Metabolic Bone Disorders

Orthopedic Surgeons and Bone

- Orthopedic surgeons have to deal with all types of bone : healthy or diseased; and that's why they have to know about bone metabolism
- Bones in the body protect vital organs
- Bones give support to muscles and tendons
- Bone may become weak in certain conditions

Bone is a living structure

- There is a continuous activity in bone during all stages of life
- There is continuous bone resorption and bone formation as well as remodeling
- That means bone is not only for protection and support but its contents play an important part in blood homeostasis
- Many factors are involved in this process

Bone Metabolism

- Bone metabolism is controlled by many factors:

- Calcium
- Phosphorus
- Parathyroid gland
- Thyroid gland
- Estrogen
- Glucocorticoid hormones
- Intestinal absorption
- Renal excretion
- Diet
- Vitamin D
- Sun exposure

Bone Structure

- Bone is formed by

  Bone matrix : which consists of

  40% organic : collagen type1 (responsible for tensile strength)

  60% Minerals : mainly Calcium hydroxyapatite, Phosphorus, and traces of other minerals like zinc

  Cells in bone : osteoblasts, osteoclasts, osteocytes

Plasma levels

- Calcium : 2.2-2.6 mmol/l
- Phosphorus : 0.9-1.3 mmol/l

  Both absorbed by intestine and secreted by kidney in urine
- Alkaline phosphatase : 30-180 units/l

  Is elevated in bone increased activity like during growth or in metabolic bone disease or destruction

  Vitamin D level : 70-150 nmol/l

Parathyroid Hormone (PTH)

- Production levels are related to serum calcium levels
- PTH secretion is increased when serum calcium is low
- Action of PTH: it increases calcium levels in the blood by increasing its release from bone

& increase absorption from the intestine

& and increase reabsorption from the kidney (also increase secretion of phosphorus)

Hyperparathyroidism

- Primary : Adenoma of the gland
- Secondary : as a result of low calcium
- Tertiary : as a result of prolonged or sustained stimulation = hyperactive nodule or hyperplasia

Calcitonin

- Is secreted by C cells of thyroid gland
- Its secretion is regulated by serum calcium
- Its action is to cause inhibition of bone resorption and increasing calcium excretion by this it causes lowering of serum calcium

Bone Strength

- Bone strength is affected by mechanical stress which means exercise and weight bearing
- Bone strength gets reduced with menopause and advancing age
- Reduced bone density on X rays is called Osteopenia
- Osteopenia is also a term used to describe a degree of reduced bone density, which if advanced becomes Osteoporosis

Bone Density

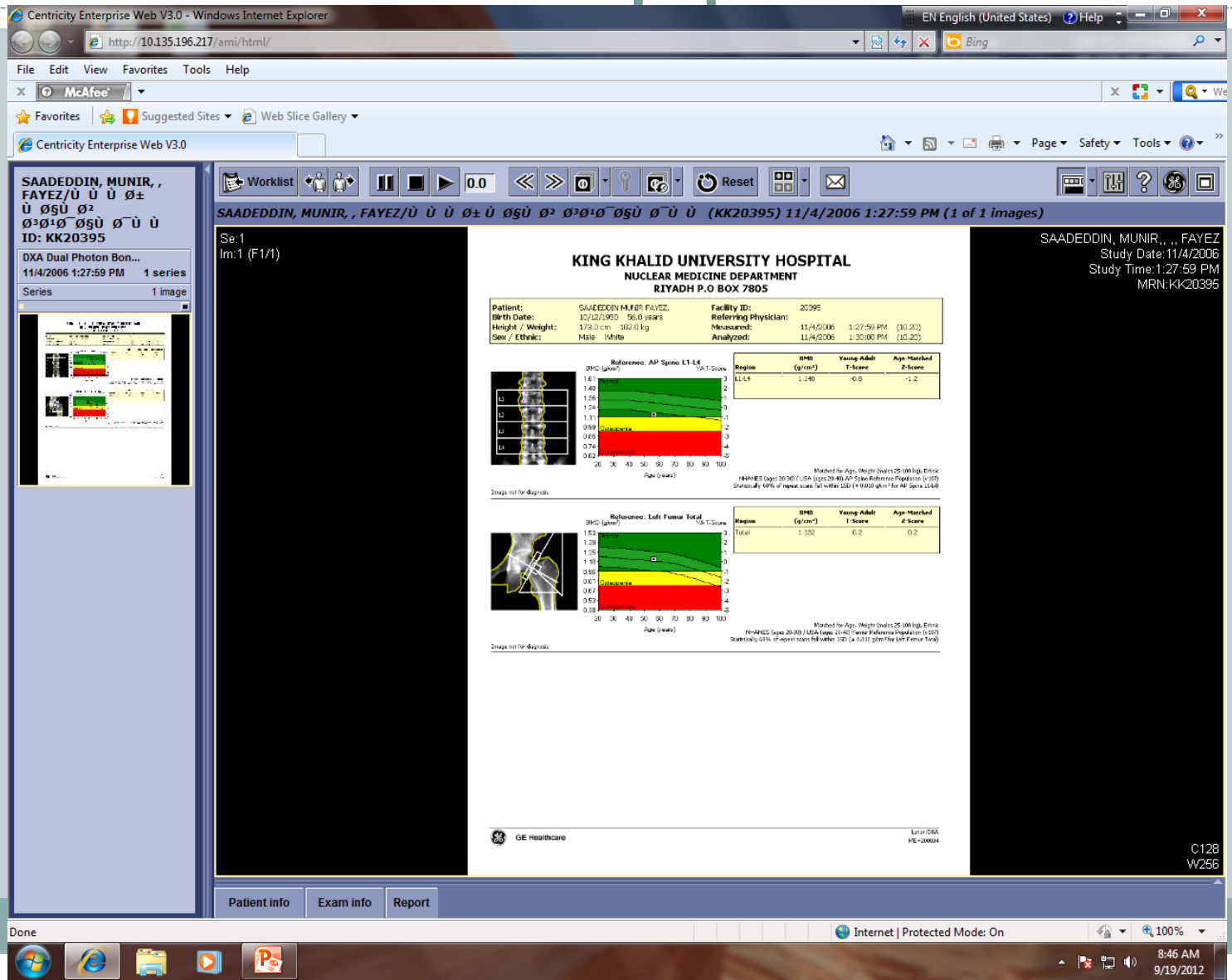
- Bone density is diagnosed at current time by a test done at radiology department called :

  DEXA scan

- DEXA is (Dual Energy X ray Absorbtionometry)

- However: increased bone density does not always mean increased bone strength, as sometimes in Brittle bone disease (which is a dense bone) is not a strong bone but fragile bone which may break easily

Dexa Scan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NUCLEAR MEDICINE DEPARTMENT
RIYADH P.O BOX 7805
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Birth Date: 10/12/1950 56.0 years
Height / Weight: 173.0 cm 102.0 kg
Sex / Ethnic: Male White
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Disorders to be discussed

- Rickets
- Osteomalacia
- Osteoporosis
- Hyperparathyroidism

Rickets & Osteomalacia

- Different expressions of the same disease which is :

