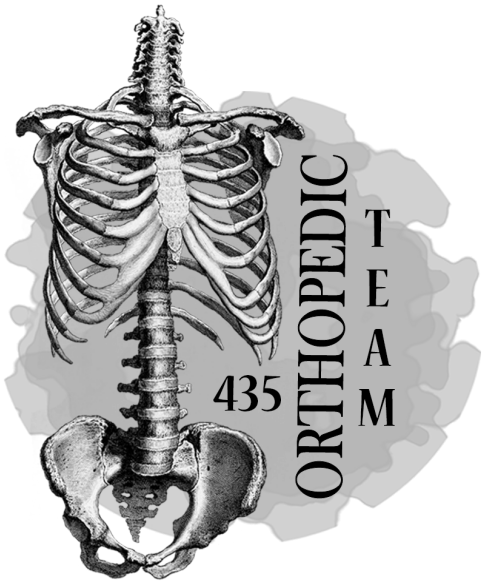

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Metabolic Bone Disorders

Objectives:

★ To know about the function of the bone
★ To understand why metabolic disorders can happen
★ To learn about pathology and clinical picture of common metabolic bone disorders.
★ To know possible complications of metabolic bone disorders.
★ To understand principles of management of metabolic disorders.

Done by: Jawharah Almalki
Revised by: Bedoor Julaidan, Dalal Alhuzaimi
References: 435 Slides And Notes, **435 A1 Teamwork**, 433 Teamwork

Introduction

وصلتوا خير، المحاضرة الأسهل و الأروع :) خلفيتكم عن موضوع المحاضرة صدقوني أكثر و أعمق من محتوى المحاضرة

المحاضرة هي عبارة عن نبذة بسيطة عن أمراض العظام الأيضية، يمكن بعضكم أول مرة يسمع كلمة أيضية هي نفسها metabolic فيعني عمليات الأيض هي الهدم و البناء و كلنا نعرف إن العظم عضو حي فينا مثله مثل أي عضو يستمر بالتجدد بعد كل فترة فيه هدم و إزالة للخلايا الخربانة الزايدة الميتة و أيضاً بناء تعويضي ، هالشيء في العظام يعتمد على خلايا البناء الاوستيوبلاست و خلايا الهدم الاوستيوكلاست إلي يتأثر نشاطها بهرمونات معينة بالجسم بالإضافة إن العظم يتعامل مع المعادن مثل الفسفور و الكالسيوم و فيتامين د، فلما نقول أمراض أيضية يعني عندنا خلل فالهدم و البناء يا تو متش بناء يا تو متش هدم أو ممكن خلل بالمعدات إلي نتعامل معاها (المعادن) فنلاقي أمراض فيها زيادة نشاط بالاوستيوكلاست أو حتى نقص في نشاطها أو نقص بفيتامين د أو نقص بالكالسيوم و هكذا، المحاضرة جداً خفيفة ما تاخذ منكم أكثر من ساعتين بمشيئة الله (أتكلم عن مذاكرة من قلب).

الجزء الأول من المحاضرة سوالف مبزرة كله كلام عام و فاضي و تعرفونه يقولكم وظيفة العظم و إنه مو بس مهم لثبات الجسم و قوته لكن أيضاً مهم في اتزان مستوى المعادن بجسمنا يتكلم أيضاً عن تركيبة العظم إنه عبارة عن كولاجين نوع1 و كالسيوم و فسفور و بيقولكم إن عمليات الأيض بالعظم تتأثر بعوامل مختلفة منها الهرمونات: الباراثايرويد الكالسيتونين الاستروجين الكورتيكوستيرويدز فيتامين د الكالسيوم وظيفة الكلى التعرض للشمس و غيرهم و بيتكلم عن بعضهم بأشياء كلكم تعرفوها، بيقول كم نقطة عن قوة العظم و كثافة العظم كلها أشياء بسيطة تسهل عليكم الفهم بس اقروها للاسترجاع

