VERTEBRAL FRACTURE INITIATIVE
Part II

Recognition and reporting of vertebral fractures

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Recognition and reporting of vertebral fractures

Topics to be covered

- Technical considerations for radiographs
- Vertebral fracture shape recognition
- Semi-quantitative visual grading examples
- Radiographic osteopenia or osteoporosis and differential diagnosis
- Other imaging methods or analysis
- Differential diagnosis of fractures versus deformities

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Background

- Worldwide, a substantial percentage of vertebral fractures are not diagnosed by radiologists or clinicians[1]
- It is likely that this contributes to unnecessary pain and suffering and to the under treatment of osteoporosis
- Identification of patients with a vertebral fracture is important because the presence of prevalent fracture greatly increases the risk of future fracture
- Recent widespread approval of effective treatments for patients with osteoporotic vertebral fractures

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[1] *Delmas PD et al. (2005) JBMR 20: 557-563*

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Technical considerations

Ensure:
- Overlap T12 and L1
- Spine parallel to film

Film focus distance = 100cm

So avoid false biconcave endplates 'bean can effect'

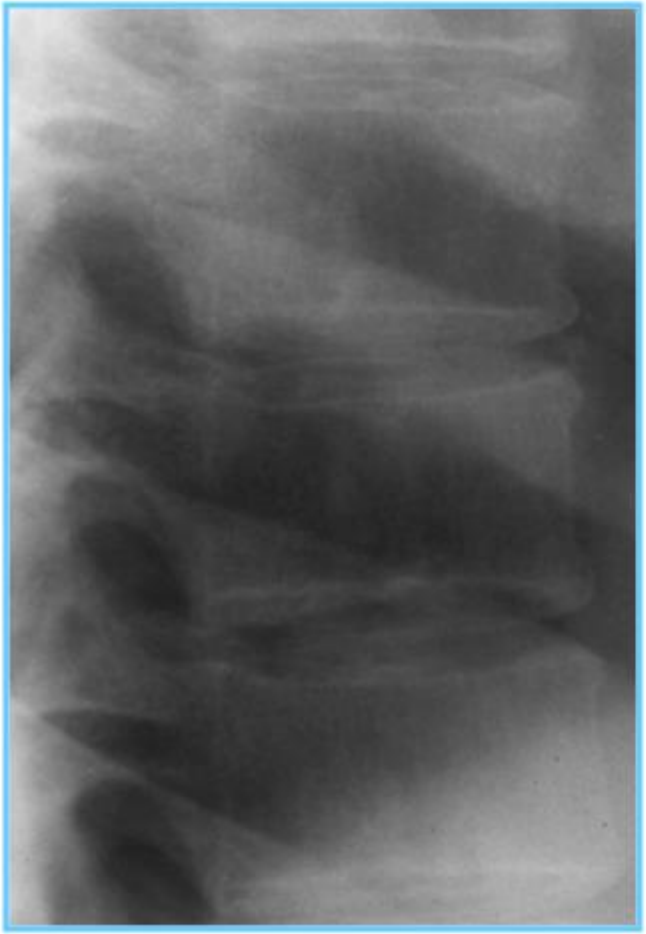
AP view may add useful information

Technical considerations

Orthograde

X-ray beam parallel to vertebral endplate

Oblique



Endplate oblique to X-ray beam causes `bean can' effect of biconcave endplates

Technical considerations

Under-penetrated

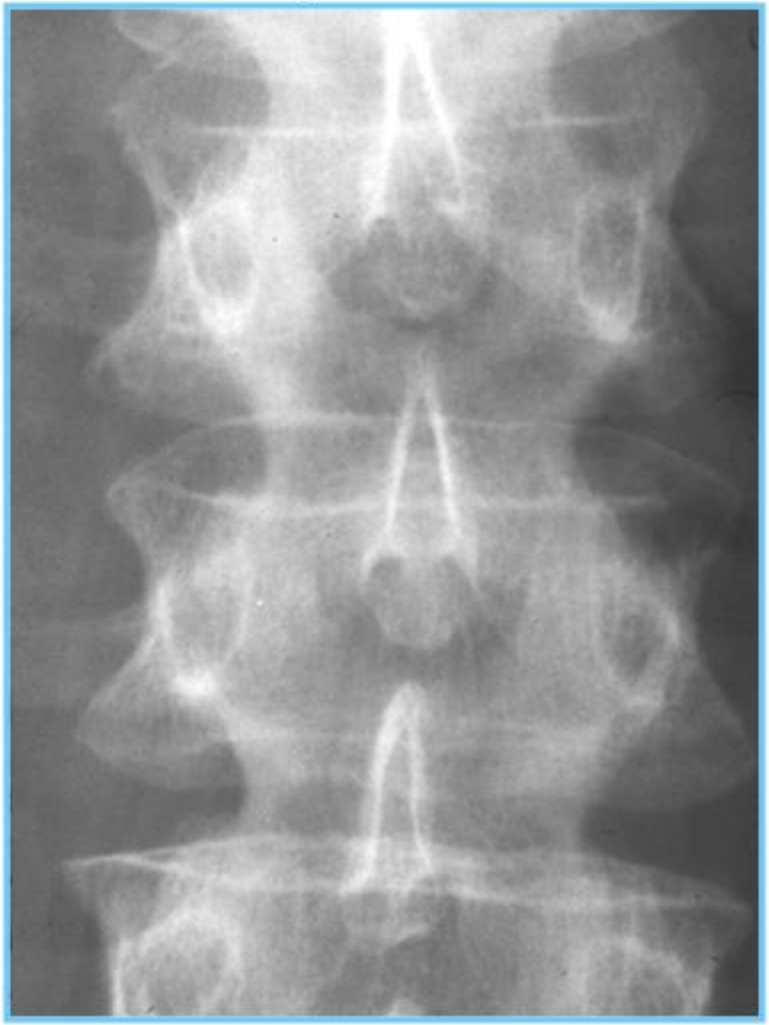
Simulates `osteosclerosis'

Over-penetrated

Simulates `osteoporosis'

Technical considerations

Under-penetrated



Simulates ‘osteosclerosis’

Over-penetrated

Simulates ‘osteoporosis’

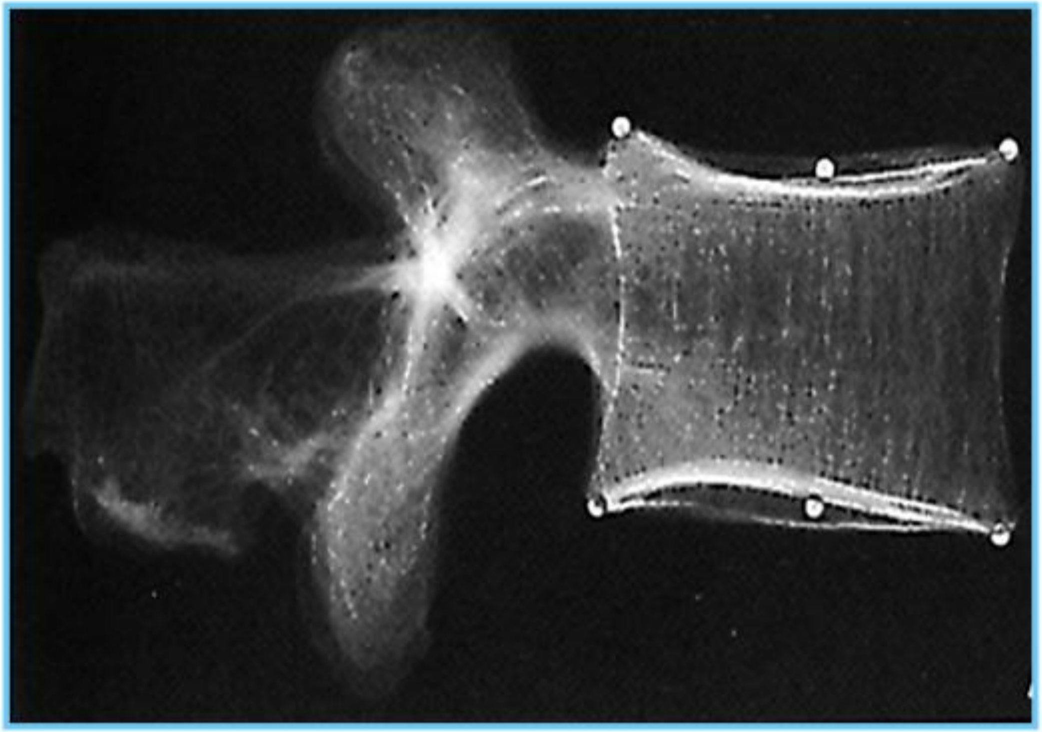
Technical considerations

Typical patient effective radiation doses for radiologic examinations

Type of exposure	Effective dose (mSv)
Thoracic spine	
AP	0.4
Lateral	0.3
Lumbar spine	
AP	0.7
Lateral	0.3
PA Chest	0.02
Pencil beam DXA (spine)	<0.001
Fan beam DXA (spine)	~ 0.01
Quantitative computed tomography (QCT): spine	0.06
Average annual natural background radiation (NBR)	2.4
Return transatlantic flight (16 hours total flight time)	~0.07

Hart D, Wall BF (2002) National Radiation Protection Board, Oxon.

Challenges in vertebral fracture assessment shape recognition



Key to visual identification of fracture and non-fracture deformity is knowledge of the normal range and variation in vertebral shape

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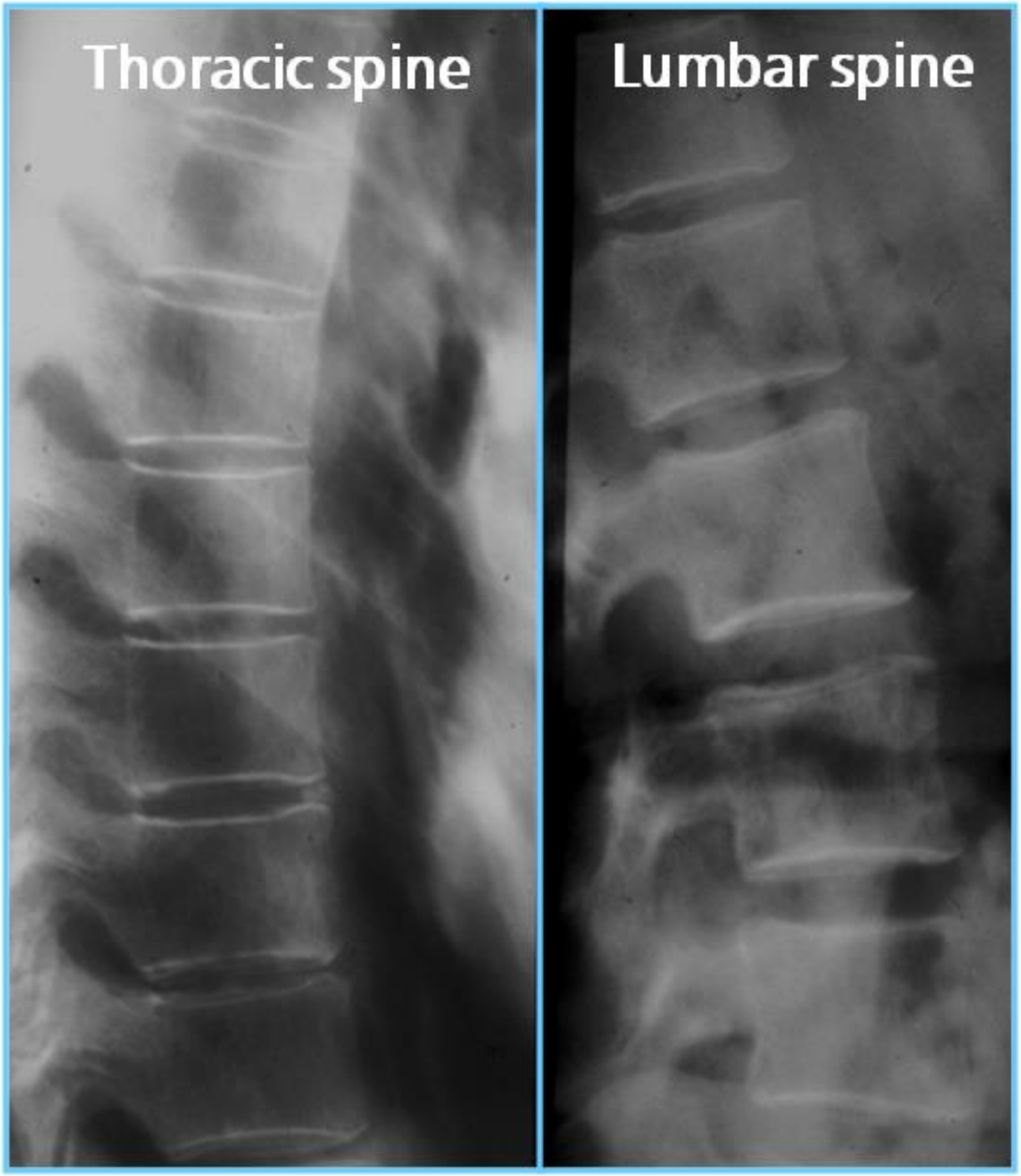
Genant HK et al. (1995) Vertebral Fracture in Osteoporosis, eds.