  Inadequate mineralization

- Rickets affects

  : Areas of endochondral growth in children

- Osteomalacia

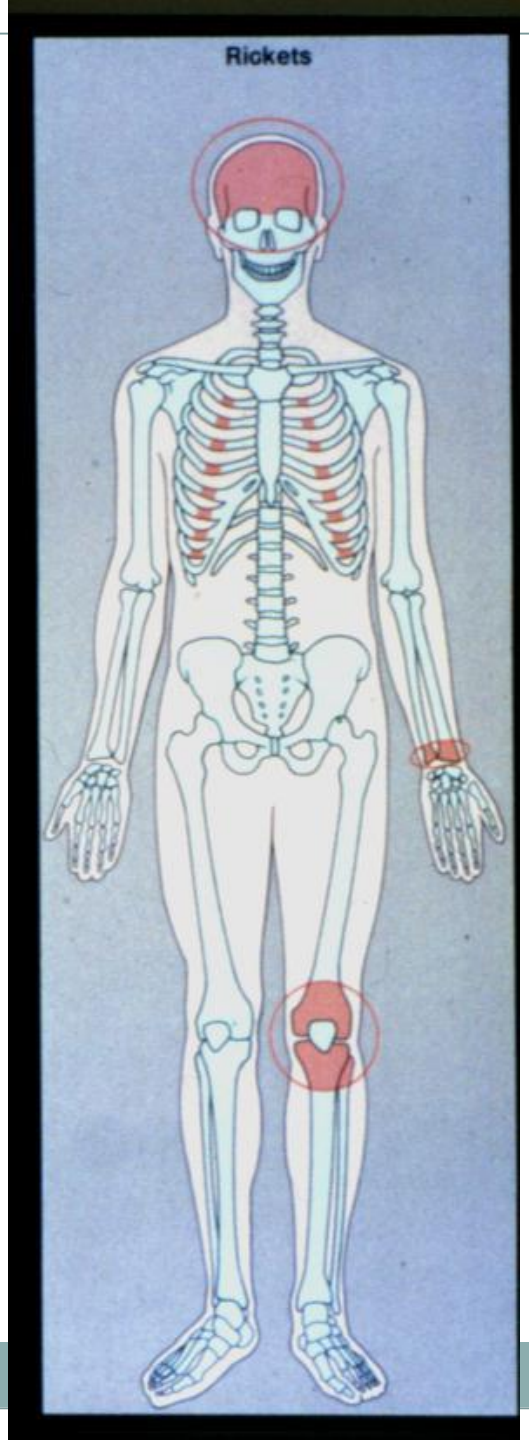
  : All skeleton is incompletely calcified in adults

Rickets & Osteomalacia

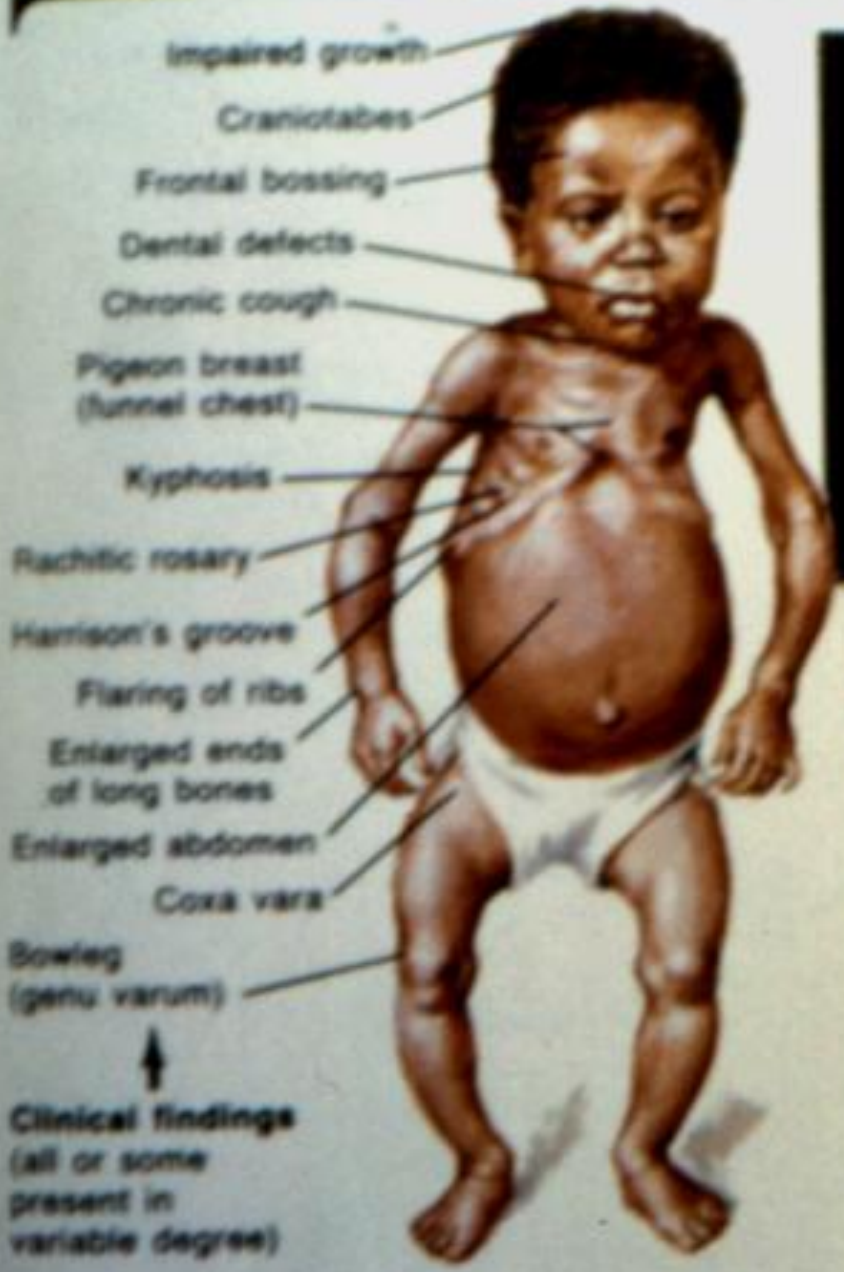
* **Causes**
  - Calcium deficiency
  - Hypophosphataemia
  - Defect in Vitamin D metabolism
    - nutritional
    - underexposure to sunlight
    - intestinal malabsorption
    - liver & kidney diseases

Rickets: Symptoms and Signs

- Child is restless, babies cry without obvious reason
- Failure to thrive
- Muscle weakness
- In severe cases with very low calcium: tetany or convulsions
- Joint thickening especially around wrists and knees
- Deformity of limbs, mostly Genu varum or Genu Valgum
- Pigeon chest deformity, Rickety Rosary, craniotabes

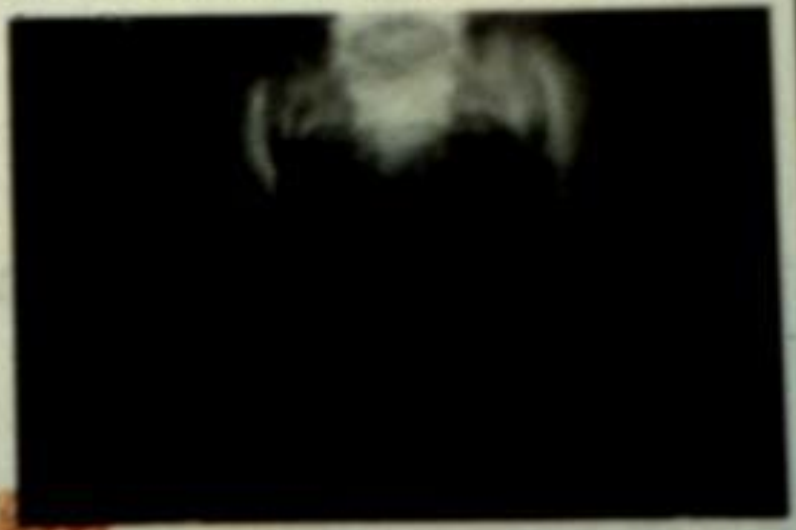

Rickets

Childhood Rickets



Clinical findings (all or some present in variable degree)

Flaring of metaphyseal ends of tibia and femur. Growth plates thickened, irregular, cupped, and axially widened. Zones of provisional calcification fuzzy and indistinct. Bone cortices thinned and medullae rarefied



X Ray Findings in Rickets

- Growth plate widening and thickening
- Metaphysial cupping
- Long bones deformities

