

Metabolic Bone Disorders



**DR HAZEM ALKHAWASHKI, FRCSED
ASSOC. PROF & CONSULTANT
ORTHOPEDIC DEPARTMENT
COLLEGE OF MEDICINE
KING SAUD UNIVERSITY**

Courtesy Dr. Muneer Saadeddin

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
- Bone is not only for protection and support but its contents play an important part in blood homeostasis(bone marrow).

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 material: collagen type1
(responsible for tensile strength)

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

Cells : 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(exercise and weight bearing)
- Bone strength gets reduced in 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 (**D**ual **E**nergy **X** ray **A**bsorbtionometry)
- 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

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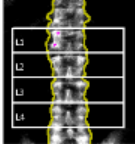
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KING KHALID UNIVERSITY HOSPITAL NUCLEAR MEDICINE DEPARTMENT RIYADH P.O BOX 7805

Patient: SAADEDDIN MUNIR FAYEZ,	Facility ID: 20395
Birth Date: 10/12/1950 56.0 years	Referring Physician:
Height / Weight: 173.0 cm 102.0 kg	Measured: 11/4/2006 1:27:59 PM (10.20)
Sex / Ethnic: Male White	Analyzed: 11/4/2006 1:30:00 PM (10.20)

Region	BMD (g/cm ³)	Young Adult T-Score	Age-Matched Z-Score
L1-L4	1.140	-0.8	-1.2




Reference: AP Spine L1-L4 YA T-Score

BMD (g/cm³) vs Age (years) graph showing a red shaded area for osteoporosis.

Matched for Age, Weight (Scale 25-100 kg), Ethnic NHANES (ages 20-50) / USA (ages 20-40) AP Spine Reference Population (n=107)
 Statistically 89% of repeat scans fall within 1SD (+0.020 g/cm³) for AP Spine L1-L4

Image not for diagnosis

Region	BMD (g/cm ³)	Young Adult T-Score	Age-Matched Z-Score
Total	1.132	0.2	0.2



Reference: Left Femur Total YA T-Score

BMD (g/cm³) vs Age (years) graph showing a yellow shaded area for osteopenia.

Matched for Age, Weight (Scale 25-100 kg), Ethnic NHANES (ages 20-50) / USA (ages 20-40) Femur Reference Population (n=52)
 Statistically 61% of repeat scans fall within 1SD (+0.012 g/cm³) for Left Femur Total

Image not for diagnosis

GE Healthcare Lunar (USA)
ME-200034

SAADEDIN, MUNIR, , FAYEZ
 Study Date: 11/4/2006
 Study Time: 1:27:59 PM
 MRN: KK20395

