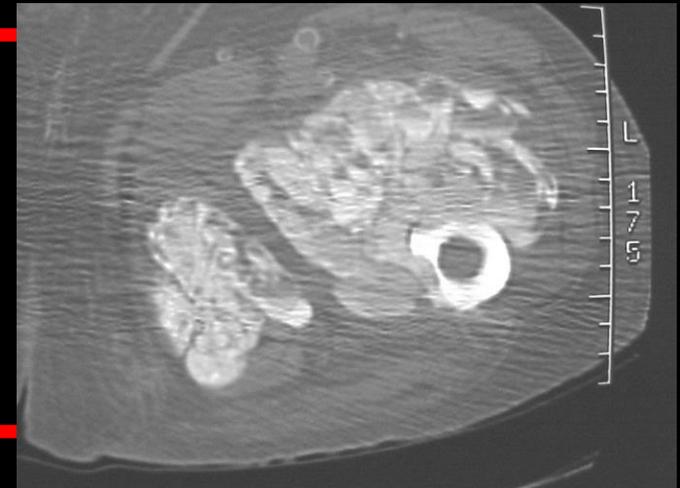




Metabolic and Endocrine Bone Disease Imaging

Dr. Tudor H. Hughes M.D., FRCR
Department of Radiology
University of California School of Medicine
San Diego, California

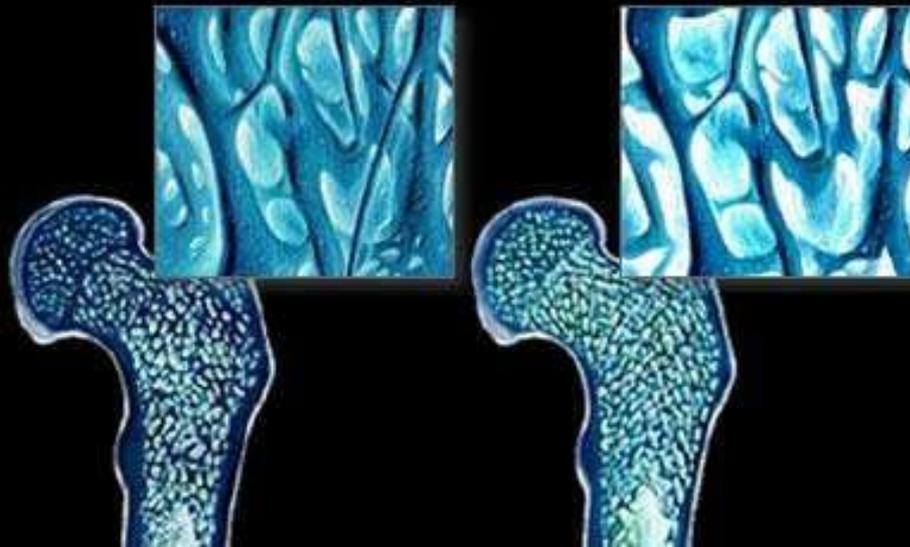


Osteoporosis

Osteoporosis is the most common metabolic bone disorder. It has been defined by the National Institutes of Health as an age-related disorder characterized by

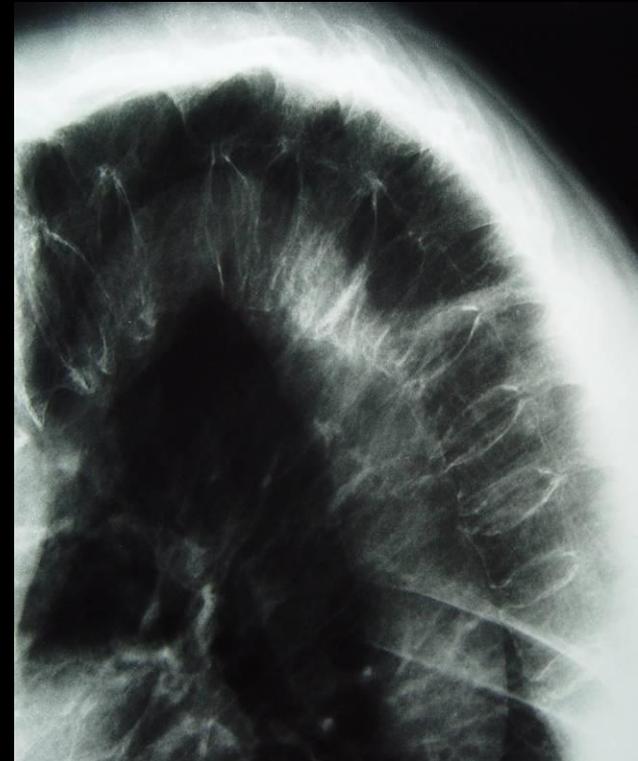
decreased bone mass and increased susceptibility to fractures

in the absence of other recognizable causes of bone loss.



Osteoporosis

- **Type 1. Involutional osteoporosis** affects mainly trabecular bone, occurs in women during the 15-20 years after the menopause, and is related to a **lack of estrogen**. This is thought to account for wrist and vertebral crush fractures, which occur through areas of principally trabecular bone.
- **Type 2. Senile involutional osteoporosis.** The fractures of old age seen at the hip, proximal humerus, pelvis and asymptomatic **vertebral wedge fractures**. This affects both trabecular and cortical bone and represents progressive loss of bone mass from the peak around the age of 18-35 years.
- **Secondary osteoporosis** is due to an underlying medical condition, such as renal disease, malabsorption, or hormonal imbalance, or to medical treatment such as steroids or certain anticonvulsants



Osteoporosis Measurement

- Plain film,
 - Subjective
 - Radiogrammetry
 - Radioabsorptiometry
- SPA
- DPA
- DEXA
- QCT
- US
- MRI



DEXA

DEXA has very high

accuracy

(the difference in the measurement from a known standard)

and

precision

(observed deviation of serial measurements with time),

both short and long term, to **within 1%** at the hip and spine

Bone Densitometry

WHO uses T scores

- Normal
 - > -1 SD below young adult
- Osteopenia
 - $-1 -2.49$ SD
- Osteoporosis
 - ≤ -2.5 SD
- Established (Manifest) Osteoporosis
 - + Fxs, usually spine, hip, proximal humerus, wrist, rib

Bone Densitometry

- **T** score is compared to reference population, 20-45 years, same sex, any race, any weight.
- **Z** score is matched for age, sex, weight and ethnicity.

Osteoporosis - OGI

REGION	BMD ¹ g/cm ²	Young Adult ² %	T	Age Matched ³ %	Z
NECK	0.702	66	-3.07	67	-2.84
WARDS	0.736	77	-1.73	80	-1.43
TROCH	0.598	64	-3.02	65	-2.91

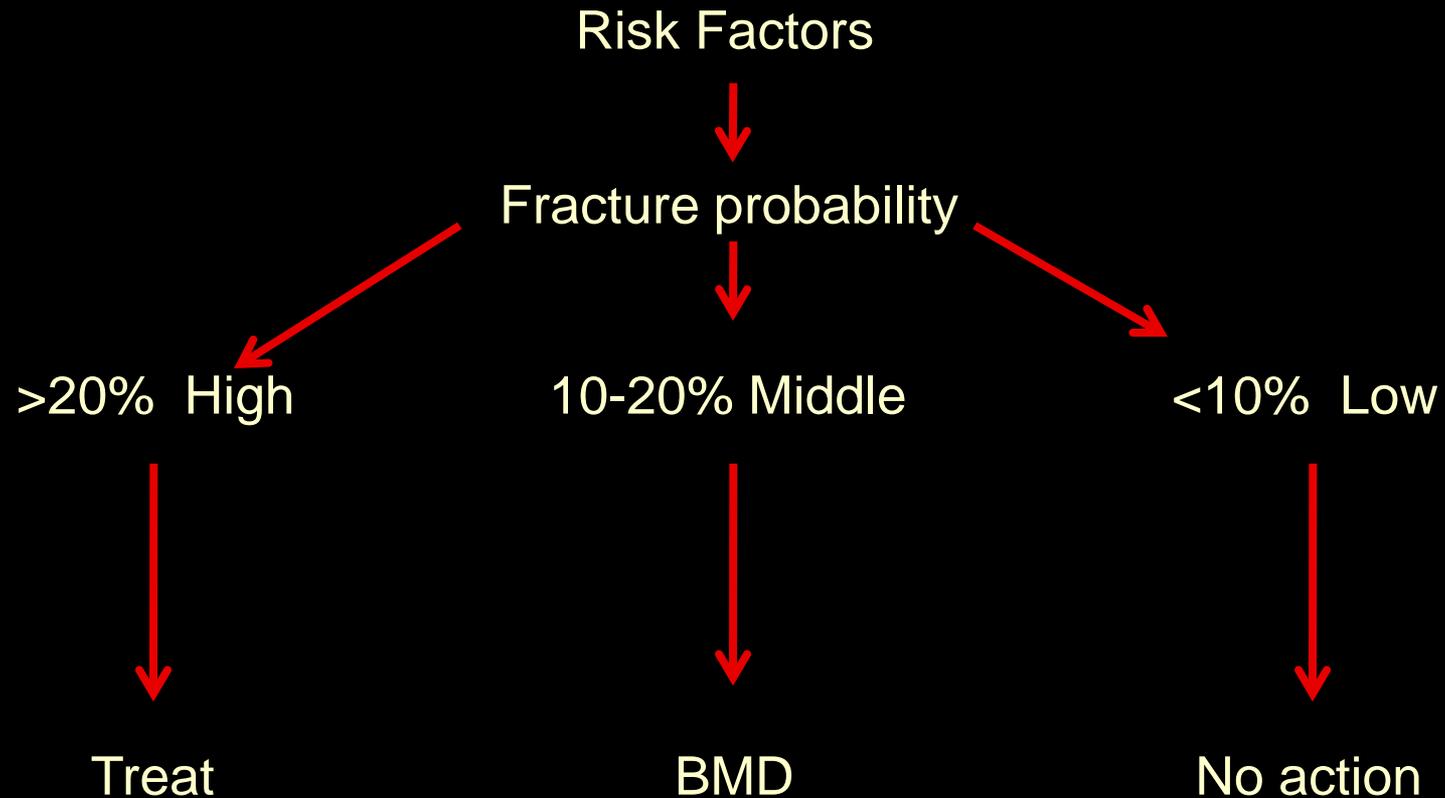
REGION	BMD ¹ g/cm ²	Young Adult ² %	T	Age Matched ³ %	Z
L1	0.537	46	-5.19	48	-4.92
L2	0.704	57	-4.47	58	-4.20
L3	0.640	52	-5.00	53	-4.74
L4	0.653	53	-4.89	54	-4.62
L1-L2	0.627	52	-4.77	54	-4.50
L1-L3	0.632	52	-4.82	54	-4.55
L1-L4	0.637	52	-4.86	54	-4.59
L2-L3	0.673	54	-4.73	56	-4.46
L2-L4	0.666	54	-4.78	55	-4.52
L3-L4	0.647	52	-4.95	54	-4.68

