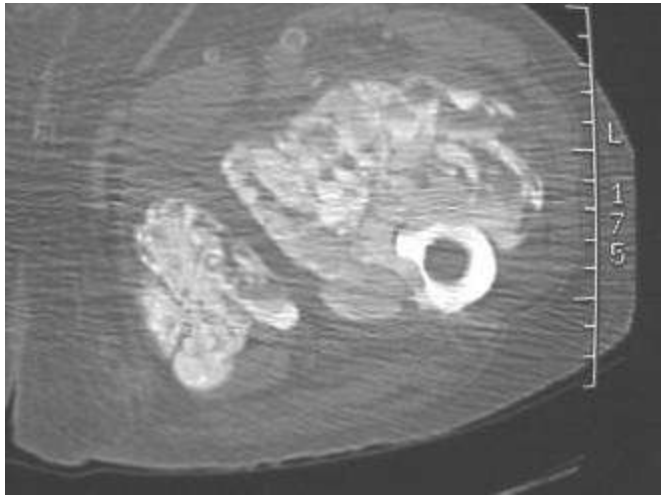
Metabolic and Endocrine Bone Disease Imaging



Tumoral Calcinosis

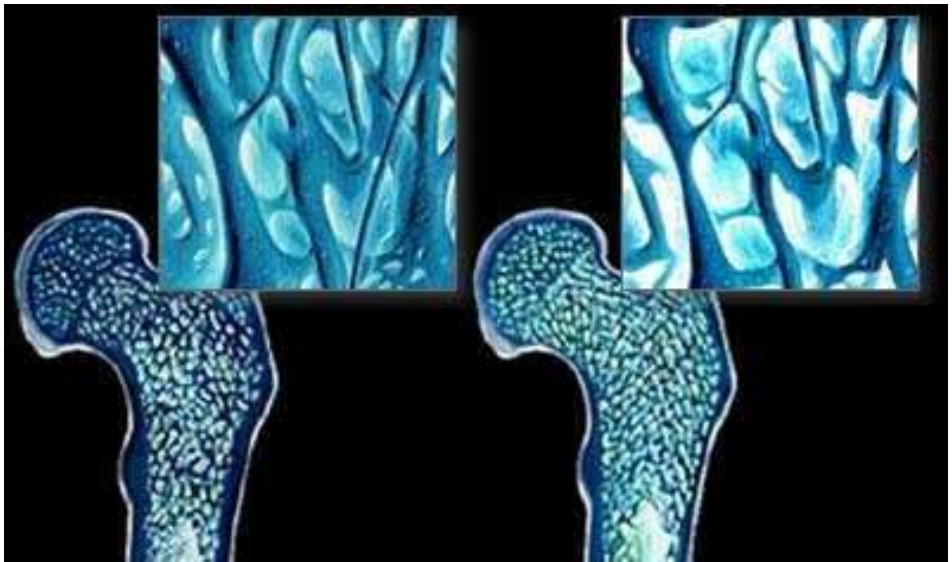
Osteoporosis

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.

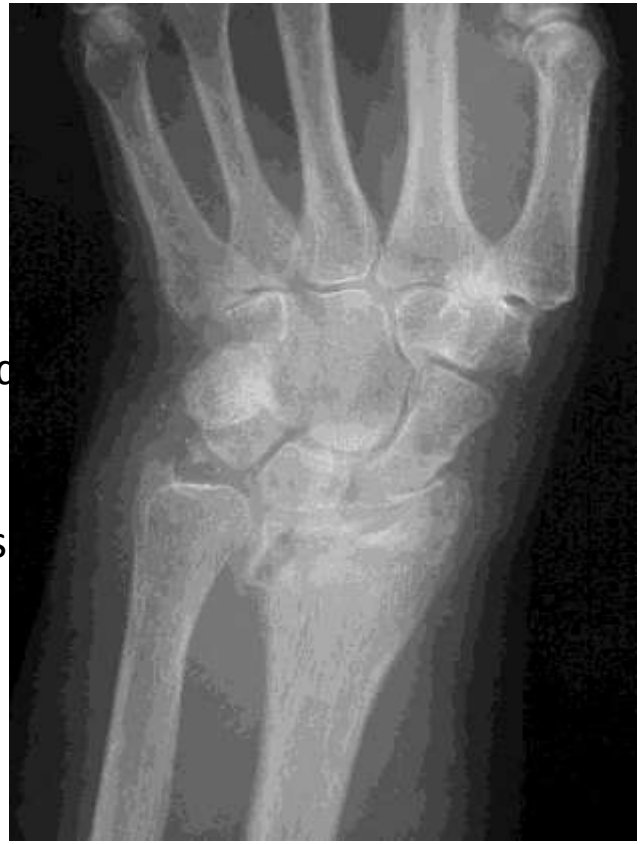


Osteoporosis

- 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.

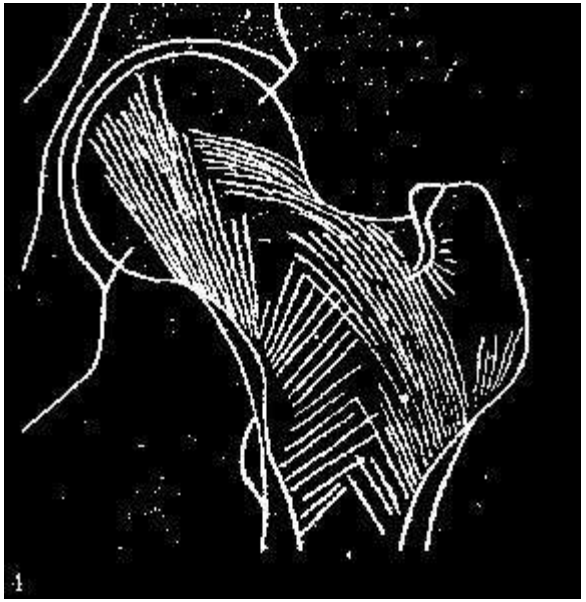
- Secondary osteoporosis is due to an underlying medical condition, such as renal disease, malabsorption, or hormonal imbalance, or to medical treatment such as steroids or certain anticonvulsants



Colles fracture

Osteoporosis Measurement

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



- Grade VI:
  - all normal trabecular groups are visible
  - upper end of femur seems to be completely occupied by cancellous bone;

DEXA

DEXA has very high

accuracy

(the difference between the measurement and a known standard)

Because photons of different energy are differentially attenuated by bone and soft-tissues, by measuring the percentage of each transmitted beam and then applying simple simultaneous equations, the absorption by bone alone and hence bone density can be calculated. This assumes that soft tissue is uniform, and to hence account for fat interspersed with water density tissue, the region adjacent to bone is taken as a soft tissue standard. This measurement is not a true density but rather an areal density, represented in gms/cm^2