Note the similarity of vertebral shape and size among contiguous levels

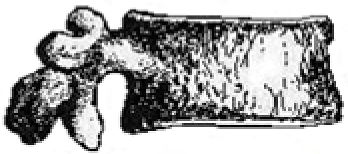
SQ

Semi-quantitative:

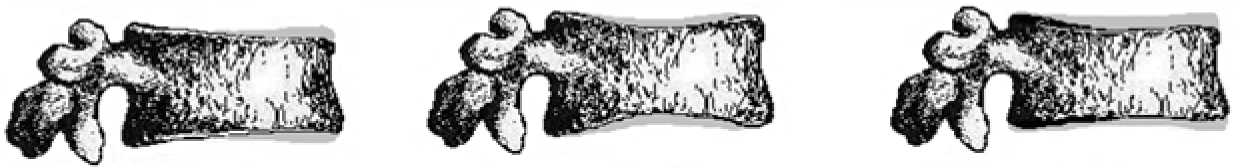
visually normal spine

Semi-quantitative visual grading of vertebral fractures

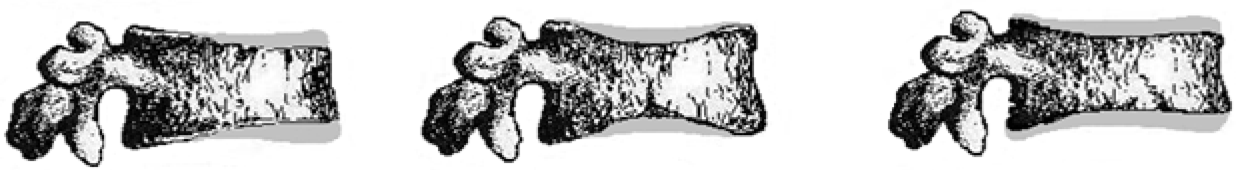
Grade 0: normal, non fractured vertebra



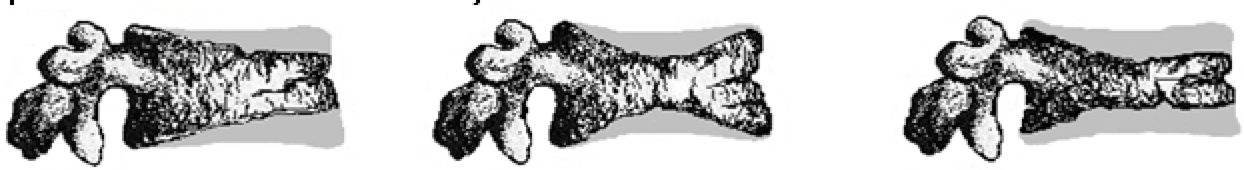
Grade 1: mild fracture with approximately 20-25% reduction in anterior, middle and posterior relative to the same or adjacent vertebrae.



Grade 2: moderate fracture with approximately 25-40% reduction in anterior, middle and posterior relative to the same or adjacent vertebrae.



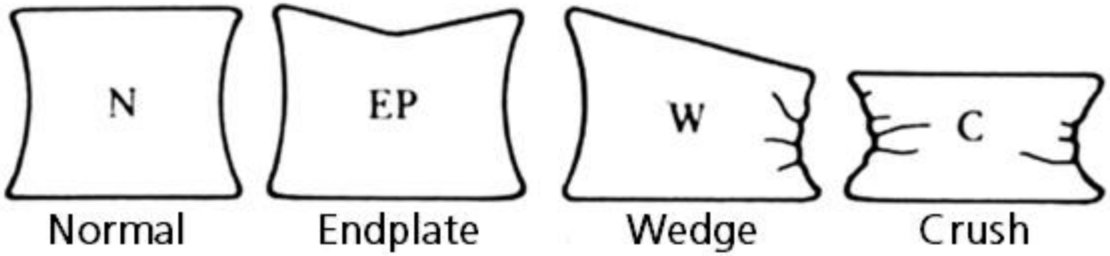
Grade 3: severe fracture with approximately >40% reduction in anterior, middle and posterior relative to the same or adjacent vertebrae.



Genant HK et al. (1993) JBMR 8(9): 1137-48

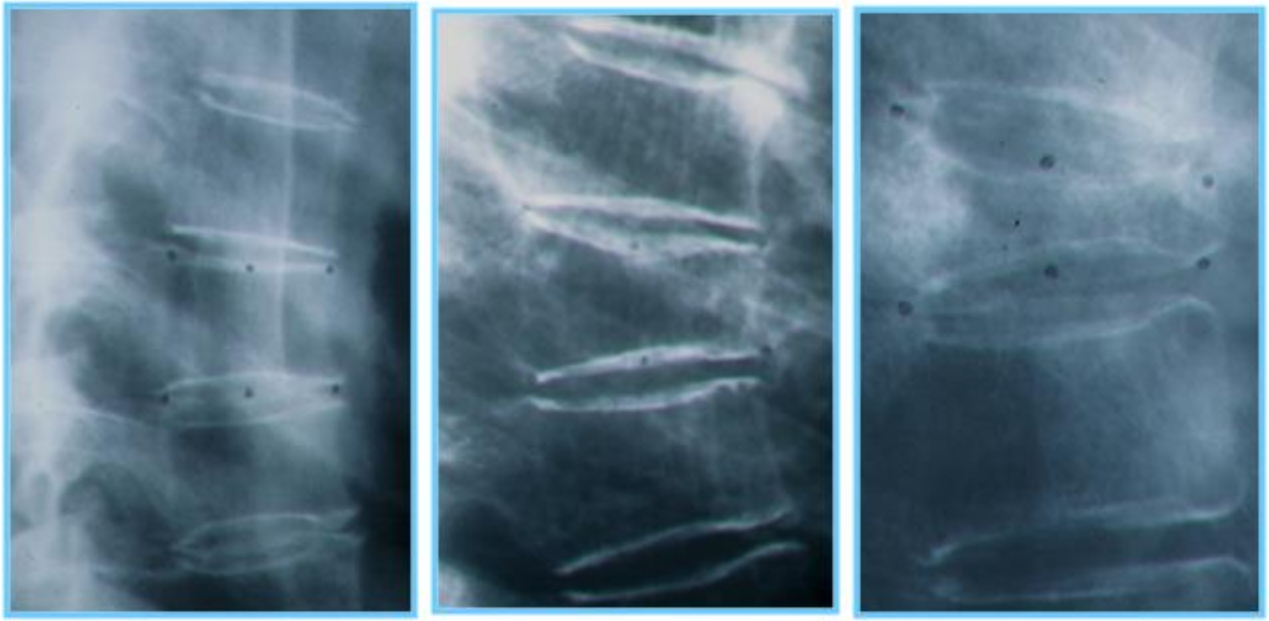
Vertebral shapes and grading

Shape



These changes in shape are often combined

% change in shape



Grade 1
~ 20-25%

Grade 2
~26-40%

Grade 3
~40% +

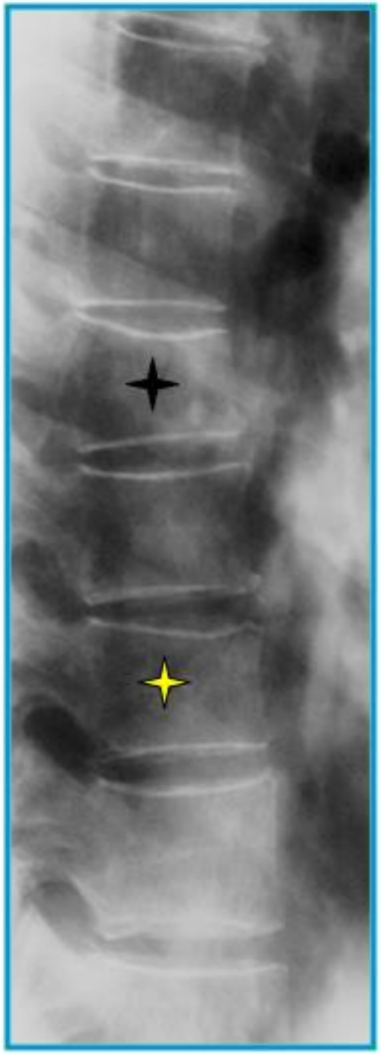
The higher the grade of fracture the higher the risk of future fracture

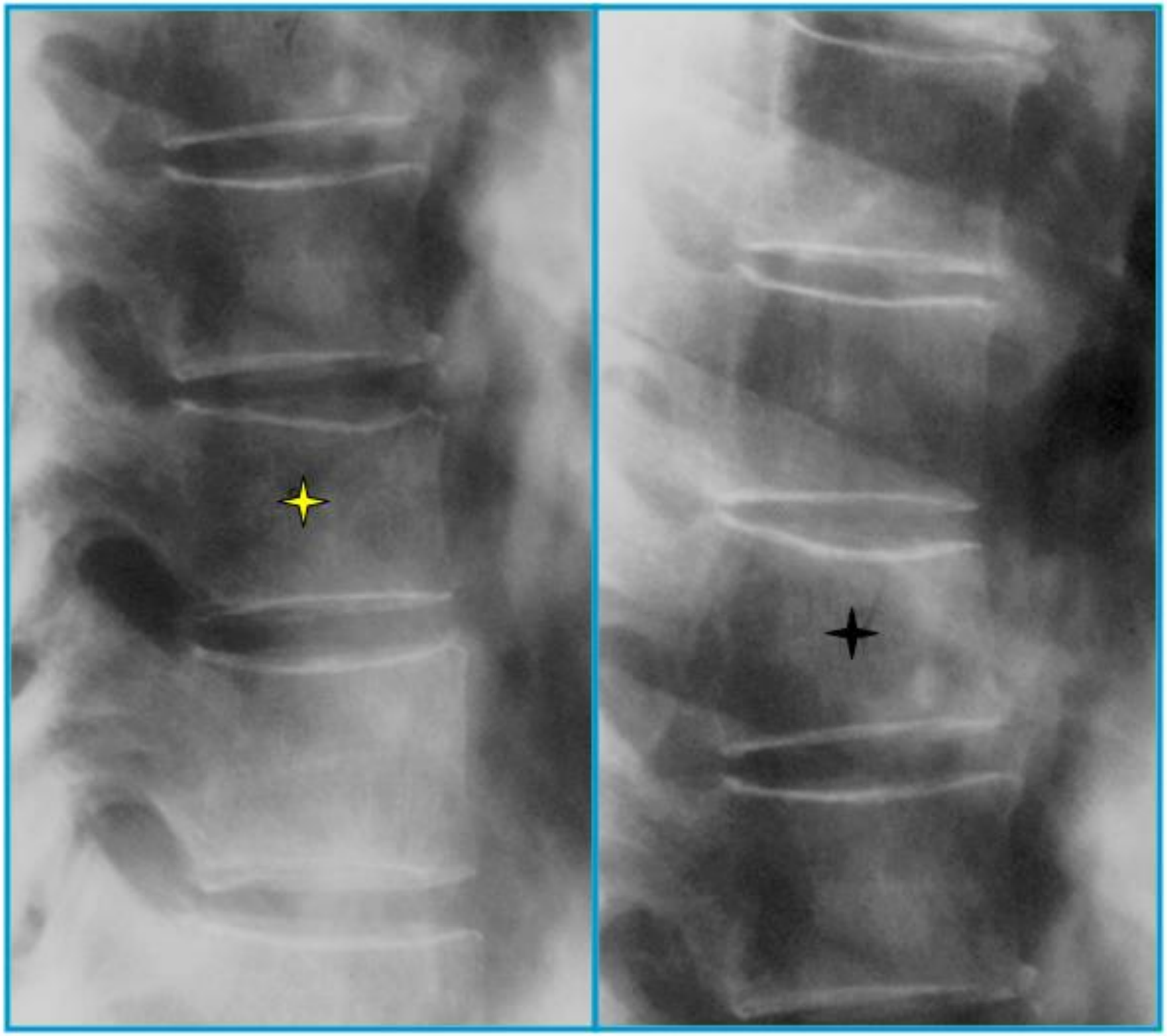
Examples of SQ vertebral fractures

Grade 0 Normal | Grade 1 Mild | Grade 2 Moderate | Grade 3 Severe

SQ mild fractures

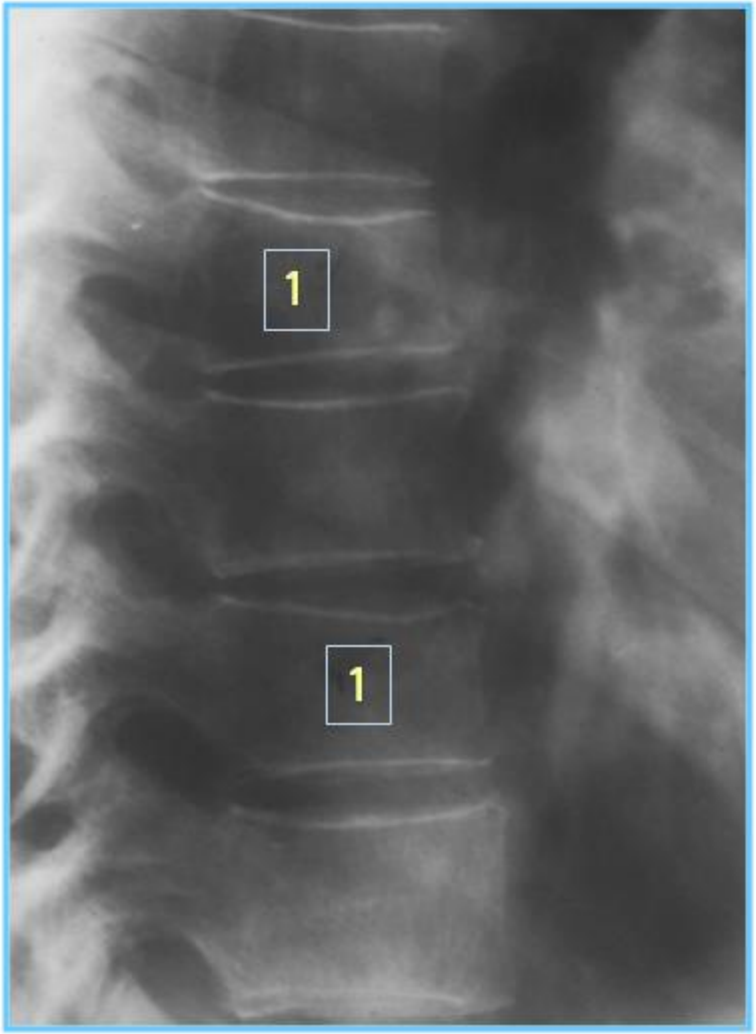
Loss of contiguity and parallelism of adjacent endplates