Bone Densitometry

FRAX – Fracture risk assessment tool

- Age
- Sex
- Weight / Height - BMI
- Spontaneous previous adult fracture
- Parent fractured hip
- Current smoking
- Glucocorticoids
- Rheumatoid arthritis
- Secondary osteoporosis
- Alcohol
- Bone mineral density

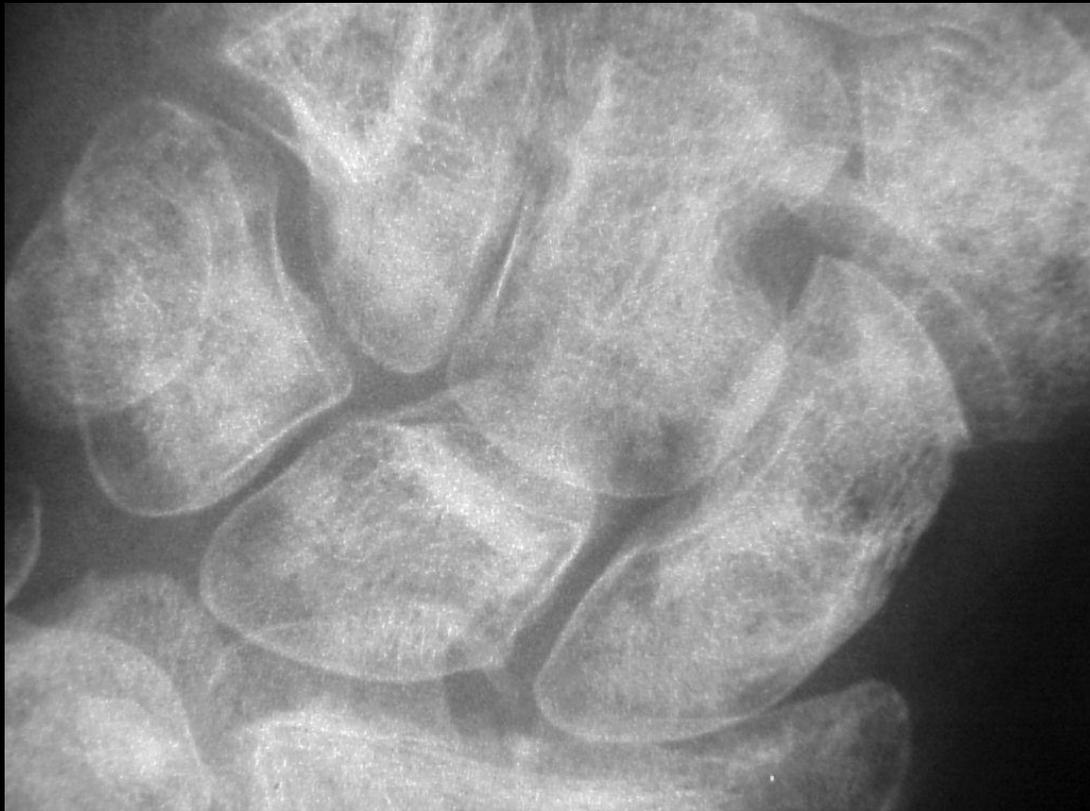
Bone Densitometry



Osteoporosis - Secondary

- Regional
 - Disuse
- General
 - Hormonal
 - Malabsorption
 - Drugs
 - Steroids
 - Anticonvulsants

