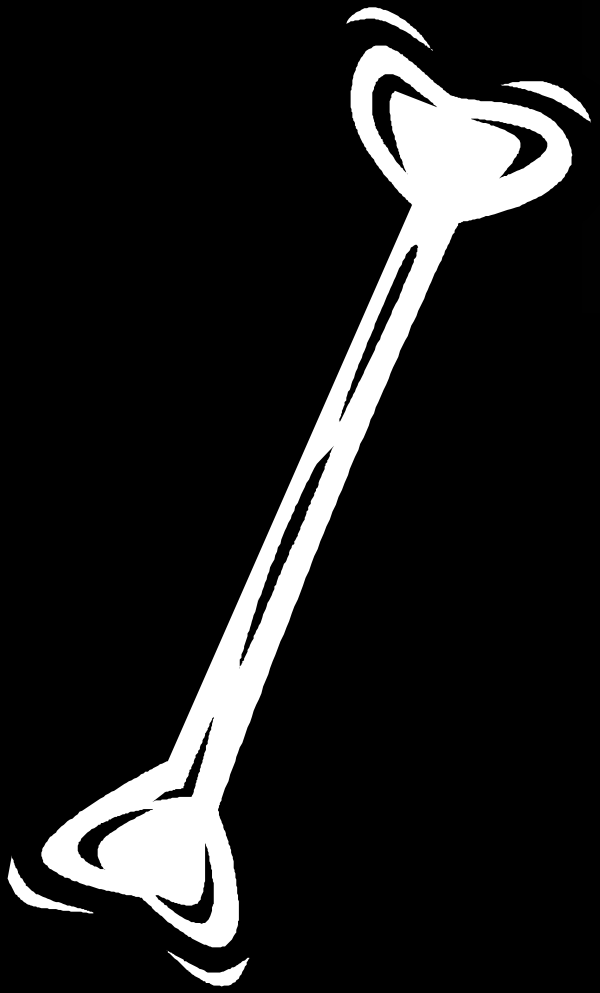


Bone Health and Osteoporosis

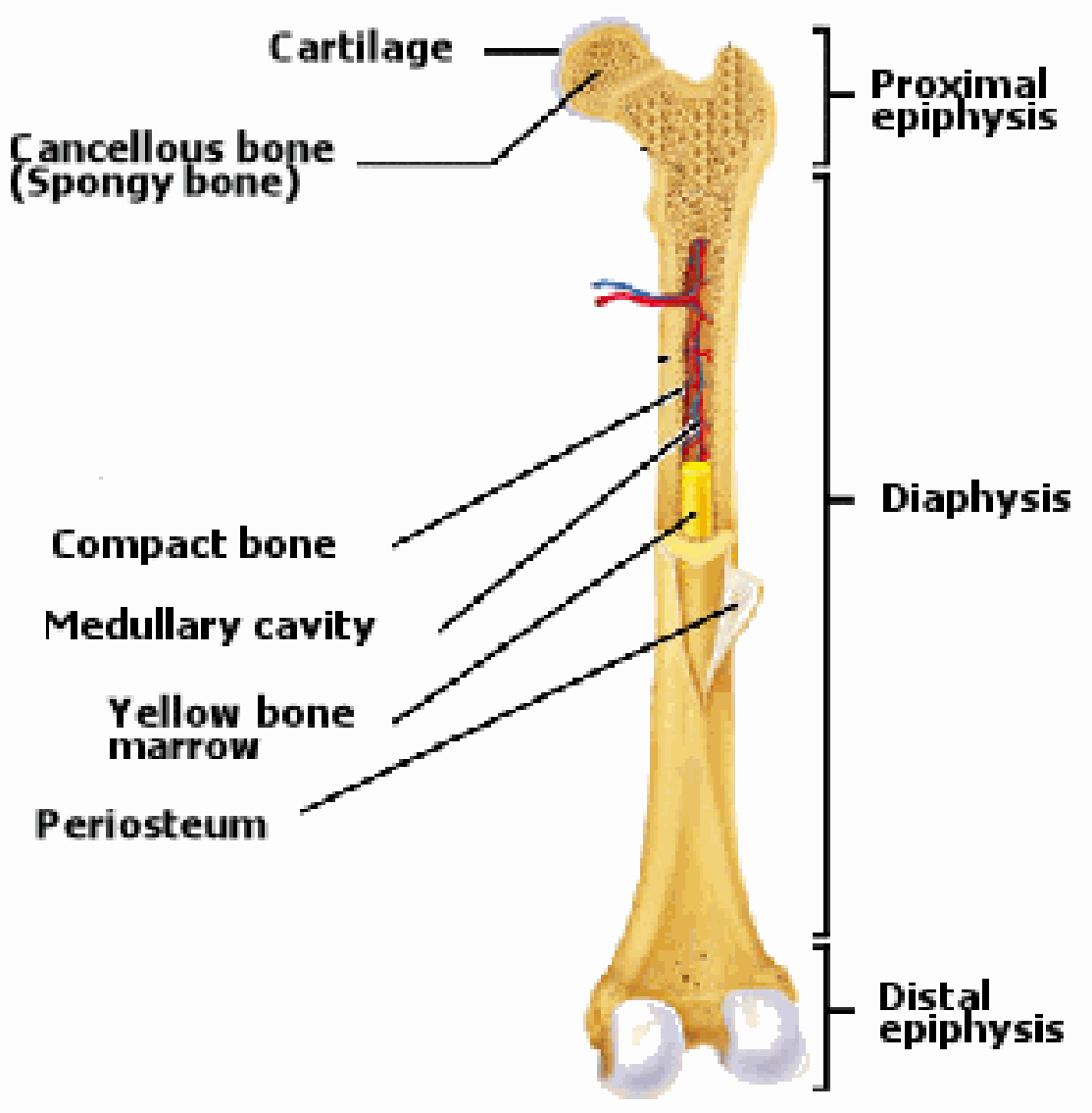
- Katie Garrett
  Jessica Christensen
  Brittney Scott
  McKenzie Smith