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

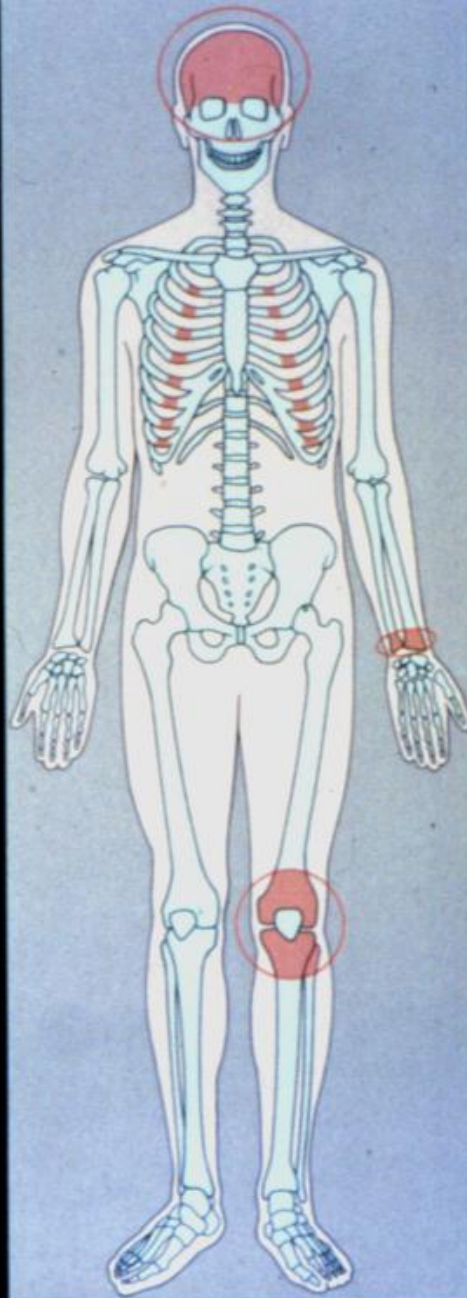
liver & kidney diseases

1) Rickets: Symptoms and Signs

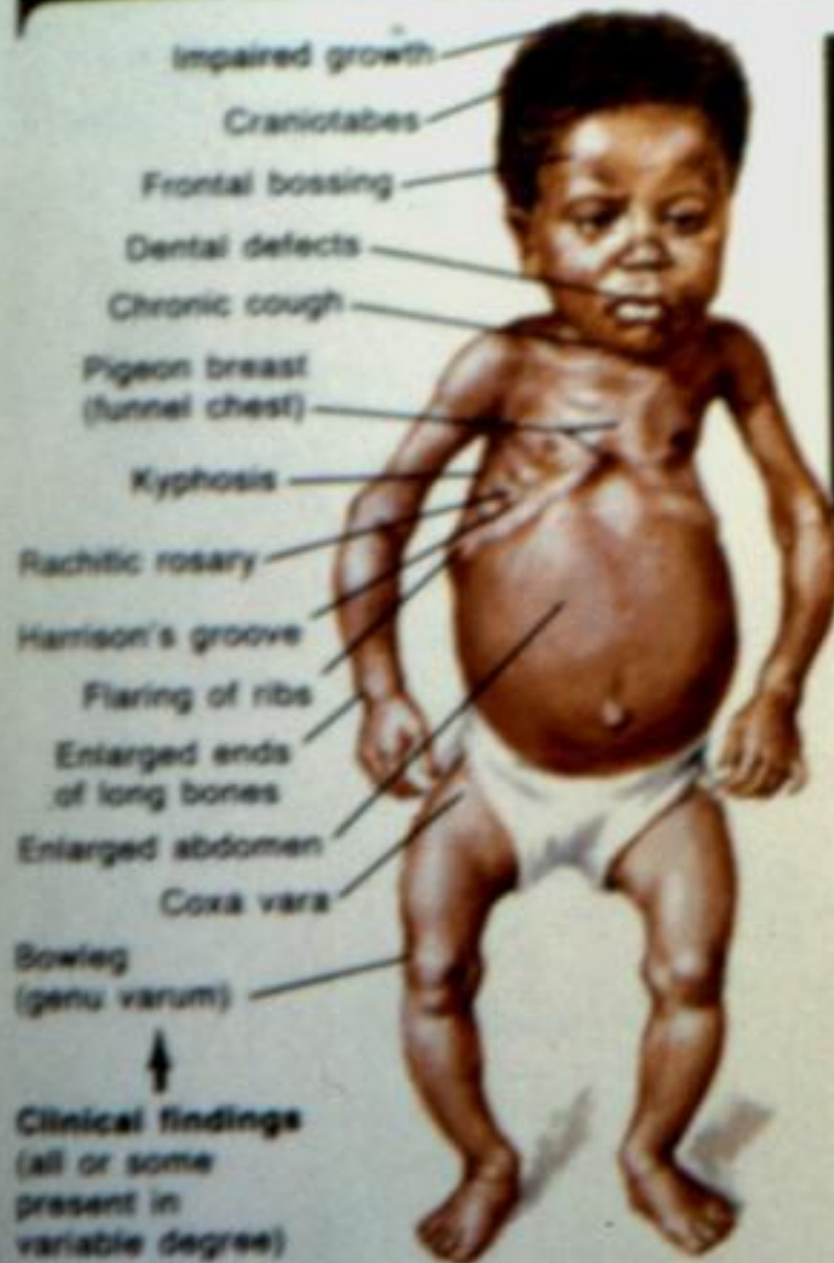


- Child is restless, babies cry without obvious reason
- Failure to thrive
- Muscle weakness
- In severe cases with very low calcium: tetany or convulsions
- Joint thickening especially around wrists and knees
- Deformity of limbs, mostly Genu varum or Genu Valgum
- Pigeon chest deformity, Rickety Rosary,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

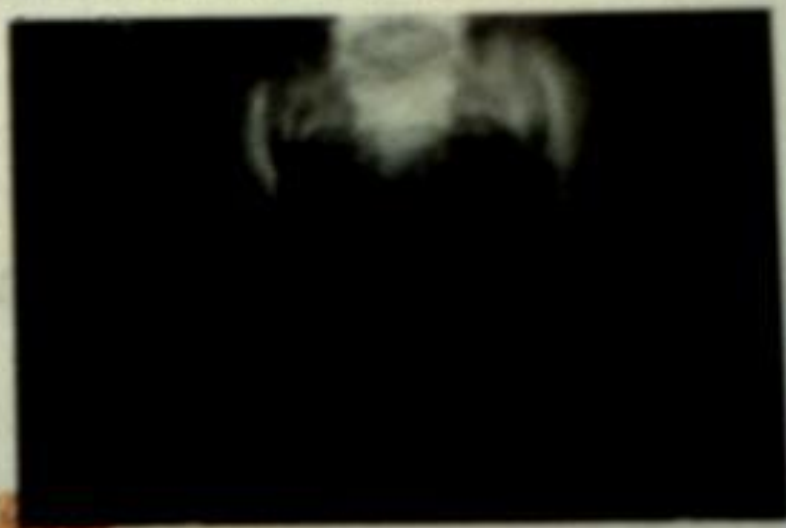
Rickets



Childhood Rickets



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



2)Osteomalacia

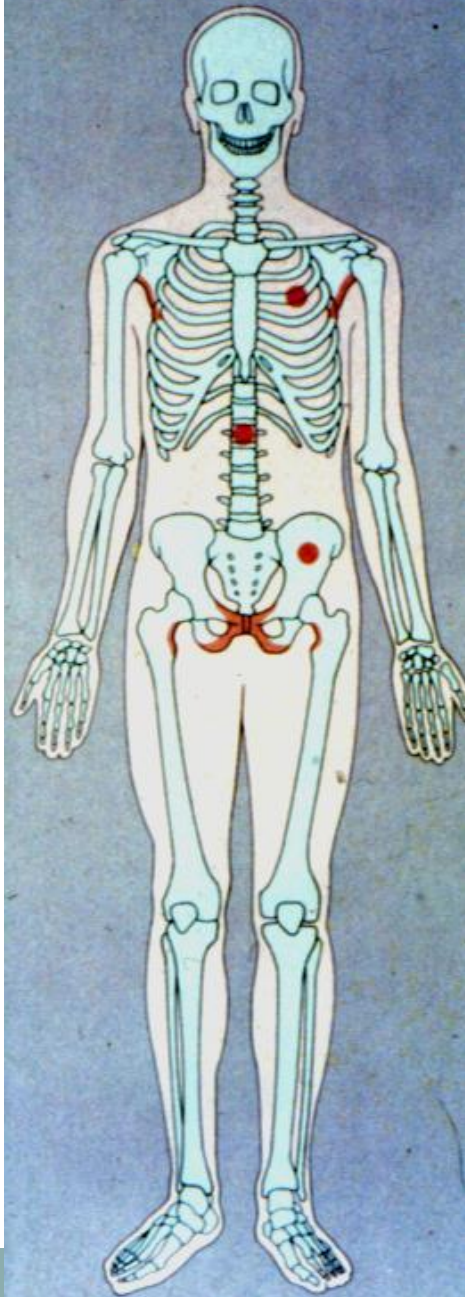


- Metabolic Bone Disorder in **Adults** :