Disuse Osteoporosis



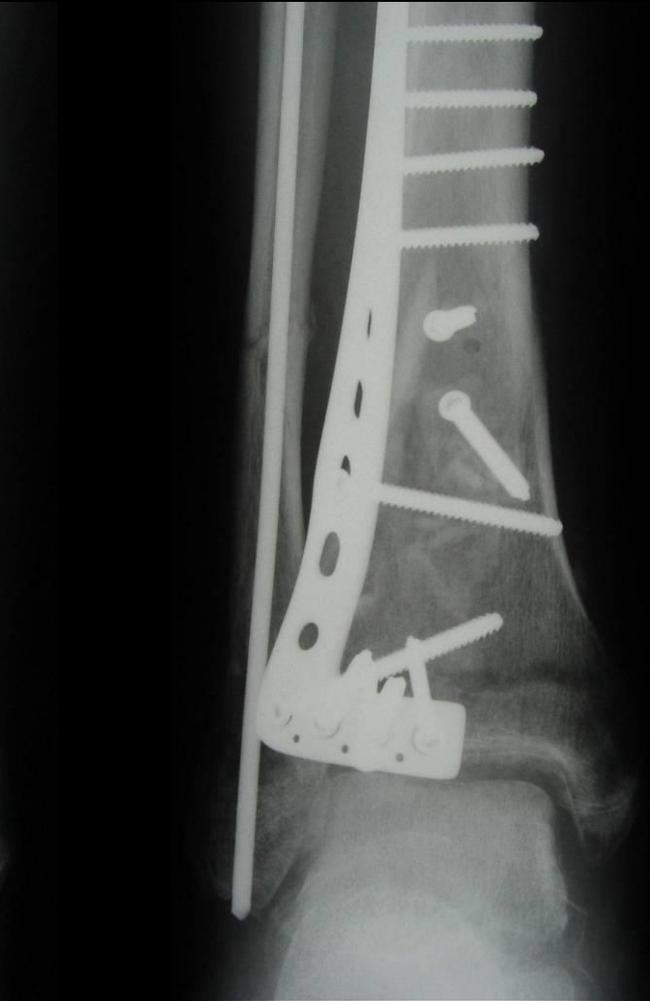
Disuse Metaphyseal Lucency



Acute



1m



2m

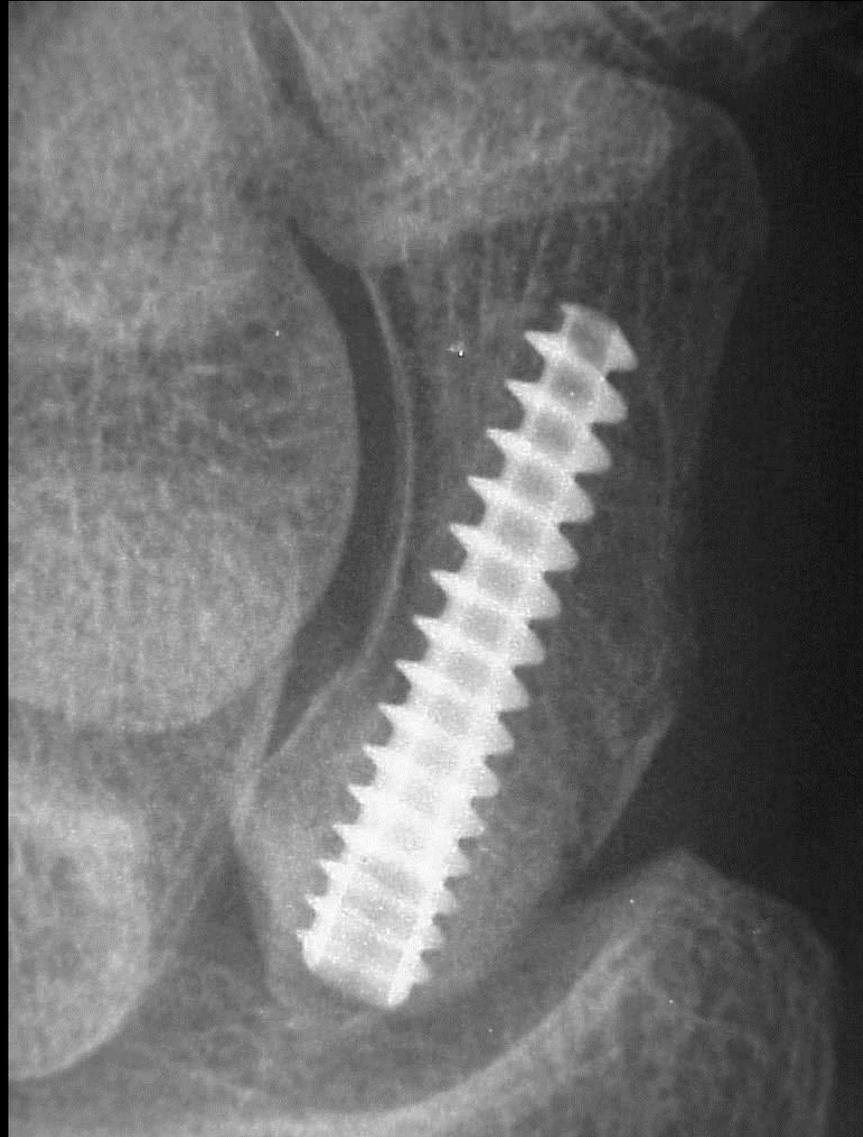
Disuse Osteoporosis of Sesamoid



Acute

6w later

“Hawkins” Scaphoid



Disuse Osteoporosis



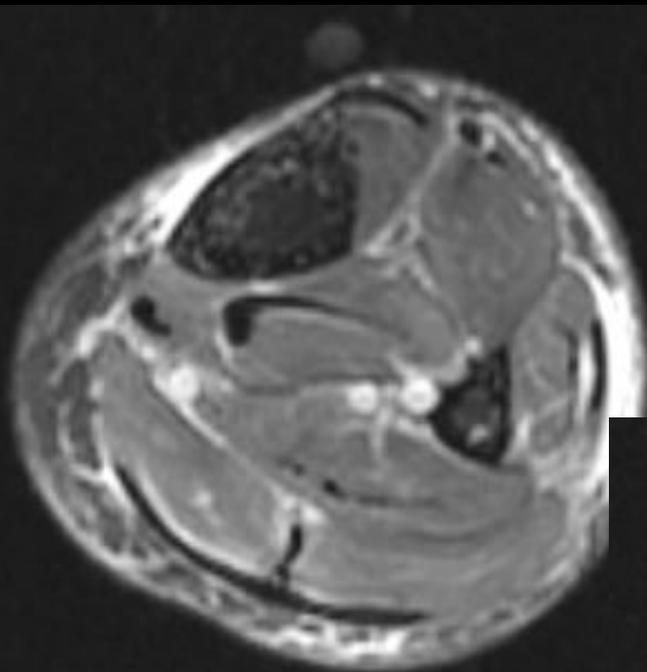
Sag PDFS



Sag T1FS Gd

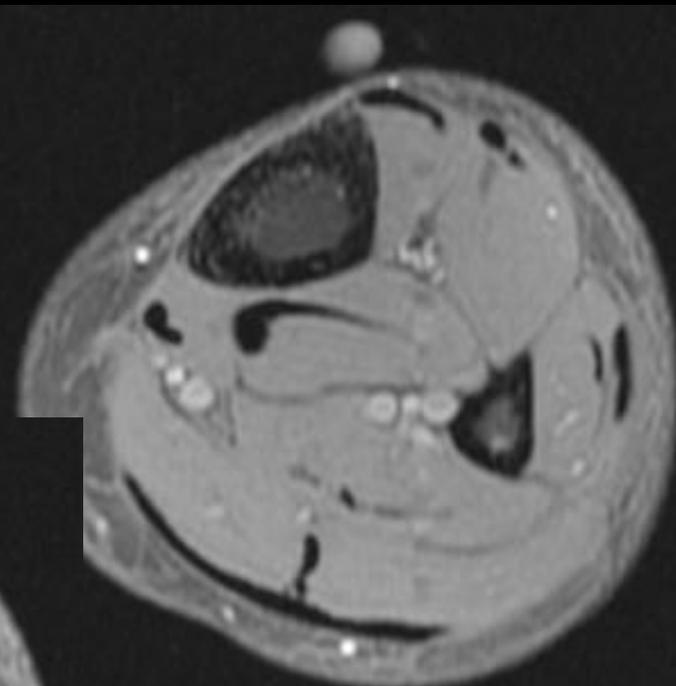
Patchy Enhancement

Disuse Osteoporosis

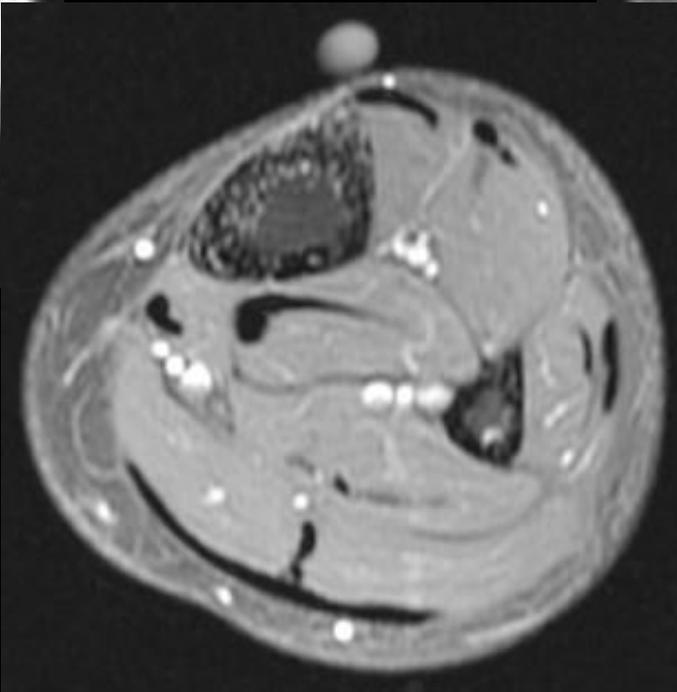


AxPDFS

Ax T1FS



Ax T1FS IVGd



52F injured left tibia after fall with persistent pain exacerbated with prolonged standing

Cushing's Osteoporosis

- Syndrome
 - ↑ cortisol
- Pituitary 80% Cushing's disease
 - 90% adenoma
 - 20% visible radiographically
- Adrenal 20%
 - Adenoma
 - Carcinoma
- Ectopic ACTH (Ca bronchus)

Cushing's Osteoporosis

- 50% of Cushing's syndrome adults are osteoporotic
- 30-50% pathologic fractures (trabecular-spine)
- Children also growth retardation
- Cortisol multifactorial effect on bone
 - Growth hormone
 - Hypogonadism
 - Calcium absorption
 - Renal calcium excretion

Cushing's Osteoporosis

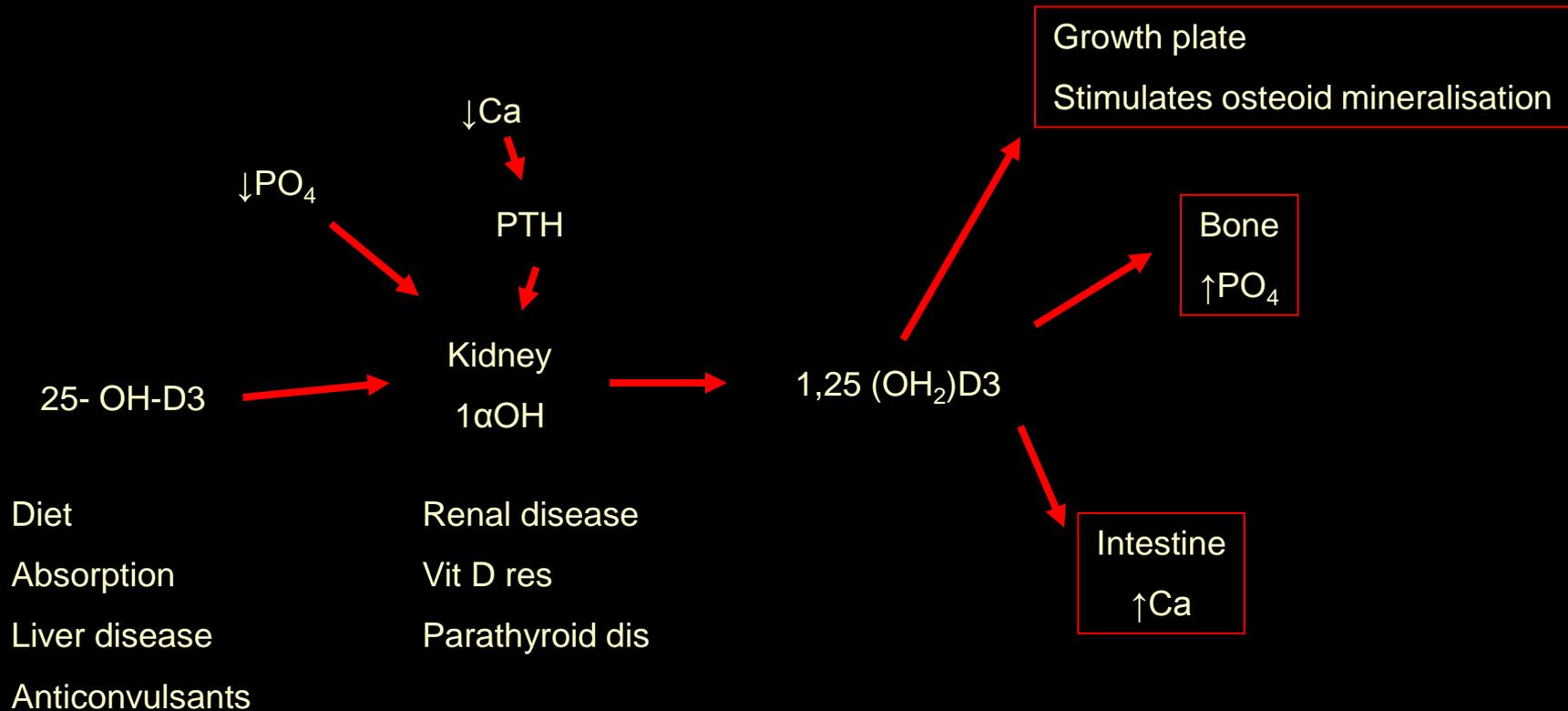


Cushing's Osteoporosis



Vitamin D

- 1,25 dihydroxycholecalciferol



Rickets

- Increased uncalcified osteoid in the immature skeleton
- Lack of Vitamin D
 - Dietary
 - Malabsorption
 - Renal tubular disease

Rickets – Growth Plate changes

- Widened growth plate
- Metaphysis
 - Fraying
 - Splaying
 - Cupping
 - Spurs
- Diaphysis
 - Indistinct cortex
- Rickety rosary
- Looser's zones



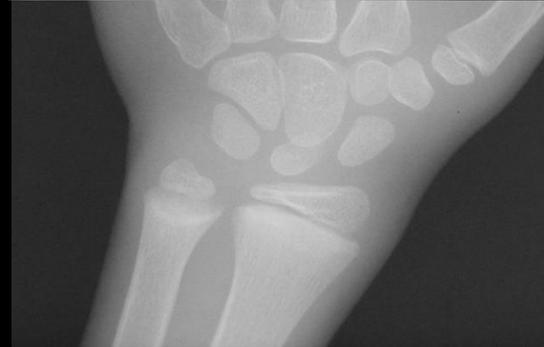
Rickets – Changes of Soft Bones

- Bowing
- **Triradiate pelvis**
- Harrison's sulcus
 - Soft ribs
- Scoliosis
- Biconcave vertebrae
- Basilar invagination
- Craniotabes



Rickets – Follow up

- Dietary Rickets
 - Full recovery on Rx



2002

2004

Rickets – Follow up



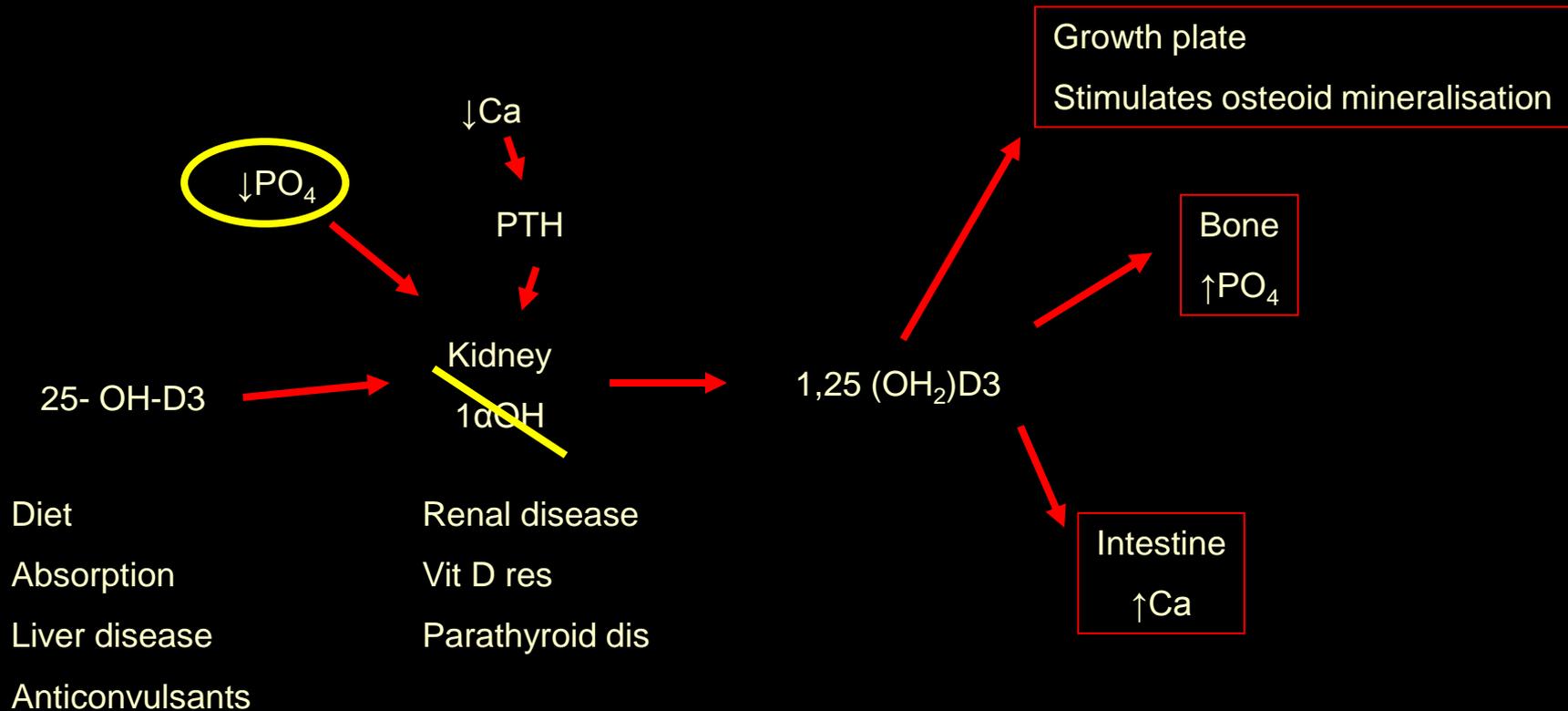
6 year old with bowed legs

X-linked Hypophosphatemic Rickets

- Vitamin D resistant Rickets
- Familial Hypophosphatemic Rickets
- X-linked
 - Phosphate levels equally low, M=F
 - 1^{α} hydroxylation reduced in males
- Imaging
 - Identical to dietary Rickets