Growth Plate& Metaphysial Changes

Long Bones Deformities

Rickets & Osteomalacia

Biochemistry

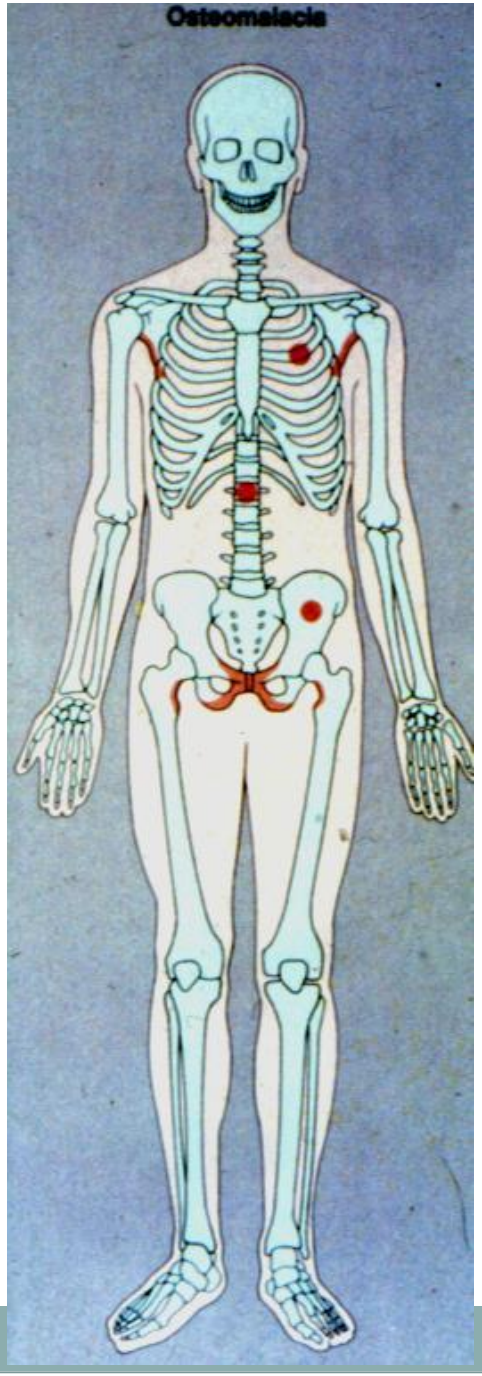
Hypocalcaemia,… Hypocalciuria

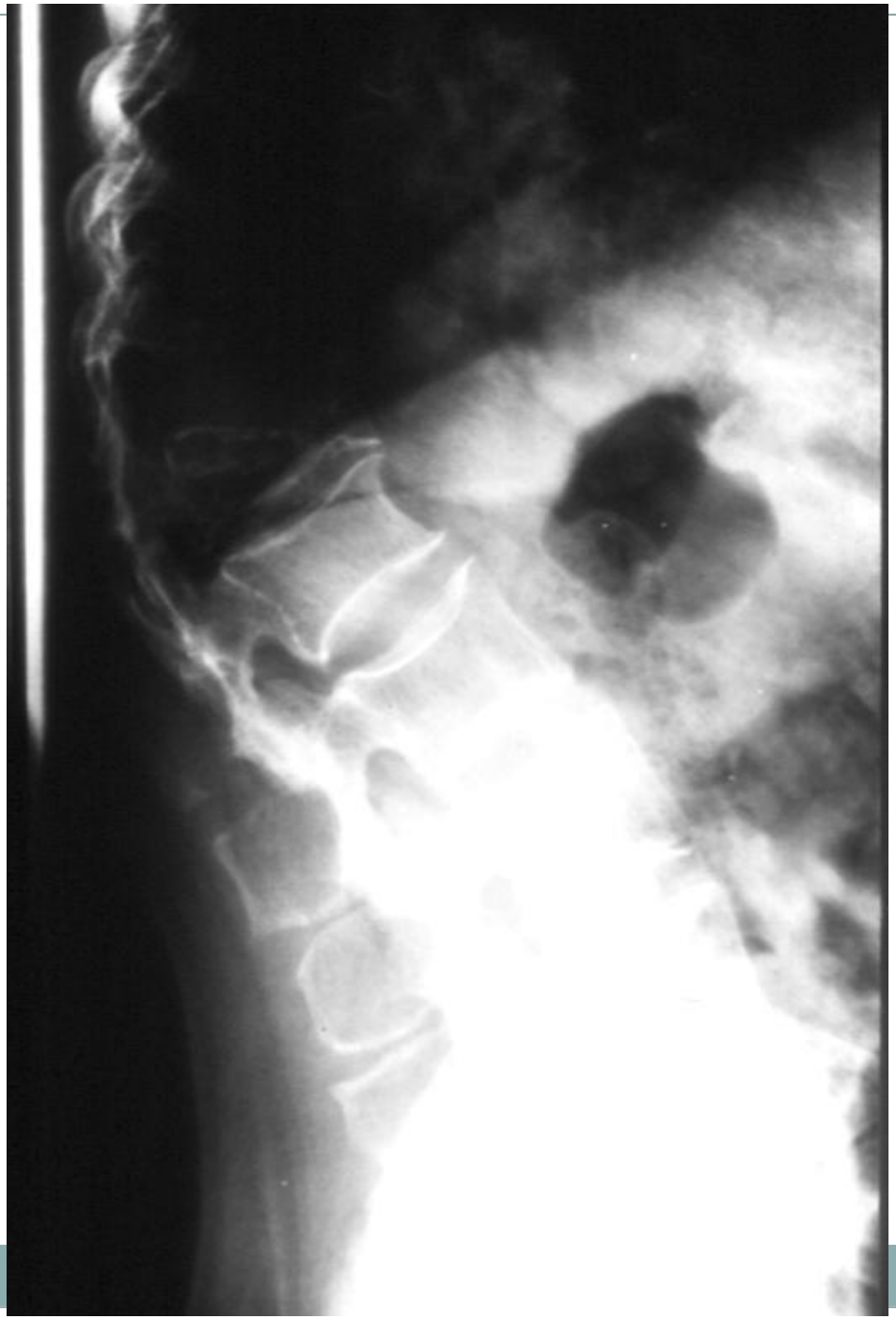
High alkaline phosphatase

Osteomalacia

- Metabolic Bone Disorder in Adults :
  symptoms and signs

- Bone pain, mainly backache
- Muscle weakness
- Reduced bone density
- Vertebral changes : Bi-concave vertebra, vertebral collapse , kyphosis
- Stress fractures : Loosers zones in scapula, ribs ,pelvis, proximal femur