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 - Secondary

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

Cushing's Osteoporosis

- Syndrome
  - ↑ cortisol

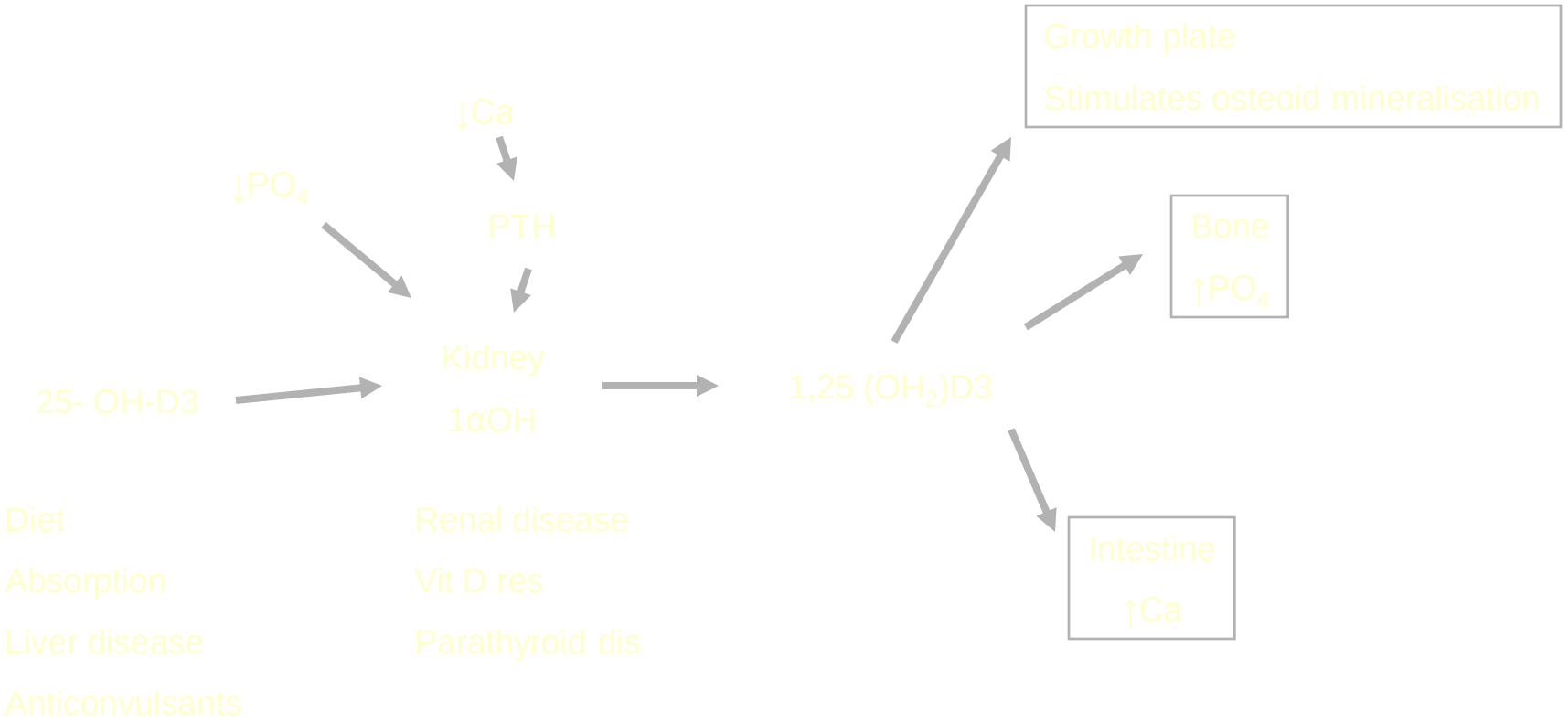
- Pituitary 80% Cushings disease
  - 90% adenoma
  - 20% visible radiographically
- Adrenal 20%
  - Adenoma
  - Carcinoma
- Ectopic ACTH (Ca bronchus)