X-linked Hypophosphatemic Rickets

- 1,25 dihydroxycholecalciferol



X-linked Hypophosphatemic Rickets



Hypophosphatasia

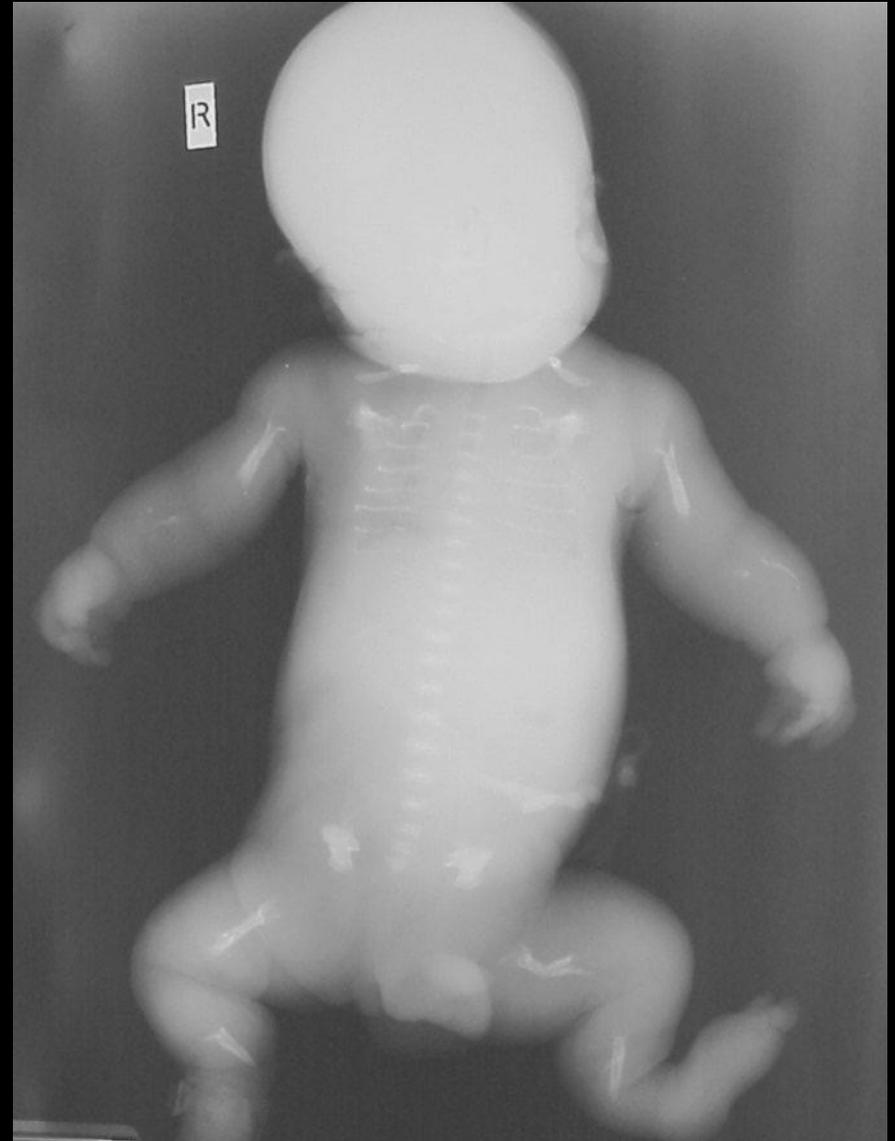
- Tissue nonspecific alkaline phosphatase
 - TNSALP
- Causes defective mineralisation of bone
- Low serum alkaline phosphatase
- High serum phosphoethanolamine

Hypophosphatasia

- Perinatal – Fatal
- Infantile – 50% fatality
- Childhood – Rickets
- Adult – Poorly healing stress fractures
- Odontohypophosphatasia – Loss of teeth

Hypophosphatasia - Neonatal

- Profoundly deficient mineralization
 - Knees
 - Wrists
 - Costochondral
- Fractures



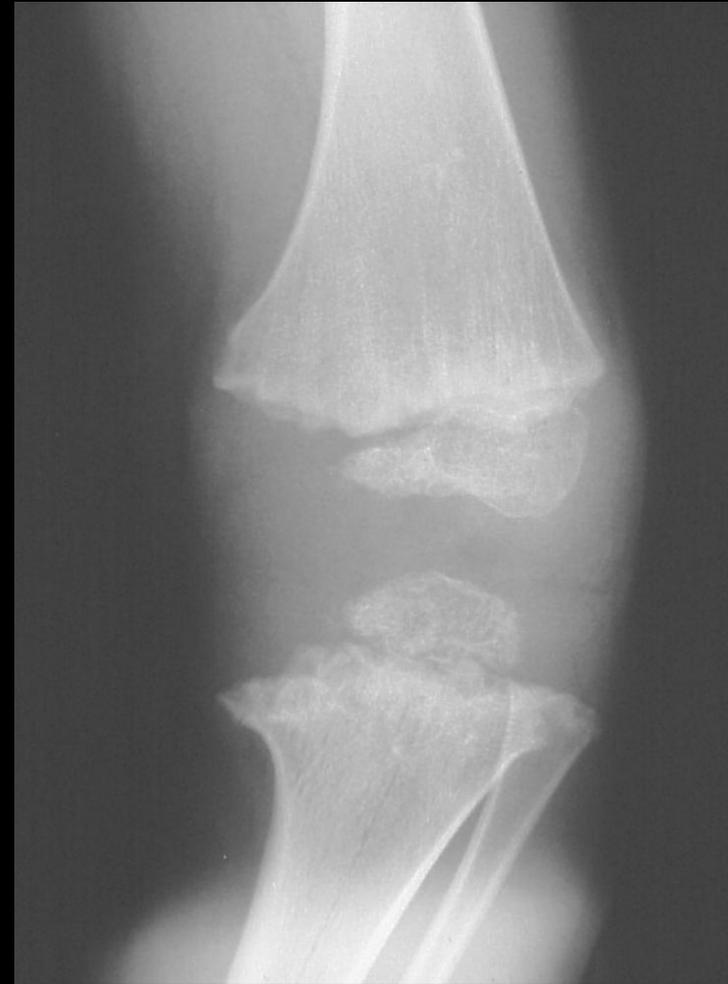
Hypophosphatasia - Infantile

- Physes
 - Widened
- Metaphyses
 - Cupped
 - Frayed
- Demineralised epiphyses.
- Widened cranial sutures
- Craniostenosis brachycephaly



Hypophosphatasia - Childhood

- Physes
 - Widened
- Metaphyses
 - Cupped
 - Frayed
- Demineralised epiphyses
- Widened cranial sutures
- Craniostenosis
brachycephaly



Hypophosphatasia - Adult

- Osteomalacia
- With ↓ bone density



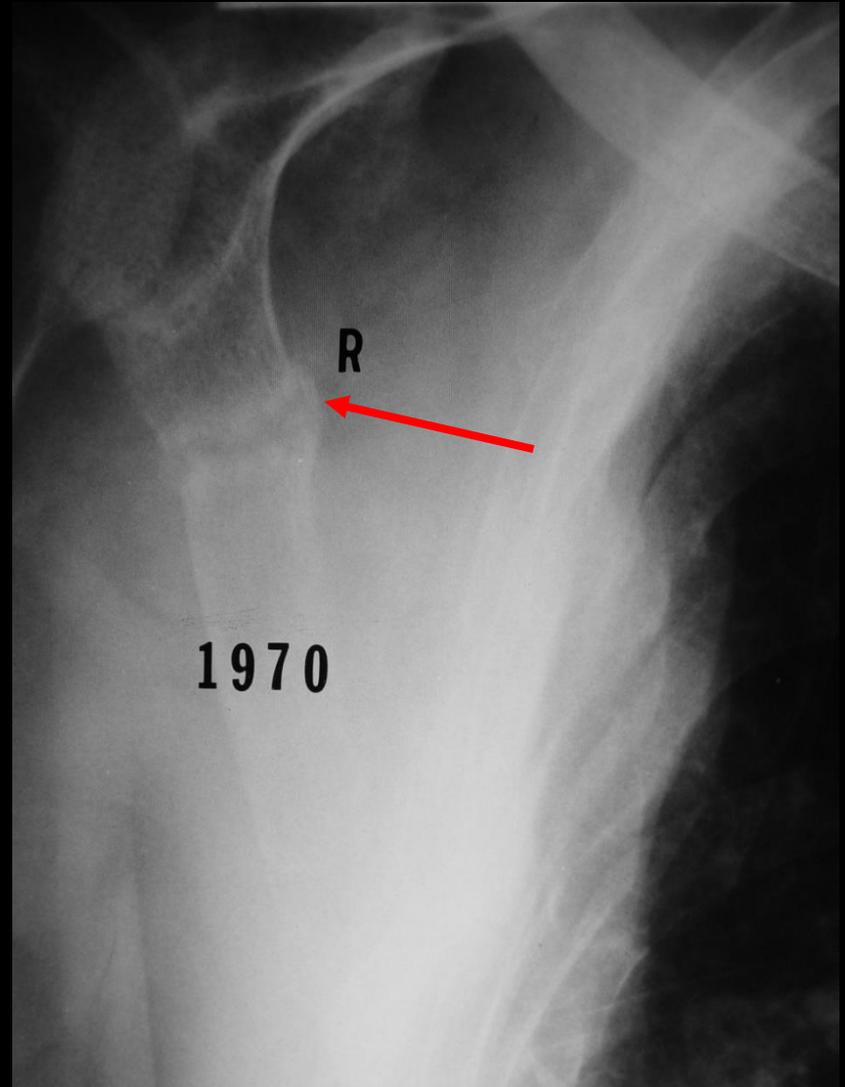
Hypophosphatasia - Adult



27F multiple fractures, some incomplete, poorly healing, over 3 yrs

Osteomalacia

- ↑ uncalcified osteoid in the mature skeleton
- ↓ bone density
- Looser's zones
 - Scapula
 - Femoral neck
 - Femoral shaft.
 - Pubic rami
 - Ribs
- Coarsened ill defined trabeculae
- Bone softening
 - Protrusio
 - Bowing
 - Biconcave vertebrae
 - Basilar invagination