Bone Physiology

Bone composition

- Osteoids
  - Collagen fibers primarily
  - Organic protein structure matrix
  - Gives strength and flexibility
- Hydroxyapatite
  - Crystalline structure of calcium phosphate and calcium carbonate
  - Gives strength and rigidity

Basic anatomy



Cortical vs trabecular bone

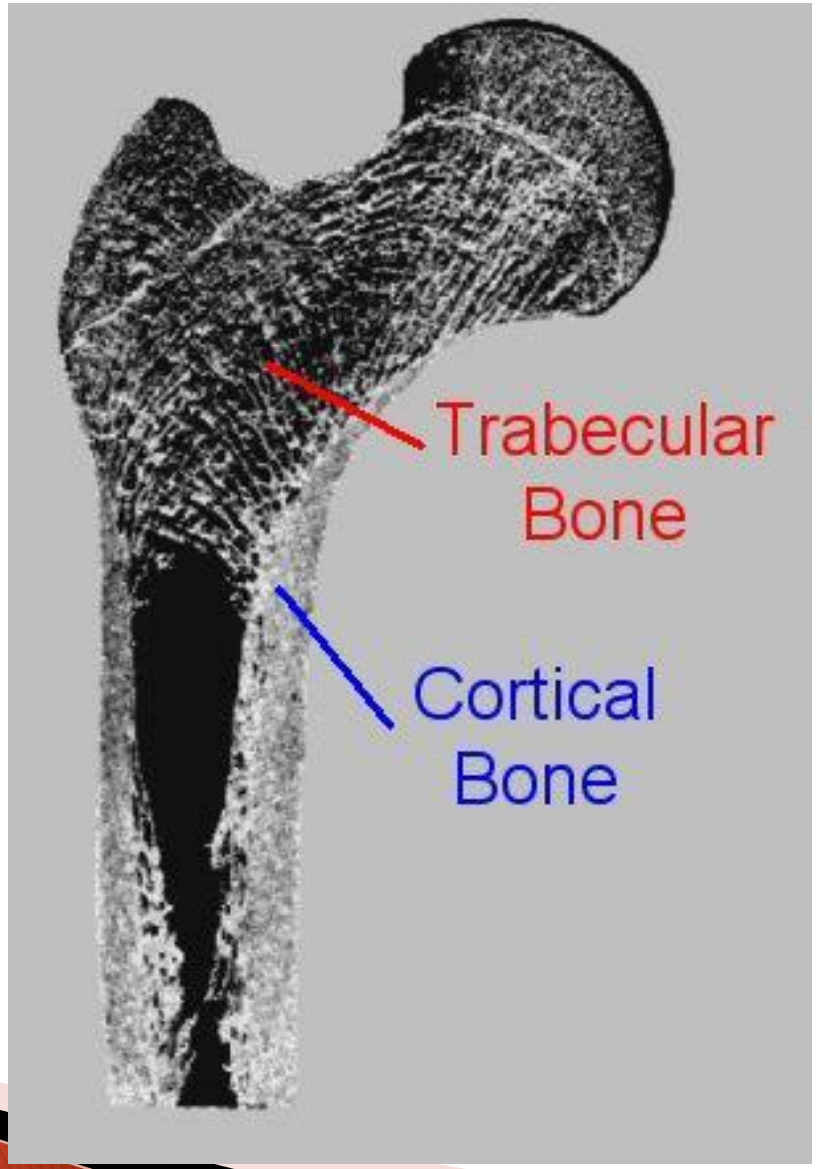
Cortical:

- Compact bone
- Surrounds the marrow cavity
- Much denser
- 80% of wt of skeleton
- Protects medullary cavities
- Shaft of bone
- Osteon

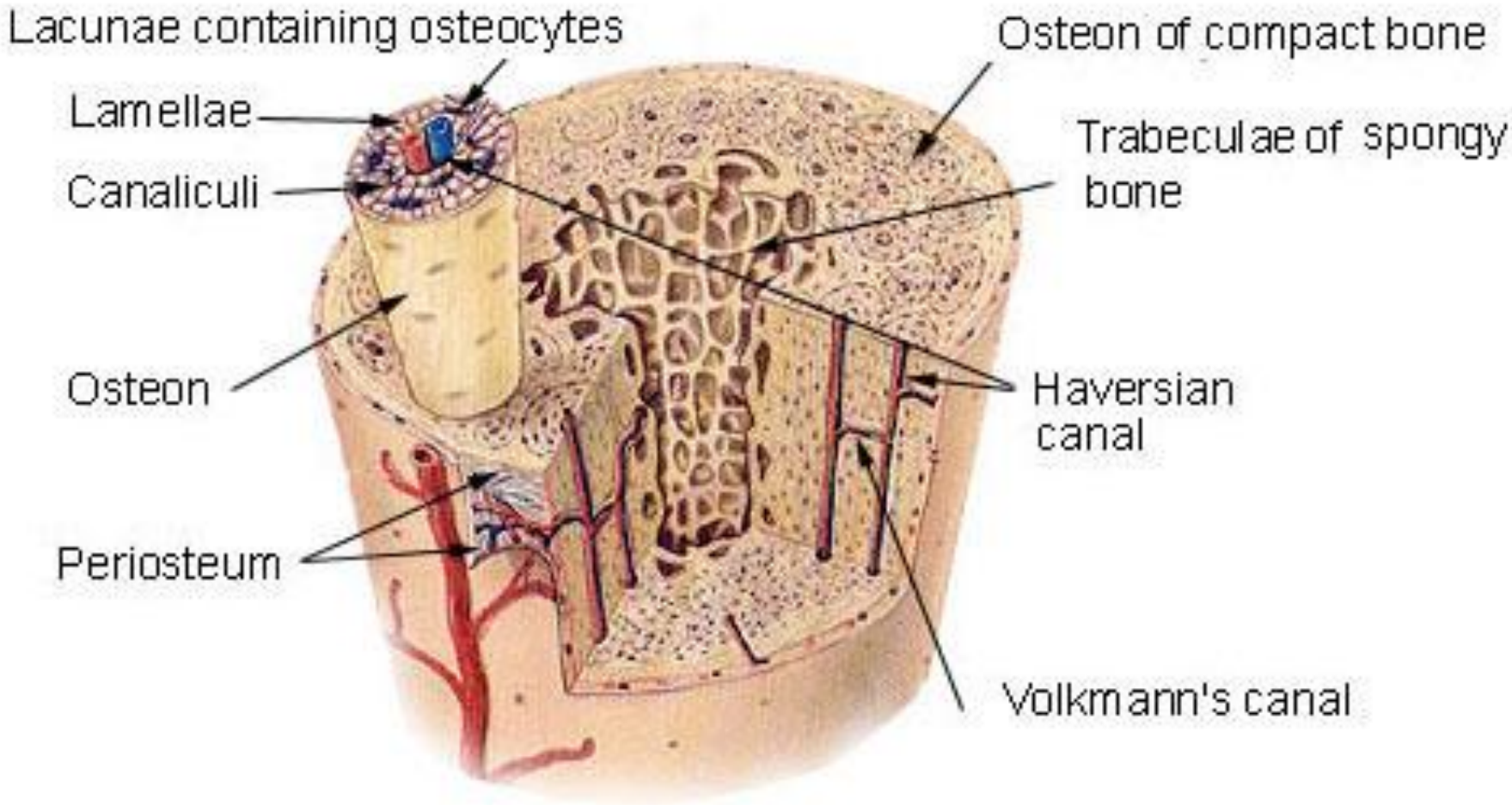
Trabecular:

- Spongy or cancellous bone
- Softer, weaker
- Less dense
- More surface area
- Typically at end of long bones
- Ideal for exchange of Ca ions
- Trabecula

Cortical vs trabecular bone



Compact Bone & Spongy (Cancellous Bone)



Bone terms

- Bone mineral content (BMC)=bone accumulated before end growth, mineral g/cm of bone
- Bone mineral density (BMD)= bone mass after development, g/cm^2
- Peak bone mass (PBM)=greatest amount of bone accumulated within lifetime- usually age 30. Greater in men than woman b/c larger frame
- Bone mass=BMC, not BMD

Bone cells

Osteoblasts

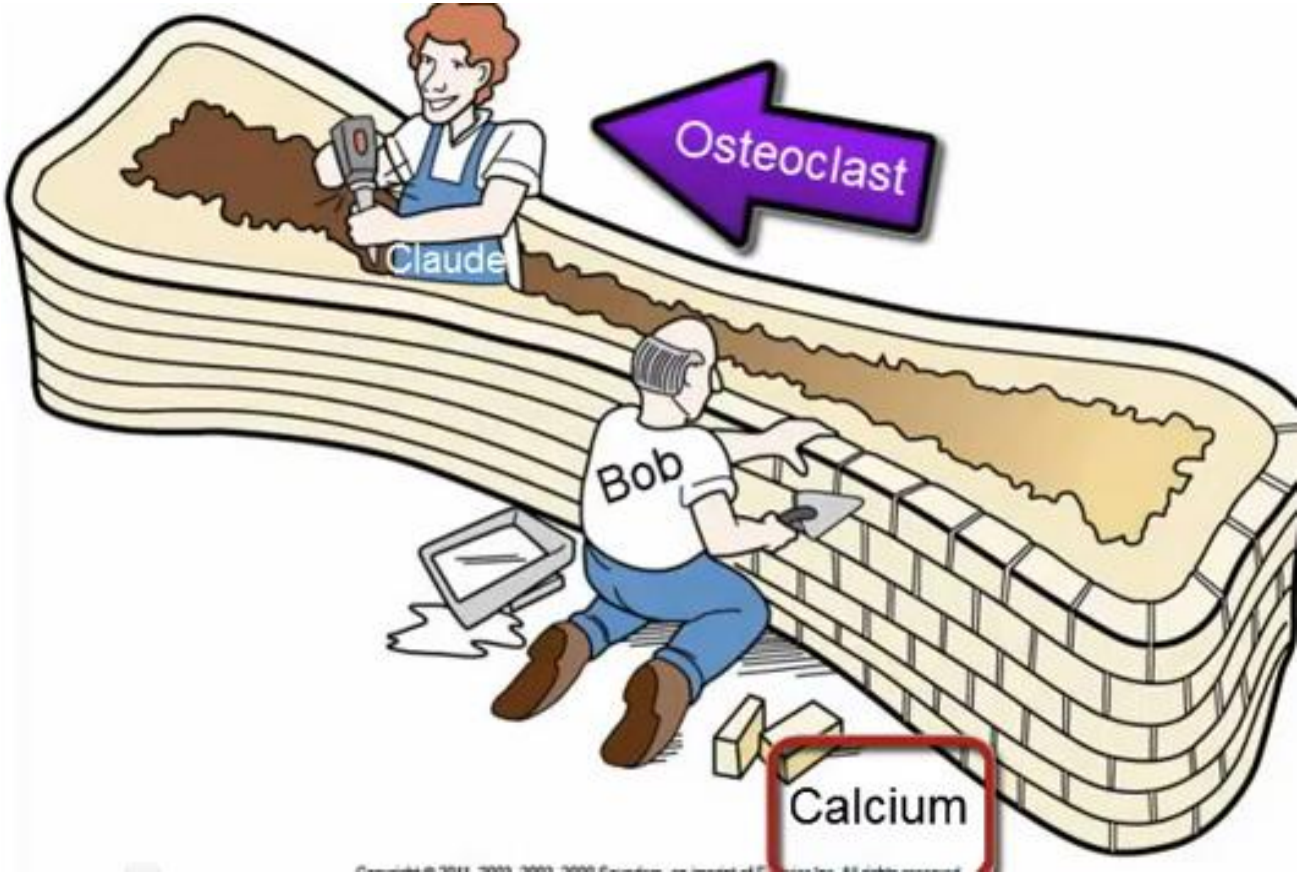
- Bob the builder
- Matrix protein synthesis
- Secretion of cytokines that act on osteoblasts
- Osteocytes and bone-ling cells derived

Osteoclasts

- Claude the carver
- Degradation of bone via H+ secretion and enzymes
- Communication
- Secretion of cytokines that act on osteoclasts
- Macrophages, immune system

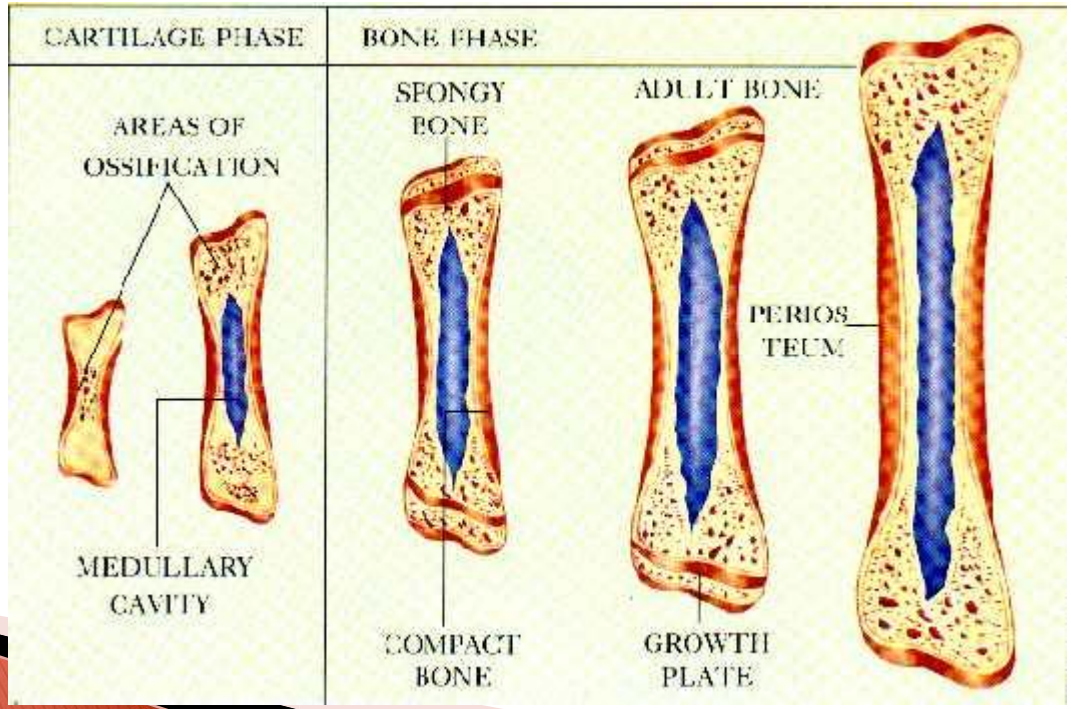
Both made in bone marrow, stimulated by hormones and growth factors