الجزء الثاني من المحاضرة يتكلم عن الركتس (الكساح) - إذا نتكلم عن أطفال، أو الاوستيومالايشيا (لين العظام) لو بنتكلم عن بالغين إلي فيه يكون عند المريض مشكلة بالمعادن، إحنا قلنا إن العظم يستخدم المعادن كمعدات في بناءه و هالمعادن تعطيه الصلابة المطلوبة لكن إلي يصير عند مريض الكساح بسبب نقص فيتامين د يقل معدل إمتصاص المعادن من الأمعاء فللحفاظ على مستوى المعادن الطبيعي بالدم يستعين الجسم بالعظم و يبدأ ياخذ منه المعادن للتعويض و بالتالي مخزون العظم يقل و يبدأ العظم يضعف و يلين و يبدأ الطفل يصير عنده إنحناء بالعظام أو تقوس و ضعف بالعضلات و مشاكل بالنمو و غيرها من الأعراض إلي بتتكلم عنها المحاضرة و بتحفظونها و تميزون بين الأعراض عند الطفل و البالغ و بالنهاية نقول إن العلاج نعطيهم ما ينقصهم إلي هو فيتامين د و خلصنا :)

الجزء الثاني من المحاضرة يتكلم عن الاوستيوبوروسيس أو هشاشة العظام، المشكلة هنا مو في المعادن زي لين العظام لكن العظم بكبره بكل مكوناته متآكل و رقيق و بالتالي أكثر هشاشة و أكثر عرضة للكسور، المريض هنا مايشتكي من آلام عادة لكن يتم تشخيصه بعد ما يتعرض لكسور غريبة من ضربات أو طيحات خفيفة، نتكلم عنه أكثر بالمحاضرة و نتطرق لأعراض أكثر منها إن المرضى تجيهم كسور صغيرة بالعامود الفقري يعني نقدر نقول "تهشم" بالعادة ما يدرون عنها بس تسبب لهم آلام و بنتكلم عن علاجها بالاسمنت مثل التلييس بالضبط :) و بنعرف علاقة هشاشة العظام بالاستروجين و ليش نصير أكثر عرضة بعد انقطاع الطمث للإصابة بهشاشة العظام (أتوقع السالفة طلعت من خشمكم لكن التكرار يعلم الشطار ٨.٨)

الجزء الثالث و الأخير يتكلم عن الهايبرباراثايرويدزم أو زيادة هرمون الجار درقية إلي ينشط الاوستيوكلاست إلي هي الخلايا إلي تهدم العظم و بالتالي و بسبب زيادة الهدم يصير عندنا مثل التآكل بالعظم و الحفر إلي تصير بالأشعة كأنها أورام و لذلك سموها brown tumor لكنها بالحقيقة مو أورام لكن حفر و تآكل على كلام الدكتور إن هذا شيء جداً نادر

وبس والله :) هذي هي المحاضرة بشكل مجمل، جيبوا لكم لو موية و اقعدوا عليها شويتين و أوعدكم تخلصوها بكل سلاسة و معظمها معلومات تعرفوها ، بالتوفيق يا رب يا كريم.

Orthopedics 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.** The bone is an active organ just like the heart and the kidney in that there is a continuous metabolism.
- While osteoblasts are forming new bones, osteoclasts are removing the dead or aged ones. This process accelerates with aging and when estrogen levels drop (Ex, menopause) the rate of formation decreases and the rate of loss increases. Opposite happens in the childhood where bone formation is higher than resorption.
- 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 is controlled by many factors

- **Calcium and Phosphorus.**
- **Parathyroid and Thyroid glands.**
- Estrogen and Glucocorticoid hormones.
- Intestinal absorption (patient with malabsorption such as celiac can't absorb calcium).
- **Renal excretion** because all components of blood gets filtered by the kidney including the calcium, e.g. tubular necrosis, or glomerular nephropathy they will not benefit from the dietary or supplemental calcium or Vitamin D intake until this condition is corrected
- Diet inadequate food intake affects the calcium level
- Vitamin D nowadays VD is very important for adrenal glands, brain, muscles, more likely it affects everything in our body
- Sun exposure.

Bone structure: (Bone matrix)

- **40% organic**: collagen type 1 (responsible for tensile strength).
- **60% Minerals:** mainly Calcium hydroxyapatite, Phosphorus, and traces of other minerals like zinc.

Cells in bone: osteoblasts, osteoclasts, osteocytes. (**in adults:** Osteoblast daily form 10,000 new cells while osteoclast removes 11,000).