Symptoms and signs

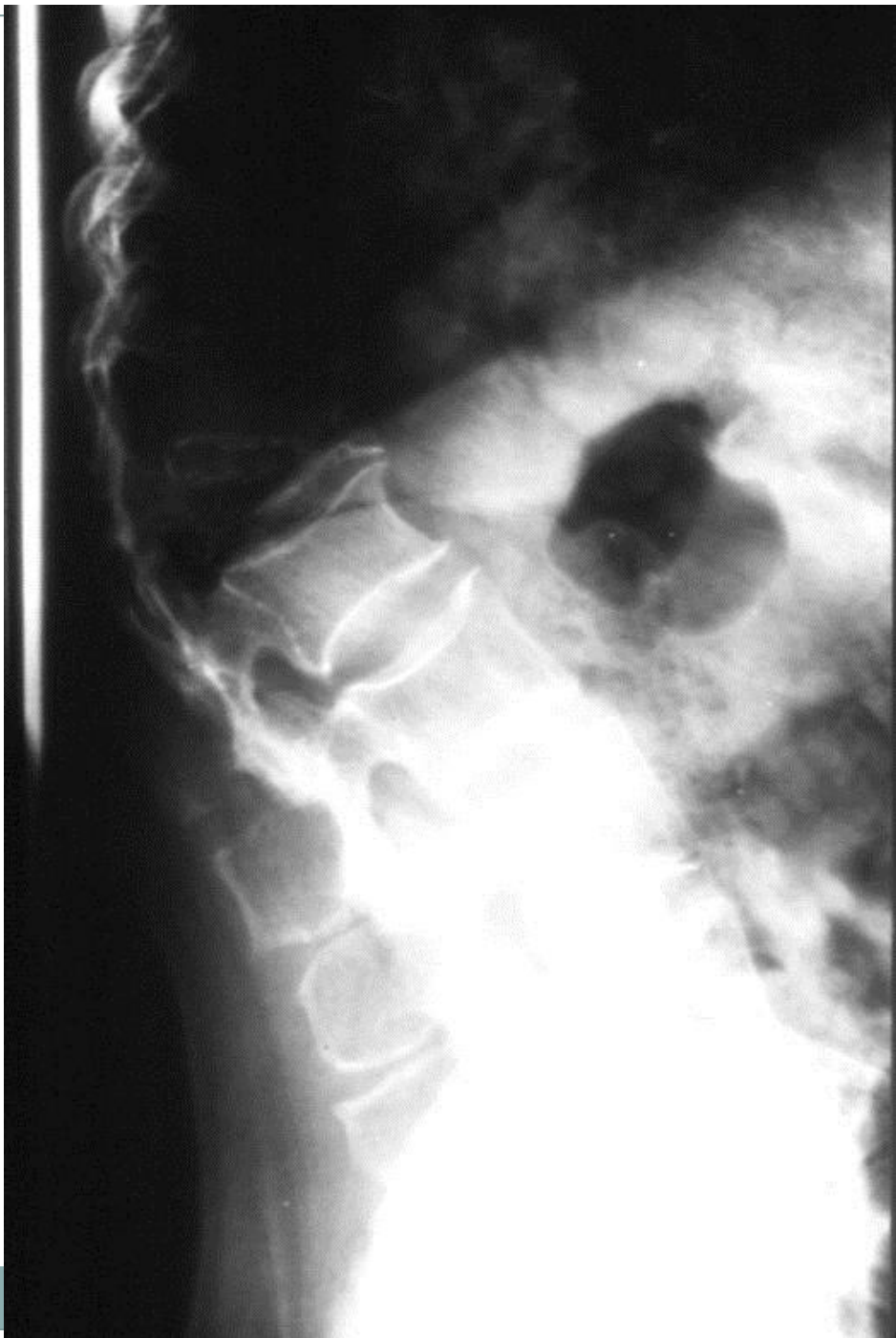
- Bone pain, mainly backache
- Muscle weakness
- Reduced bone density
- Vertebral changes : Bi-concave vertebra, vertebral collapse , kyphosis
- Stress fractures : Loosers zones in scapula, ribs ,pelvis, proximal femur