Cushing's Osteoporosis

- 50% of Cushings 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

Vitamin D

- 1,25 dihydroxycholecalciferol



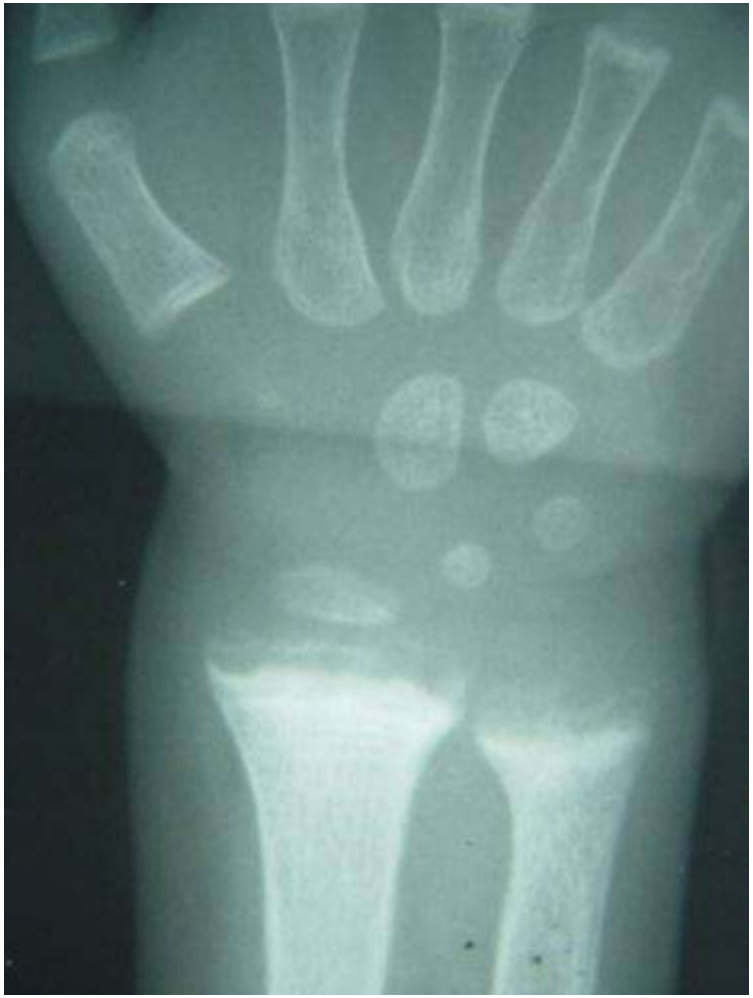
Rickets

- Increased uncalcified osteoid in the immature skeleton

- Lack of Vitamin D
  - Dietary
  - Malabsorption
  - Renal tubular disease

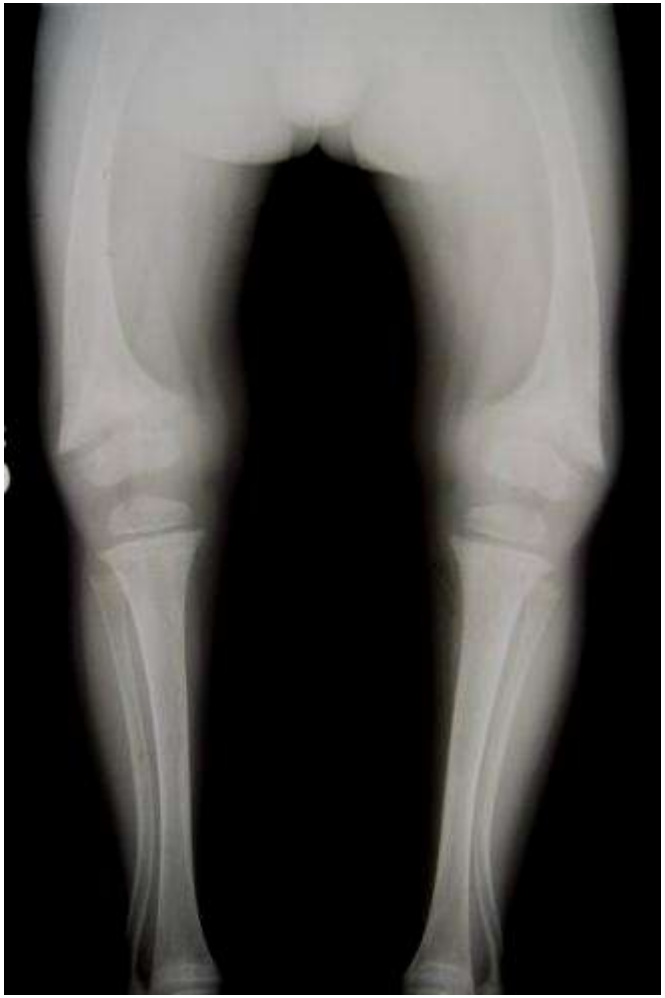
Rickets – Growth Plate changes

- 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

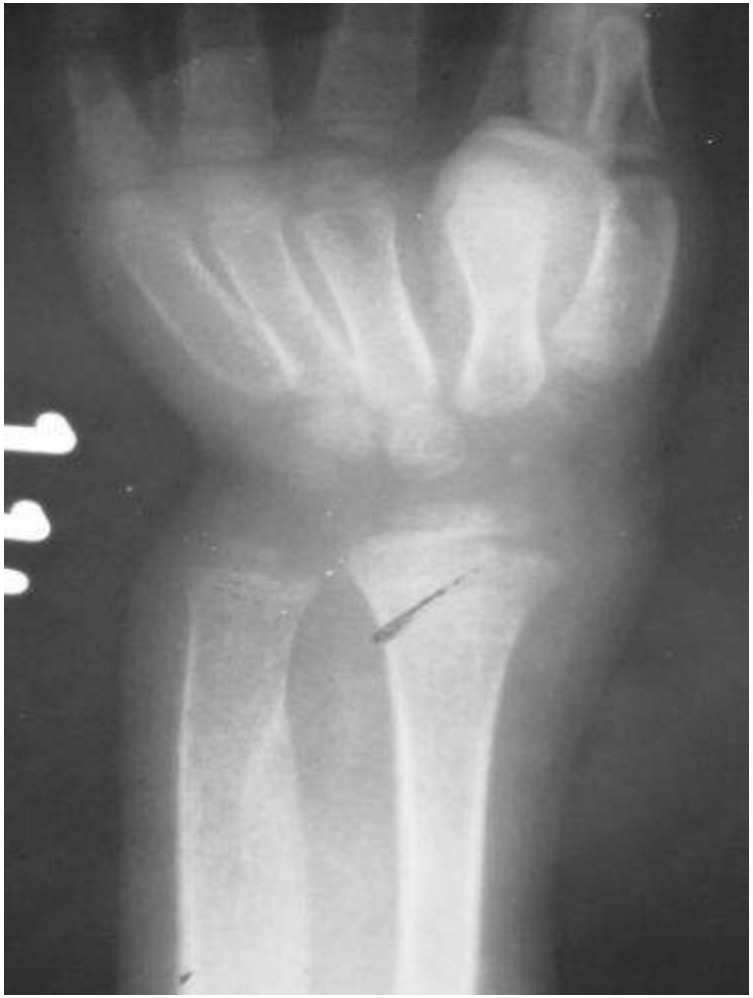


Hypophosphatemic Ricketts

Rickets – General Changes

- Retarded bone maturation and growth

- Decreased bone density
  - uncommon



Biliary atresia, metaphyseal irregularity, osteopenia

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

Hypophosphatasia

- Tissue nonspecific alkaline phosphatase
  - TNSALP

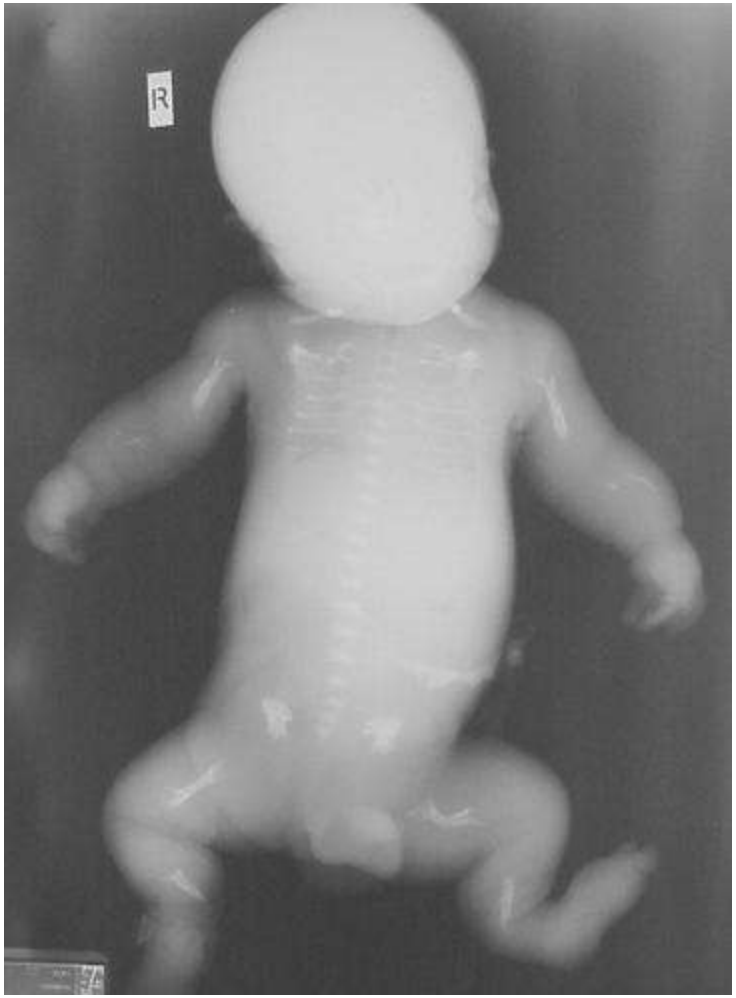
- Causes defective mineralisation of bone
- Low serum alkaline phosphatase
- High serum phosphoethanolamine