Hyperparathyroidism

- Primary
 - Parathyroid adenoma 90%
 - 2% are multiple
 - Hyperplasia of all four glands 5%
 - Familial
 - Carcinoma
 - Ectopic
 - MEN type 1 (hyperplasia or adenoma)
 - Pituitary adenoma and pancreatic tumor

Hyperparathyroidism

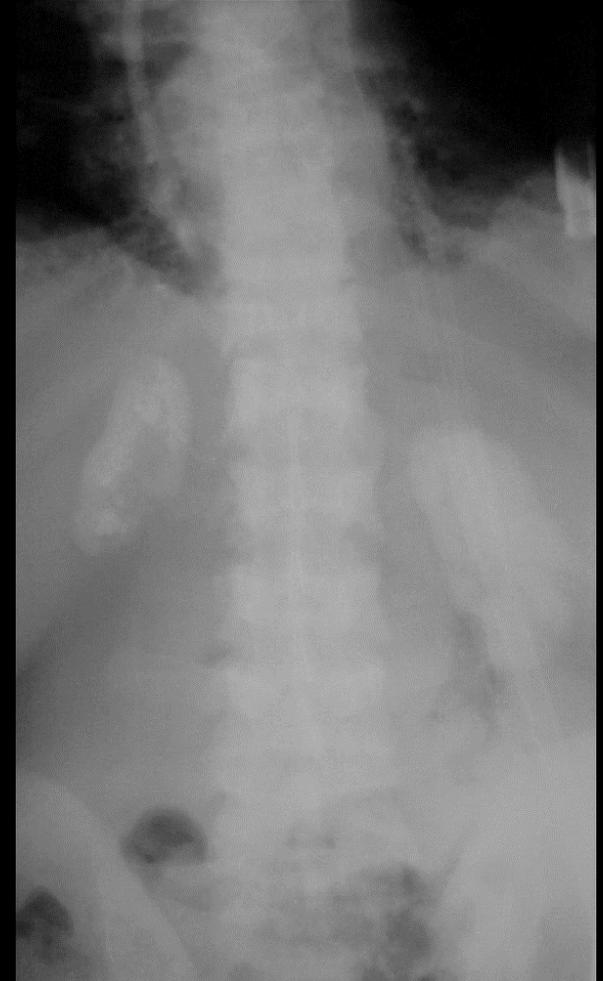
- Secondary
 - Failure to excrete phosphate in renal failure
 - Phosphate binds with Calcium
 - Due to ↓ serum Calcium

Hyperparathyroidism - Imaging

- Primary and secondary HPT have similar findings now that patients with renal failure have increased life expectancy.
- Previously thought that Brown tumors were more common in Primary HPT

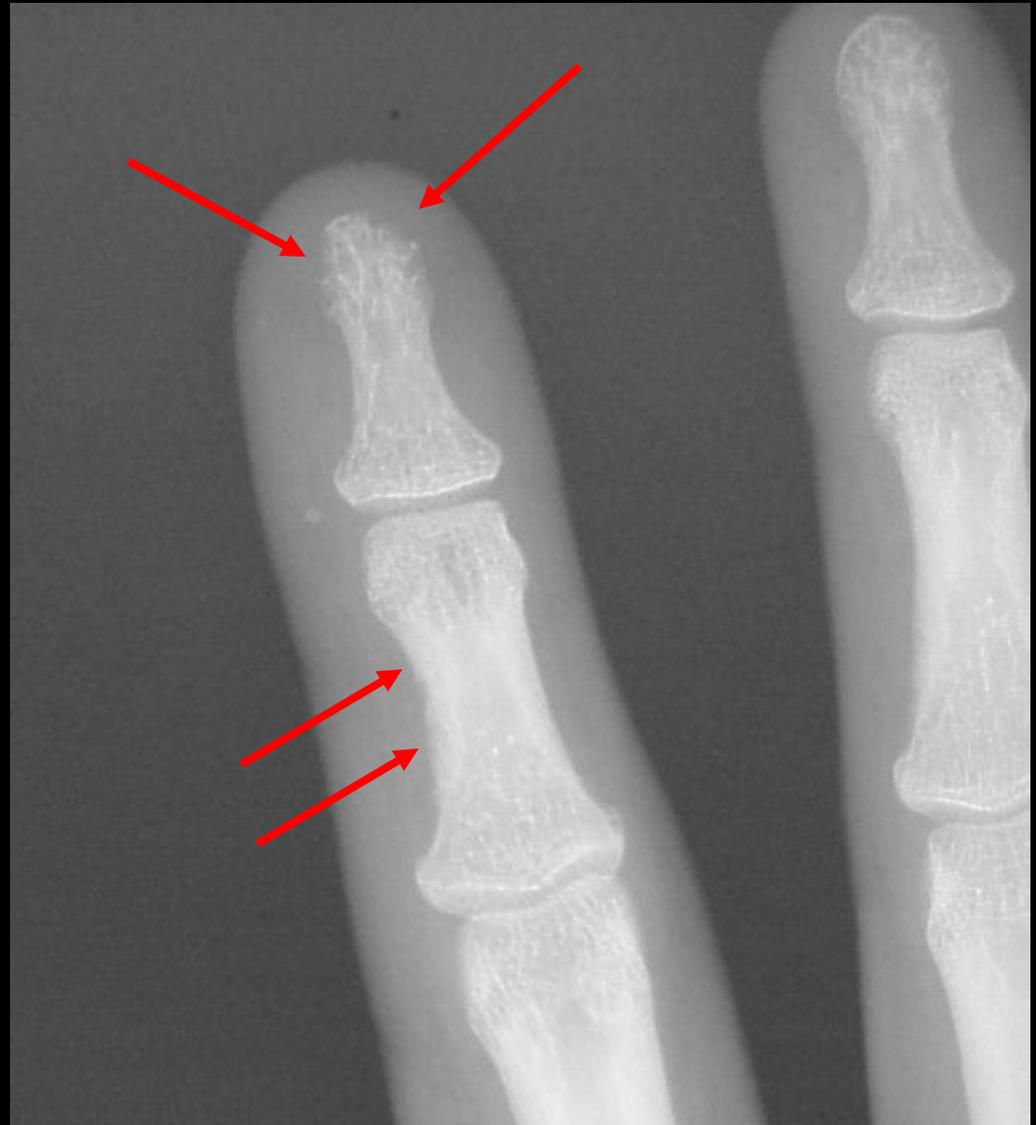
Renal Osteodystrophy

- Renal glomerular disease
 - Bilateral reflux nephropathy
 - Pyelonephritis
 - Chronic glomerulonephritis
- Osteomalacia or Rickets
 - Failure to hydroxylate
- Secondary hyperparathyroidism
 - Failure to excrete phosphate
- Osteosclerosis
- Calcification more prominent in adults

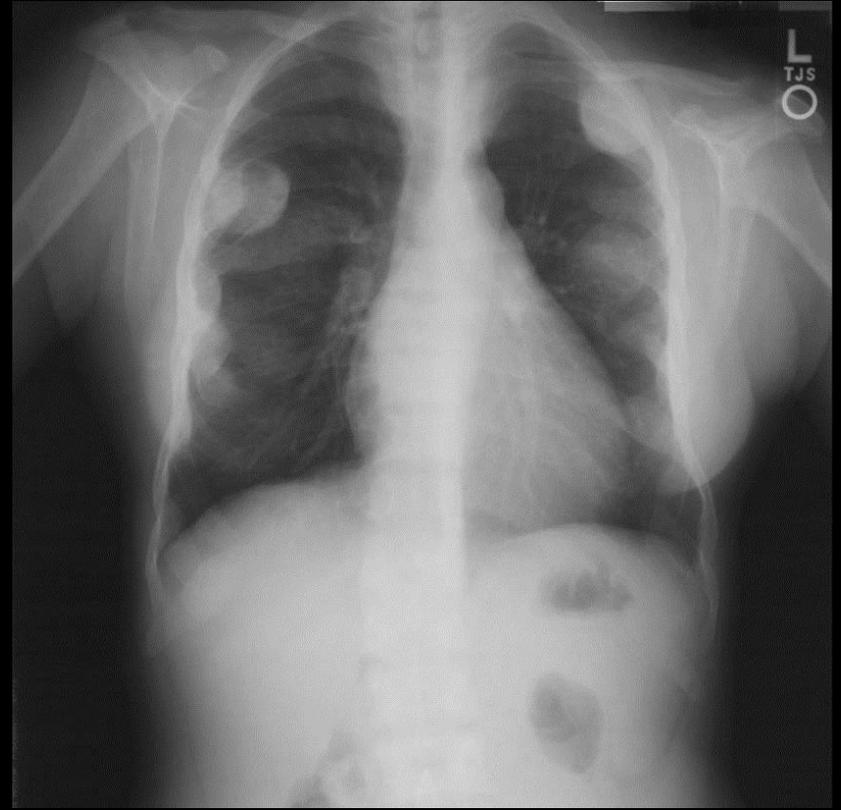
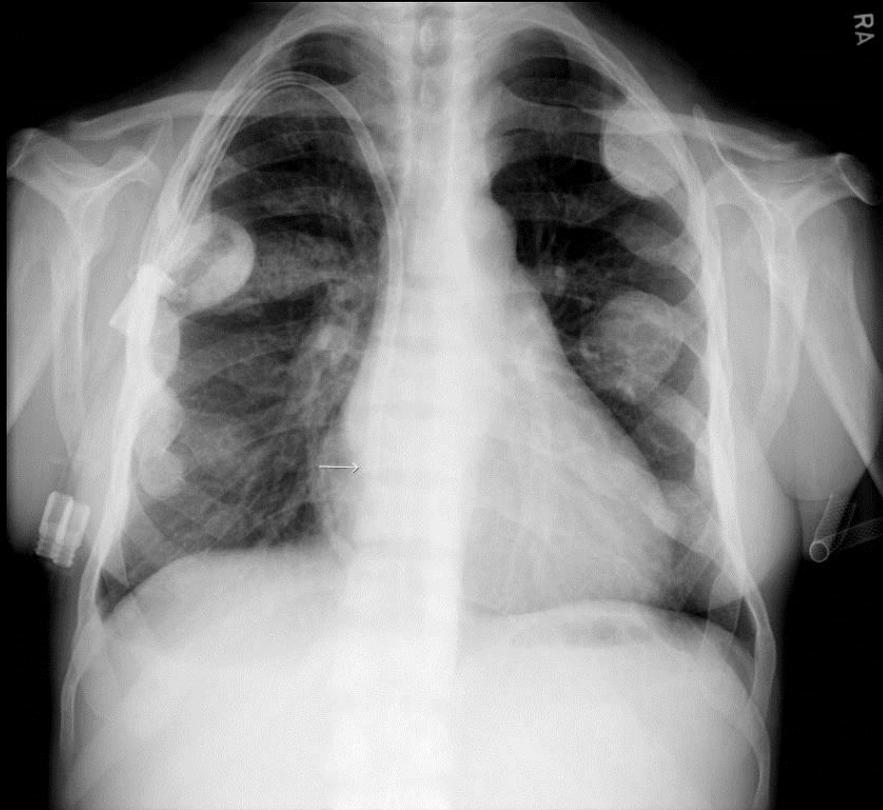