Osteomalacia









Rickets & Osteomalacia



Biochemistry

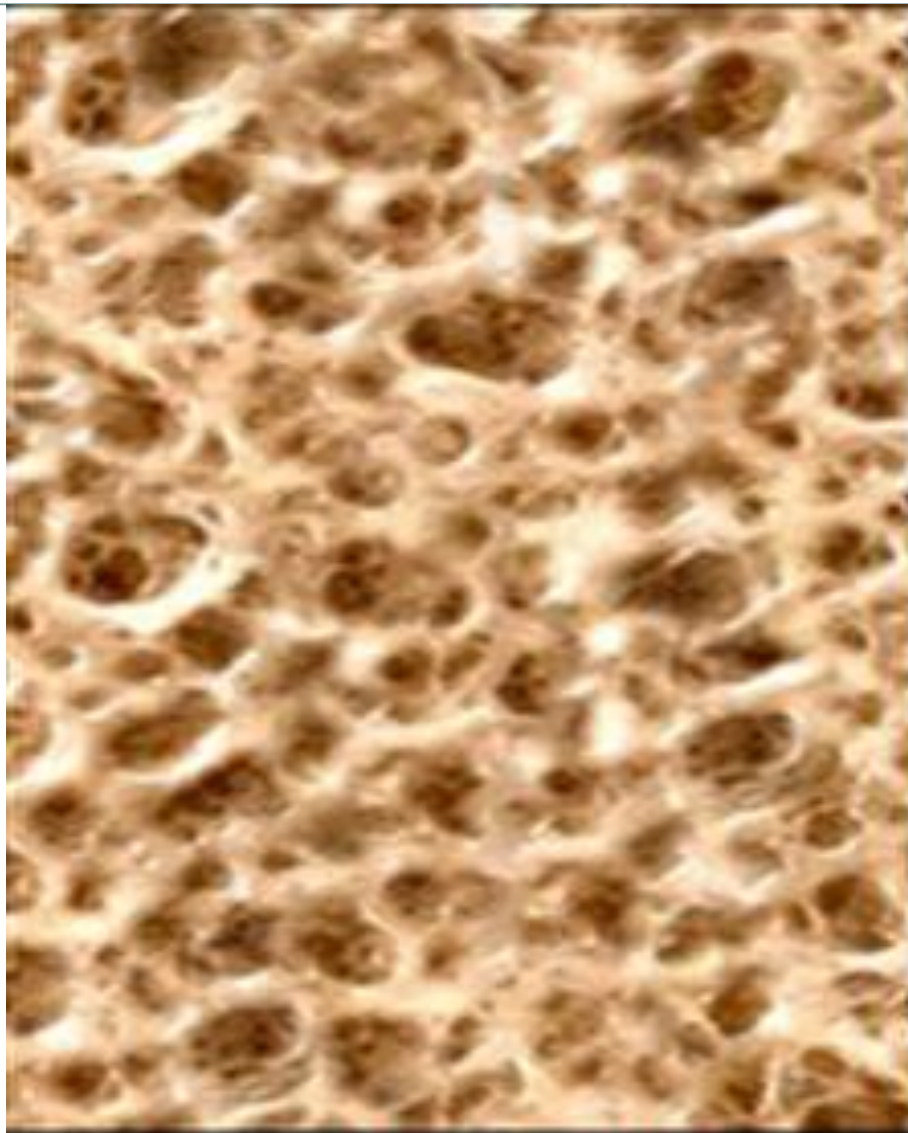
Hypocalcaemia,... Hypocalciuria

High alkaline phosphatase

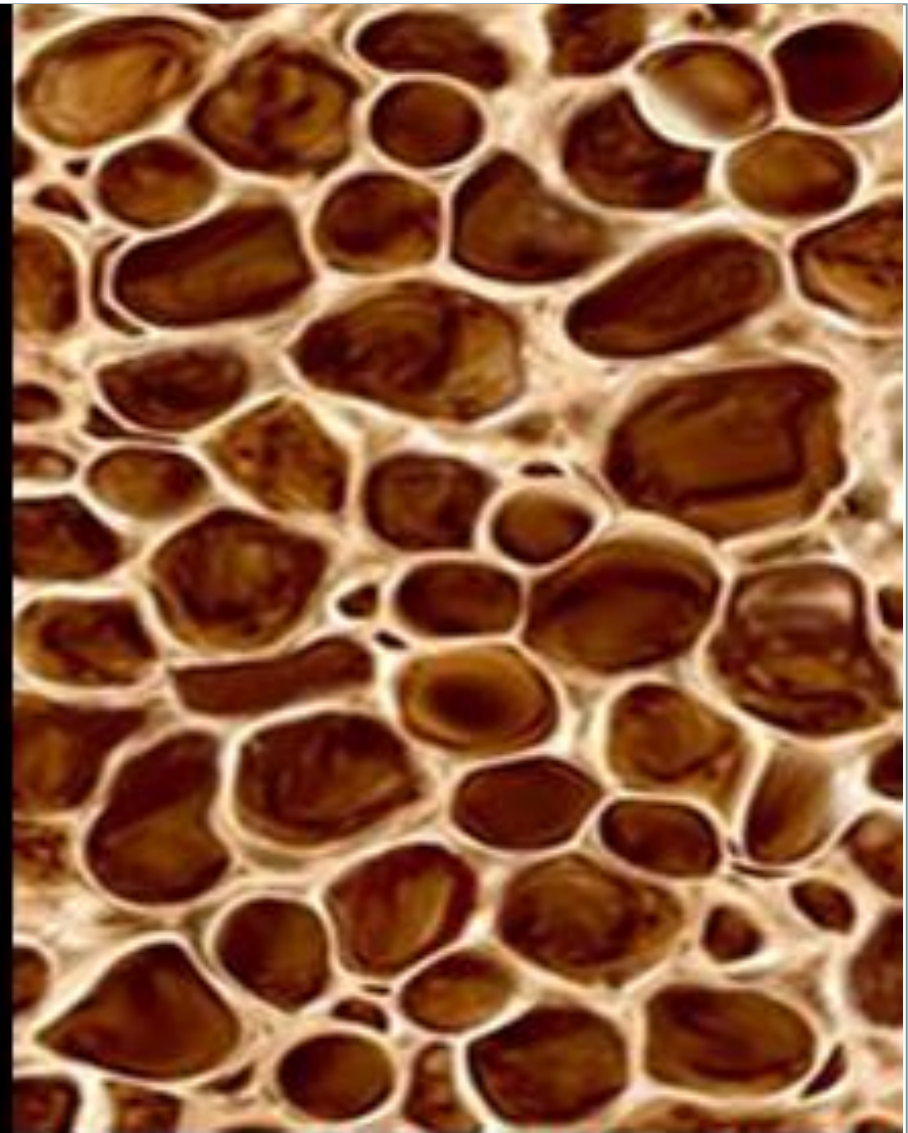
Osteoporosis



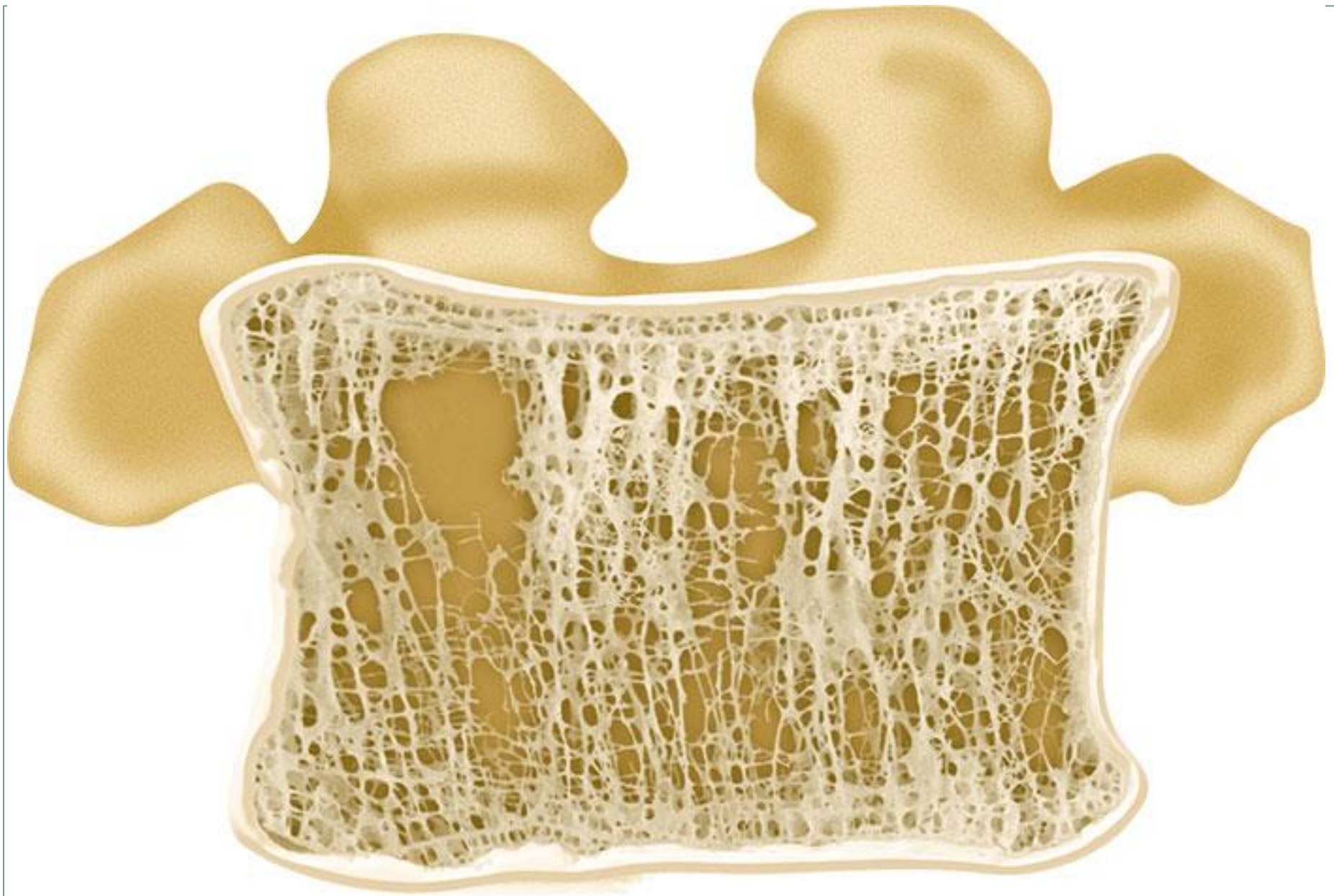
- Decreased bone mass : decreased amount of bone per unit volume (and this causes reduced density)
- Mineralisation is not affected
- Mainly post-menopausal and age related