Plasma level:

you don't have to memorize the numbers

- **Calcium**: 2.2-2.6 mmol/l — Both of them are absorbed and secreted
- **Phosphorus**: 0.9-1.3 mmol/l — by the **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 it shows how much activity in the bones, when increased it means increased turnover

- **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 (eg, kidney and intestine problems)
- **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 **lowers the serum calcium.**

Bone strength:

- Bone strength is affected by mechanical stress which means exercise and weight bearing.

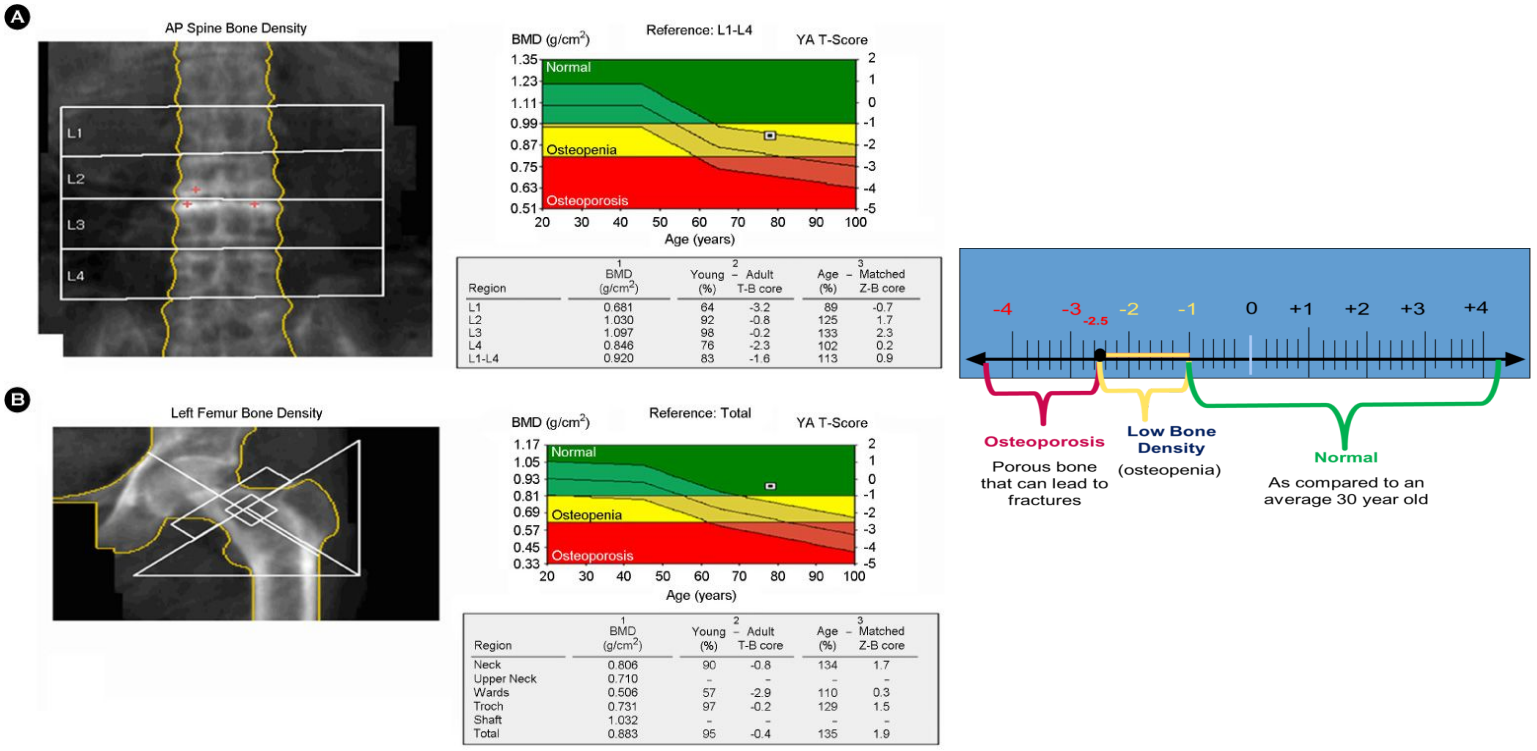
لو مسكنا مريض و خليناه ما يمشي أسبوعين راح يخسر 50% من قوته للجزء السفلي