Osteomalacia



Rickets & Osteomalacia

Treatment

*Vitamin D deficiency

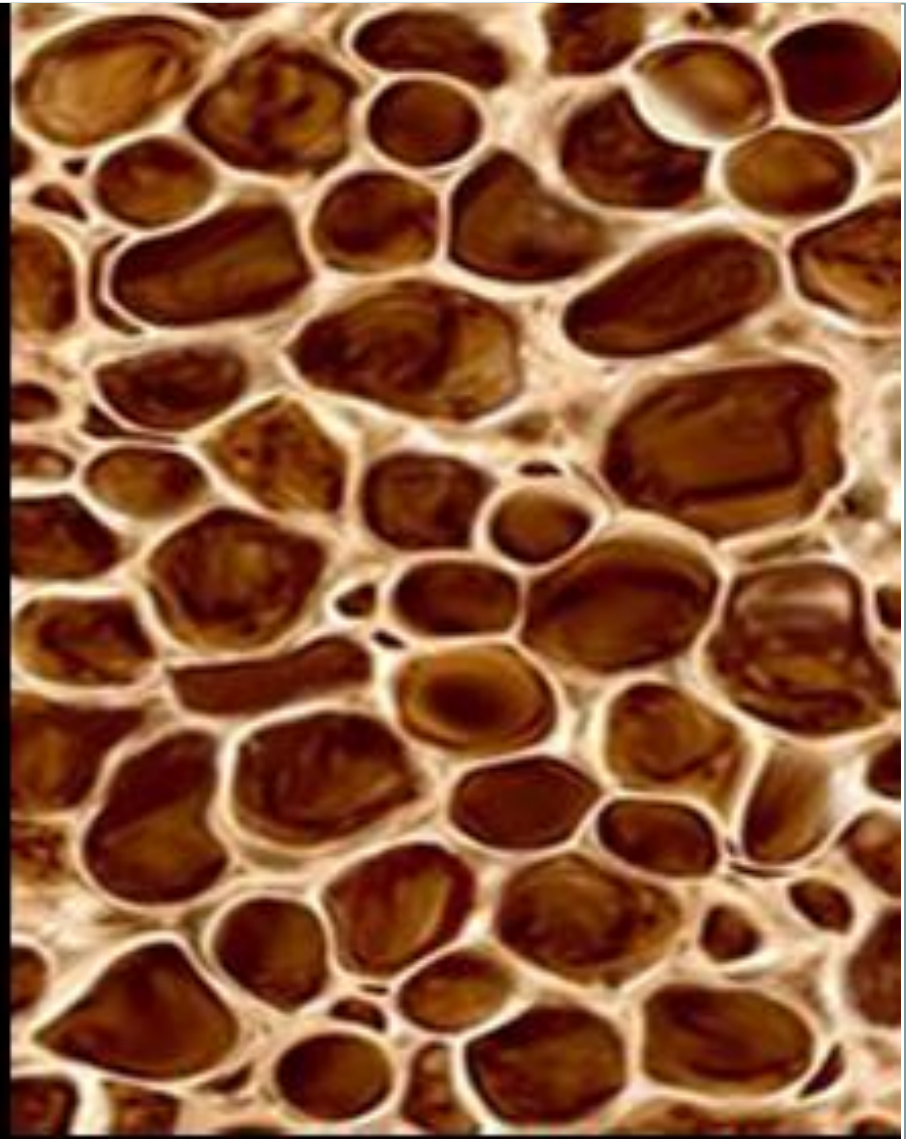
- Rickets
  - adequate Vitamin D replacement
  - sun exposure
  - correct residual deformities

- Osteomalacia
  - Vitamin D + Ca
  - fracture management
  - correct deformity if needed

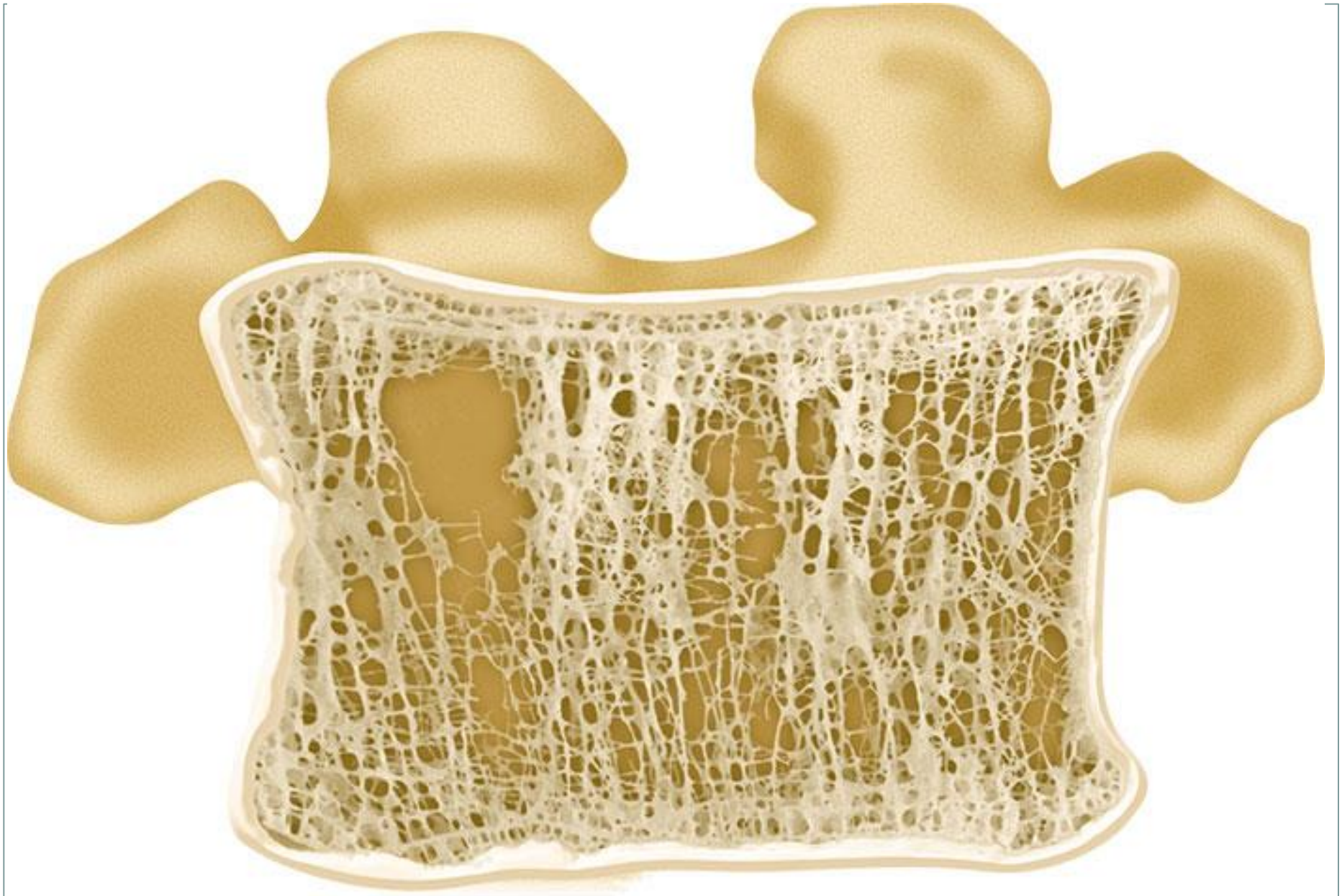
Osteoporosis

- Decreased bone mass : decreased amount of bone per unit volume (and this causes reduced density)
- Mineralisation is not affected
- Mainly post-menopausal and age related

Honey Comb Pattern
In Normal Bone



Honey Comb Pattern With
Big Holes In Osteoporosis



Osteoporosis: Primary and Secondary

- Primary Osteoporosis :

  Post menopausal

  Senile

Post menopausal Osteoporosis

- Due to rapid decline in estrogen level
- This results in increased osteoclastic activity
- Normal bone loss usually 0.3% per year
- Post menopausal bone loss 3% per year

Risk Factors in Post menopausal Osteoporosis

- Race
- Hereditary
- Body build
- Early menopause
- Smoking/ alcohol intake/ drug abuse
- ? Calcium intake