Honey Comb Pattern
In Normal Bone



Honey Comb Pattern With
Big Holes In Osteoporosis



Osteoporosis: Primary and Secondary



- **Primary** Osteoporosis :

Post menopausal

Senile

Primary Osteoporosis



Post menopausal

- 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, Asians, Black
- Hereditary
- Body build, Small, Short
- Early menopause
- Smoking/ alcohol intake/ drug abuse
- ? Calcium intake



Senile Osteoporosis

- Usually by 7th to 8th 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



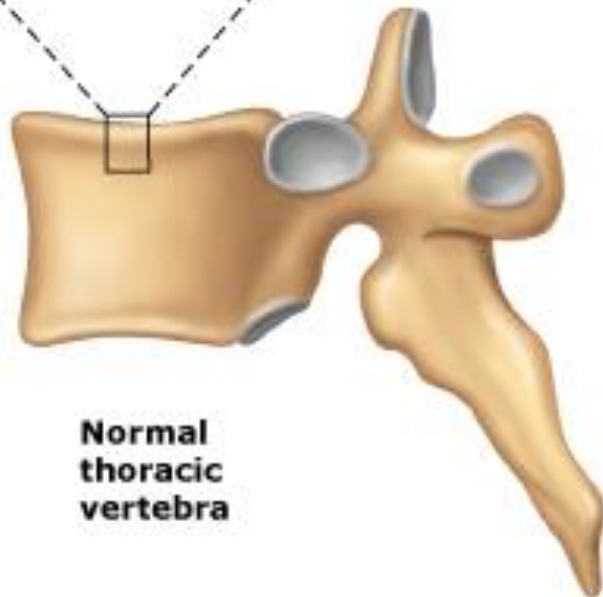
Normal

Osteoporosis

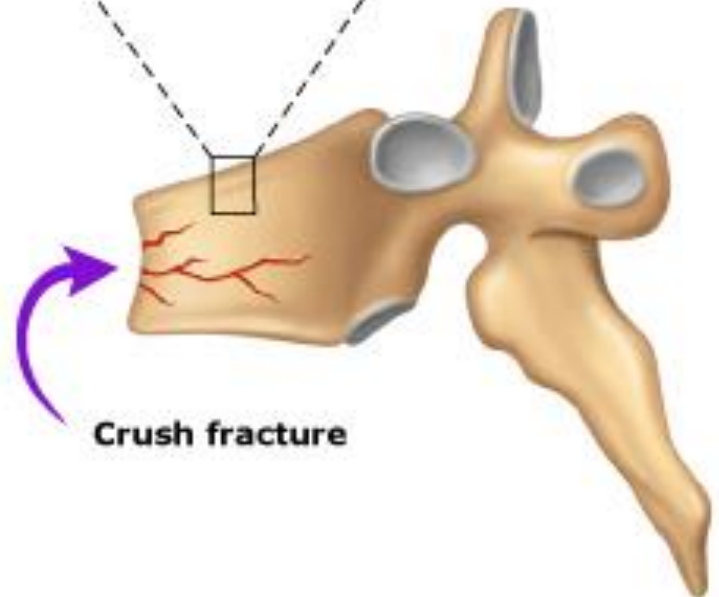


Compact bone

Trabecular bone

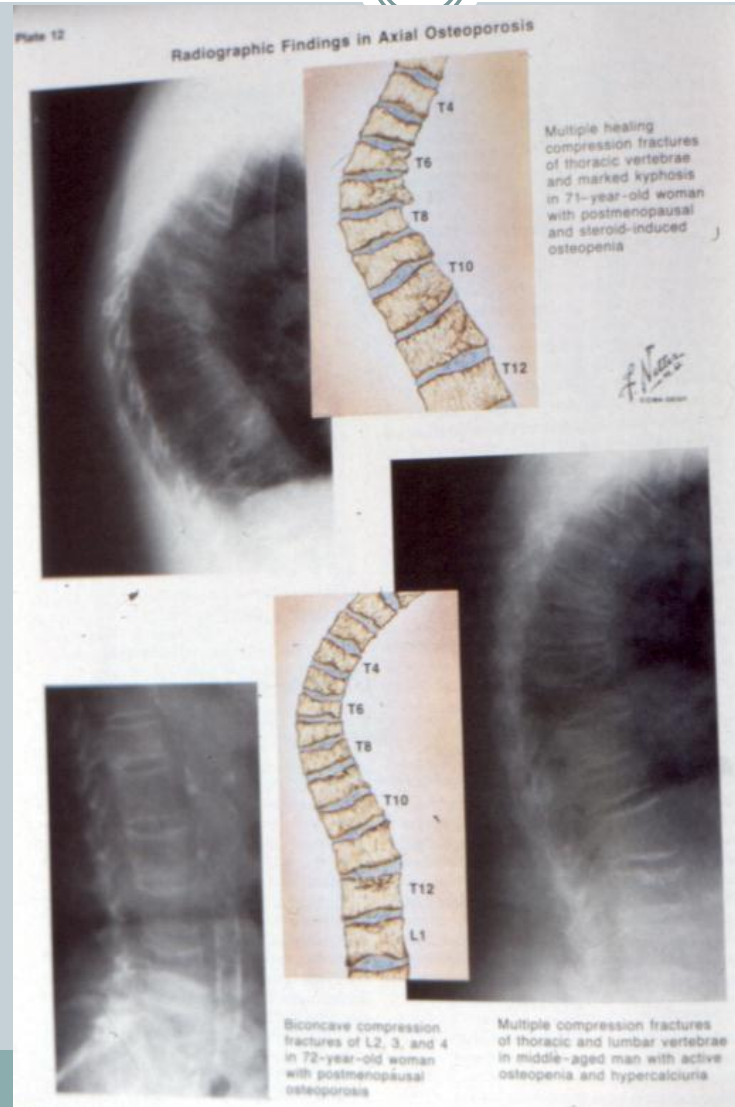


**Normal
thoracic
vertebra**



Crush fracture

How does kyphosis and loss of height occurs







Osteoporotic Fractures



- They are Pathological fractures
- Most common is osteoporotic vertebral compression fracture (OVC #s)
- Vertebral micro fractures occur unnoticed (dull ache)
- Most serious is the NON-vertebral fractures:
hip fractures, HIGH MORTALITY
wrist fractures (Colles fracture), not serious



