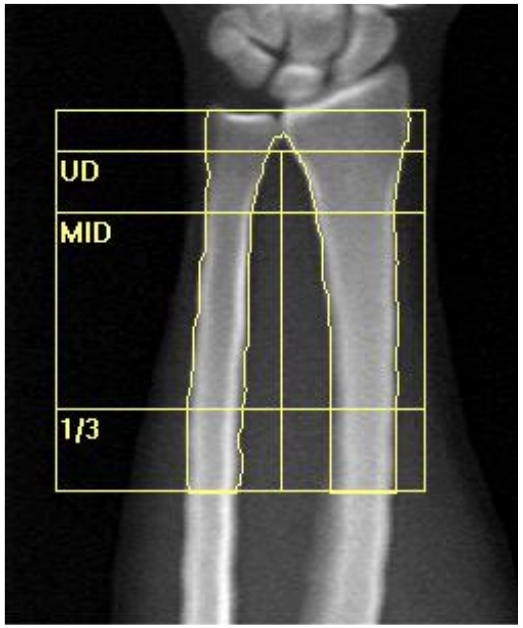
Scan Information:

Scan Date: November 07, 1994 ID: Y11079405
Scan Type: a R.Forearm
Analysis: October 04, 2001 18:36 Version 10.0:0
Right Forearm
Operator:
Model: QDR 4500A (S/N 4503)
Comment:

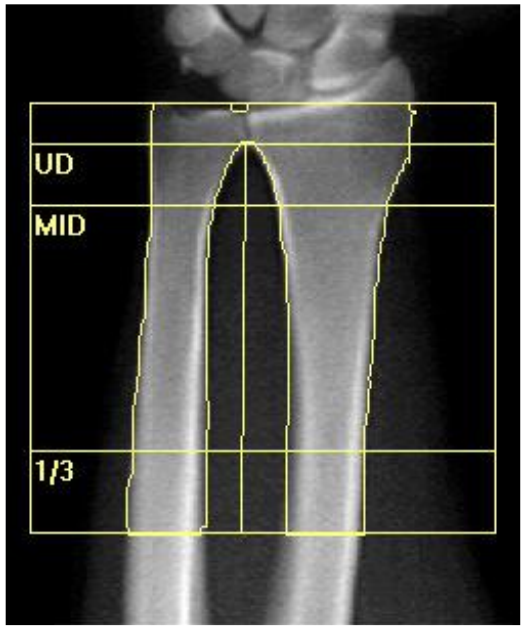
DXA Results Summary:

Radius + Ulna	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - Score	Z - Score
1/3	6.33	5.47	0.864	3.1	
MID	14.72	11.38	0.773	3.5	
UD	6.52	3.60	0.552	2.7	
Total	**27.57**	**20.44**	**0.741**	**3.5**	

Total BMD CV 1.0%, ACF = 1.017, BCF = 0.992
WHO Classification: Normal
Fracture Risk: Not Increased



Radius	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
UD	3.09	1.81	0.587	2.5	2.8
MID	7.18	5.06	0.704	1.8	2.2
1/3	**3.01**	**2.26**	**0.753**	**1.0**	**1.4**
Total	13.28	9.14	0.688	2.0	2.4



Radius	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - score	Z - score
UD	4.45	2.57	0.578	0.5	1.2
MID	11.20	8.47	0.756	0.9	1.3
1/3	**3.55**	**3.05**	**0.859**	**0.8**	**1.3**
Total	19.20	14.09	0.734	0.9	1.4

The ROIs

%-based ROIs are related to overall length of Ulna

- This is regardless of whether to select the radius or ulna for analysis
- Ultradistal ROI is 4-5% of the ulnar length

Mm-based ROIs are located on either bone at the point bone separation is either 5 or 8 mm's apart