Hyperparathyroidism – Imaging - Bones

- Osteopenia
 - Ground-glass
- Resorption
 - Subperiosteal
 - Fingers
 - Proximal tibia
 - Lateral clavicle
 - Symphysis pubis
 - Ischial tuberosity
 - Medial femoral neck
 - Cortical
 - Cortical tunneling
 - Pepper pot skull
- Osteosclerosis
 - Rugger jersey spine
- Brown tumors
 - Solitary sign in 3%
- Bone softening

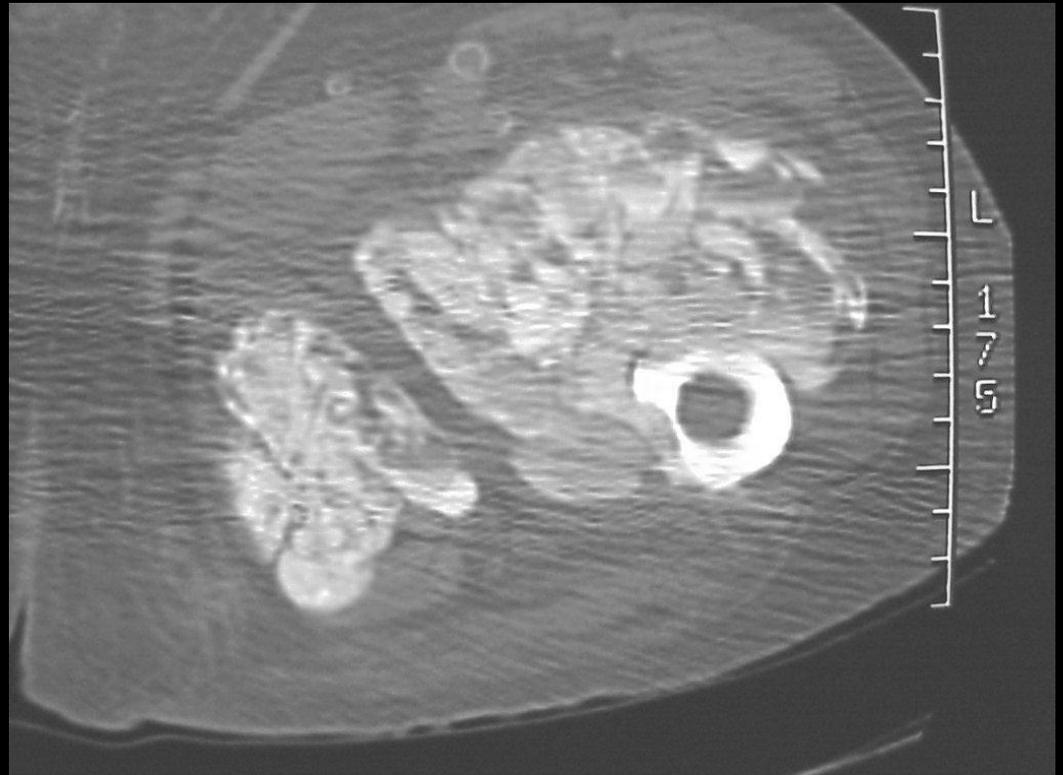


Renal Osteodystrophy and Brown Tumors



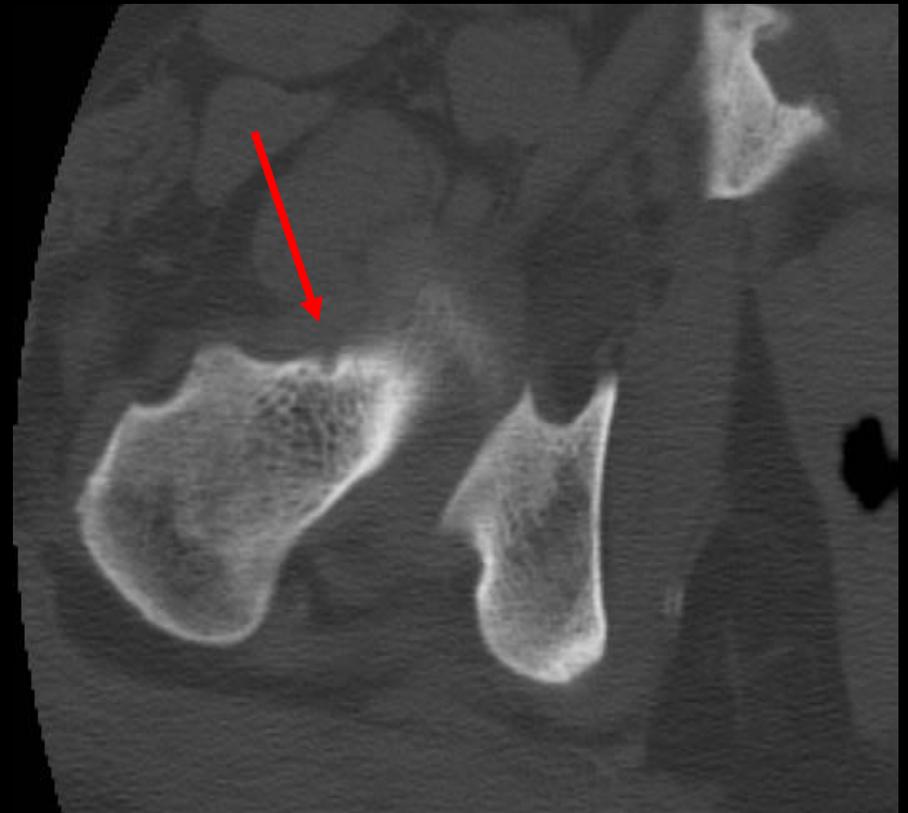
Hyperparathyroidism – Imaging – Soft Tissues

- ST Cal
 - Arteries
 - Periarticular
 - Capsule
 - Tendon
 - **Tumoral**



Hyperparathyroidism – Imaging - Joints

- **Marginal erosions**
 - DIPJ
 - Ulnar side base of 5th MC
 - Hamate
 - No JSN
- Subchondral collapse
- Chondrocalcinosis
 - CPPD
 - Gout



Dialysis Spondylosis

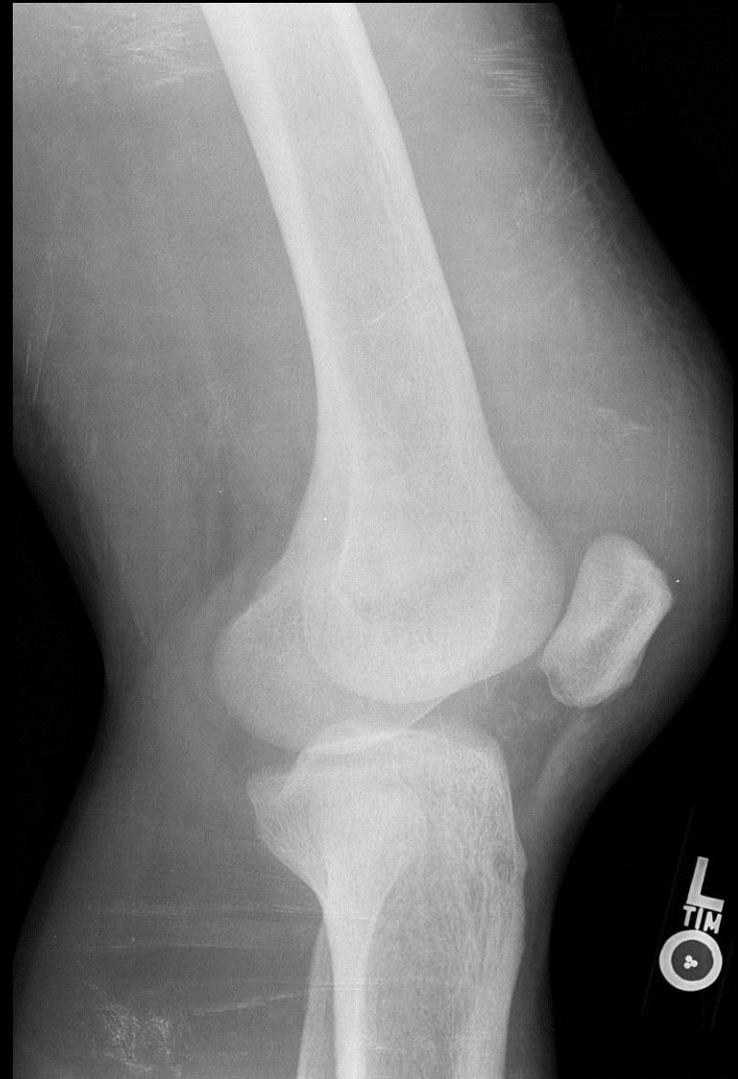


Beta2 microglobulin destructive spondyloarthropathy

Primary and secondary HPT



Primary oxalosis

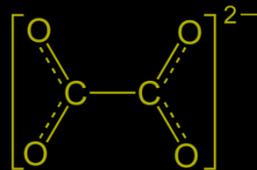


Primary and secondary HPT 27M

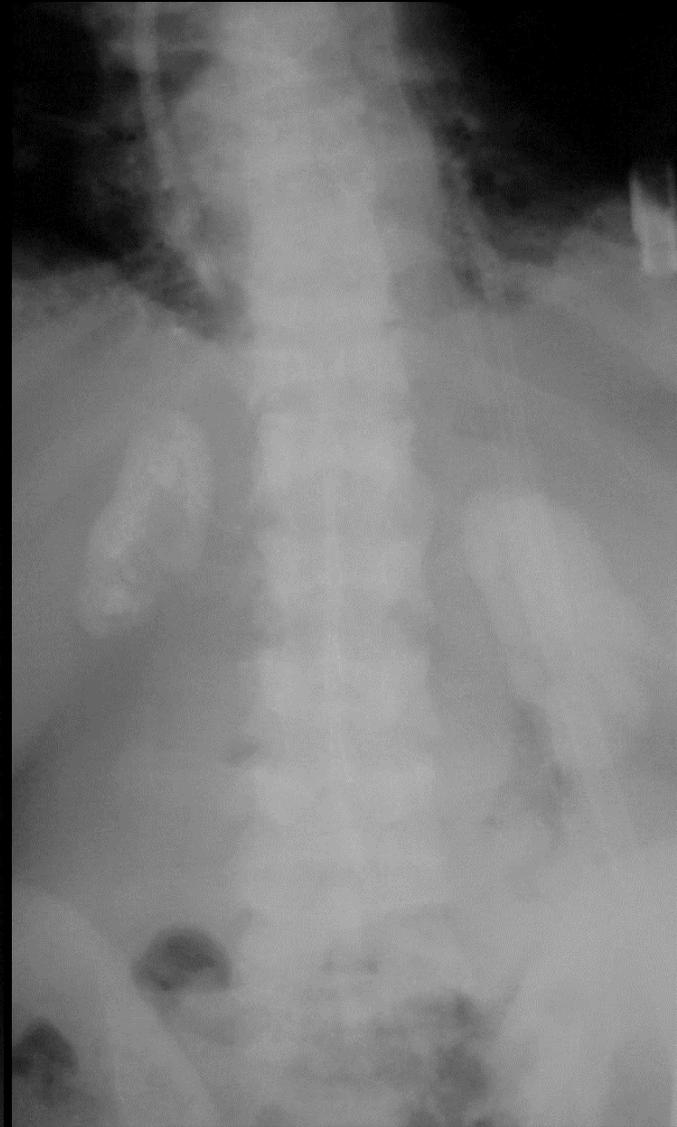
Primary oxalosis

secondary hyperparathyroidism

- Primary
 - Hereditary hyperoxaluria
 - AR, enzyme deficiency - carbolicase
 - Diffuse calcium oxalate deposits
- Secondary
 - Disturbance of bile acid metabolism
 - Usually diseases of terminal ileum