- Bone strength gets reduced with menopause and advancing age.
- Reduced bone density on X rays is called Osteopenia. (The opposite is osteosclerosis).
- Osteopenia is also a term used to describe a degree of reduced bone density, which if advanced becomes Osteoporosis.
- X-ray is not accurate because sometimes the technician put overexposure or underexposure

Bone density:

it's either normal, osteopenic or osteoporotic

- Bone density is diagnosed at current time by a test done at radiology department called: **DEXA scan** (they do it in three areas: **vertebrae**, **wrist**, and **neck of femur).**
- DEXA is (Dual Energy X-ray Absorbtionometry)
- However: increased bone density does not always mean increased bone strength, as in **Brittle bone disease** (which has normal bone density) but is not a strong bone it's a fragile bone, which may break easily. another example is **osteopetrosis** (marble bone disease=العظم التصخري) in which the bone is abnormally dense in a way that makes it fragile and more prone for fractures (**hard bone doesn't mean a normal bone**)



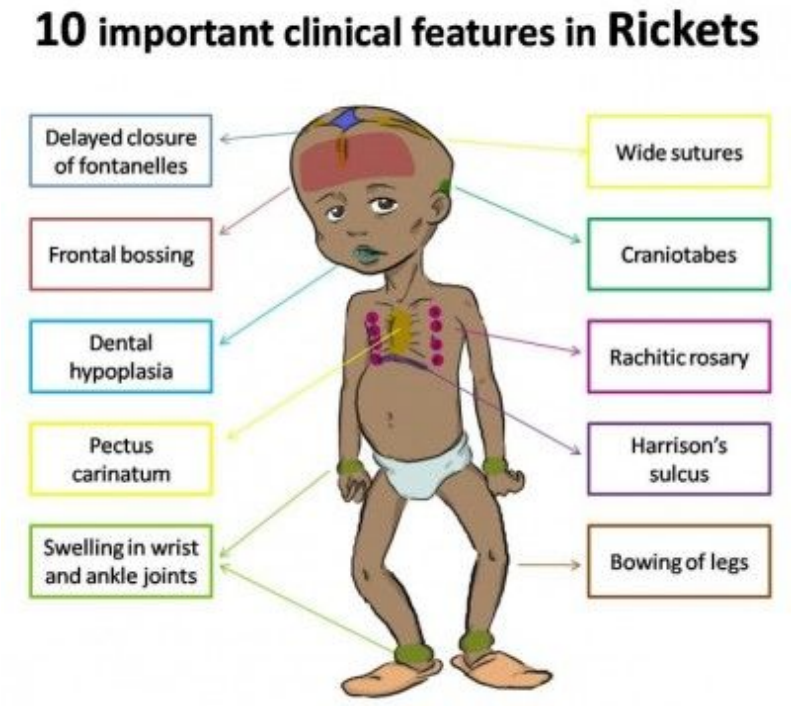
Rickets	Osteomalacia
Different expressions of the same disease, which is: **Inadequate mineralization.**	
All skeleton is incompletely calcified, it also affects areas of endochondral growth in children. (physis = growth plate)	All skeleton is incompletely calcified in adults.
Biochemistry: Hypocalcemia, Hypocalciuria, High alkaline phosphatase	
❖ **Causes:** – Calcium deficiency. – Hypophosphatemia. – Defect in Vitamin D metabolism[1] (nutritional, under exposure to sunlight, intestinal malabsorption, liver & kidney diseases).	

[1] most common cause

Rickets

Signs And symptoms:

- Child is **restless, babies cry without obvious reason.** (e.g. when changing diaper).
- **Failure to thrive.**
- **Muscle weakness.**
- In severe cases with very low calcium: **tetany or convulsions.**
- **Joint thickening** (hypertrophy) especially around wrists and knees[2].
- **Deformity** of limbs, mostly **Genu varum or Genu Valgum**.
- **Pigeon chest deformity** (ribs are weak), **Rickety Rosary**[3], craniotabes (softening or thinning of the skull in infants and children so when pressure is applied they will collapse underneath it).