Secondary Osteoporosis

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



- Disease Osteoporosis, Occurs locally adjacent to immobilised bone or joint. May be generalised in bed ridden patients

Awareness of and attempts for prevention are helpful

Osteomalacia vs. osteoporosis



Osteomalacia

Any age

Pt. ill

General ache

Weak muscles

Looser zones

Alkaline ph raised

Phos. decrease

Osteoporosis

Post-menopause, old age

Not ill

Asymptomatic till fract.

Normal

Nil

Normal

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 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

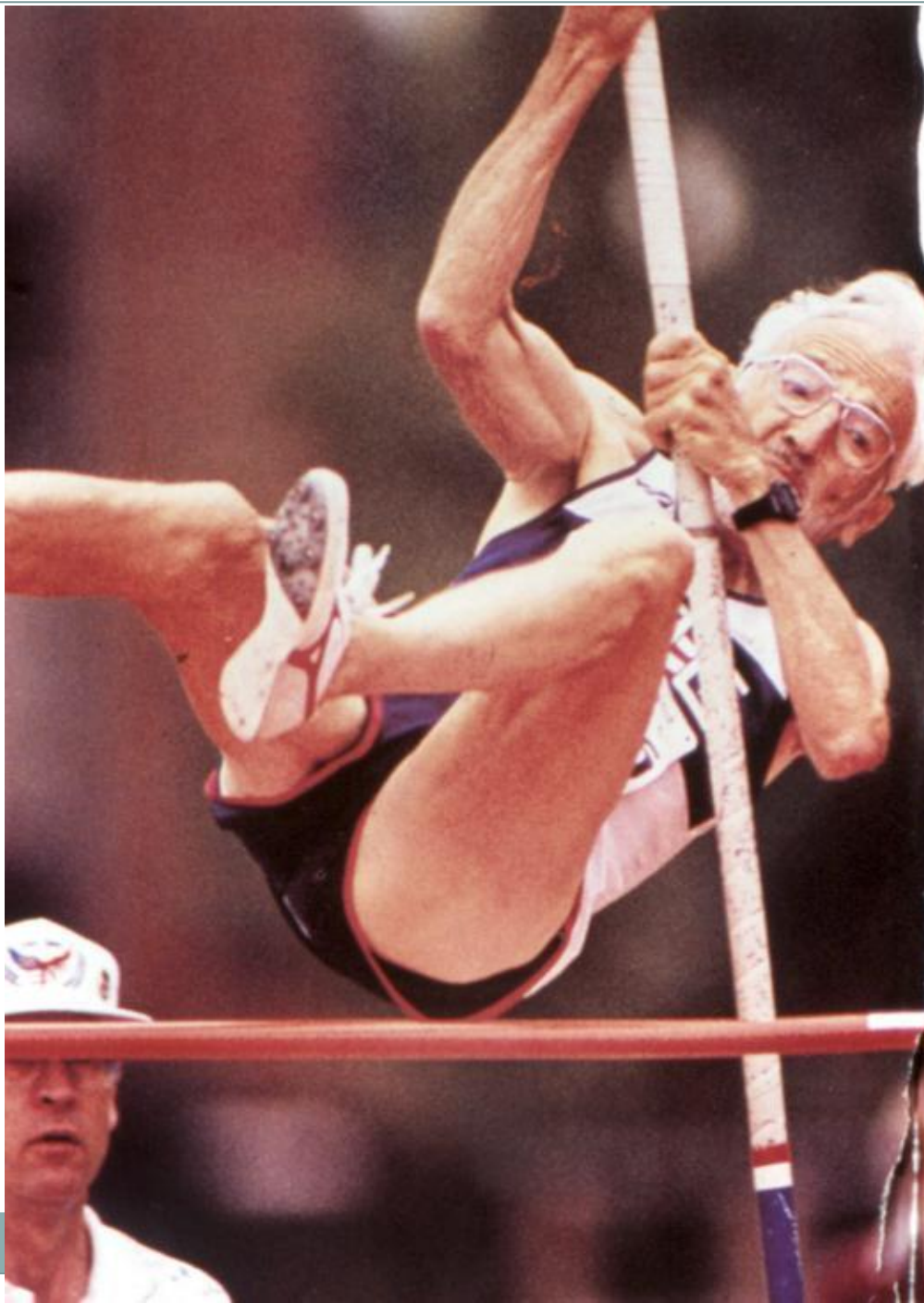


- **Estrogen** has a definite therapeutic effect and was used extensively as HRT but **CAN NOT** be recommended now due to serious possible side effects.
- Adequate intake of **calcium and vitamin D** is mandatory
- Drugs which **inhibit osteoclast** activities : e.g. Bisphosphonates like sodium alendronate FOSAMA(1/wk.) , BONVIVA(1/12)
- Drugs which **enhance osteoblast activities** : bone stimulating agents like FORTEO(teraparotide),SC injections.