Primary oxalosis secondary hyperparathyroidism



HypoParathyroidism

- Hormone deficient
 - Surgery, Idiopathic
- Imaging
 - Osteosclerosis
 - DISH like ossification
 - Thickened calvarium
 - Sutural diastasis
 - Basal ganglia calcification



Pseudohypoparathyroidism

- Hormone resistant
 - End organ unresponsiveness to PTH
 - Usually bone and renal
- X – linked dominant F>M
- Clinical – Albright's hereditary osteodystrophy
 - Short stature, thickset features
 - ↓ Calcium, ↑ Phosphate, normal or ↑ PTH
- Imaging
 - Short 4th > 5th > 1st metacarpals/tarsals
 - Exostoses
 - Basal ganglia calcification
 - Soft tissue calcification

PseudoPseudohypoparathyroidism

- Similar phenotypically to pseudohypoparathyroidism, but with normal plasma calcium

Pseudohypoparathyroidism



38 year old male with foot and heel pain with history of congenital deformity and obesity

Albright's hereditary osteodystrophy

- PseudohypoPTH (PHP) and Pseudo-pseudohypoPTH (PPHP)
- X linked dominant; females > males
- PHP
 - Low Ca^{2+} , high Ph
- PPHP (normocalcemic form of PHP)
 - Normal Ca^{2+} and Ph



PHP and PPHP

- Clinical features
 - Short stature, Obesity, Round face, Brachydactyly
- Typical radiographic findings
 - ST calcification and ossification – plaquelike, assymmetric, parallel skin surface
 - Basal ganglion Ca+ and Calvarial thickening
 - Short MC, MT, phalanges- especially 1st, 4th MC
 - Premature physeal fusion
 - Exostoses- centrally located with right angle to bone
 - Cone epiphyses
 - Wide bones



Thyroid Disorders

- Hyperthyroidism
- Thyroid Acropachy
- Hypothyroidism

Thyroid Acropachy

- 0.5% of thyrotoxicosis
- After Rx
- Exophthalmos
- Painless STS of fingers
- Pretibial myxoedema
- Finger clubbing

Thyroid Acropachy

Finger clubbing

- Periosteal new bone MC and proximal phalanges
- Radial aspect of bone
- Dense and solid
- STS

Thyroid Acropachy



Hypothyroidism Cretinism

- Appendicular skeleton
 - Delayed appearance of ossification centers
 - Delayed epiphyseal closure
 - Short slender long bones
 - Endosteal thickening
 - Dense metaphyseal bands.
 - Coxa vara with short femoral neck



Chronological Age = 22years

Hypothyroidism Cretinism

- Skull
 - Brachycephaly
 - Wormian bones
 - Delayed sutural closure
 - Poorly developed sinuses and mastoids.



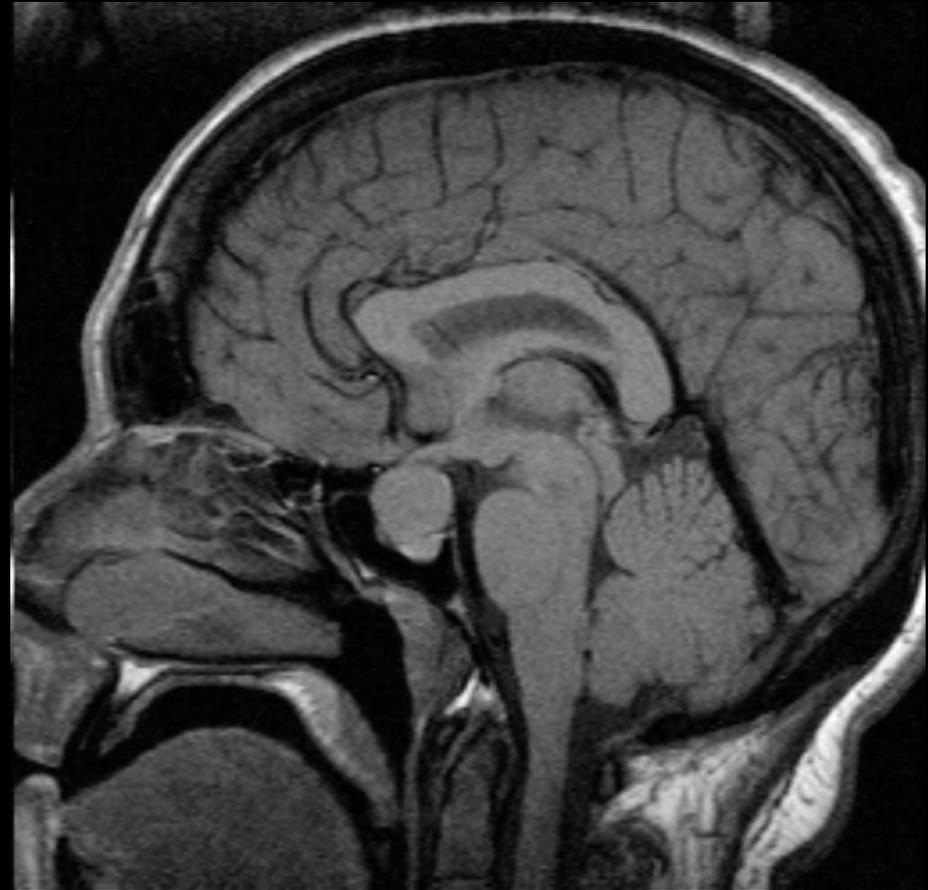
Hypothyroidism Cretinism

- Axial skeleton
 - Flattened vertebrae
Wide discs
 - Thoracolumbar
kyphosis.
 - Hypoplastic bullet L1
or L2
 - Segmental sternum



Pituitary Disorders

- Acromegaly
- Cushing's disease
- Hypopituitarism



Acromegaly

- Excessive growth hormone on mature skeleton
- Skull
 - Thickened vault
- Thorax and spine
 - ↑ sagittal diameter of chest with kyphosis
 - Enlarged vertebrae
- Appendicular skeleton
 - ↑ width of bones with normal cortical thickness
 - Terminal phalangeal tufting
 - Prominent entheses
 - Widened joint spaces
 - Premature OA
 - Osteoporosis
 - ↑ heel pad thickness



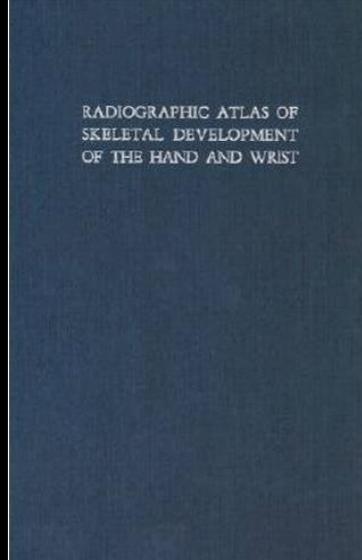
Acromegaly

- Excessive growth hormone on mature skeleton
- Skull
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- Appendicular skeleton
 - ↑ width of bones with normal cortical thickness
 - Terminal phalangeal tufting
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 - Widened joint spaces
 - Premature OA
 - Osteoporosis
 - ↑ heel pad thickness



Hypopituitarism

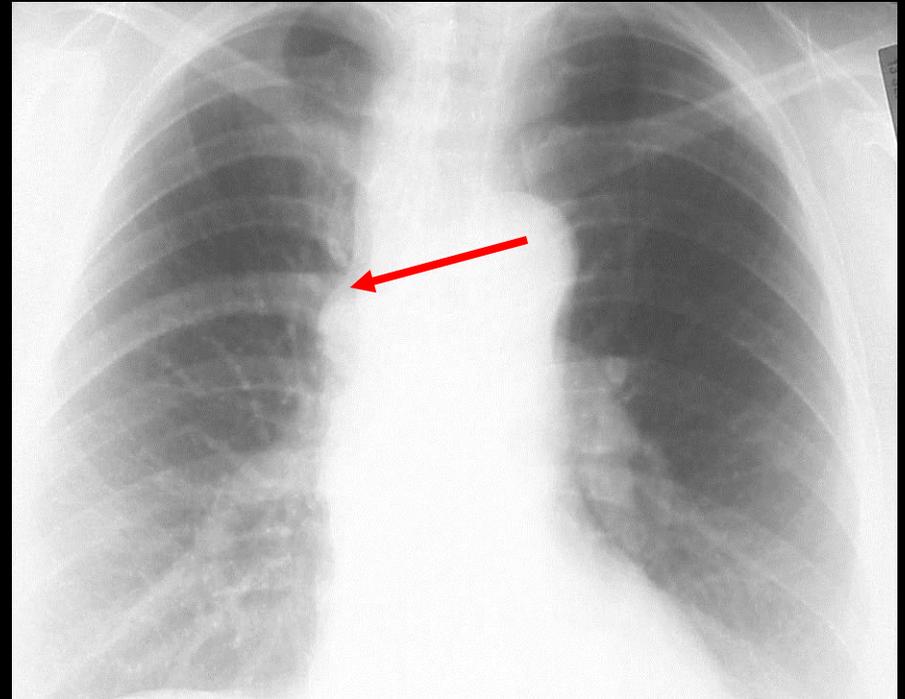
- Pituitary Dwarfism
 - Damage to anterior lobe of pituitary in childhood
- Delay in appearance and growth of ossification centers
- Delay in closure