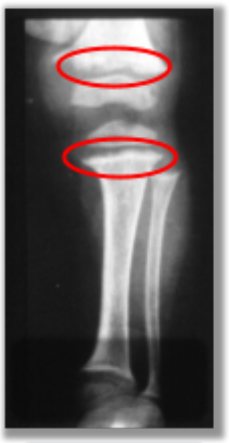
Biochemistry (most important investigation)

- **Hypocalcaemia, Hypocalciuria, High alkaline phosphatase (because of increased activity).** (If alkaline phosphatase is normal, it is most likely not metabolic bone disease).

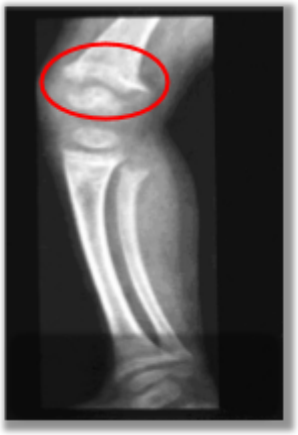
[2] from growth plate overgrowth
[3] Enlargement of the costochondral junctions

X-Ray Findings

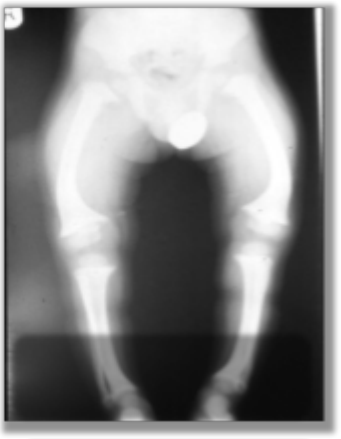
1. Growth plate widening and thickening.
2. Metaphyseal cupping.
3. Long bones deformities



Metaphyseal cupping



Growth plate widening and thickening



Long Bone Deformity

Treatment

You have to make sure first that the patient does not have systemic disease like malabsorption in intestine or kidney disease (Because there is no point of treatment without treating the primary cause).

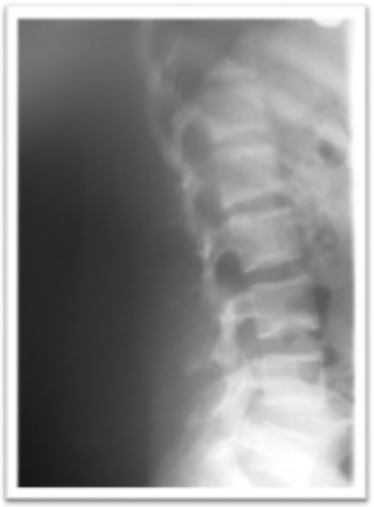
- Adequate Vitamin D replacement
- Sun exposure
- Correct residual deformities (if there is Genu varum or Genu Valgum and did not improve after the treatment we do corrective osteotomy).

Osteomalacia: Metabolic Bone Disorder in **Adults**

Signs & Symptoms

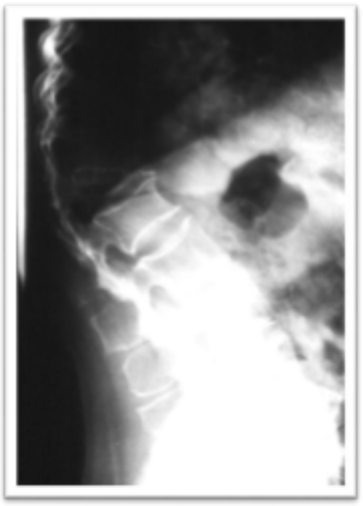
The difference here is that the growth is stopped in Adults unlike children so no growth related symptoms here.

- Generalized bone pain, **mainly backache** (because the back bears body during walking).
- Muscle weakness.
- **Reduced bone density.**
- Vertebral changes: **Biconcave vertebrae,** vertebral collapse, kyphosis (when bone becomes soft the convex shape of intervertebral disc will be concave then any press on vertebrae with this shape will cause fracture). يتغير شكل الفقرات بسبب ليونة العظام و بالتالي يصير أكثر عرضة للكسر
- **Stress fractures** or **Insufficiency fracture** (the bone is weak so it fractures but the pt still can walk because it's incomplete fracture so the bone try to heal the fracture and create **"looser's zones"** happens mainly in in scapula, ribs, pelvis, and proximal femur.