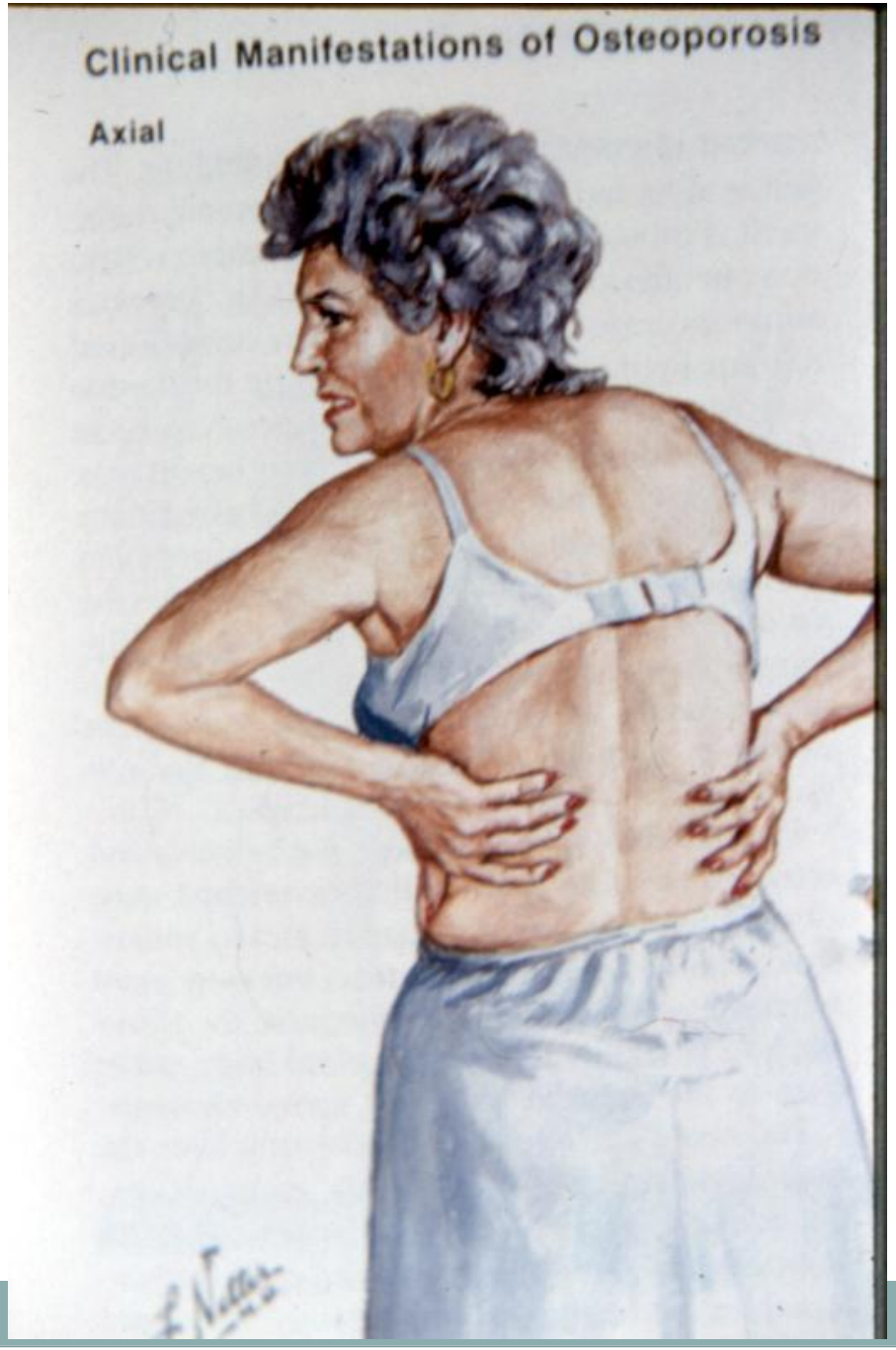
Senile Osteoporosis

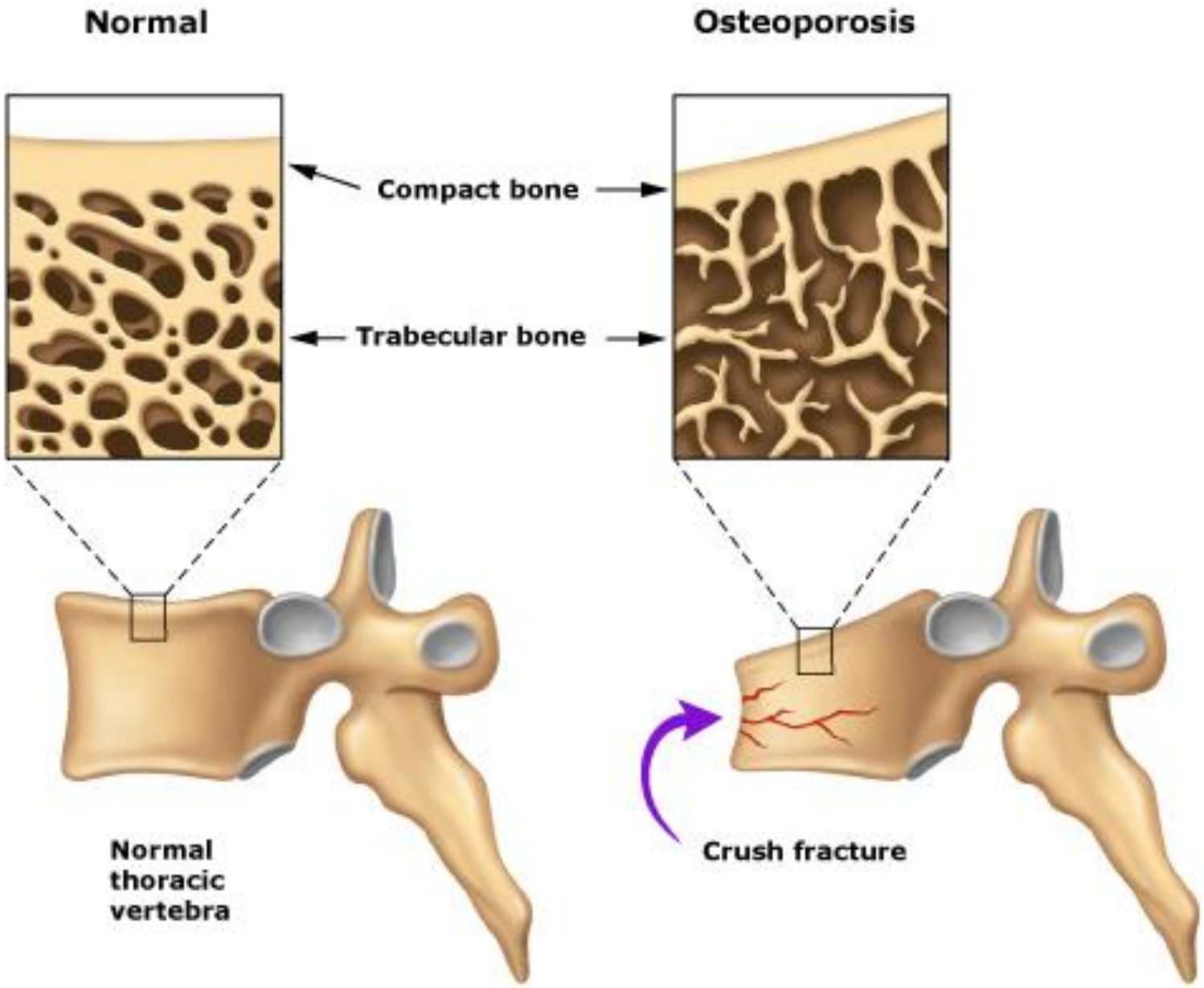
- Usually by 7^{th} to 8^{th} decades there is steady loss of at least 0.5% per year
- It is part of physiological manifestation of aging
- Risk factors in Senile Osteoporosis :

- Male menopause
- Dietary : less calcium and vitamin D and protein
- Muscle weakness
- reduced activity