Hypophosphatasia

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

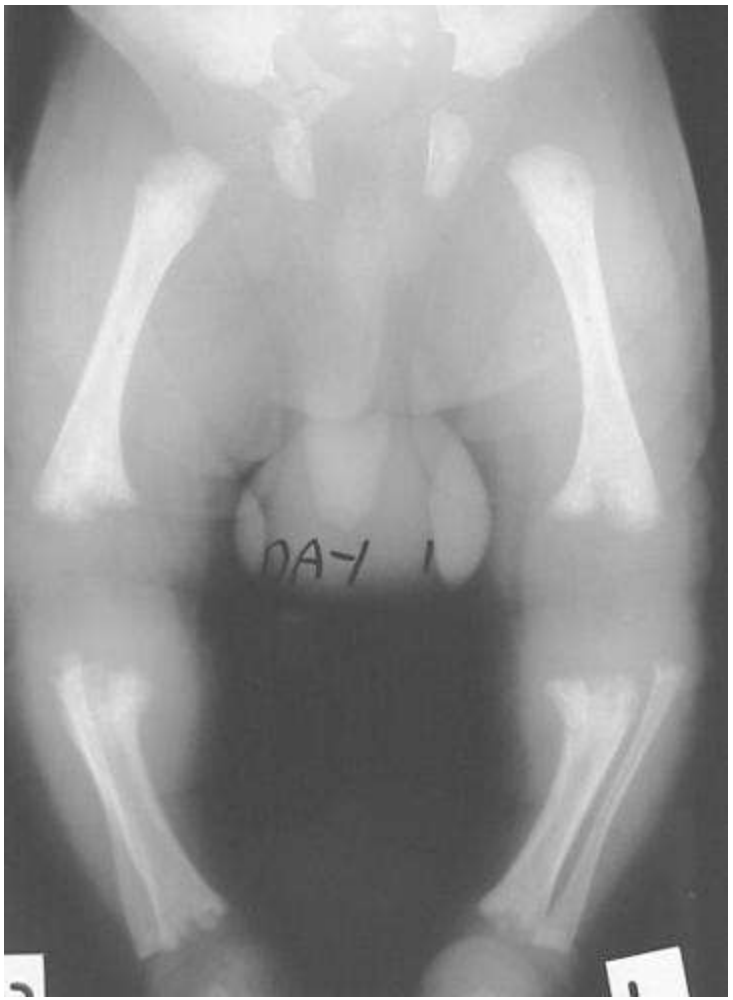
Hypophosphatasia - Neonatal

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



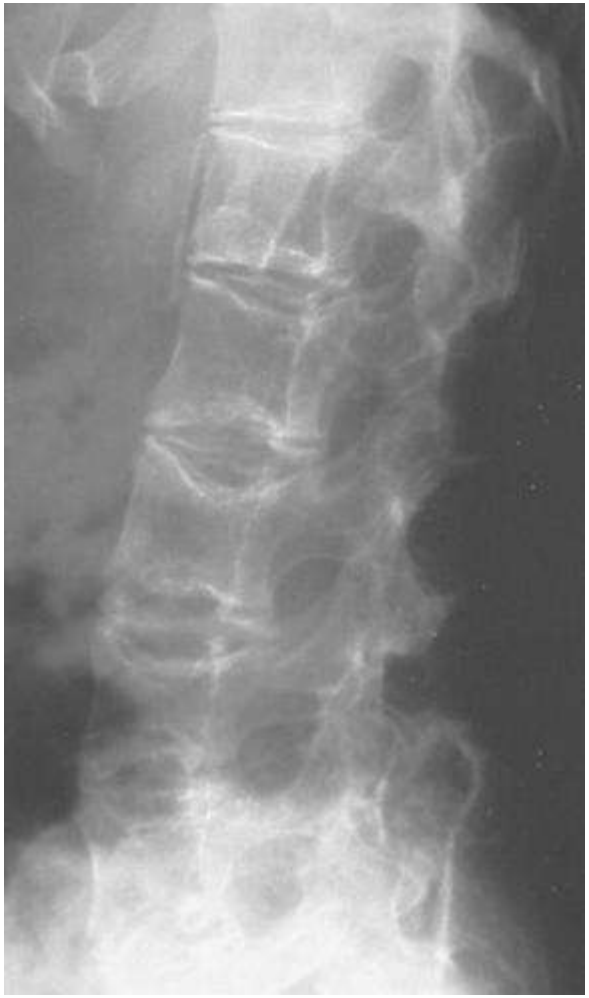
Hypophosphatasia - Infantile

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



Hypophosphatasia - Adult

- Osteomalacia
- With ↓ bone density

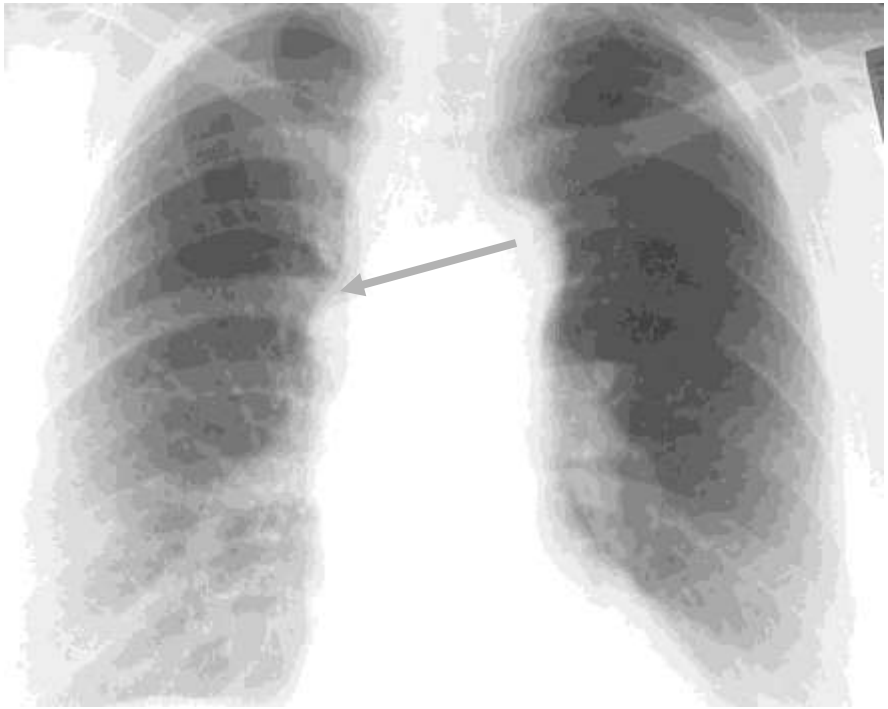


Paget's Disease

- Excessive abnormal remodeling of bone

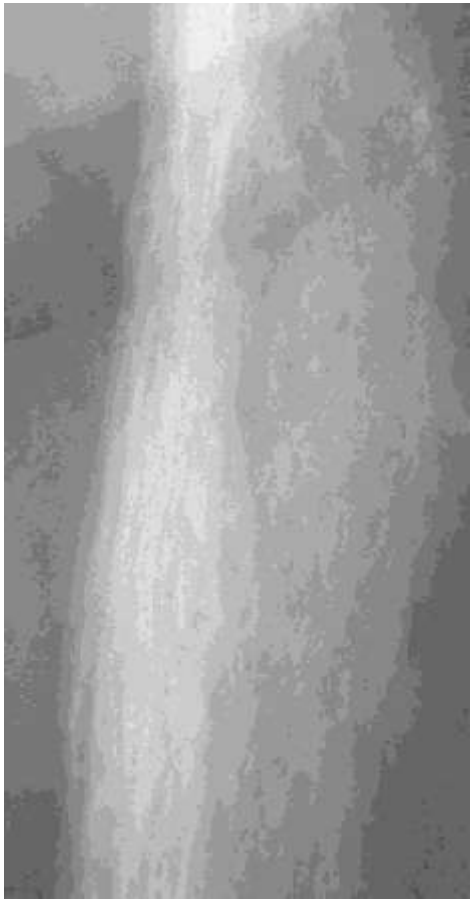
- Middle age 3%
- Old age 10%

- Spine 75%
- Skull 65%
- Pelvis 40%
- Proximal femur 75%



Paget's Disease

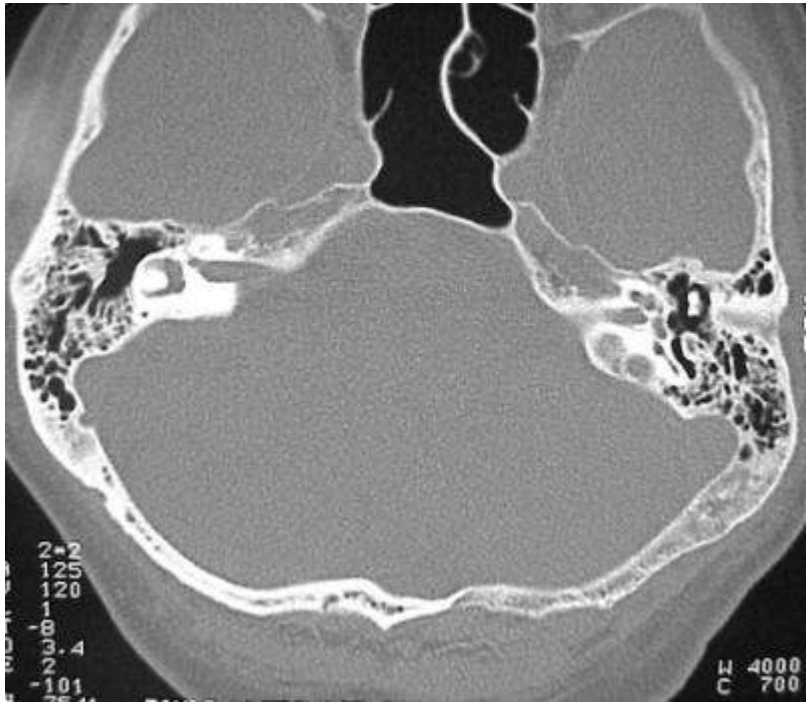
- Middle aged and elderly
- Excessive and abnormal remodeling of bone
- Initial osteolytic phase
- Subsequent osteosclerotic phase
- Enlarged bone with increased density and coarse trabecular



Paget's cortex

Paget's Disease

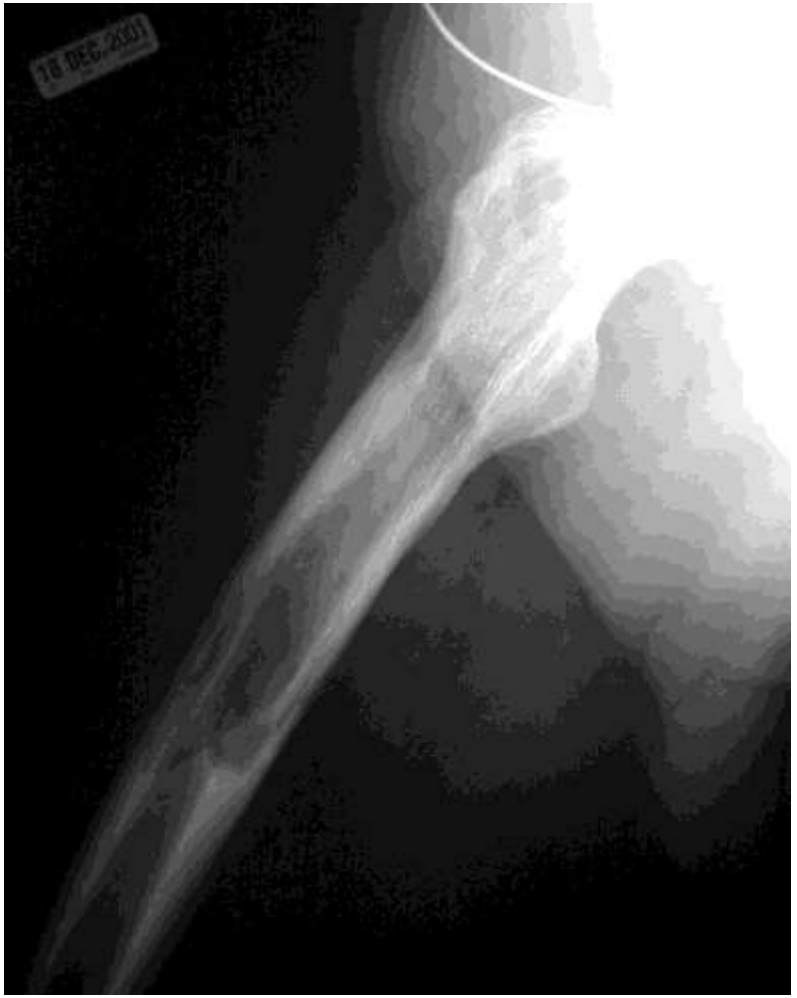
- Radiographic findings
- Active Osteolytic phase
  - Osteoporosis circumscripta
  - Advancing wedge of lucency