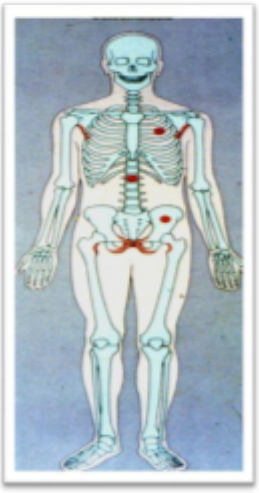
Biconcave vertebra from above and below, any fall can cause compression fracture

Looser zone



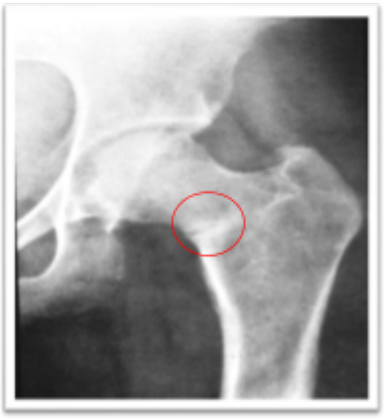
Kyphosis

In advanced stages



No changes in skull, no changes in costochondral junction.

Might be stress fracture in ribs, neck of femur.



Femoral head stress fracture

"MCQ"

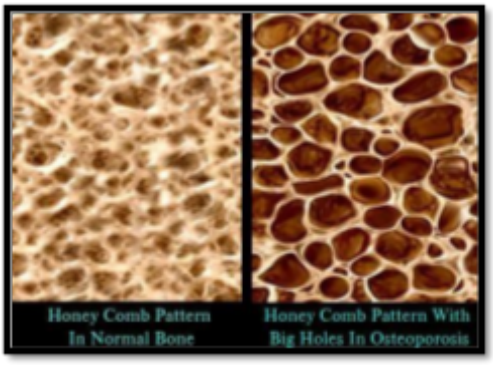
Treatment

- Exclusion of other diseases
- Vitamin D + Ca
- Fracture management
- Correct deformity if needed

Osteoporosis

لو تخيلنا الموضوع زي العمارة فيها سمنت و حديد الاوستيوبوروسس كلهم ناقصين بينما في الاوستيومااليشيا بس عندنا الحديد ناقص

- Decreased bone mass: decreased amount of bone per unit volume and this causes reduced density (Loss of bone unite unlike osteomalacia which affects bone mineralization).
- Mineralization is not affected.
- Mainly post-menopausal (Drop in Estrogen levels) and age related
- The danger is not in osteoporosis itself but in the complications that it might cause.
- Osteoporosis is painless disease unless it causes fracture.
- Osteoporotic fracture nowadays is called fragility fracture.



Primary Osteoporosis: (affect every bone)

	Postmenopausal Osteoporosis	Senile 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.	• 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	• Race (Caucasian) • Hereditary • Body build (thin people) • Early menopause • Smoking/ alcohol intake/ drug abuse • Calcium intake (low Ca)	• Male menopause (Decreased Testosterone) • Dietary: less calcium and vitamin D and protein. • Muscle weakness. • Reduced activity.

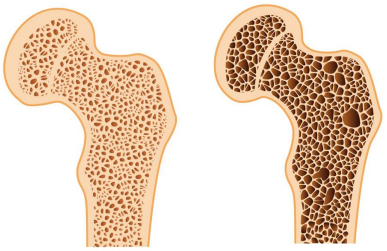
Secondary Osteoporosis

It happens most of the time in younger patient e.g. 45 years old, so in younger patient with osteoporosis suspect a secondary cause.

- **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.