Bob and Claude



Bone modeling

- Growth of skeleton until mature ht is achieved
- Elongate and widen
- New bone formation, then reabsorption of old tissue
- Starts at terminal epiphyses



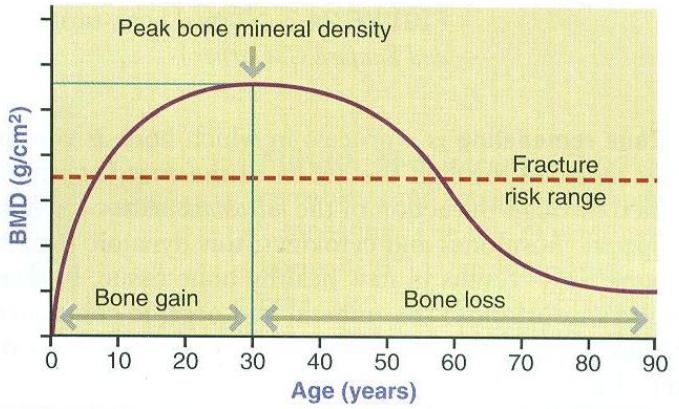
Bone growth, Ca and Vit D

- Completed 16 yof, 18 yom
- PBM at 30 yo
- What happens to bone if blood calcium is low? High?
- What if Vit D is low? High?

TABLE 24-2

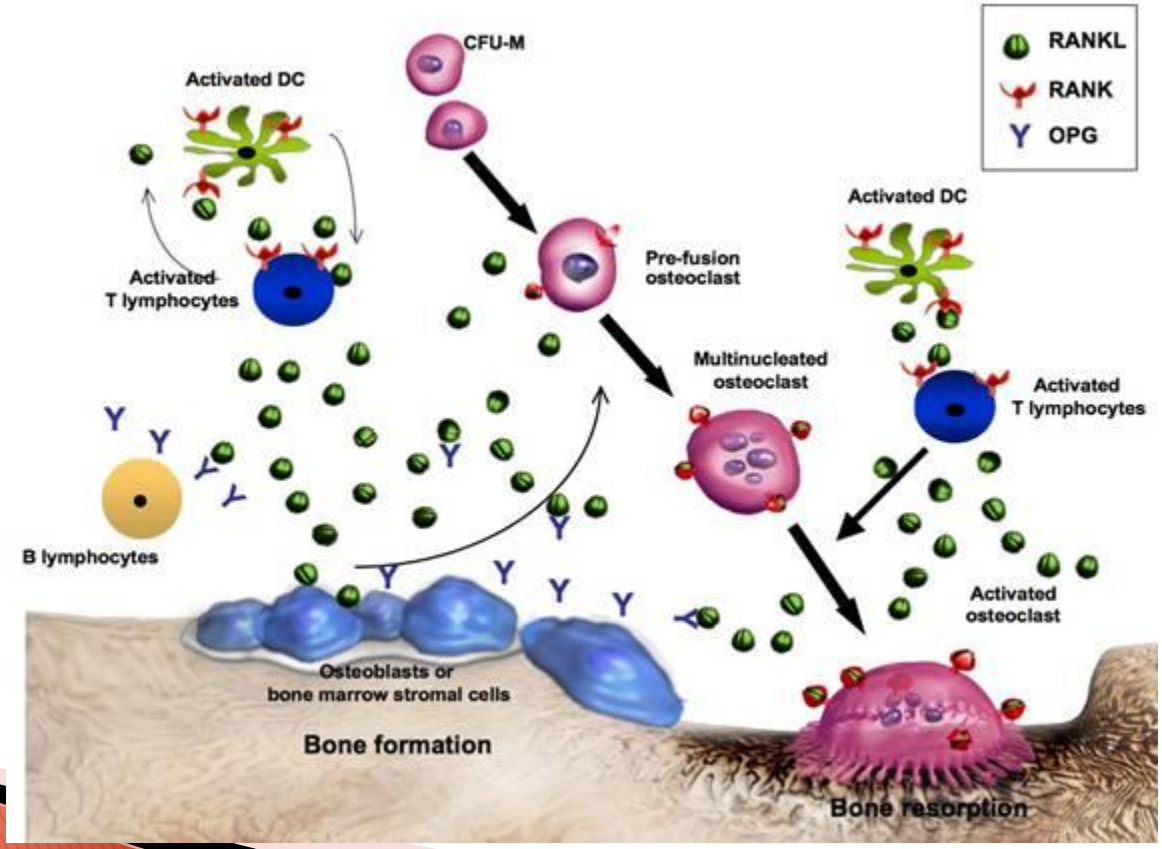
Effects of Low vs. High Vitamin D Intake on Bone