Osteoporosis circumscripta 77M

Paget's Disease

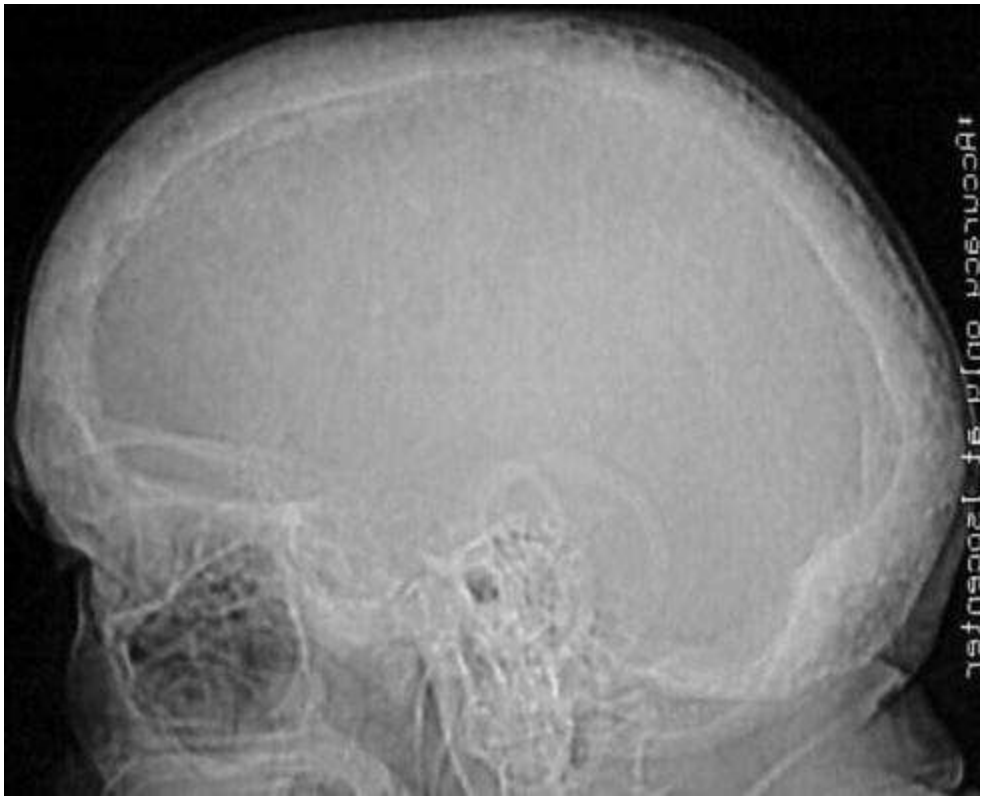
- Radiographic findings
- Mixed phase
  - Skull
    - Osteoporosis circumscripta with sclerosis
  - Pelvis
    - Mixed osteolytic and osteosclerotic
  - Long bones
    - Diaphyseal lucency
    - Epi/Meta sclerosis