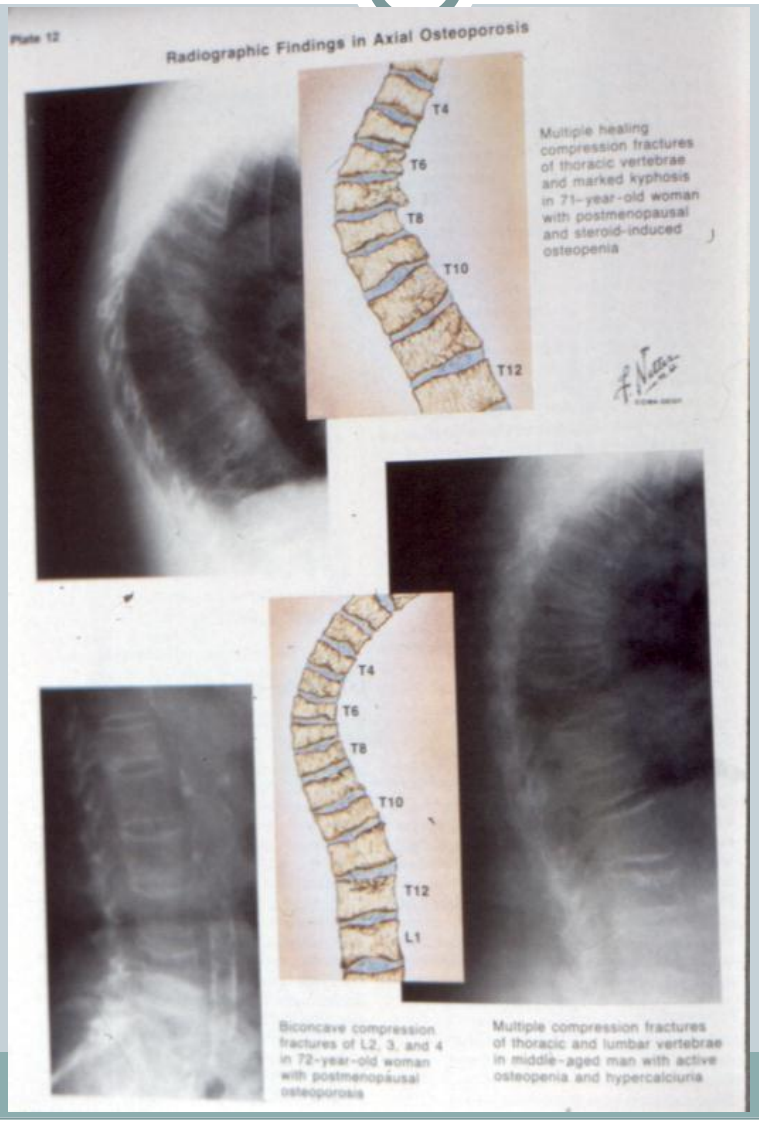
Clinical Features of Osteoporosis

- Osteoporosis is a Silent disease
- Osteoporosis is Serious due to possible complications :mainly fractures
- Osteoporosis does not cause pain usually
- Osteoporosis causes gradual increase in dorsal kyphosis
- Osteoporosis leads to loss of height
- Osteoporosis is not osteoarthritis; but the two conditions may co-exist


Clinical Manifestations of Osteoporosis
Axial


Normal
Osteoporosis
Compact bone
Trabecular bone
Normal thoracic vertebra
Crush fracture

How does kyphosis and loss of height occurs



Osteoporotic Fractures

- They are Pathological fractures
- Most common is osteoporotic compression fracture (OVC #s)
- Vertebral micro fractures occur unnoticed (dull ache)
- Most serious is hip fractures
- Also common is wrist fractures (Colles fracture)

Secondary Osteoporosis

- Drug induced : steroids, alcohol, smoking, phenytoin,heparin
- Hyperparathyroidism, hyperthyroidism, Cushing's syndrome, gonadal disorders, malabsorption, mal nutrition
- Chronic diseases : RA, renal failure, tuberculosis
- Malignancy : multiple myeloma, leukemia, metastasis

Disuse Osteoporosis

- Occurs locally adjacent to immobilised bone or joint
- May be generalised in in bed ridden patients
- Awareness of and attempts for prevention are helpful

Osteomalacia vs. osteoporosis

Osteomalacia	Osteoporosis
Any age	Post-menopause, old age
Pt. ill	Not ill
General ache	Asymptomatic till #
Weak muscles	Normal
Looser zones	Nil
Alkaline ph increase	Normal
PO_4 decrease	Normal

Prevention of Osteoporosis

- Prevention of osteoporosis should start from childhood
- Healthy diet, adequate sunshine, regular exercise, avoidance of smoking or alcohol, caution in steroid use
- At some time in the past there was a recommendation of HRT (Hormone replacement Therapy) for post menopausal women ? And men; but now this is discontinued

Management of Osteoporosis

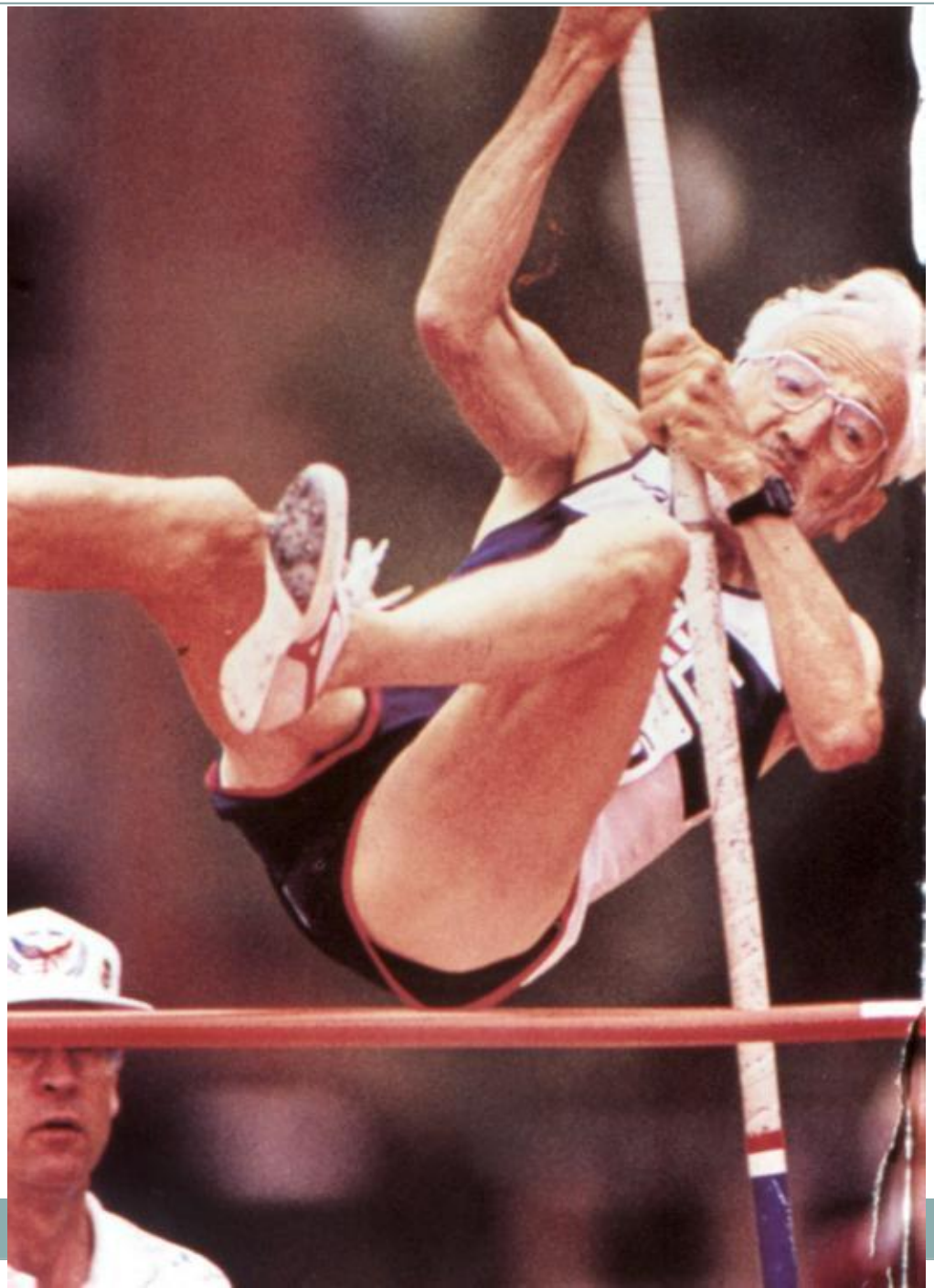
- Drugs
- Exercise
- Management of fractures