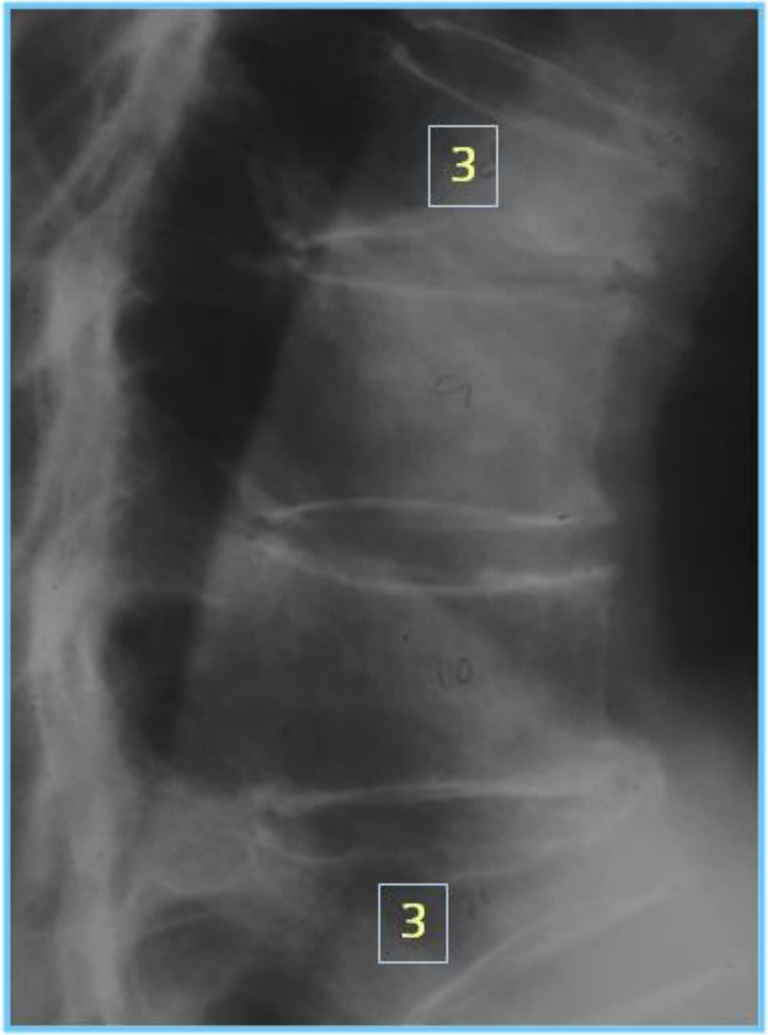


SQ mild vs. severe fractures

Mild



Severe



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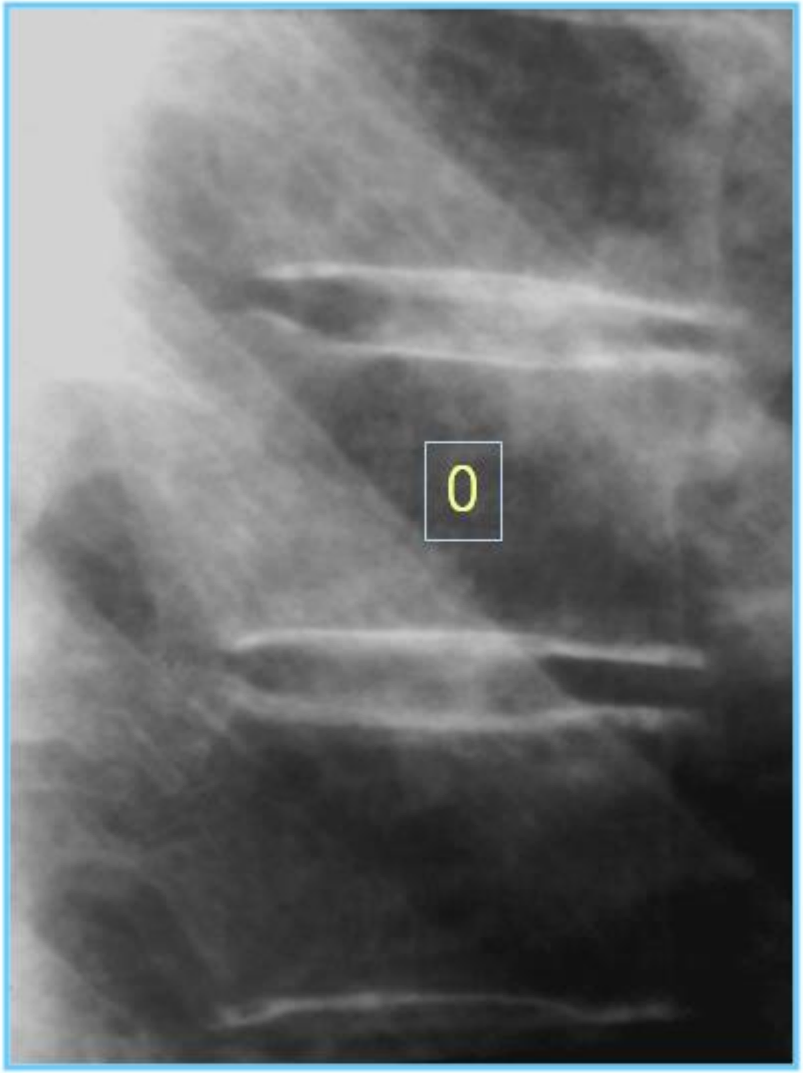
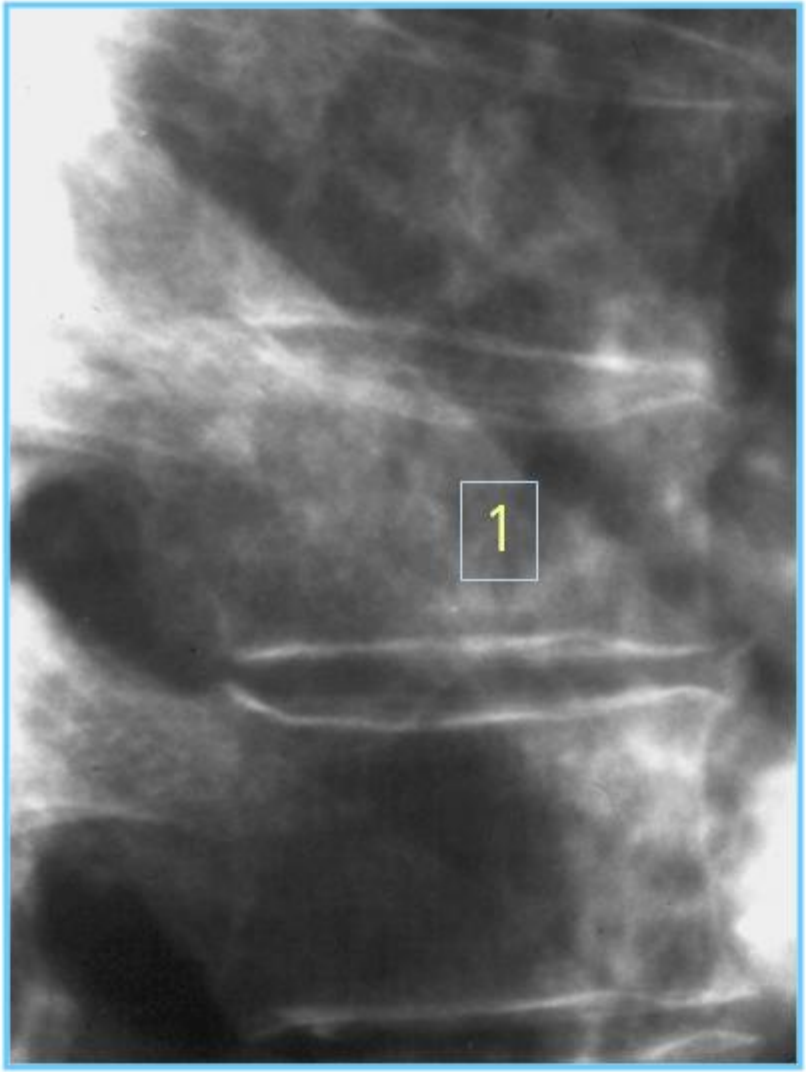
SQ incident mild fracture





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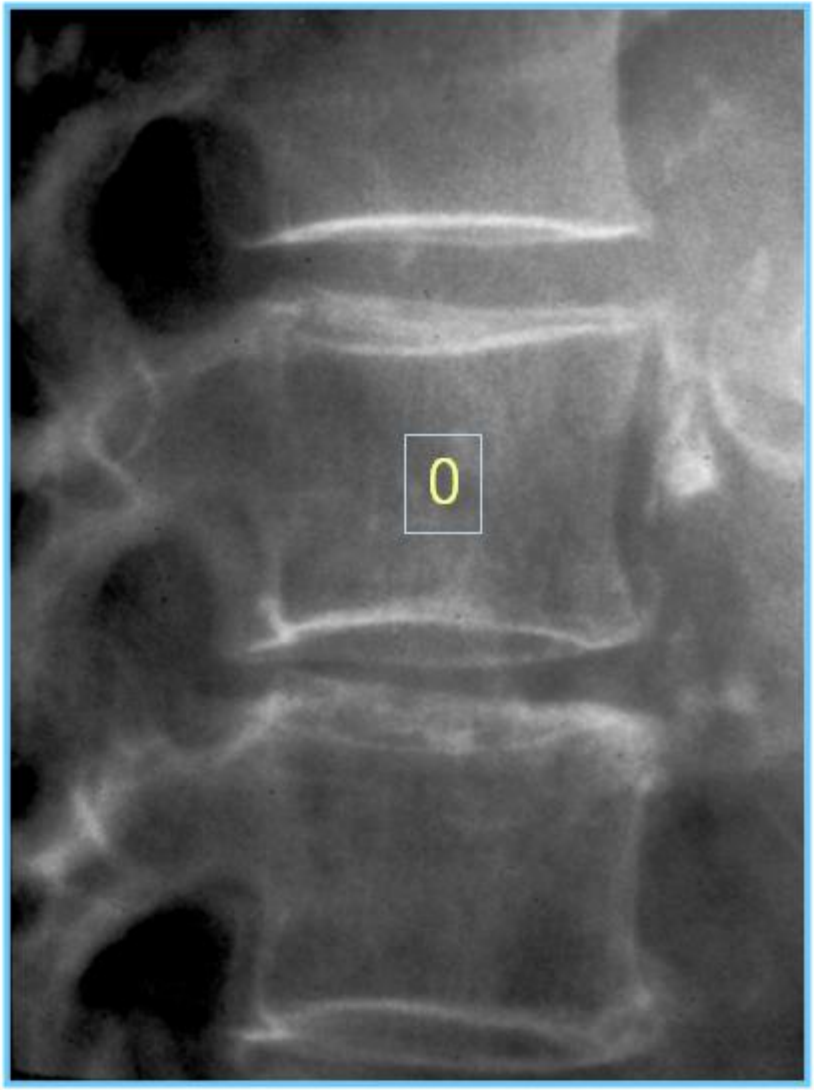
SQ incident moderate fracture