Pagets flame and mixed 75m

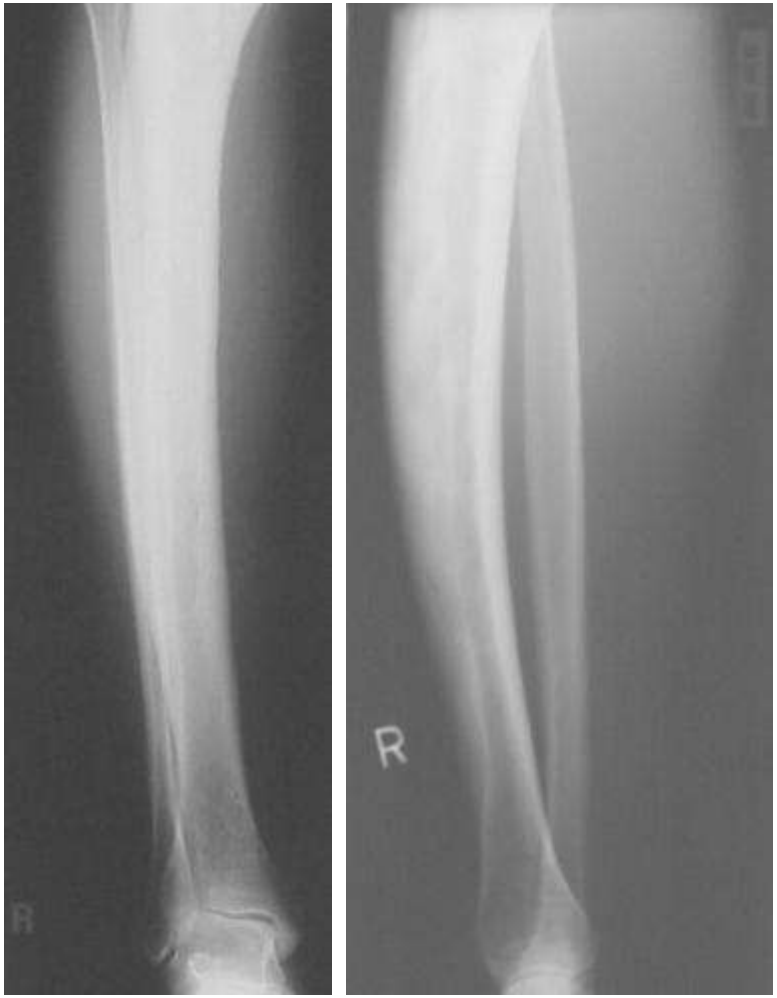
Paget's Disease

- 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



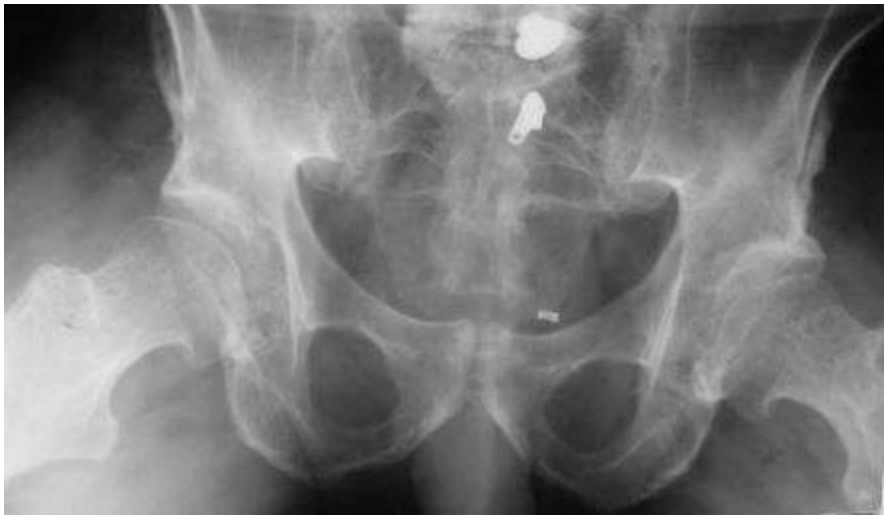
Paget's tibia with bowing

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



Hypopituitarism

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

Thyroid Disorders

- Hyperthyroidism
- Thyroid Acropachy
- Hypothyroidism

Thyroid Acropachy

- 0.5% of thyrotoxicosis
- After Rx

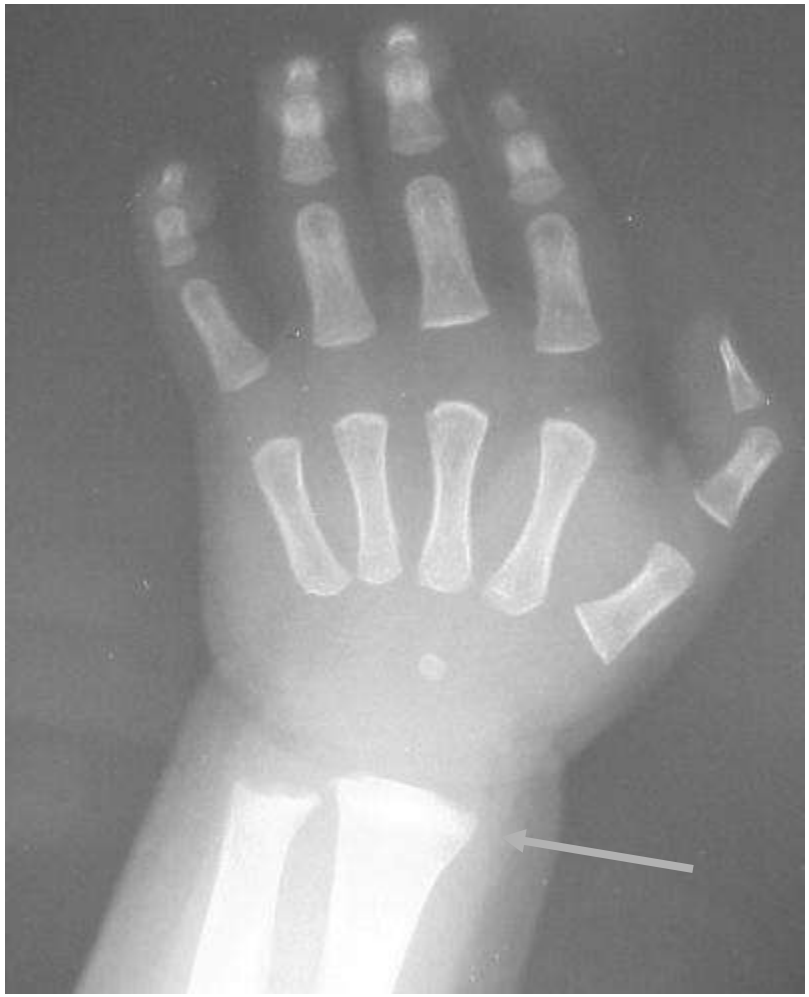
- Exopthalmos
- Painless STS of fingers
- Pretibial myxoedema
- Finger clubbing

Thyroid Acropachy

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

Hypothyroidism Cretinism

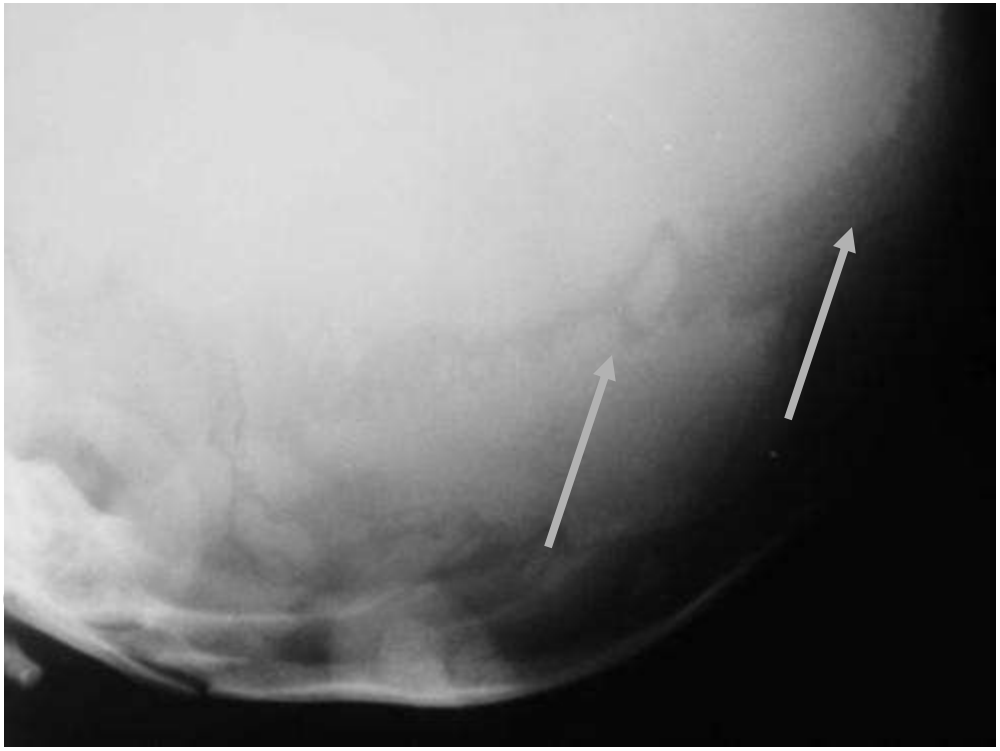
- Appendicular skeleton
  - Delayed appearance of ossification centers
  - Delayed epiphyseal closure
  - Short slender long bones
  - Endosteal thickening
  - Dense metaphyseal bands
  - Coxa vara with short femoral neck



