Metabolic Bone Disorders

◈ Introduction:

❖ **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 (NB : Alkaline phosphatase is the enzyme which indicate the activity level of the bone and the liver)
- 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 مهمه
- 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 (Steroids)
  - Intestinal absorption
  - Renal excretion
  - Diet
  - Vitamin D
  - Sun exposure

NB : any disturbance In these factors will cause metabolic bone disorders

- **The disturbance is different in adults and children**

❖ **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: (No. MCQ)**

- Calcium : 2.2-2.6 mmol/l
- Phosphorus : 0.9-1.3 mmol/l
- Both absorbed by intestine and secreted by kidney in urine (NB : the kidney and the intestine are controlled by Hormones)
- 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 : 70-75 nmol/l

1- Parathyroid gland :

❖ **Parathyroid Hormone (PTH)**
- Production levels are related to serum calcium levels:
- It increases calcium levels in the blood by
- increasing its release from bone
- increase absorption from the intestine
- 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

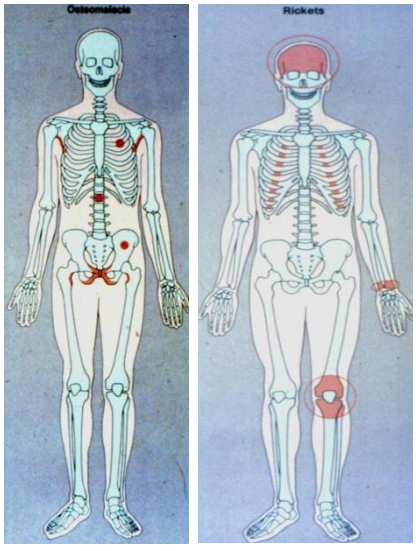
2- Thyroid gland :

❖ **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 (due to decrease E2 level)
- 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 مهمه

❖ **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)
- Increased bone density does not always mean increased bone strength, as sometimes what is called Brittle bone which is a dense bone is not a strong bone but fragile bone which may break easily

◈ 1- Rickets &Osteomalacia:

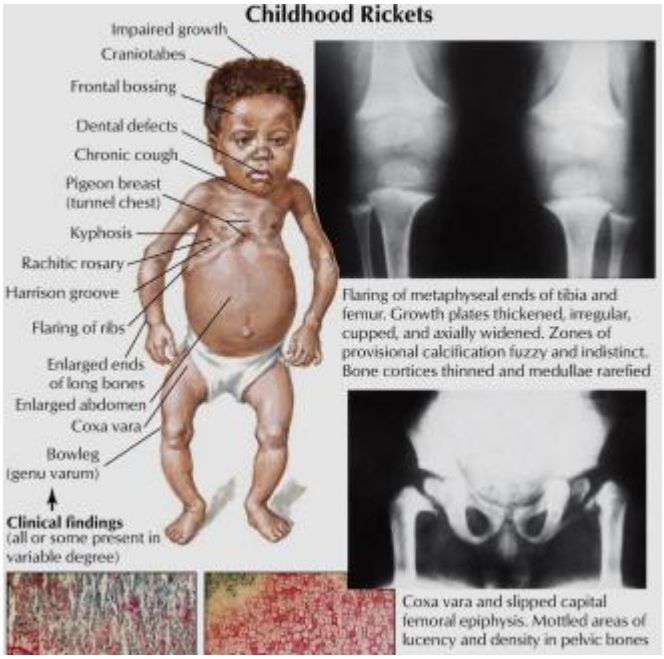


◈ Different expressions of the same disease.
◈ Inadequate mineralization. (normal matrix deficied)
◈ **Rickets** :mainly affect : Areas of endochondral growth [*Growth Plate*] – MCQ
◈ **Osteomalacia** : mainly affect : All skeleton is incompletely calcified [*the most is Spine*] – MCQ

Causes:

- Calcium deficiency
- Hypophosphataemia
- Defect in Vitamin D metabolism due to :
  - Nutritional [*especially breast-feeding baby*] (Low)
  - Underexposure to sunlight
  - Intestinal malabsorption
  - Liver & kidney diseases