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 sharing 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



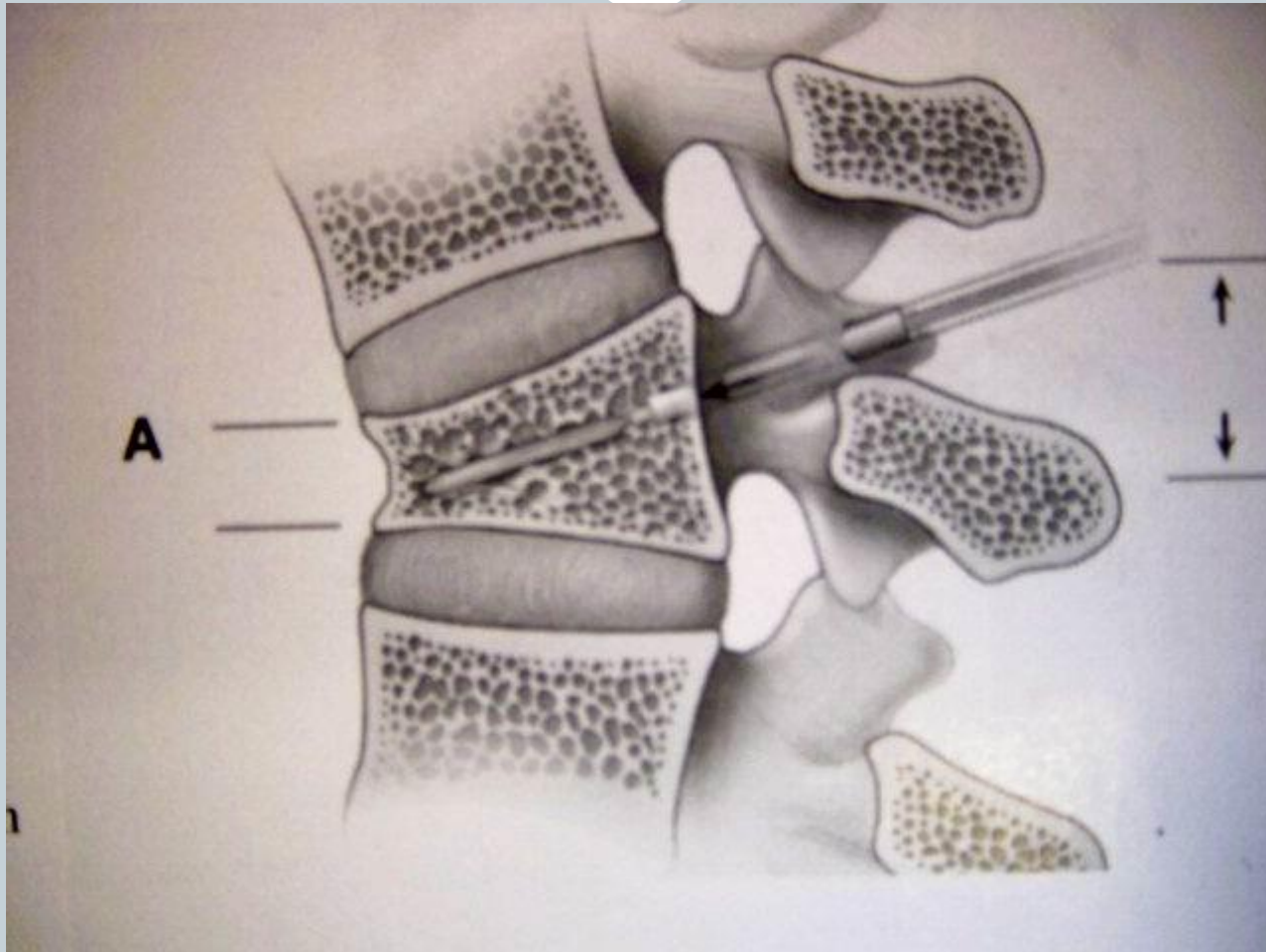
- Is the injection of bone cement into the collapsed vertebra
- The injection is done under X ray control (image intensifier) by experienced orthopedist or interventional radiologist
- It results in immediate pain relief
- It helps to prevent further OVF
- Possible complication is leakage of cement into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