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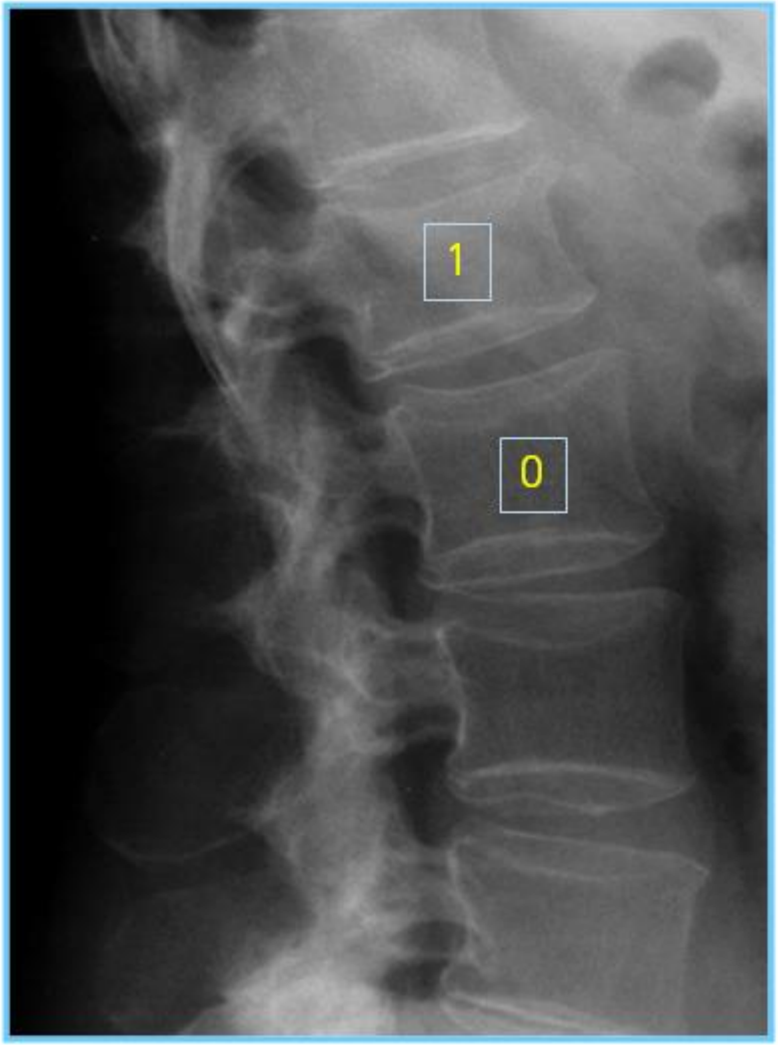
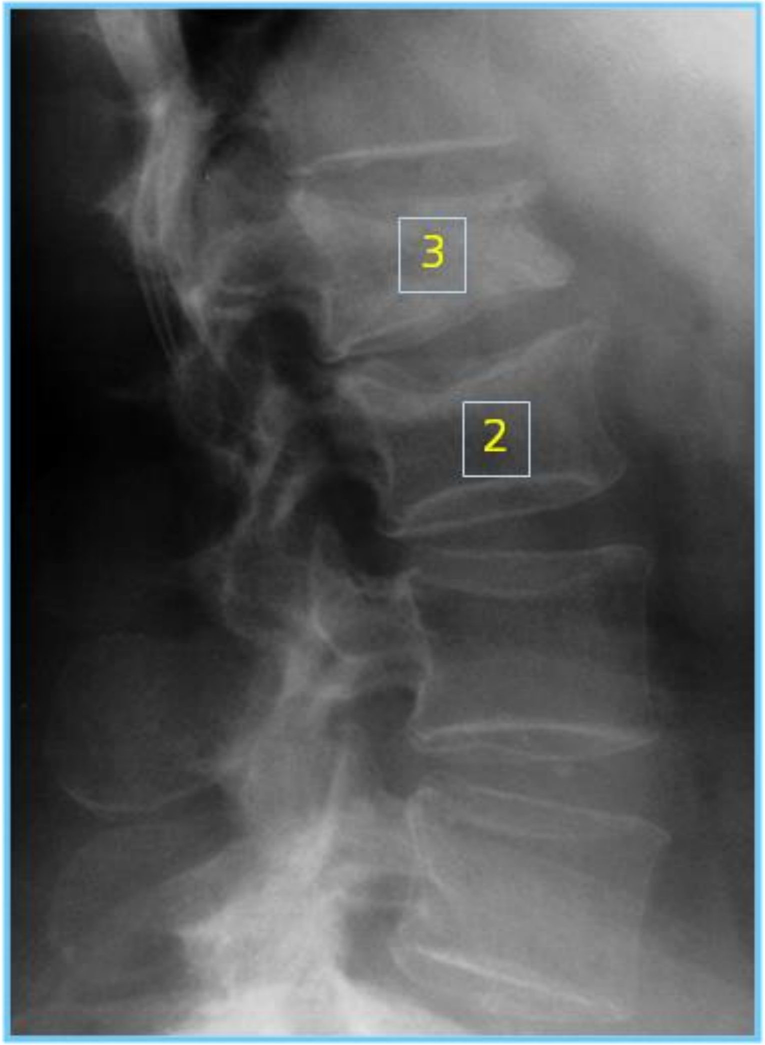
SQ incident severe & moderate fractures



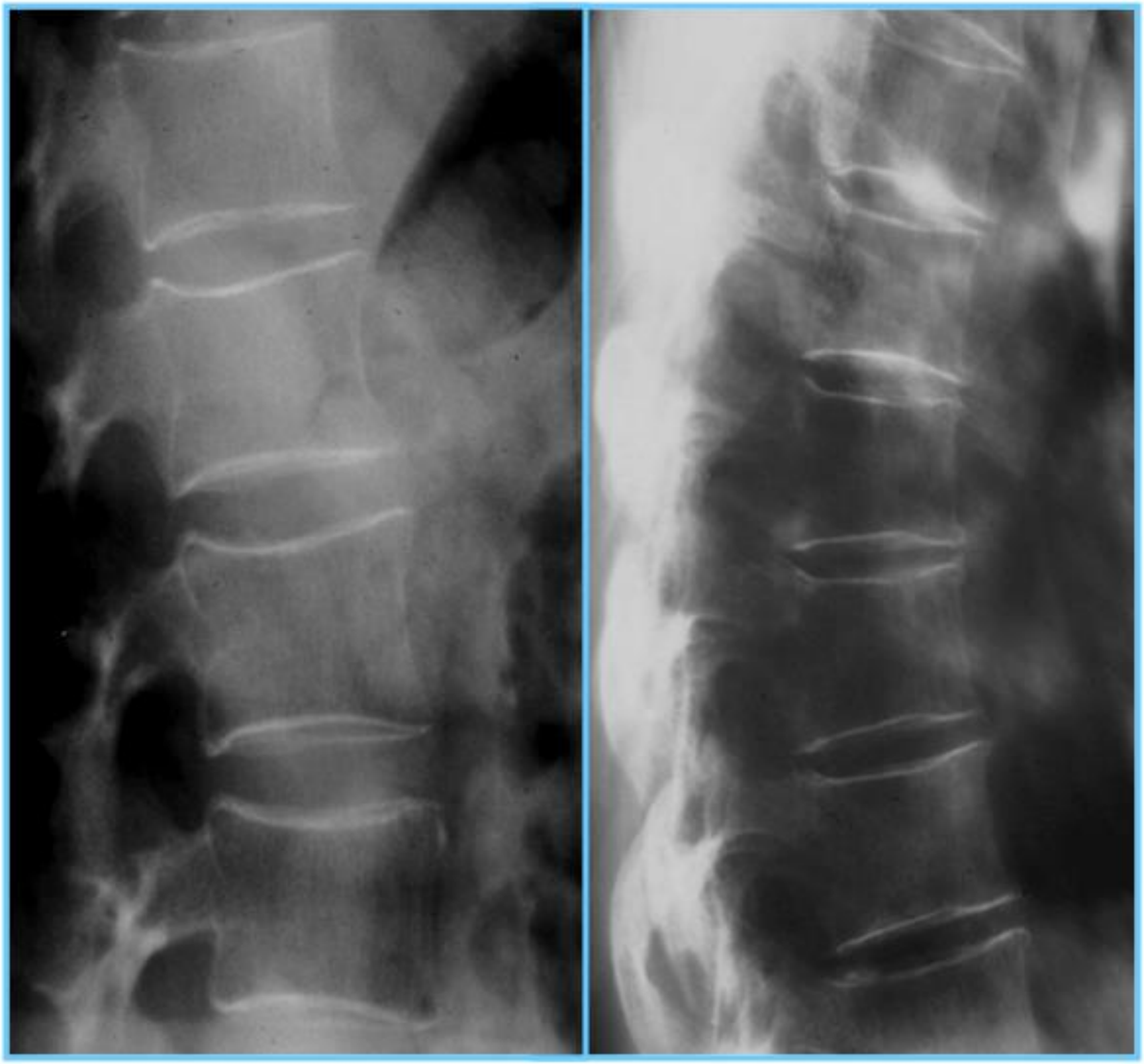


Radiographic `osteoporosis' and `osteopenia'

Differential diagnosis

- Post-menopausal
- Osteomalacia
- Hyperparathyroidism
- Hypercortisolism
- Hyperthyroidism
- Renal insufficiency
- Chronic immobilization
- Cystic Fibrosis
- Osteogenesis imperfecta
- Hepatic insufficiency
- Celiac Disease
- Multiple myeloma
- Metastatic disease
- Drug induced

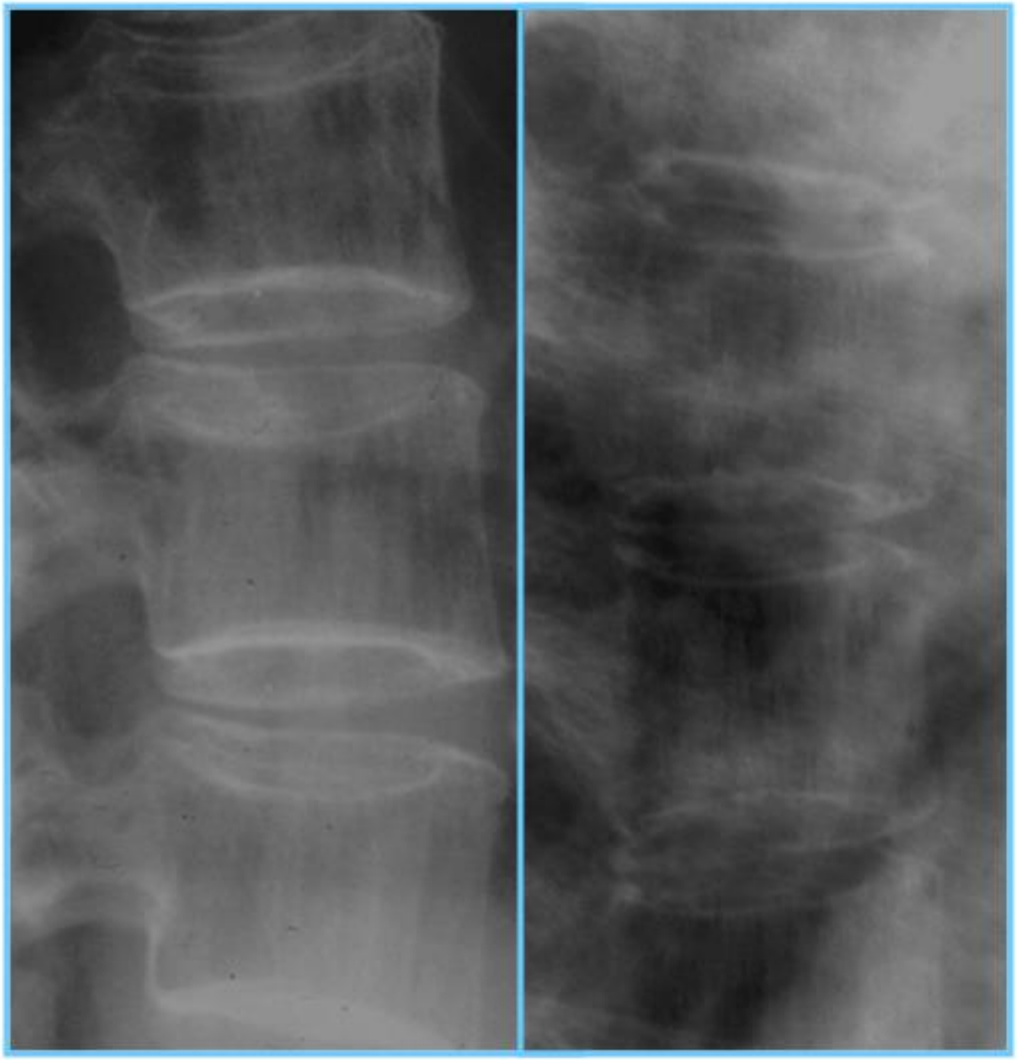
Radiographic `osteopenia' and `osteoporosis'



Osteopenia with relative accentuation of the cortical outline

If these features are present suggest central DXA bone densitometry

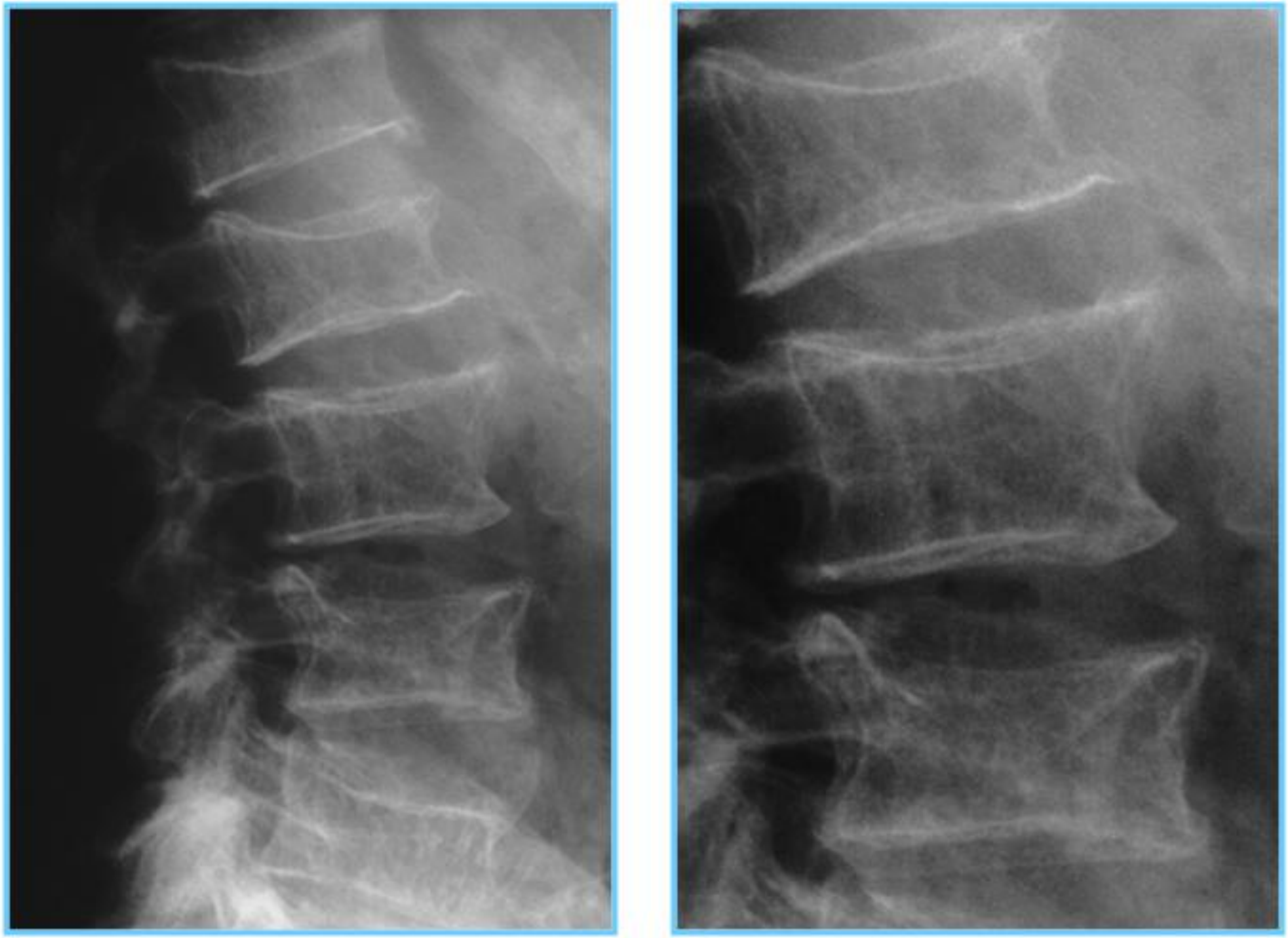
Radiographic `osteopenia' and `osteoporosis'