Clinical features of Osteoporosis

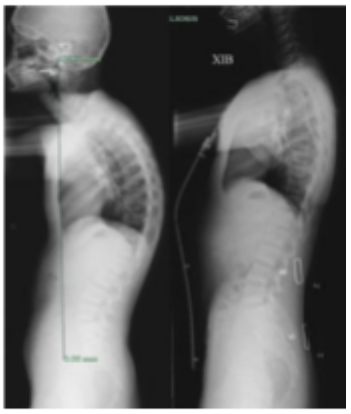
- **Osteoporosis is a Silent disease.**
- Osteoporosis is Serious due to possible complications mainly fractures (common sites are dorsal spine, wrist, and neck of femur).
- Osteoporosis does not cause pain usually.
- Osteoporosis causes gradual **increase in dorsal kyphosis.**
- Osteoporosis leads to **loss of height.**
- Osteoporosis is not osteoarthritis; but the two conditions may co-exist.



Healthy bone Osteoporosis

How does kyphosis and loss of height occurs?

With osteoporosis the anterior part of the vertebra narrows which leads to kyphosis and loss of height.



Osteoporotic fractures (fragility fractures)

- They are Pathological fractures.
- Most common in osteoporotic compression fracture (OVC).
- Vertebral microfractures occur unnoticed (dull ache).
- Most serious is hip fractures (Present to the ER unable to walk).
- Also common is wrist fractures (Colles fracture).

Disuse Osteoporosis

- Occurs locally adjacent to immobilized bone or joint.
- May be generalized in in bedridden patients.
- Awareness of and attempts for prevention are helpful (by moving the limb from time to time).

Osteomalacia	vs	Osteoporosis
Any Age		Post-Menopausal, old age
Patient is ill		Not ill
General ache		Asymptomatic until fracture
Weak muscles		Normal
Looser zones		Nil
Alkaline Ph increased		Normal
PO4 decreased		Normal

In osteomalacia the pain is a result from low calcium that leads to muscle pain.

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 (because of the side effect).

Management

- Drug Therapy
- Exercise
- Management Of Fractures

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 (such as tumors).

Adequate intake of calcium and vitamin D is mandatory

Drugs which inhibit osteoclast activities: e.g. Bisphosphonates like sodium alendronate FOSAMAX (70 mg Tablet once weekly), BONVIVA

Denosumab = PROLIA (s/c injection every 6 months)= human monoclonal IGG2 antibody

Drugs that enhance osteoblast activities: bone stimulating agents like PROTELOS, FORTEO. The problem in this type of medication is the risk of malignancies.

(New guidelines state that they should receive both which inhibit osteoclast and stimulate osteoblast activity)

Exercise in Osteoporosis:

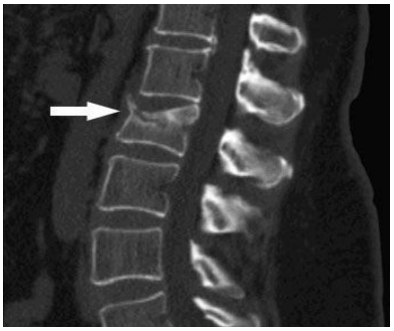
- Resistive exercises
- Weight bearing exercises
- Exercise should be intelligent to avoid injury which may lead to fractures.

Management of fractures

Use load shearing implants in fracture internal fixation (like nails) instead of plating. (We don't like plates because it's weight bearing devices and can fail)

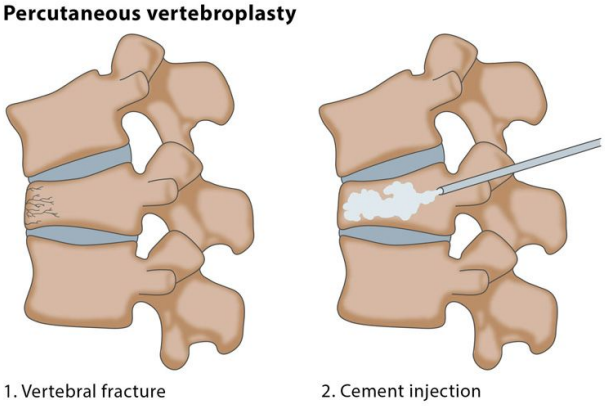
Management of Vertebral Osteoporotic Compression Fracture (OVC) :

- Pain relief
- Prevention of further fractures
- Prevention of instability to protect nerve roots
- 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 helps to prevent further OVF. so it's doesn't correct the already damaged spine only stop deterioration
- It results in immediate pain relief
- Possible complication is leakage of cement into spinal canal (nerve injury) or venous blood (cement PE).