Drug Therapy in Osteoporosis

- Estrogen has a definite therapeutic effect and was used extensively as HRT but cannot be recommended now due to serious possible side effects
- Adequate intake of calcium and vitamin D is mandatory
- Drugs which inhibit osteoclast activities : e.g. Bisphosphonates like sodium alendronate FOSAMAX , BONVIVA
- Drugs which enhance osteoblast activities : bone stimulating agents like PROTELOS, FORTEO

Exercise in Osteoporosis

- Resistive exercises
- Weight bearing exercises
- Exercise should be intelligent to avoid injury which may lead to fracture

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Management of Fractures in Osteoporosis

- Use of load shearing implants in fracture internal fixation instead of plating

Vertebral Osteoporotic Compression Fracture

Management of OVC Fractures

- Pain relief
- Prevention of further fractures
- Prevention of instability
- Vertebroplasty
- Kyphoplasty

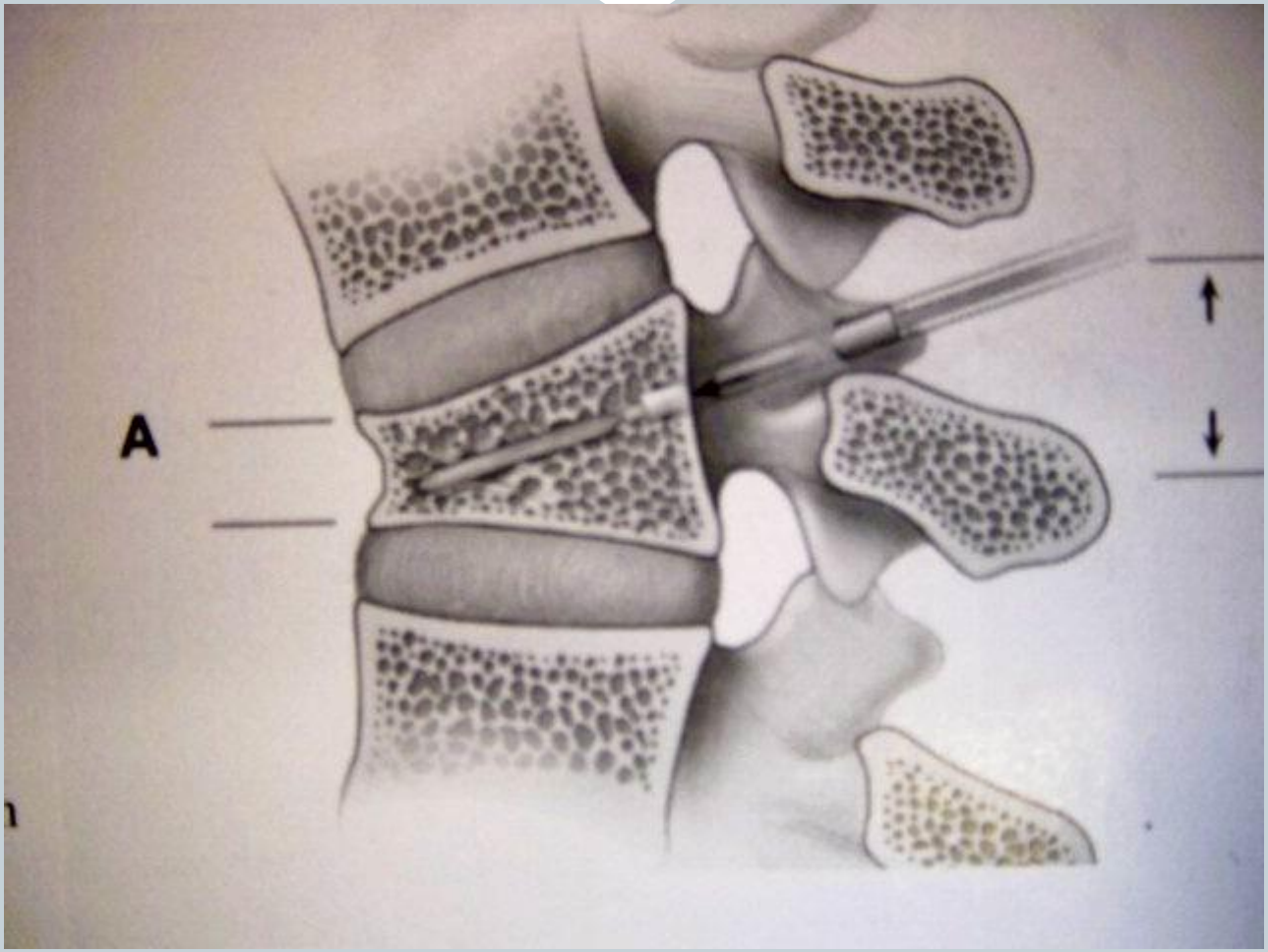
vertebroplasty

- Is the injection of bone cement into the collapsed vertebra
- The injection is done under X ray control (image intensifier) by experienced orthopedist or interventional radiologist
- It results in immediate pain relief
- It helps to prevent further OVF
- Possible complication is leakage of cement into spinal canal (nerve injury) or venous blood (cement PE)