Prominent vertical trabecular giving striated appearance

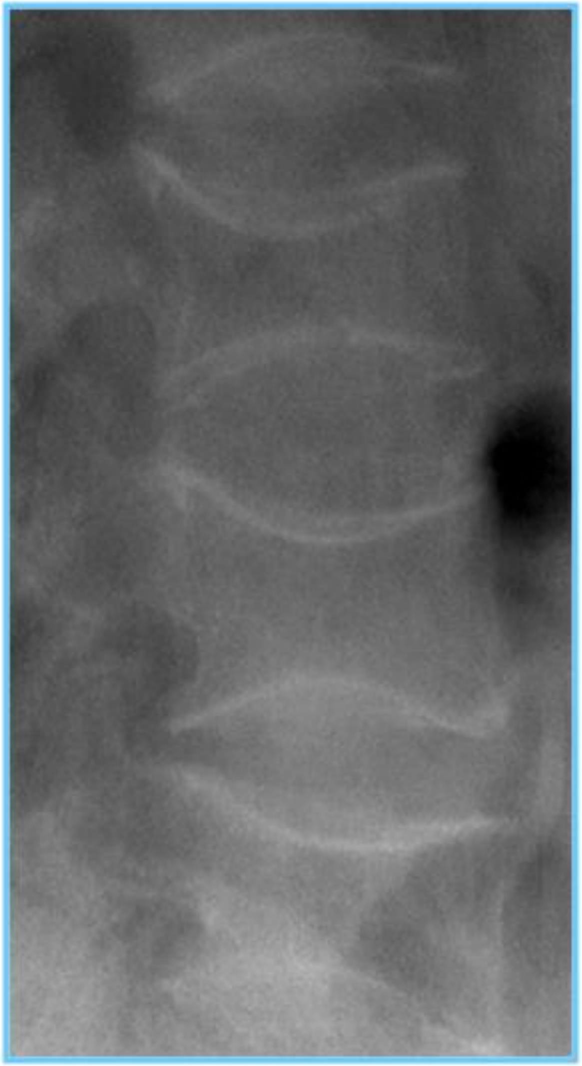
If these features are present suggest central DXA bone densitometry

Post-menopausal osteoporotic fractures



Severe radiographic osteoporotic vertebral fractures at multiple levels

Severe osteomalacia

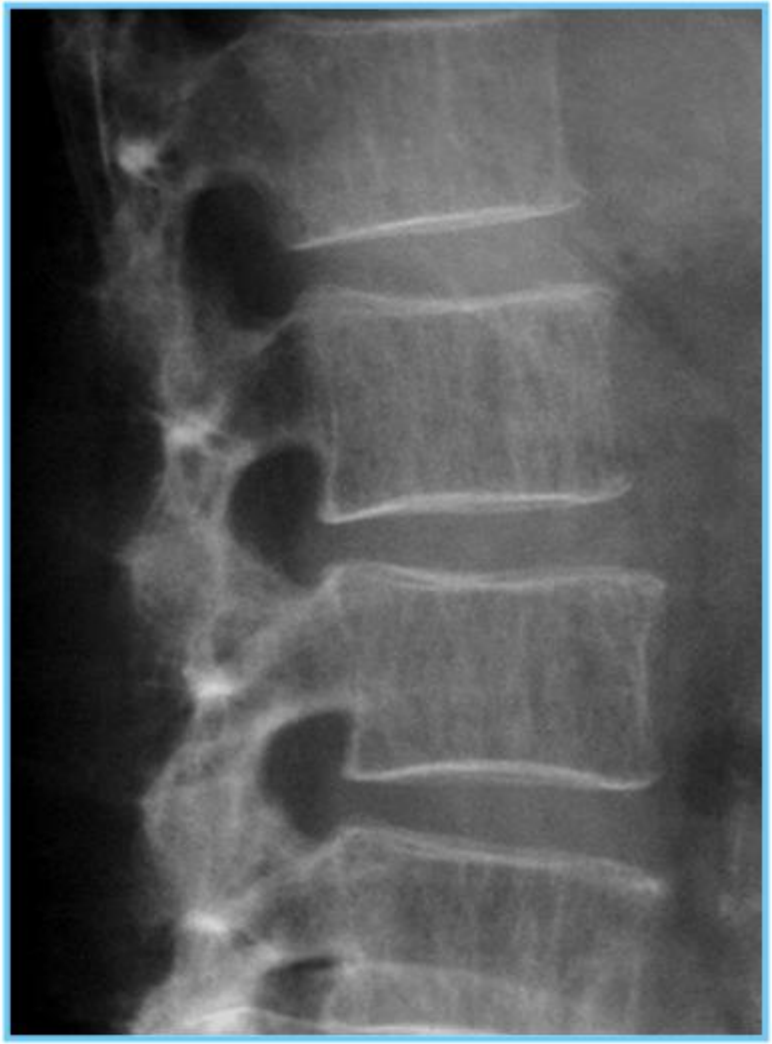


The severely osteomalacic bone is soft and bends giving biconcave endplates ['cod-fish' vertebrae]

Glucocorticoid-induced osteoporosis with vertebral fractures

Marginal condensation of the endplates from impaction and exuberant callus formation, seen only in extreme cases

Multiple myeloma



Severe radiographic 'osteoporosis' with multiple subtle lytic radiolucencies

Other imaging methods or analyses

- Quantitative Morphometry (QM)
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Dual-energy X-ray Absorptiometry (DXA)

Roles:

- To facilitate detection and/or grading of vertebral fracture
- To confirm if vertebral fracture is old, new or due to pathology other than osteoporosis (MRI)

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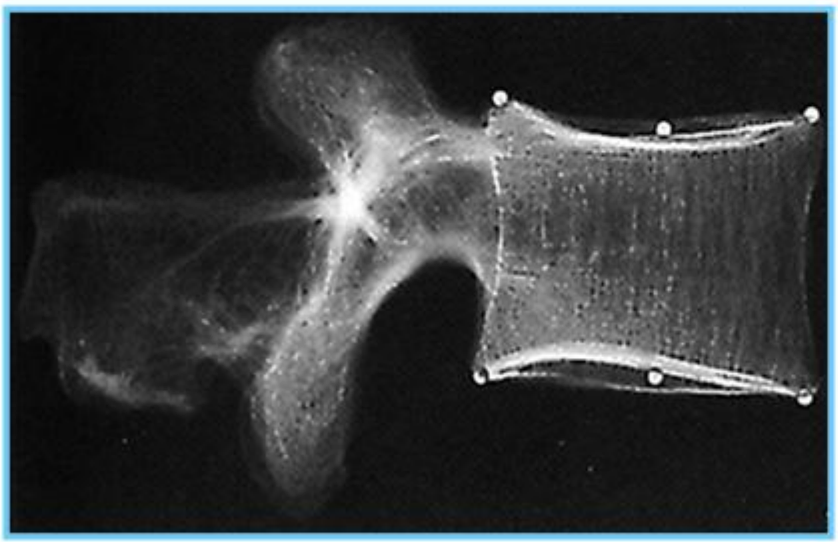
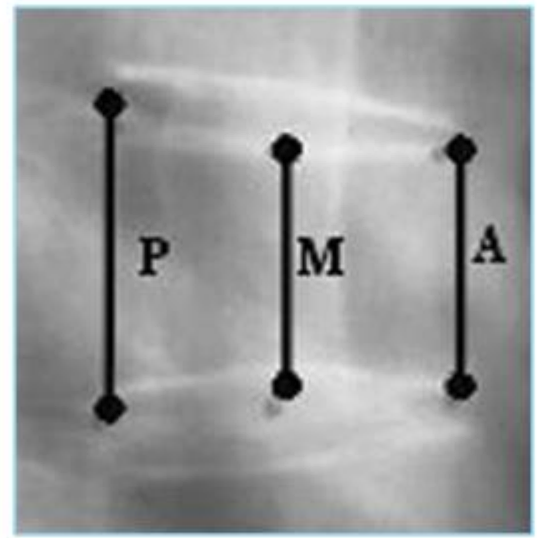
Link TM et al. (2005) Europ Radiol 15: 1521-1532

Quantitative Morphometry (QM) with six-point placements on radiographs



Shape of the vertebra is defined by placing six points on superior and inferior endplate at the front, mid and posterior margins.



The anterior (A), middle (M) and posterior (P) heights and various ratios calculated.