2Y bone age, 3M

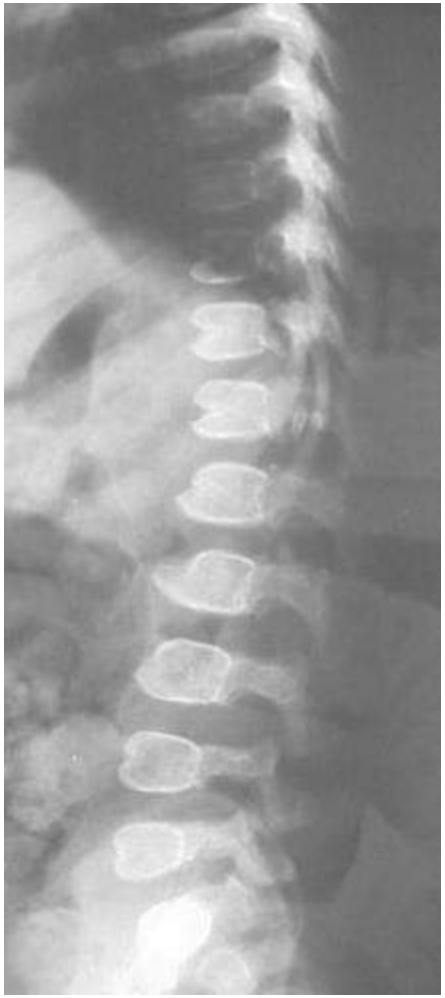
Hypothyroidism Cretinism

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



Hypothyroidism Cretinism

- Axial skeleton
  - Thoracolumbar kyphosis
  - Hypoplastic bullet L1 or L2



2Y bone age, 3M

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

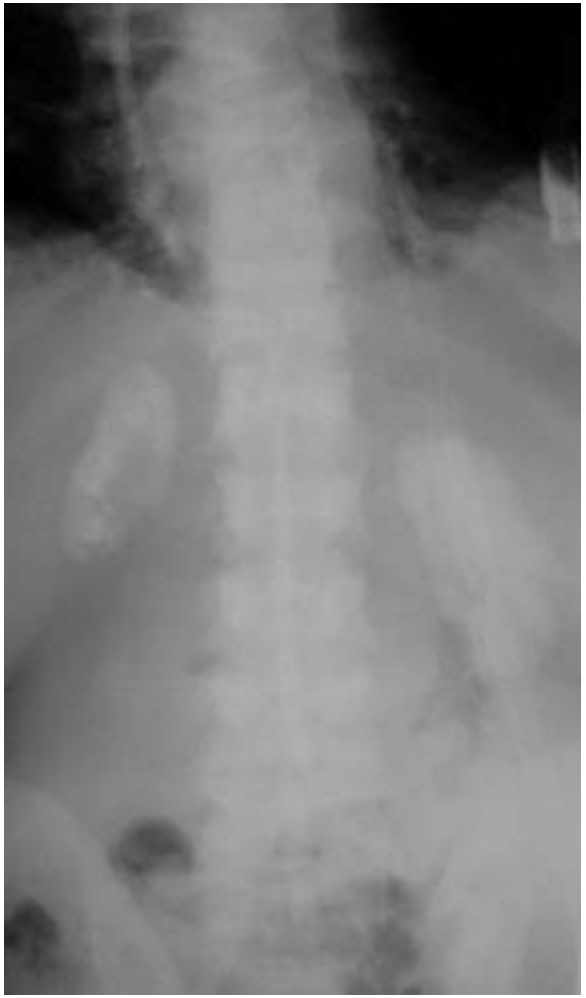
Hyperparathyroidism - Imaging

- 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

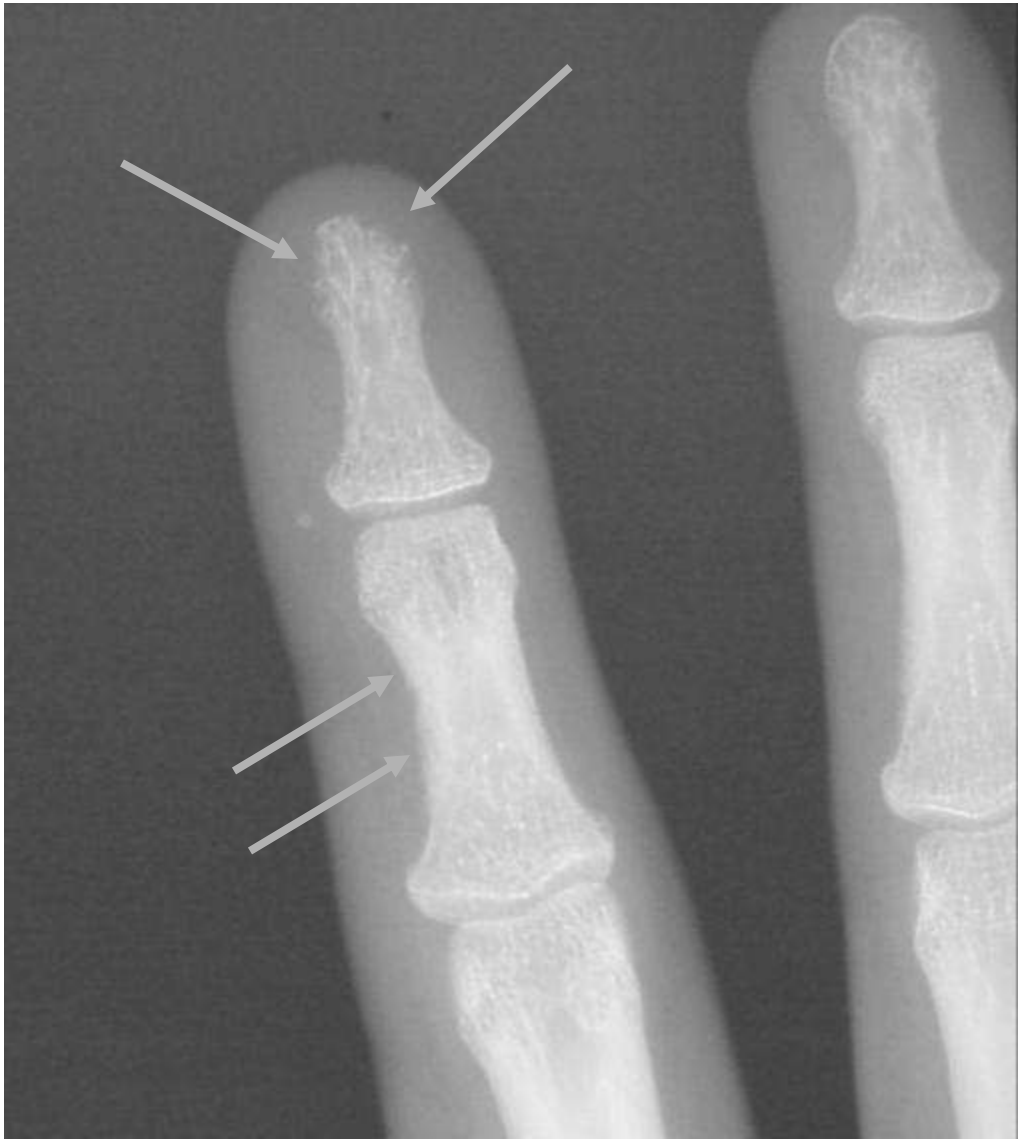
- Renal glomerular disease
  - Bilateral reflux nephropathy
  - Pyelonephritis
  - Chronic glomerulonephitis
- Osteomalacia or Rickets
  - Failure to hydroxylate
- Secondary hyperparathyroidism
  - Failure to excrete phosphate
- Osteosclerosis
- Calcification more prominent in adults