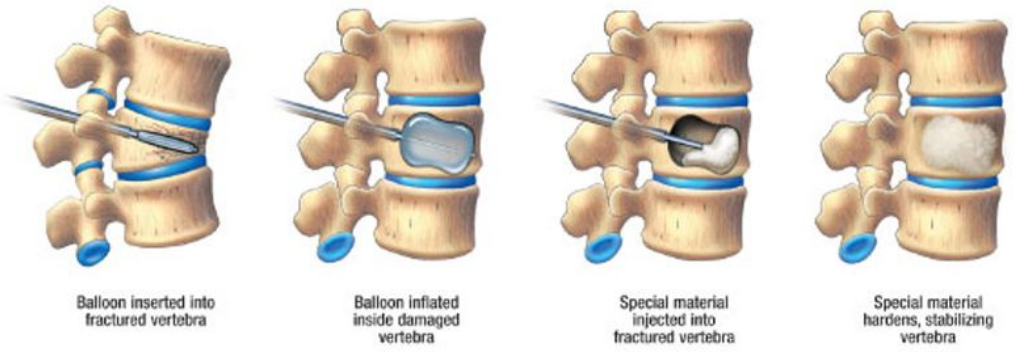
Kyphoplasty

اخترعوها عشان مشكلة تسرب السمنت في ال vertebroplasty

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. ينحط بمثل كيس

It is possible that some correction of kyphosis is achieved.

It is safer because cement is injected into a safe void.

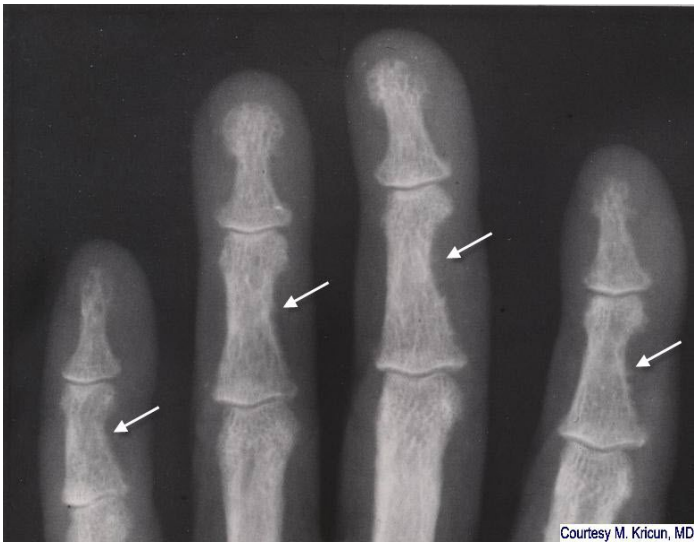


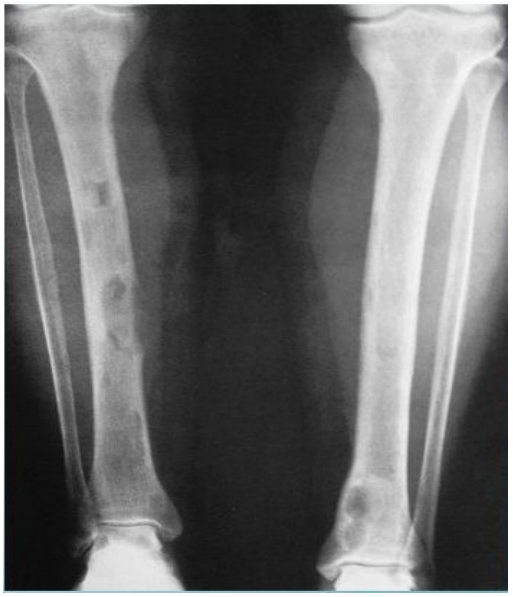
Hyperparathyroidism

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

Radiological Changes

- Generalized decrease in bone density.
- Sub-periosteal bone resorption (scalloping of metacarpals and phalanges).
- Brown tumors (too much bone reuptake causing areas of empty bone with bleeding, this blood will accumulate like paste forming what calls brown tumors).
- Chondrocalcinosis (wrist, knee, shoulder).





Management of Hyperparathyroidism (By treating 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.