QM with six-point placements on radiographs

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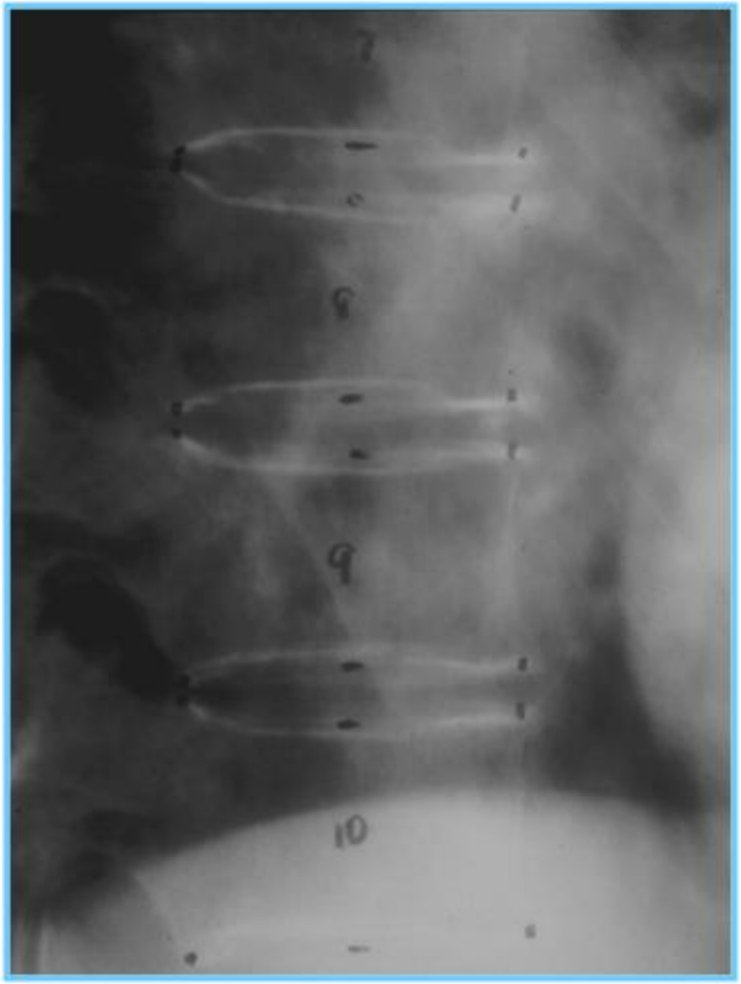
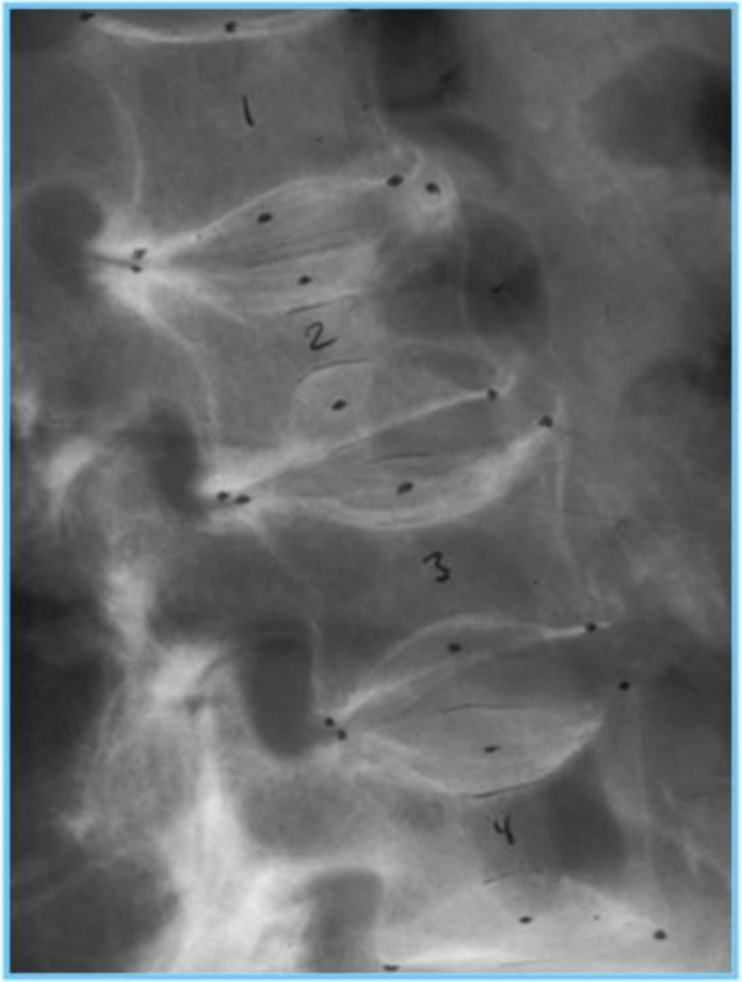
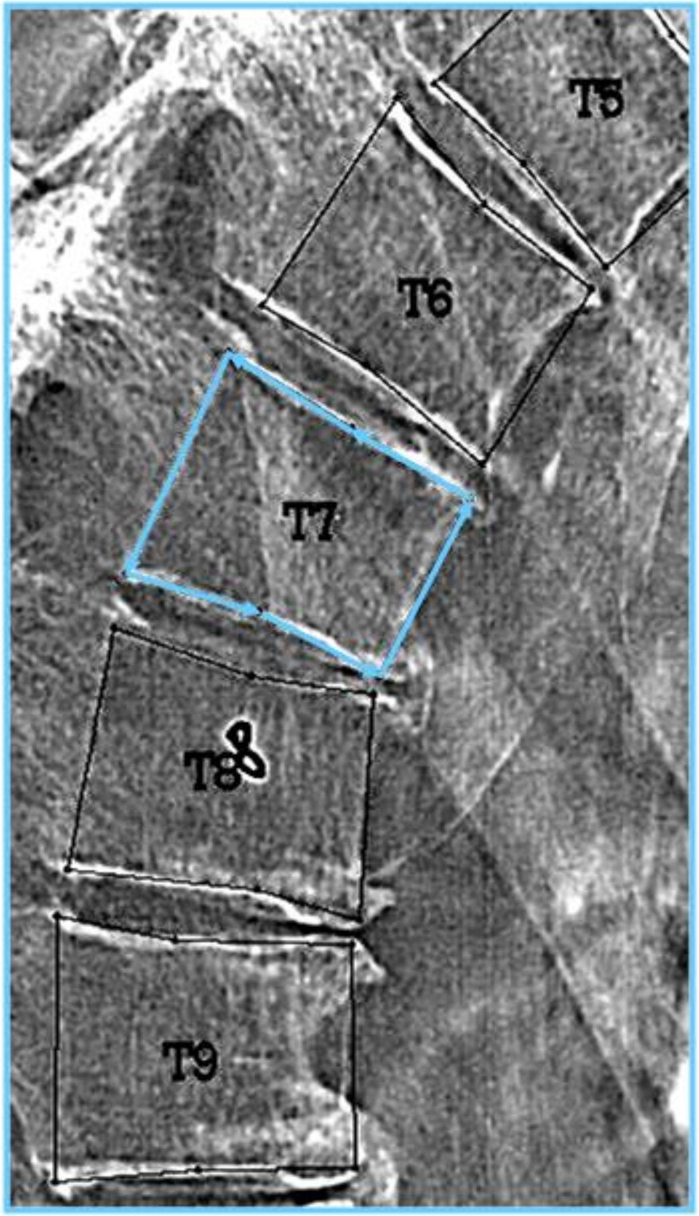


Easy point placement



Difficult point placement



Six-point video-assisted quantitative morphometry using electronic imaging

QM is used routinely in clinical research and selectively in clinical practice to confirm and grade suspected vertebral fractures

Multi-slice computed tomography in diagnosis and characterization of vertebral fracture

Fractures

No fractures

Multi-Detector Computed Tomography (MDCT)

Fractures in midline sagittal reformations

Courtesy of T Link, University of California, San Francisco

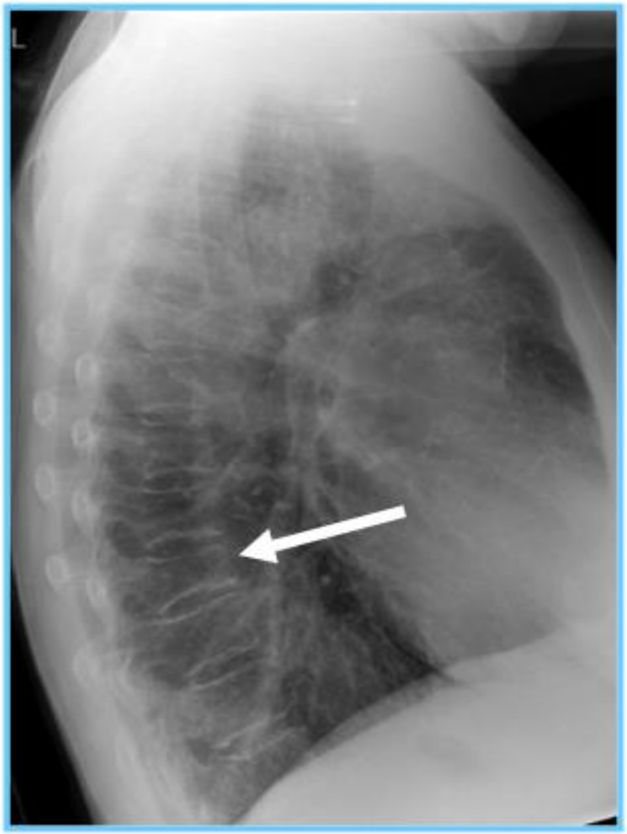
Multiple myeloma

Lateral thoracic spine radiograph and midline sagittal spine reformation MDCT showing diffuse lytic areas with vertebral fractures and destruction of cortical margins, a sinister feature in vertebral fractures

Fortuitous identification of vertebral fractures in whole body CT

In patients having MDCT of thorax and/or abdomen for other clinical reasons routine midline sagittal reformations will identify vertebral fractures not suspected clinically and not evident on transverse axial sections

Fortuitous identification of vertebral fractures in chest radiography



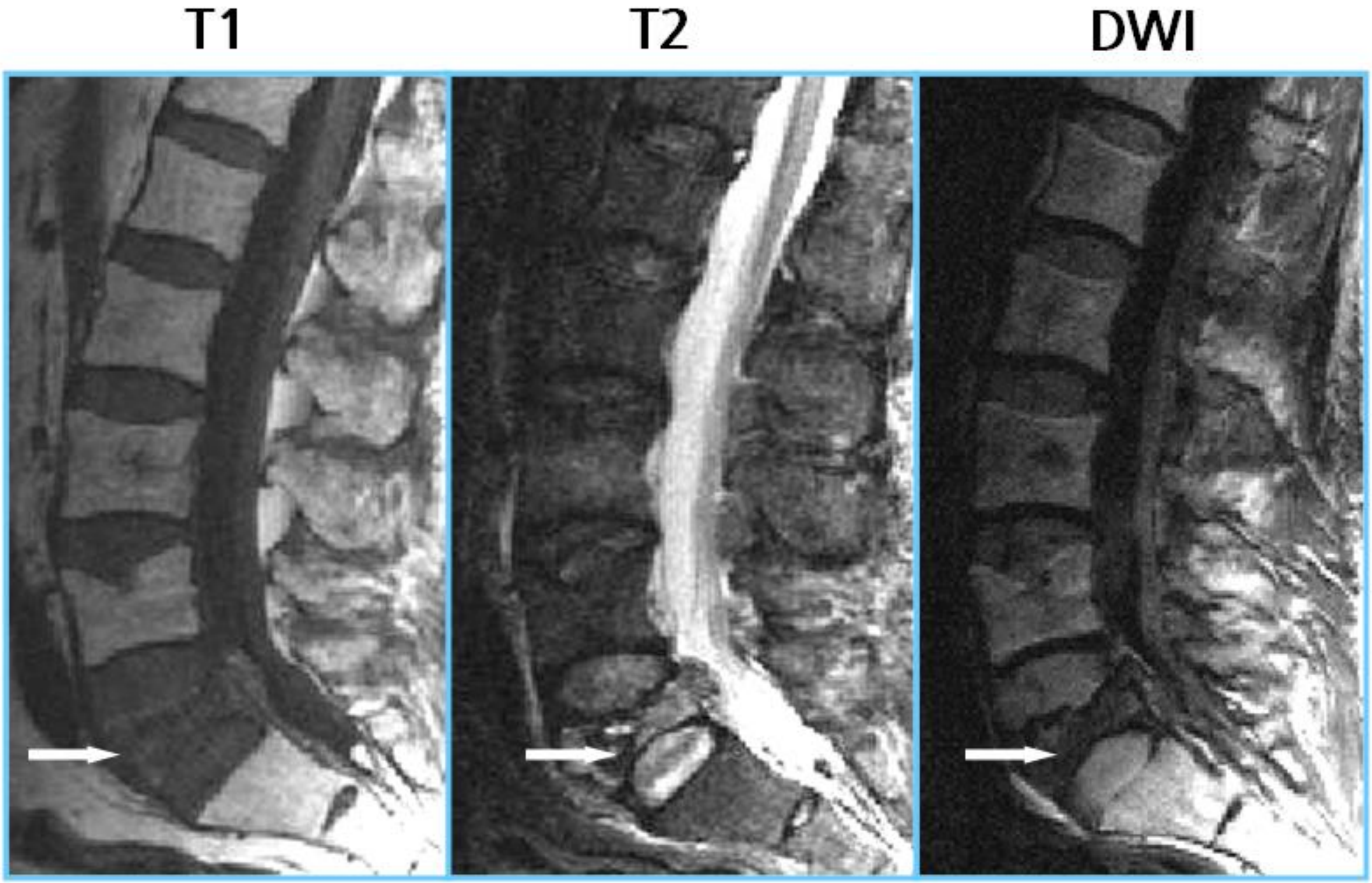
Lateral chest radiograph with Grade 2 moderate fracture lower thoracic spine

MRI assessment of vertebral fractures - differentiation of malignant versus benign vertebral fracture

Benign vertebral fractures/deformities in MRI

- Abnormal signal is parallel to fracture
- Flat posterior borders of fractured vertebrae
- Other vertebral deformities have normal signal
- Para-vertebral soft tissue mass is rare
- Normal signal in non-fractured vertebrae
- Abnormal signal of fractures stabilizes in months
- Low signal on diffusion-weighted images (DWI)

Benign fracture on sagittal MRI



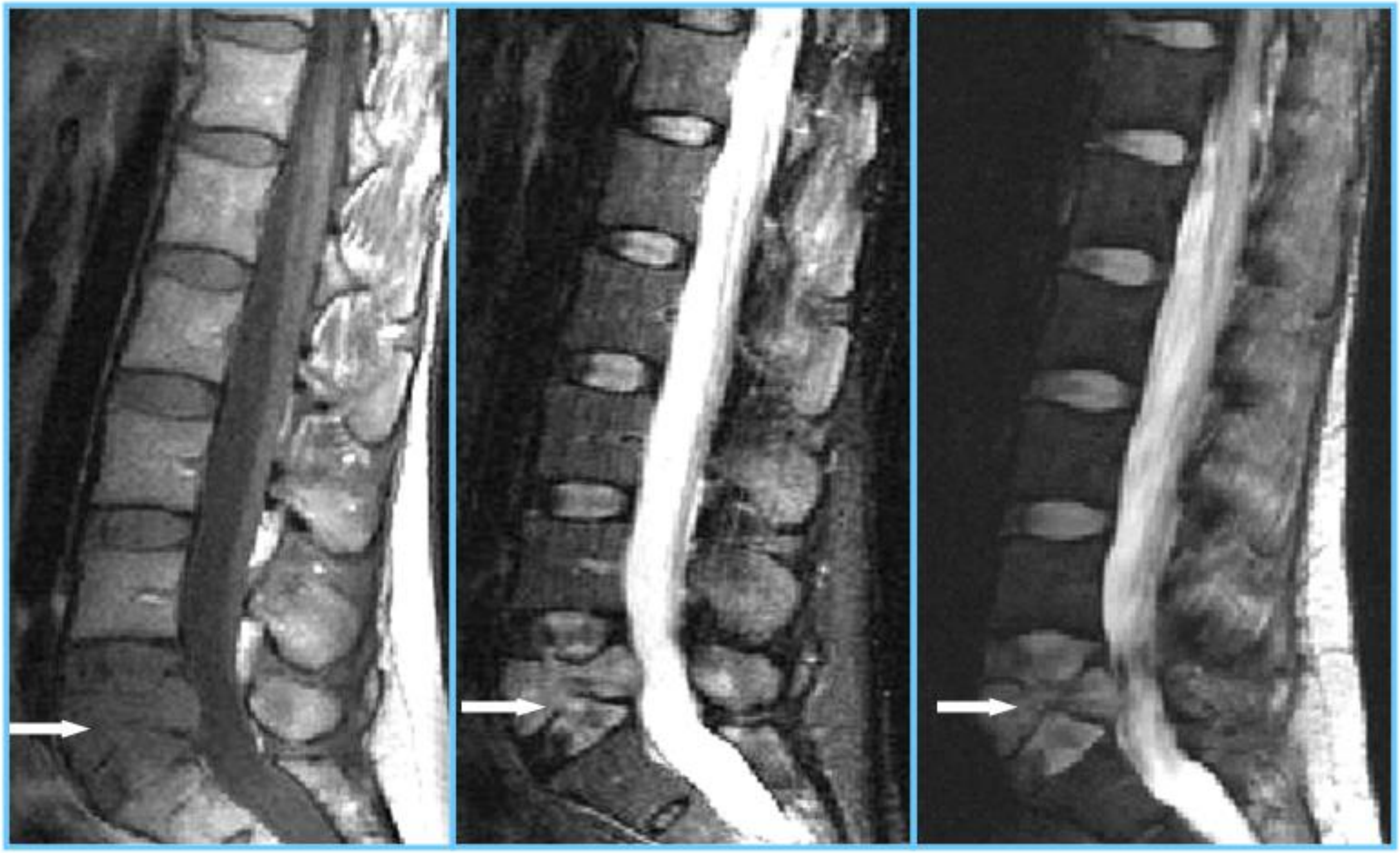
Courtesy Andrea Baur-Melnyk, Ludwig Maximilian University of Munich, Germany