RADIOGRAPHIC ATLAS OF
SKELETAL DEVELOPMENT
OF THE HAND AND WRIST

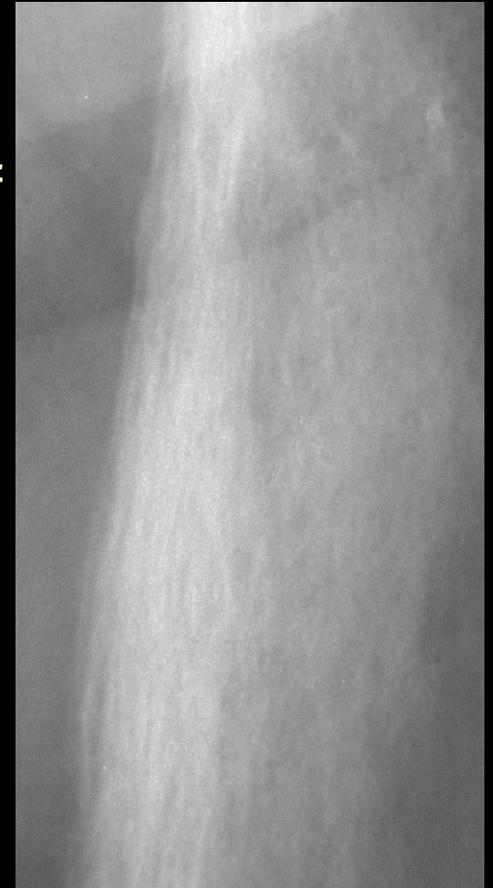
Paget's Disease

- Excessive abnormal remodeling of bone
- Middle age 3%
- Old age 10%
- Spine 75%
- Skull 65%
- Pelvis 40%
- Proximal femur 75%



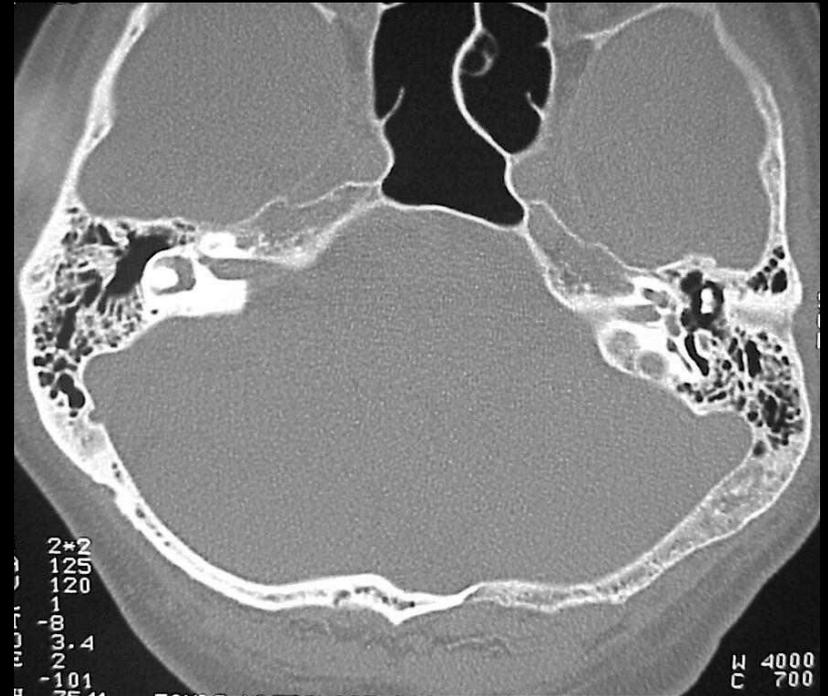
Paget's Disease

- Middle aged and elderly
- Excessive and abnormal remodeling of bone
- Initial osteolytic phase
- Subsequent osteosclerotic phase
- Enlarged bone with increased density and coarse trabecular



Paget's Disease

- Radiographic findings
- Active Osteolytic phase
 - Osteoporosis circumscripta
 - Advancing wedge of lucency



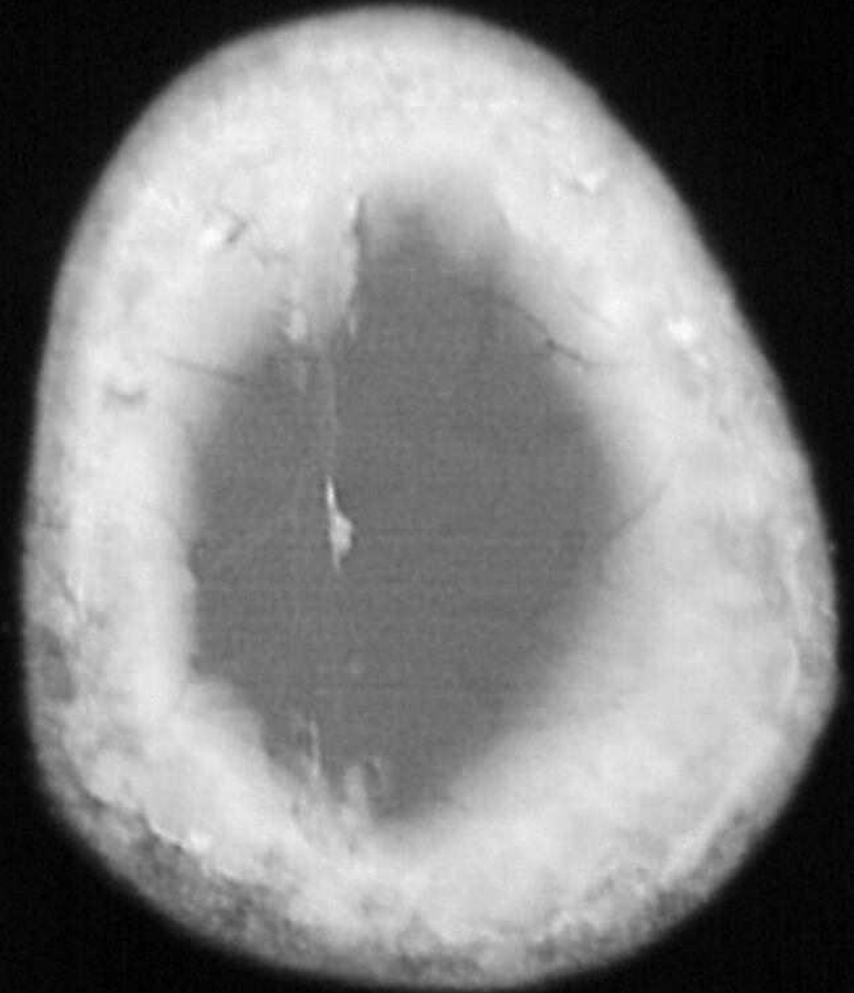
Paget's Disease

- Radiographic findings
- Mixed phase
 - Skull
 - Osteoporosis circumscripta with sclerosis
 - Pelvis
 - Mixed osteolytic and osteosclerotic
 - Long bones
 - Diaphyseal lucency
 - Epi/Meta sclerosis



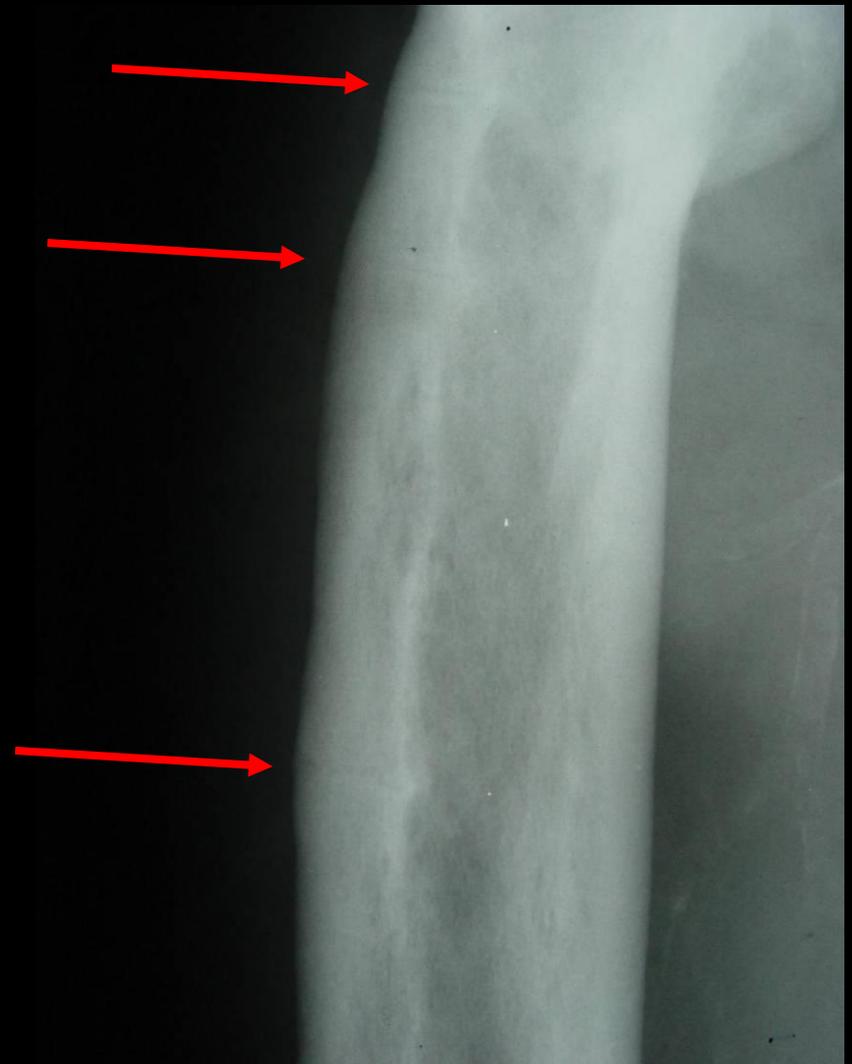
Paget's Disease

- Radiographic findings
- Osteosclerotic phase
 - Skull
 - Thickened vault
 - Spine
 - Enlarged vertebrae
 - Coarse trabeculae
 - Pelvis
 - Often asymmetric
 - Long bones
 - Cortical thickening
 - Medullary encroachment



Paget's Disease

- Complications
 - Osseous deformity
 - Fractures
 - Nerve entrapment
 - Neoplasms
 - Osteomyelitis
 - Extramedullary hematopoiesis
 - Gout
 - Degenerative joint disease



Pathological fractures in Paget's

Alkaptonuria / Ochronosis

- Absence of homogentisic acid oxidase
- Pigmentation
- Arthropathy
- Osteoporotic with dense disc calcification
- Larger joints show DJD

Alkaptonuria / Ochronosis



Idiopathic Tumoral Calcinosis

- 10-30Yrs, black > white, M=F
- Elevated phosphate, normal calcium
 - Renal tubular phosphate resorption
- Single or multiple, firm, tumor like, painless
- Hips, Shoulders, Elbows, Ankles
- Dense, Flocculent, Amorphous,
- 1-20cm, fluid levels
- Recur if resected
- Dx of exclusion Periarticular calcified masses



Tumoral Calcinosis

- DDX
 - Idiopathic
 - Renal osteodystrophy
 - Gout
 - Hyperparathyroidism
 - Collagen vascular Disease
 - Hypervitaminosis D
 - HADD

Homocystinuria – Metacarpal index



Average 2-5 abnormal if >8.4 male, >9.2 female

Homocystinuria 40F Marfanoid

Osteopetrosis