Vitamin D Intake	Effect on Bone Cells	Effect on Bone Tissue
Low (≈0.1 mg/kg)	Osteoblasts increase	Bone formation increases synthesis of osteocalcin and mineralization
High (≈1-5 mg/kg)	Osteoblasts decrease	Bone formation decreases, leading to increase in activity of osteoclasts



Bone remodeling

- Response to strains on skeleton
- Bone is continuously reabsorbed with Bob and Claude

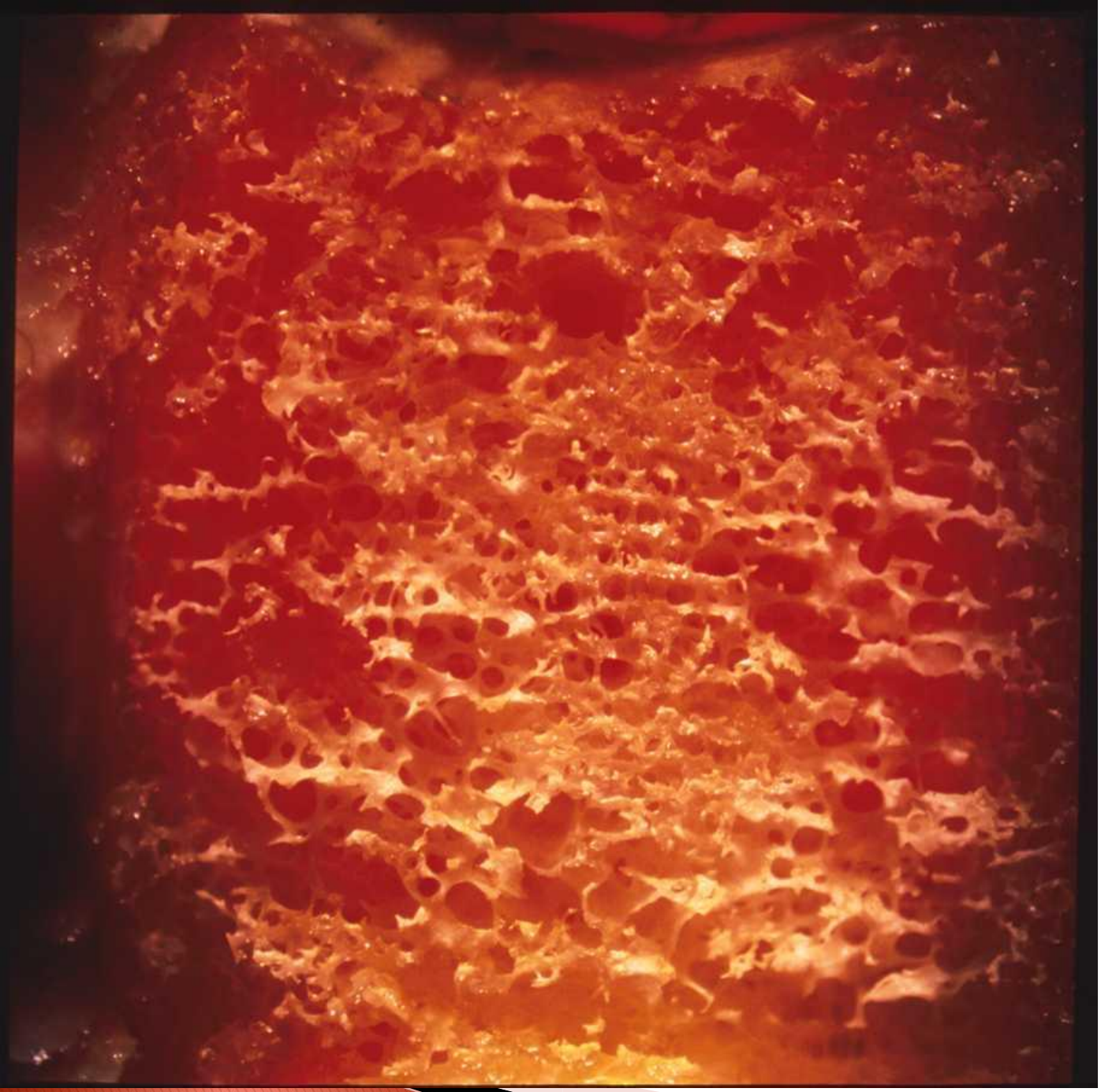


Osteoporosis

Definition

- Weakened bones can no longer sustain ordinary strains
- BMD >2.5 standard deviations below healthy levels

- Found in the wrist, hip, and spine



31
YOM

81
YOM

Use the terms “low bone mass” or “low bone density” NOT “osteoporosis” for men <50 or women who are premenopausal.

Etiology

- Excessive resorption
- Suboptimal peak bone mass leads to fragile bones that are easy to fracture

Incidence/Prevelance

- 10 million diagnosed
- 34 million at risk
- 80% are women

Cost

- In 2005, $19 billion dollars were spent on treatment and there were 2 million osteoporosis related bone fractures

- By 2025 these numbers are expected to increases to $25 billion dollars and 3 million bone fractures

Types of Osteoporosis

- Postmenopausal or Estrogen/Androgen Deficient Osteoporosis (Type 1)
- Age-related Osteoporosis (type 2)
- Secondary Osteoporosis

Type 1

- Within a few years of menopause