Malignant vertebral fracture on MRI

- Abnormal signal in non-fractured vertebrae
- Abnormal signal of entire fractured vertebrae
- Convex posterior border of fractured vertebra
- No vertebral deformities with normal signal
- Occasional para-vertebral soft tissue mass
- Abnormal signal progresses to destruction
- High signal on diffusion weighted images (DWI)

Malignant fracture on sagittal MRI

T1 T2 DWI



Courtesy Andrea Baur-Melnyk, Ludwig Maximilian University of Munich, Germany

Multiple metastases by MRI

- Pathological fracture of T11
- Posterior bulging of posterior margin
- Sinister feature in atraumatic vertebral fracture

- T2 weighted sagittal MRI scan
- Heterogenous signal intensity of other vertebrae

Differential diagnosis between fractures and deformities

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Vertebral fracture versus deformity

- All vertebral fractures cause deformity (change in shape) of vertebrae
- Not all changes in vertebral shape (deformities) are vertebral fractures

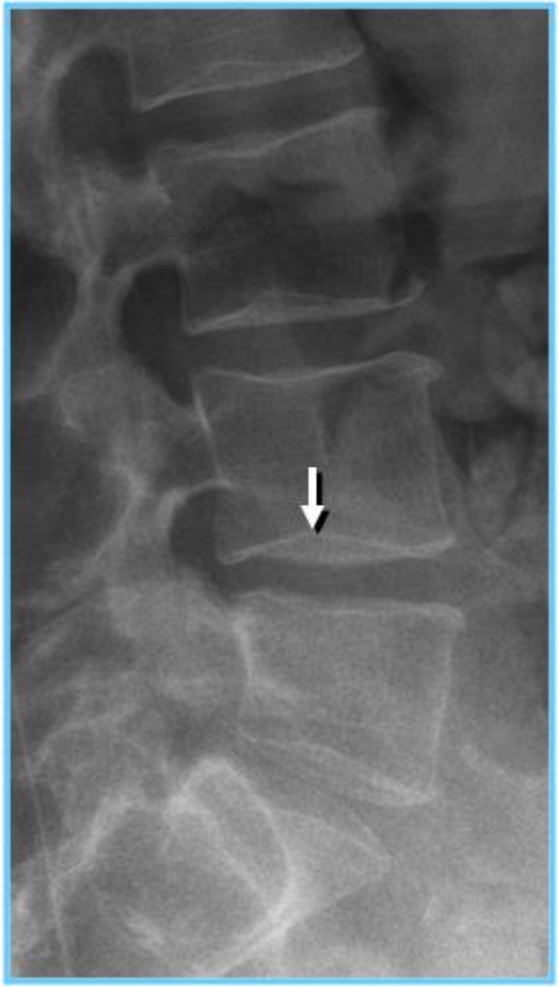
Important that fractures are differentiated from deformities.
Clear and unambiguous words must be used in reports
(e.g. fractures, not collapse etc)

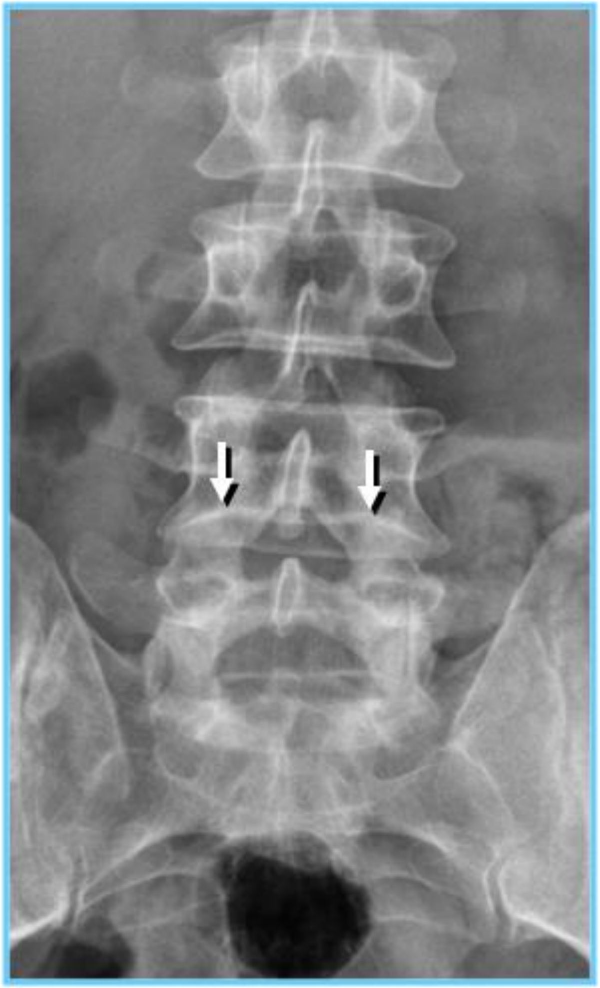
Differential diagnosis of changes in the shape of vertebral bodies

Vertebral fractures	Vertebral deformities
• **Osteoporotic** (low trauma) • **Traumatic** • **Pathological** (neoplastic, hemopoietic diseases and infections)	• **Developmental** (short vertebral height, 'butterfly' vertebra and other abnormalities of spinal segmentation, `block' vertebrae) • **Normal variants** (`cupid's bow', anterior step deformity) • **Scheuermann's disease** (osteochondritis) • **Spondylosis** (degenerative disc disease) • **Metabolic** (osteomalacia, Paget's disease)

Deformities

Developmental anomalies





Cupid's bow (arrows): smooth curvature inferior L4 endplate

Deformities
Congenital anomalies

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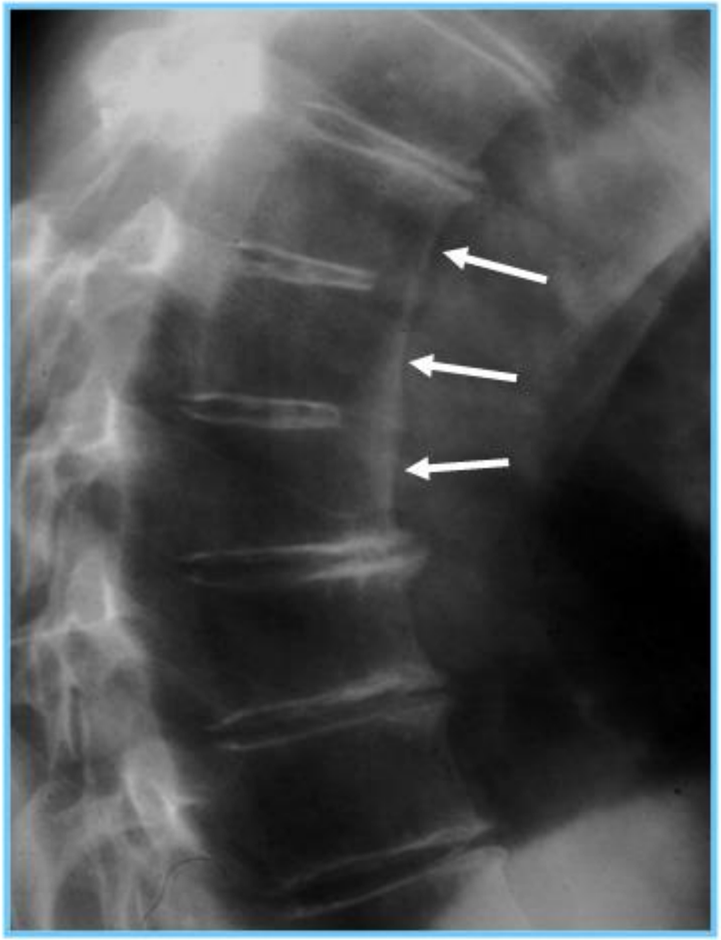
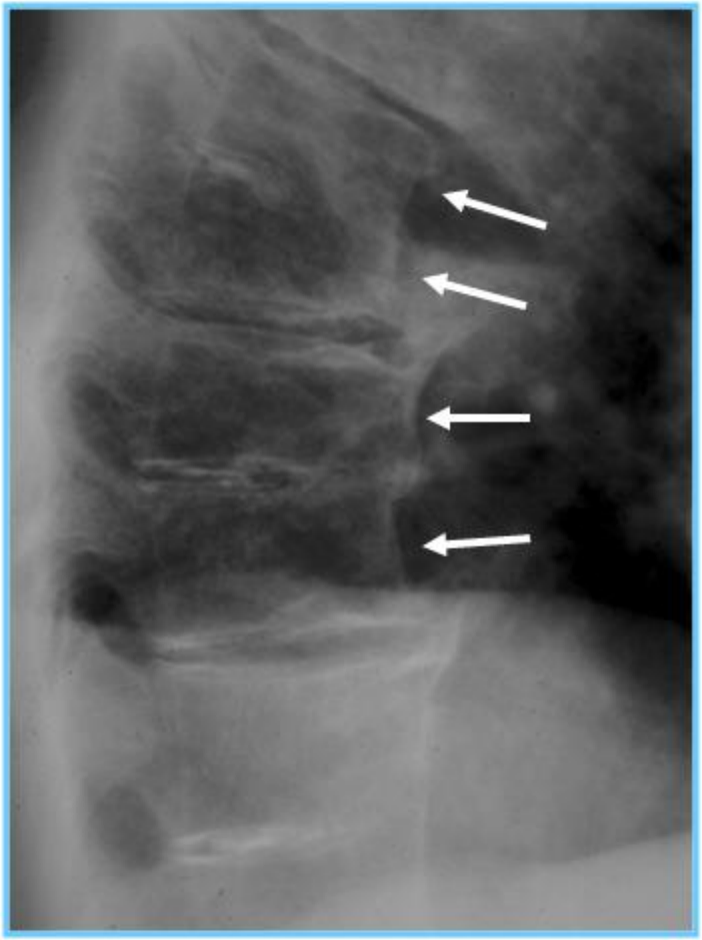
Notochordal remnant

'Block' vertebrae
with vestigial disc space

Deformities

Congenital anomalies - Fusion

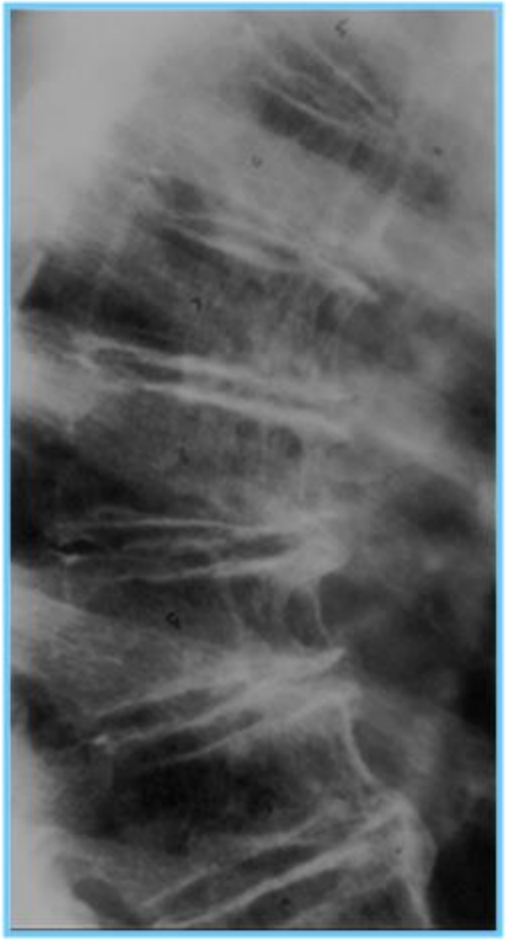




Acquired deformities

Scheuermann's diseases
Numerous adjacent vertebrae elongated & wedged, irregular endplates, Schmorl's nodes, kyphosis

Schmorl's nodes
Herniation of disc material tend to be anterior or posterior in endplate, with sclerotic margins