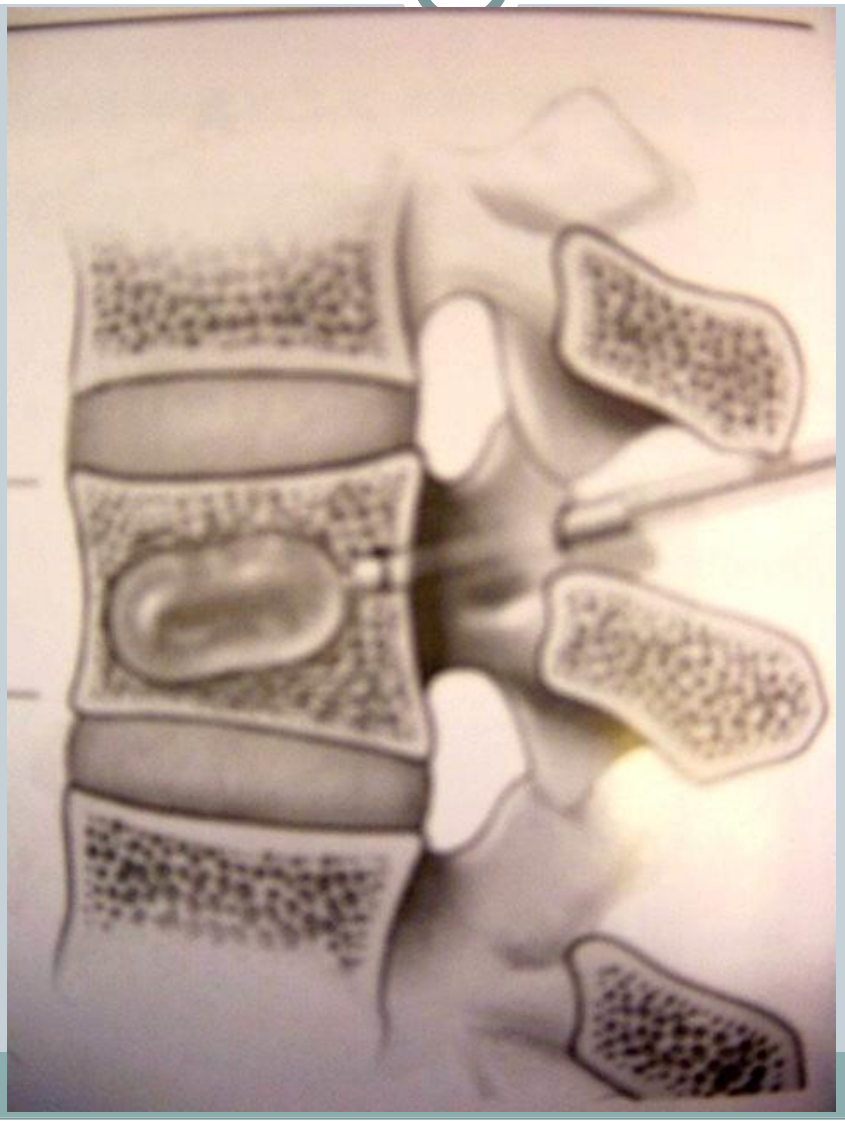
Kyphoplasty

- Is the injection of bone cement into the collapsed vertebra AFTER inflating a balloon in it to correct collapse and make a void (empty space) into which cement is injected
- It is possible that some correction of kyphosis is achieved
- It is safer because cement is injected into a safe void

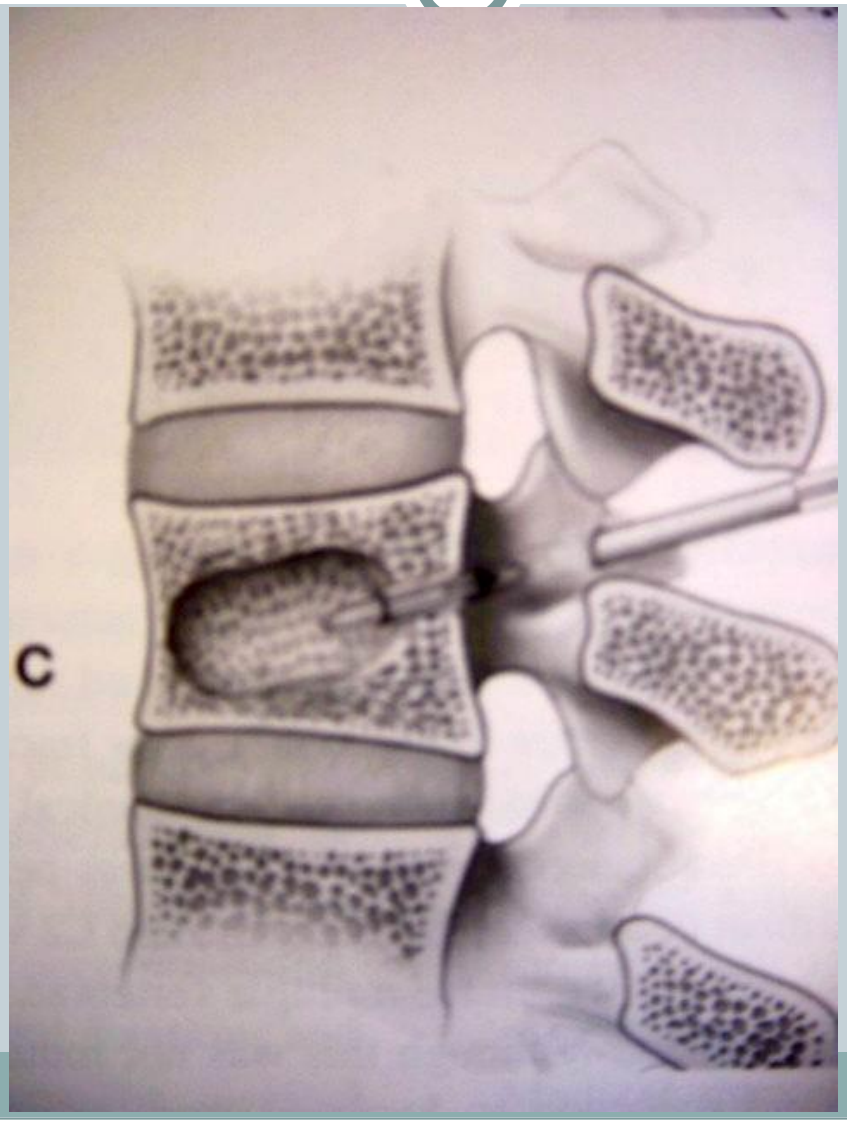
Vertebroplasty



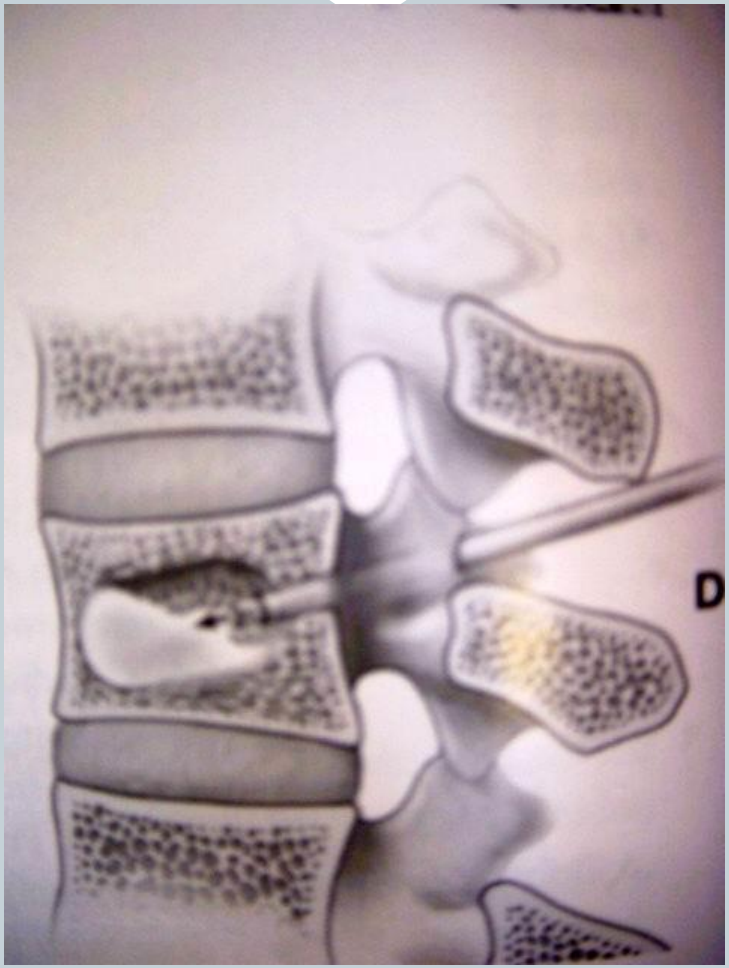
Kyphoplasty



Balloon Kyphoplasty



Kyphoplasty



Hyperparathyroidism

- Excessive PTH secretion : primary, secondary or tertiary
- Leads to increased bone resorption , sub periosteal erosions, osteitis manifested by fibrous replacement of bone
- Significant feature is hypercalcemia
- In severe cases : osteitis fibrosa cystica and formation of Brown tumours

Radiological changes in Hyperparathyroidism

- Generalised decrease in bone density
- Sub-periosteal bone resorption (scalloping of metacarpals and phalanges)
- Brown tumours
- Chondrocalcinosis (wrist, knee, shoulder)

Management of Hyperparathyroidism

- By management of the cause :
- Primary hyperparathyroidism due to neoplasm (adenoma or carcinoma) by excision
- Secondary hyperparathyroidism by correcting the cause of hypocalcaemia
- Tertiary hyperparathyroidism by excision of hyperactive (autonomous)nodule
- Extreme care should be applied after surgery to avoid hypocalcaemia due hungry bones syndrome