Primary oxalosis

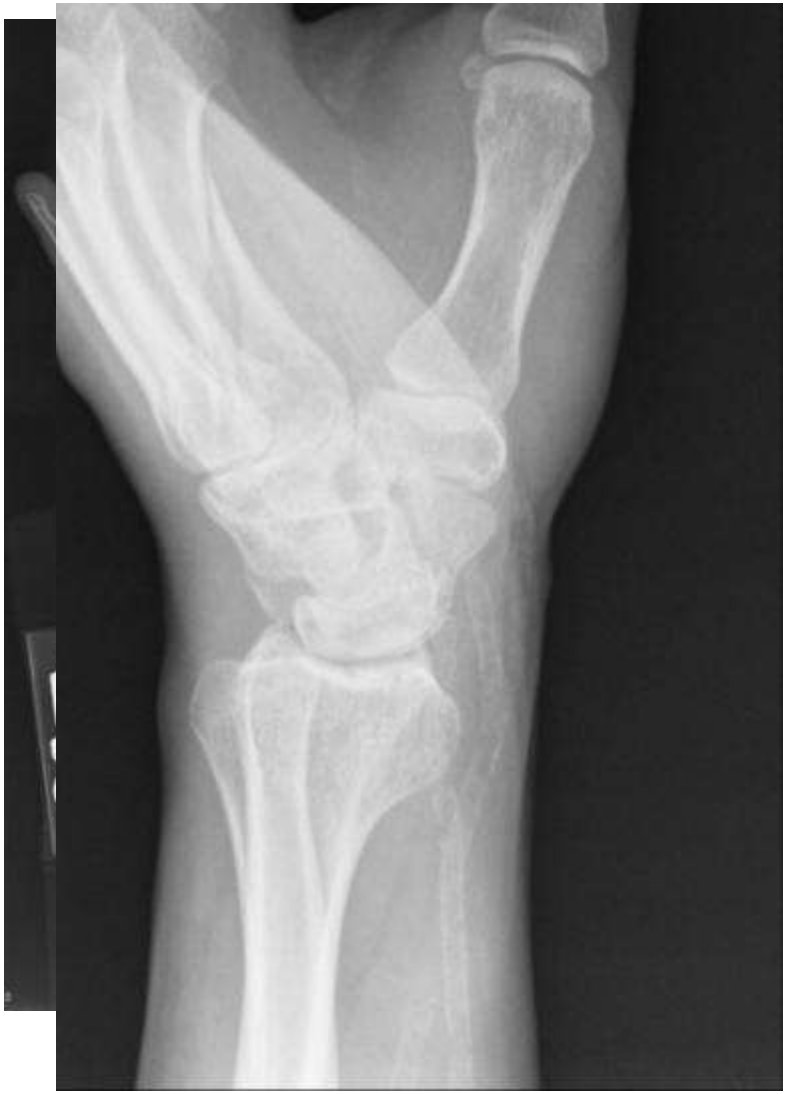
Hyperparathyroidism – Imaging - Bones

- 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



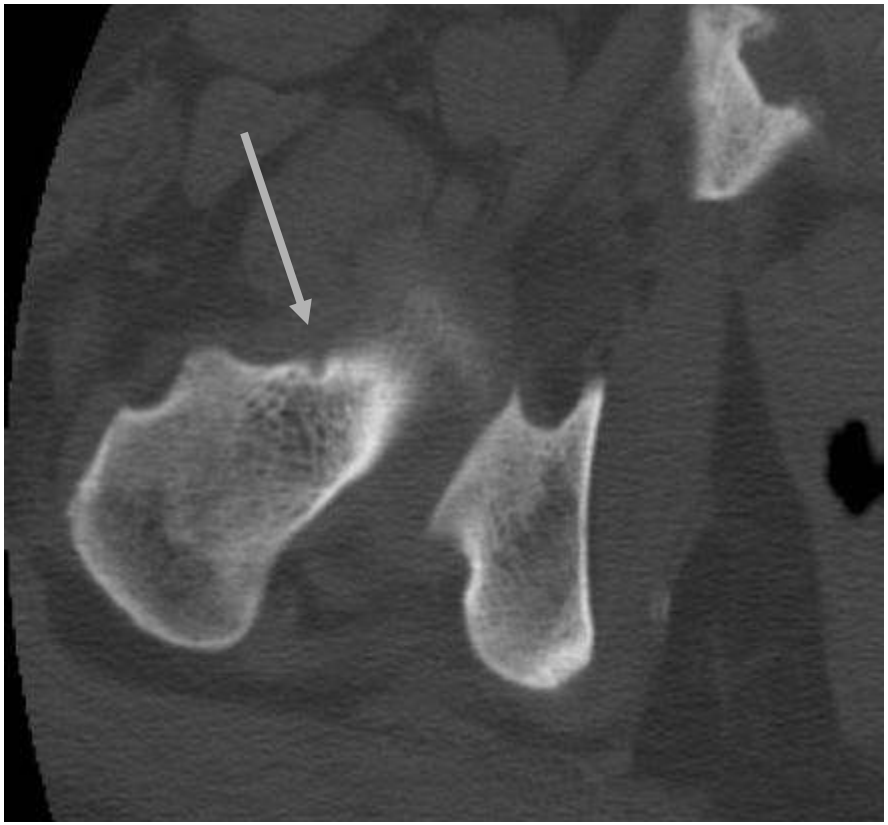
Hyperparathyroidism – Imaging – Soft Tissues

- 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



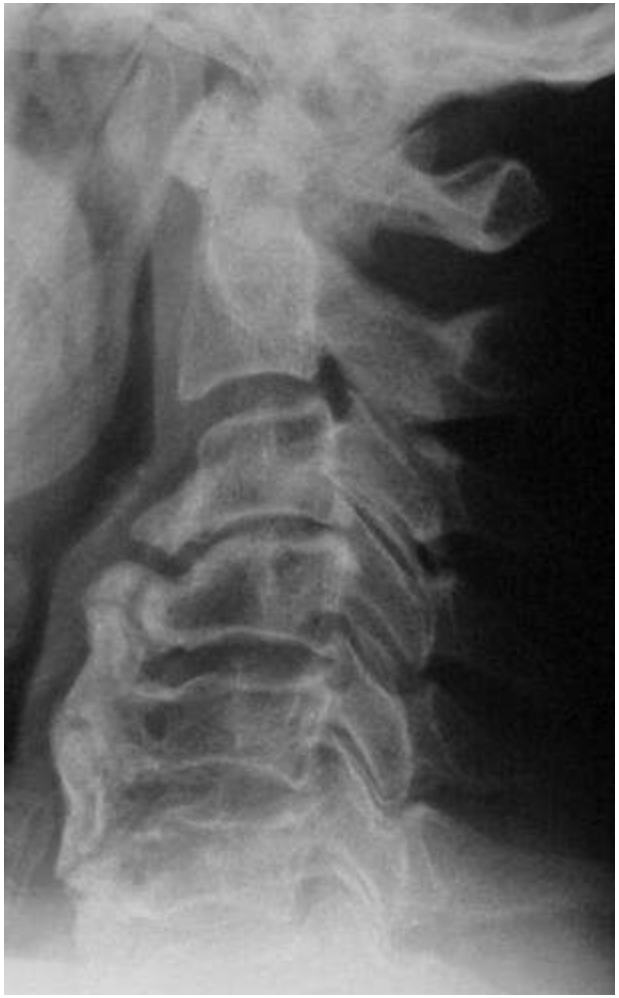
Primary oxalosis
secondary hyperparathyroidism

- Primary
  - Hereditary hyperoxaluria
  - AR, enzyme deficiency - carboligase
  - Diffuse calcium oxalate deposits

- Secondary
  - Disturbance of bile acid metabolism
  - Usually diseases of terminal ileum

HypoPararthyroidism

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



Pseudohypoparathyroidism

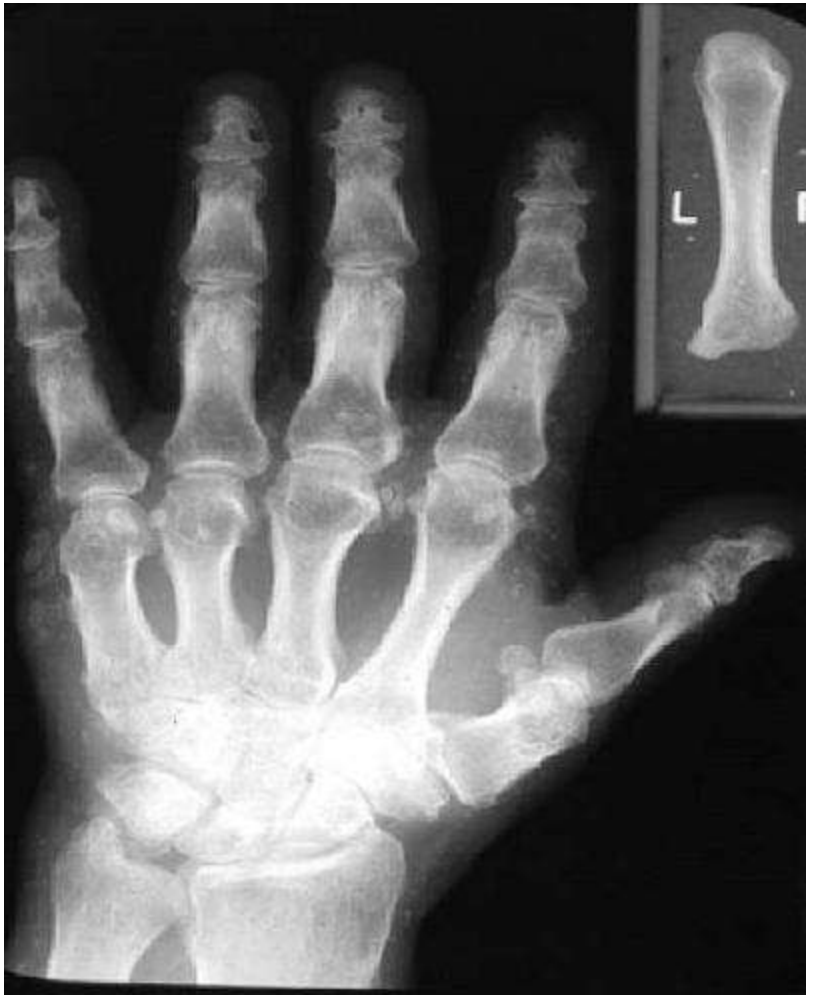
- Hormone resistant
  - End organ unresponsiveness to PTH
    - Usually bone and renal
- X – linked dominant F>M
- Clinical – Albright's hereditary osteodystrophy
  - Short statue, thickset features
  - ↓ Calcium, ↑Phosphate, normal or ↑ PTH
- Imaging
  - Short $4^{th} > 5^{th} > 1^{st}$ metacarpals/tarsals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

PseudoPseudohypoparathyroidism

- Similar phenotypically to pseudohypoparathyroidism, but with normal plasma calcium

Albright's hereditary osteodystrophy

- PseudohypoPTH (PHP) and Pseudo-pseudohypoPTH (PPHP)
- X linked dominant; females > males
- PHP
  - Low Ca2+, high Ph
- PPHP (normocalcemic form of PHP)
  - Normal Ca2+ and Ph



PHP and PPHP

- Clinical features
  - Short stature, Obesity, Round face, Brachydactyly
- Typical radiographic findings
  - ST calcification and ossification – plaquelike, assymetric, 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