Symptoms & Signs



Rickets

- Child is restless, babies cry without obvious reason → it is due to pain from the Growth plates
- Failure to thrive
- Muscle weakness
- In severe cases with very low calcium: tetany or convulsions مهمه جدا
- Joint thickening especially around wrists and knees
- Deformity of limbs, mostly Genu varum or Genu Valgum
- Pigeon chest ,
- Rickety rosary ((thickening of all costochodral joint)), عقد على جدار الصدر
- Craniotabes اليافوخ لا يغلق لذلك الراس يكون كبير

2- Osteomalacia (Adult version)

- Bone pain, mainly backache
- Muscle weakness
- Reduced bone density
- Vertebral changes : Bi-concave vertebra, vertebral collapse , kyphosis
- Stress fractures : called : Loosers zones in scapula, ribs ,pelvis, proximal femur (it usually affect the flat bones and it usually transverse fracture not involving the whole bone) - MCQ
- Deformities & stress fractures (*pathological*)

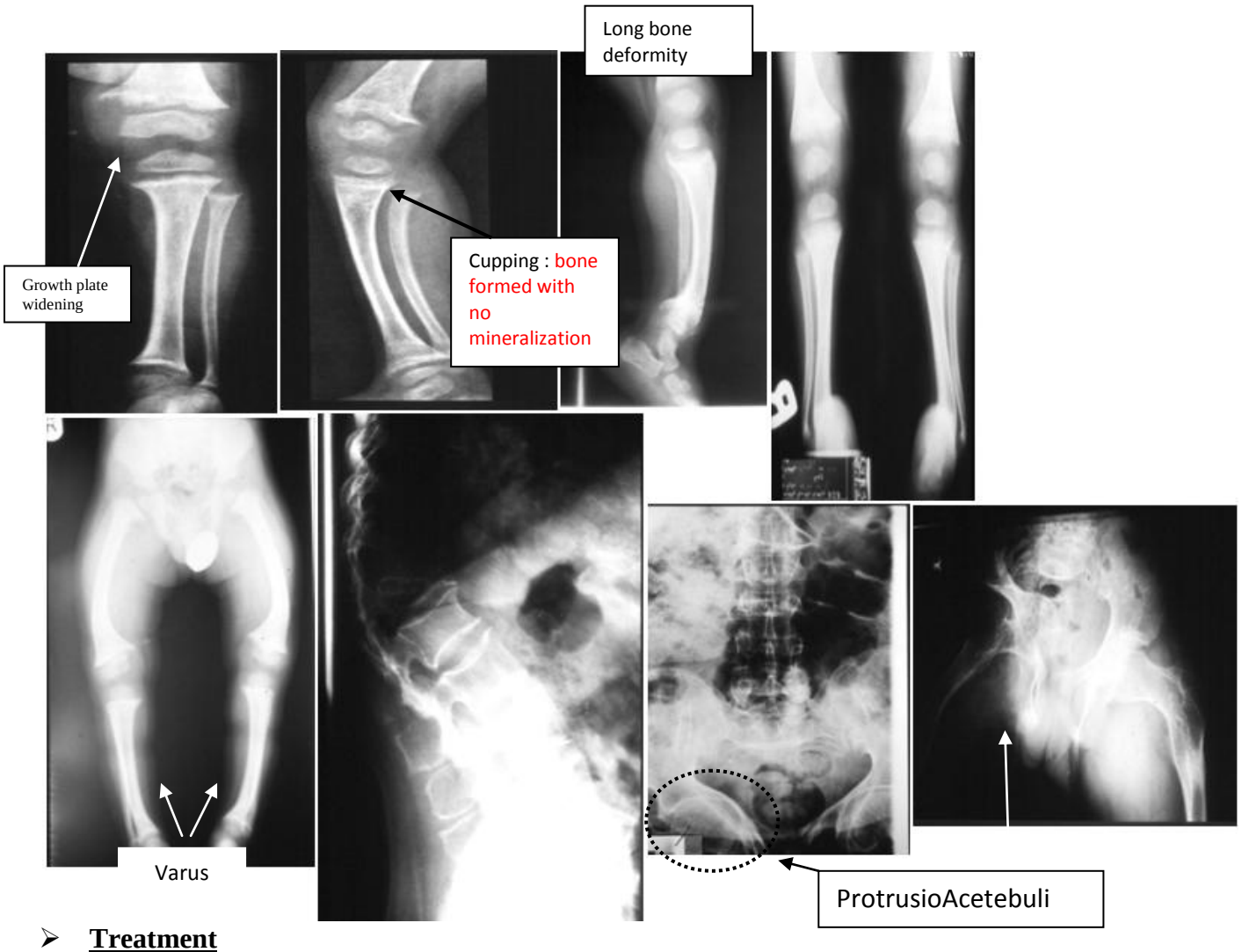
Show low bone density

Show vertebral changes : biconcave vertebra with risk of path fracture

Biochemistry: (bold test)

- ***Hypocalcaemia,Hypocalcuria***
- ***High alkaline phosphatase***

- **X-rays (MCQ)** انظر الصور الصفحه السابقه
  - **Rickets**
    - Growth plate widening & thickening