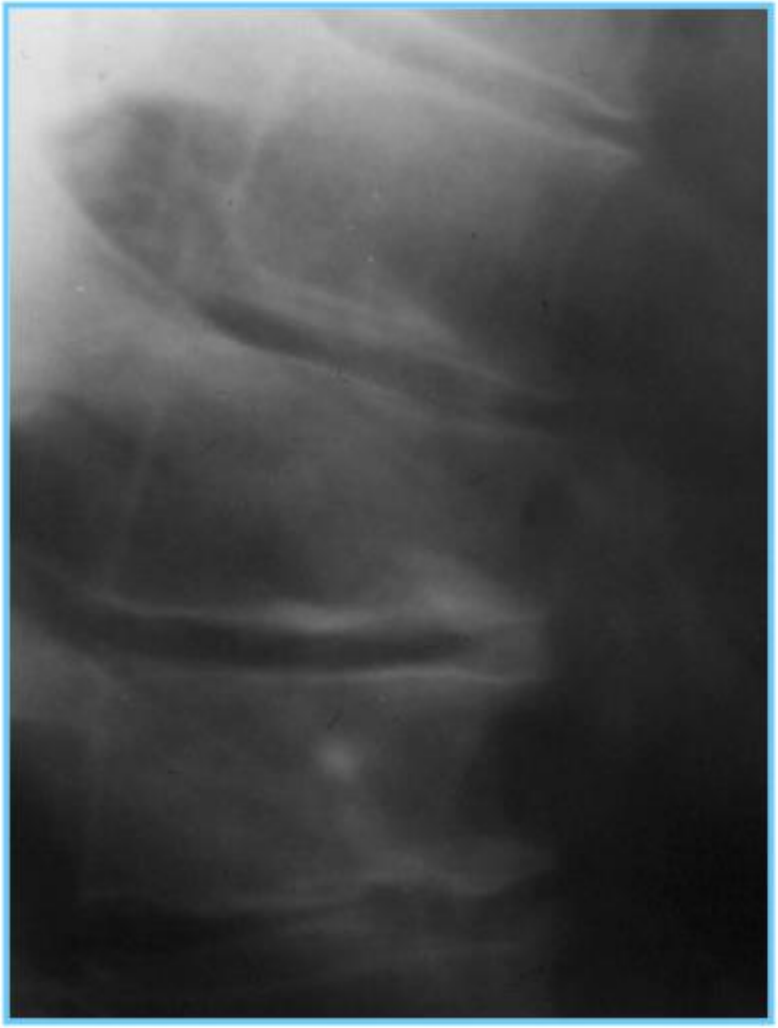
Senile spondylosis
Adjacent vertebrae elongated, wedged endplate sclerosis and osteophytosis

Acquired deformities - scheuermann's

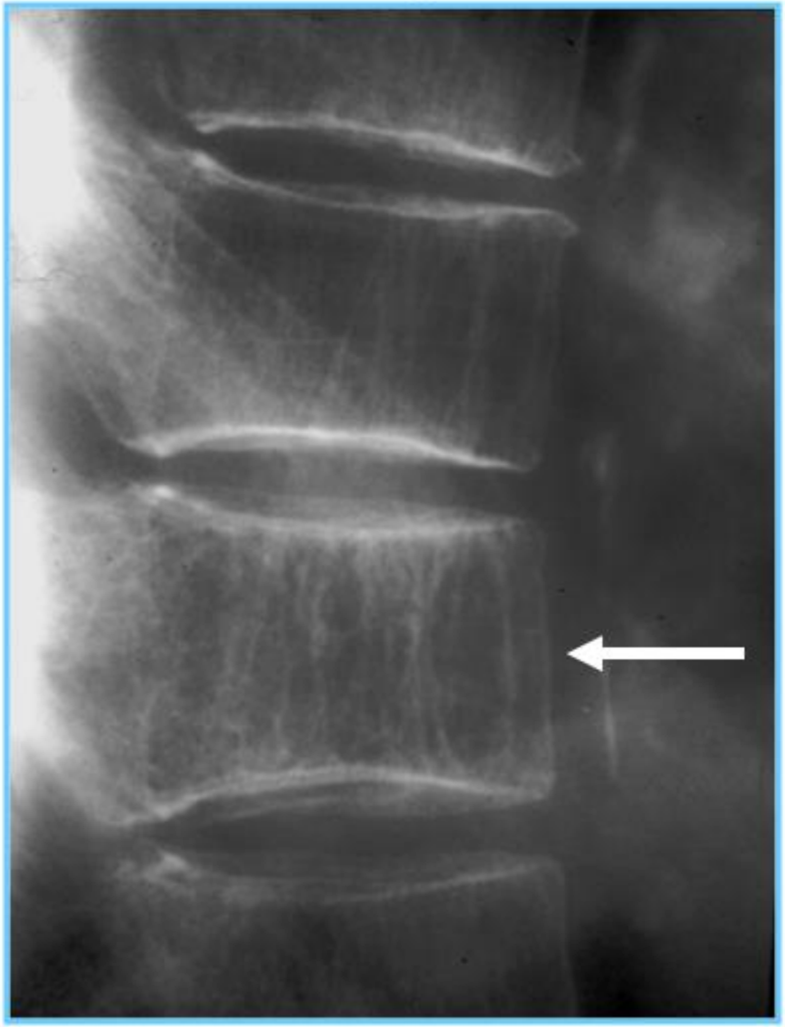
Numerous adjacent vertebrae elongated and wedged, irregular endplates, Schmorl's nodes, kyphosis

Non-osteoporotic vertebral deformities

Remote (old) trauma



Hemangioma



Algorithm-Based Qualitative (ABQ) method

- Endplate depression is central to definition of a vertebral fracture
- ABQ is a qualitative method developed to avoid labeling vertebral bodies with short vertebral height as fractured
- Reliable, reproducible on both standard radiographs and VFA images
- Predictive validity (eg prospective fracture prediction) has yet to be demonstrated and compared to the SQ method

Algorithm-based Qualitative (ABQ) Assessment

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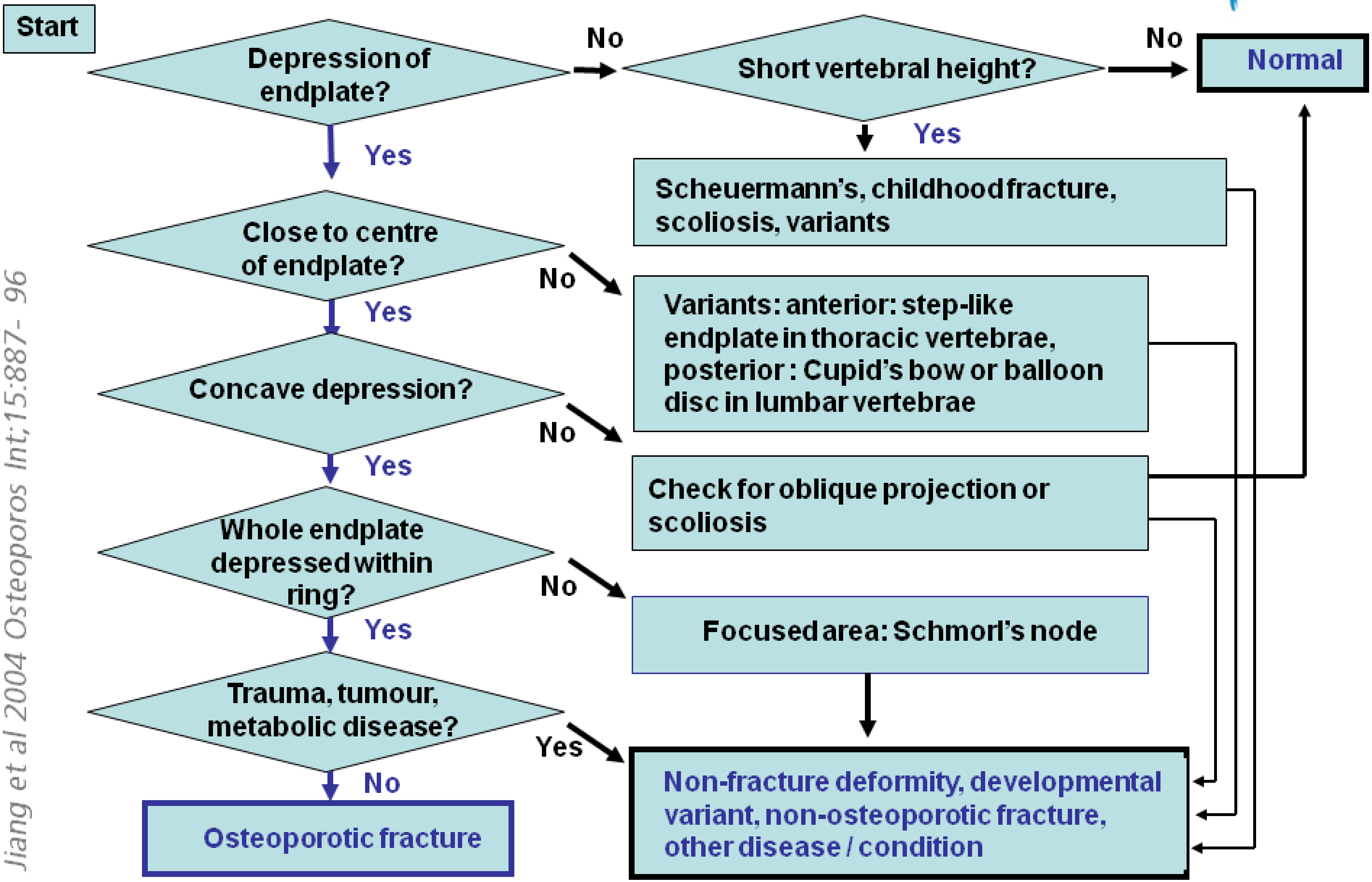
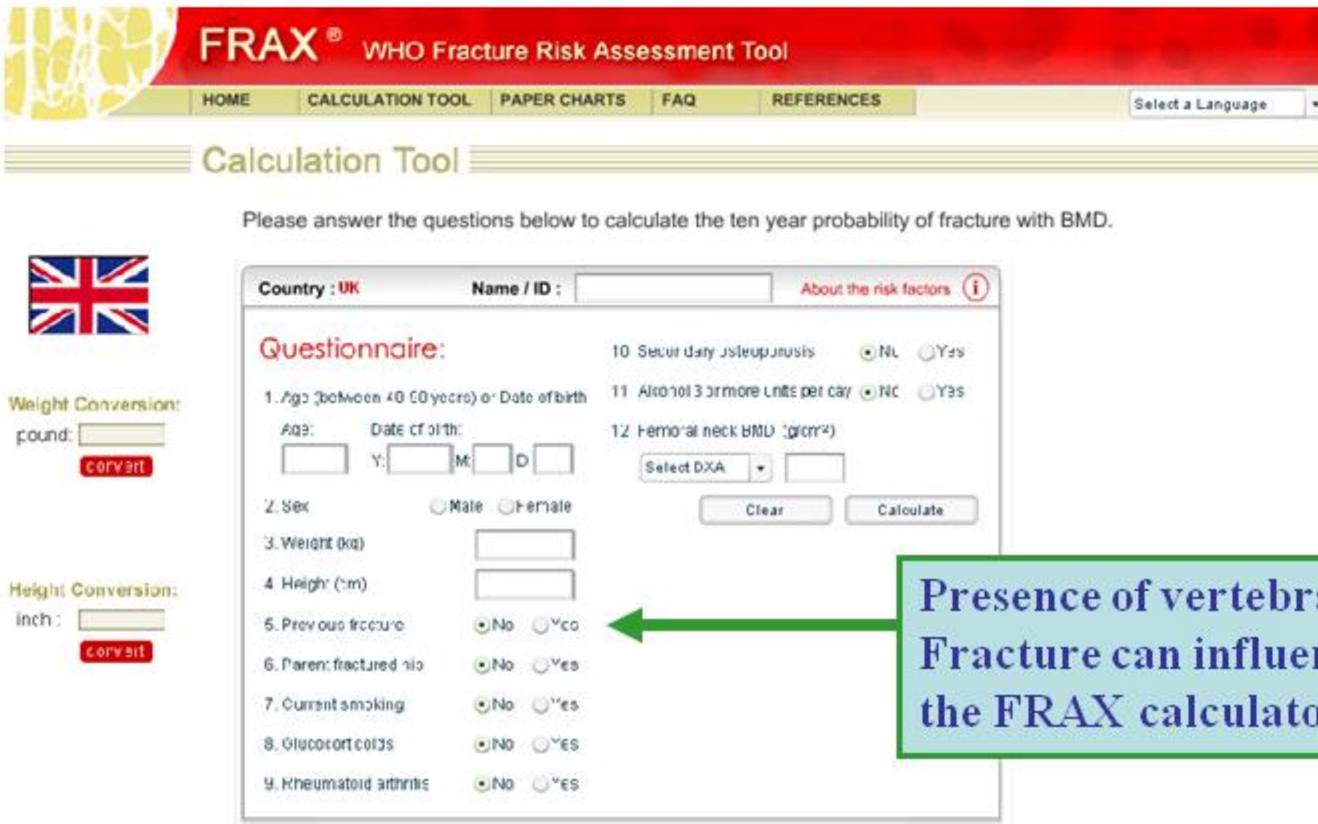


Jiang et al 2004 Osteoporos Int;15:887- 96

WHO Fracture Risk Assessment Tool (FRAX®)

http://www.shef.ac.uk/FRAX/tool



Presence of vertebral Fracture can influence the FRAX calculator

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Kanis JA et al. (2005) Osteoporos Int 16: 581-589

Summary: reporting vertebral fractures

- Scrutinise all images for such fractures
- Use clear, unambiguous and accurate terminology
  e.g. vertebral fracture not 'collapse' and/or other terms
- Give number and grades of fractures:
  mild =1, moderate=2, severe=3
- Indicate if osteoporotic, traumatic or pathological and suggest further appropriate imaging, if relevant
- If osteoporotic in origin, suggested measures should be considered to reduce future fracture risk
- If the change in shape is not due to a fracture, use the term 'deformity' and suggest cause (congenital anomaly, normal variant, acquired disorder)