Kyphoplasty

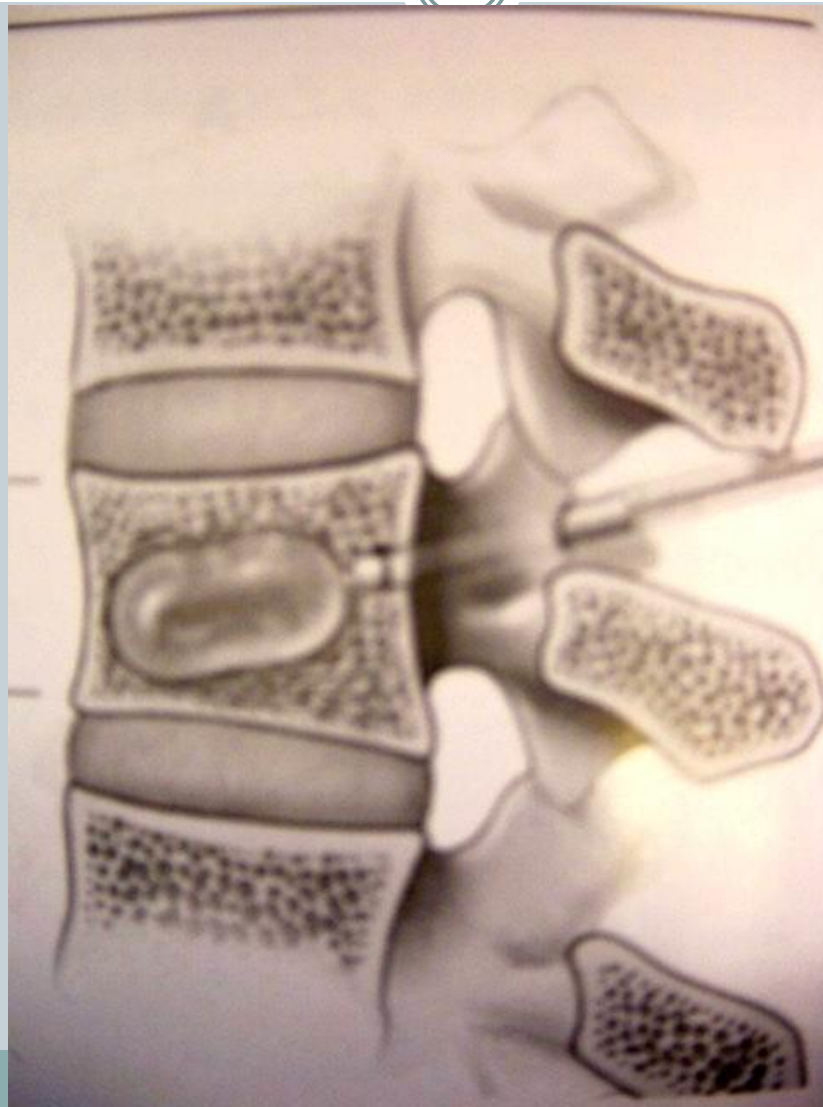


- Is the injection of bone cement into the collapsed vertebra AFTER inflating a balloon in it to correct collapse and make a void (empty space) into which cement is injected
- It is possible that some correction of kyphosis is achieved
- It is safer because cement is injected into a safe void

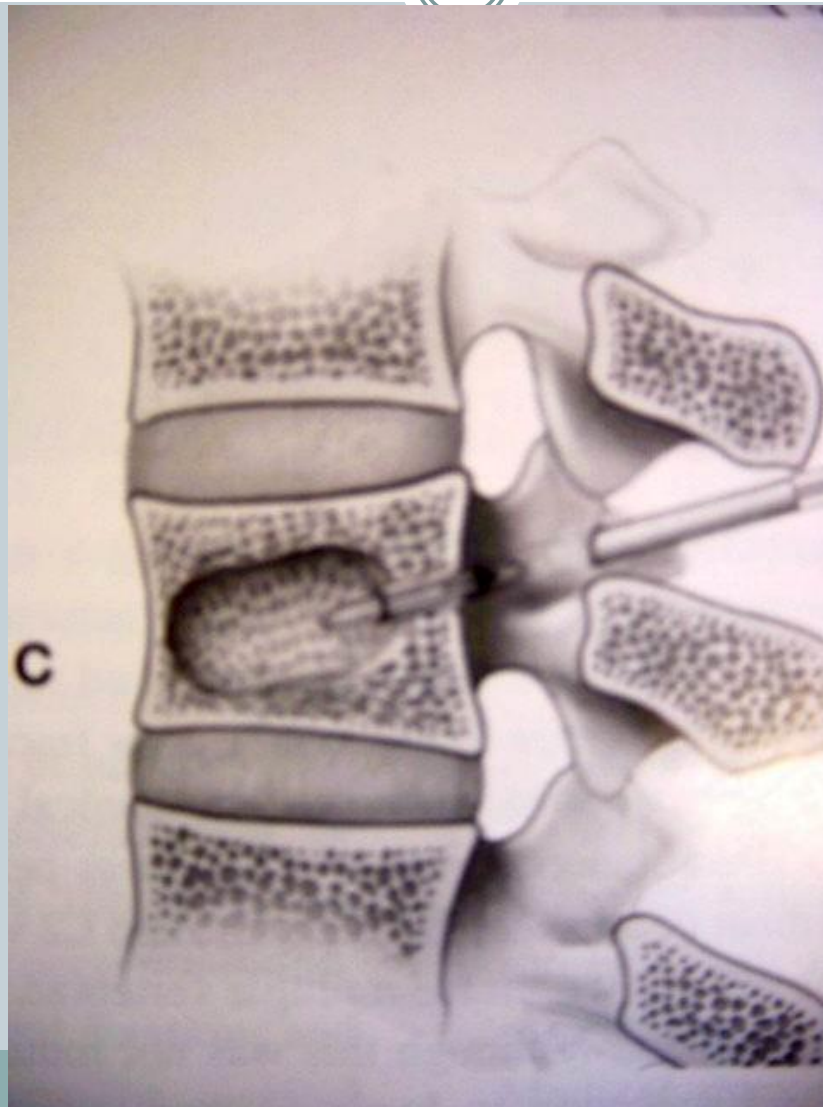
Vertebroplasty



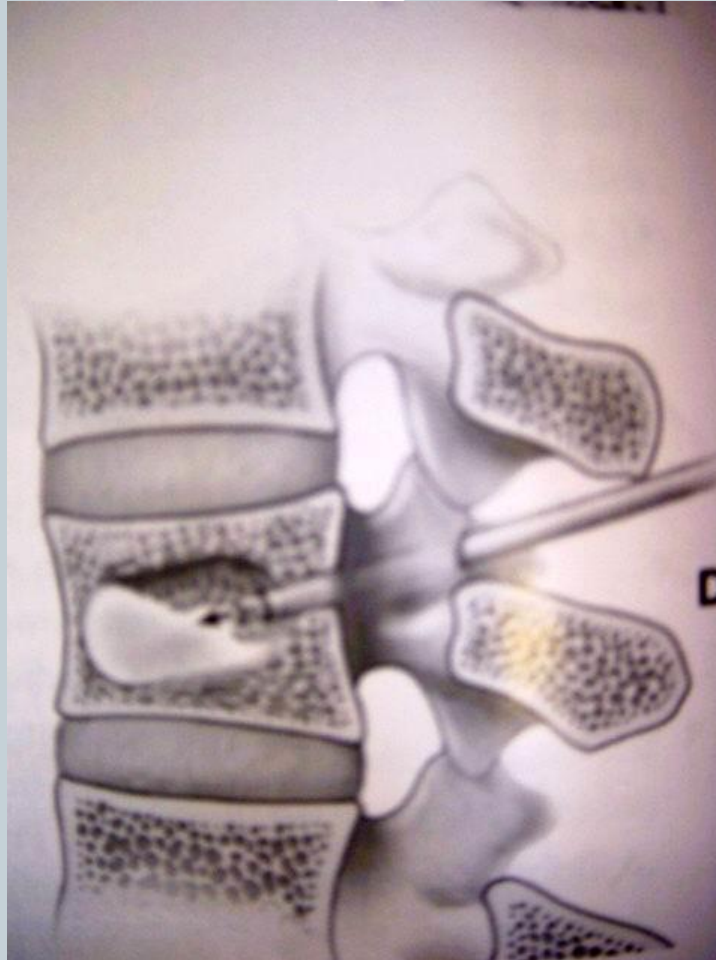
Kyphoplasty



Balloon Kyphoplasty



Balloon 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