    - Metaphyseal cupping to accumulate the growth plate widening.
    - Long bone deformities [*2y.o. : varus | 4y.o. : Valgus*]
  - **Osteomalacia**
    - Looser zone , biconcave vertebra , protrusioacetabuli
    - Spontaneous fractures. {stress fracture}
  - Signs of secondary hyperparathyroidism: due to prolonged hypocalcemia.



- **Treatment**
  - ***Rickets***
    1. controlled Vitamin D
    2. sun exposure

    NB: 1 and 2 are the 1st line treatment
    3. correct residual deformities ***(never do it unless you did 1 and 2)***
  - ***Osteomalacia:***
    1. Vit. D + Ca
    2. fracture management

    NB: 1 and 2 are the 1st line treatment

    3. correct deformity if needed ***(never do it unless you did 1 and 2)***

◈ 3- Osteoporosis

- Mineralisation is not affected
- Decrease bone mass (amount of bone per unit volume) {deficient matrix} → Activate oseoclast
- Mainly post-menopausal and age related

NB : it mainly affect the trapecular bones : Vertebra – neck of femur – flat bones

❖ Primary Osteoprosis :

1- Post menopausal Osteoporosis: (Most common form)

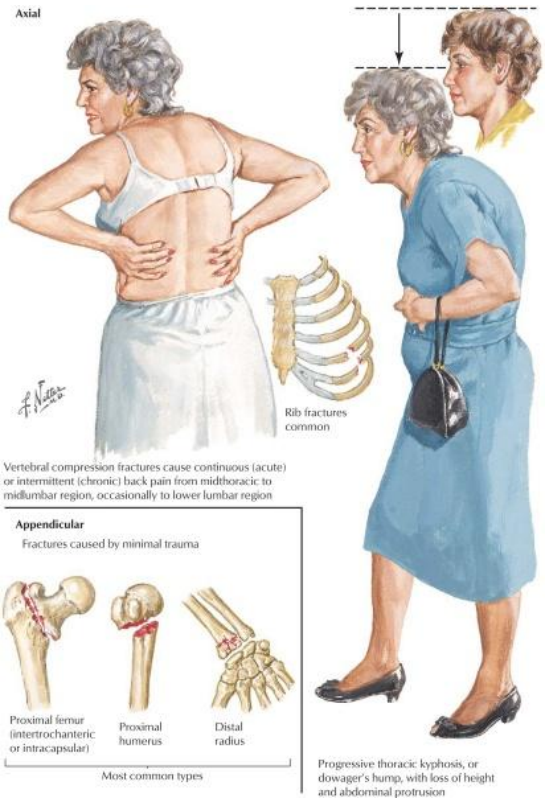
- Due to rapid decline in estrogen level
- This results in increased osteoclastic activity
- Normal bone loss usually 0.3% per year
- Post menopausal bone loss 3% per year

- ***Risk Factors in Post-menopausal Osteoporosis:***
  - Race (black > white)
  - Hereditary
  - Body build (thin > obese) مهمه
  - Early menopause رجل مخصي او رجل ياخذ ادويه ضد التيستيرون مثل مرضى سرطان البروستات
  - Smoking/ alcohol intake/ drug abuse
  - ? Calcium intake

2- 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 (if pain present suspect Micro fractures)
  - Osteoporosis causes gradual increase in dorsal kyphosis → due to partial collapse of the vertebra
  - Osteoporosis leads to loss of height
  - Osteoporosis is not osteoarthritis; but the two conditions may co-exist



- **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 – MCQ
  - Also common is wrist fractures (Colles fracture – collapsed joint)

❖ 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 , AIDS
- Malignancy : multiple myeloma, leukemia, metastasis

❖ Disuse Osteoporosis (local)

- Occurs locally adjacent to immobilised bone or joint اللي حط جبس لفتره طويله او الشلل
- May be generalised in in bed ridden patients
- Awareness of and attempts for prevention are helpful

❖ 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 (due to risks of brest cancer and heart problems)

◈ Management of Osteoporosis

❖ Drug Therapy:

- 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:

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

❖ Management of Fractures

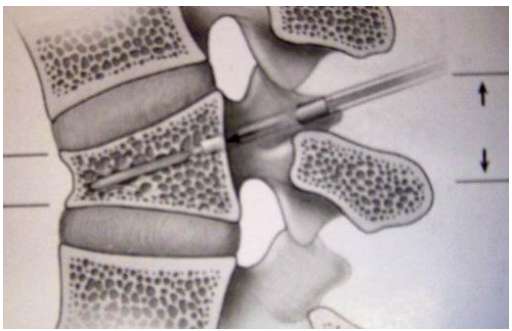
- Use of load shearing implants in fracture internal fixation instead of plating (MCQ)

◈ Management of OVC Fractures:

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

❖ Vertebroplasty:

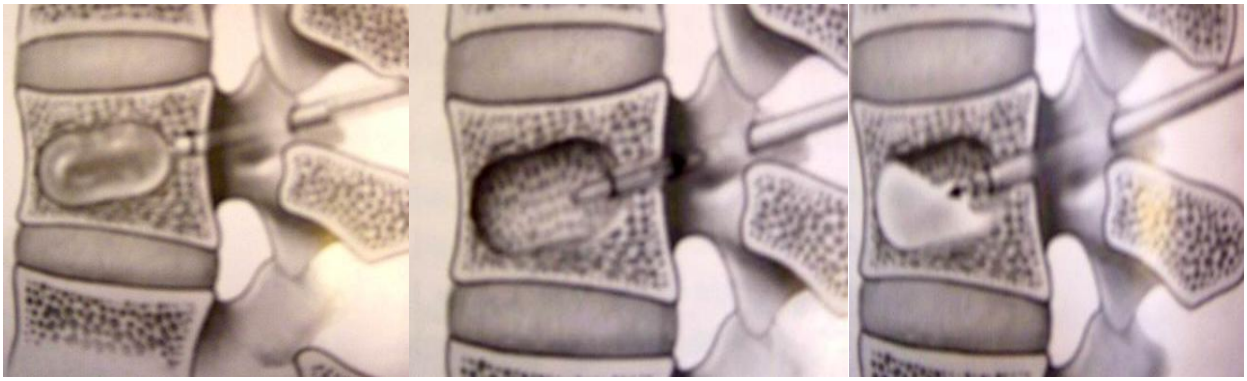
- Is the injection of bone cement into the collapsed vertebra



- 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



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
PO4 decrease	Normal

◈ Hyperparathyroidism: ليست من المنهج ولكن اقراها

- 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 : osteitisfibrosacystica and formation of Brown tumours

❖ **Radiological changes:** مهمه

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

Show : Sub-periosteal bone resorption

Show : Sub-periosteal bone resorption

Show : Brown tumours

Show : Chondrocalcinosis

Management: "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