- Loss of bone tissue because of cessation of estrogen production
- Decreased BMD in lumbar spine, pelvis, ribs, proximal femur
  - Leads to “crush” fractures of lumbar vertebrae or distal radius
- Men can develop, but rare

Type 2

- 70+ for both male/female
- Characterized by fractures of the hip
- Leads to loss of height, spinal deformity, back pain
- Women more affected because of smaller bones and longer life

Secondary Osteoporosis

- Identifiable drug or disease process causes loss of bone and tissue

Secondary Osteoporosis: Diseases

- CF
- Anorexia nervosa
- Bulimia
- Diabetes mellitus
- IBD
- Gastric bypass
- Emphysema
- End stage renal disease
- GI surgery
- Pancreatic disease
- Thalessemia
- Sickle cell
- Leukemia & lymphomas
- Rheumatoid arthritis
- Parenteral nutrition
- Congestive heart failure
- malabsorption

Non-Modifiable vs Modifiable Risk Factors for Osteoporosis

Non-Modifiable

- Age
- Sex
- Ethnicity
- Menopausal
- Family history
- Low body weight
- Broken bones or height loss

Modifiable

- Not getting enough Ca or vitamin D
- Not eating enough fruits and vegetables
- Too much protein, sodium, and caffeine
- Being inactive
- Smoking
- Heavy drinking
- Losing weight

MNT

- Calcium and vitamin D supplementation
- Protein supplements
- Best MNT is prevention during adolescence rather than treatment after diagnosis

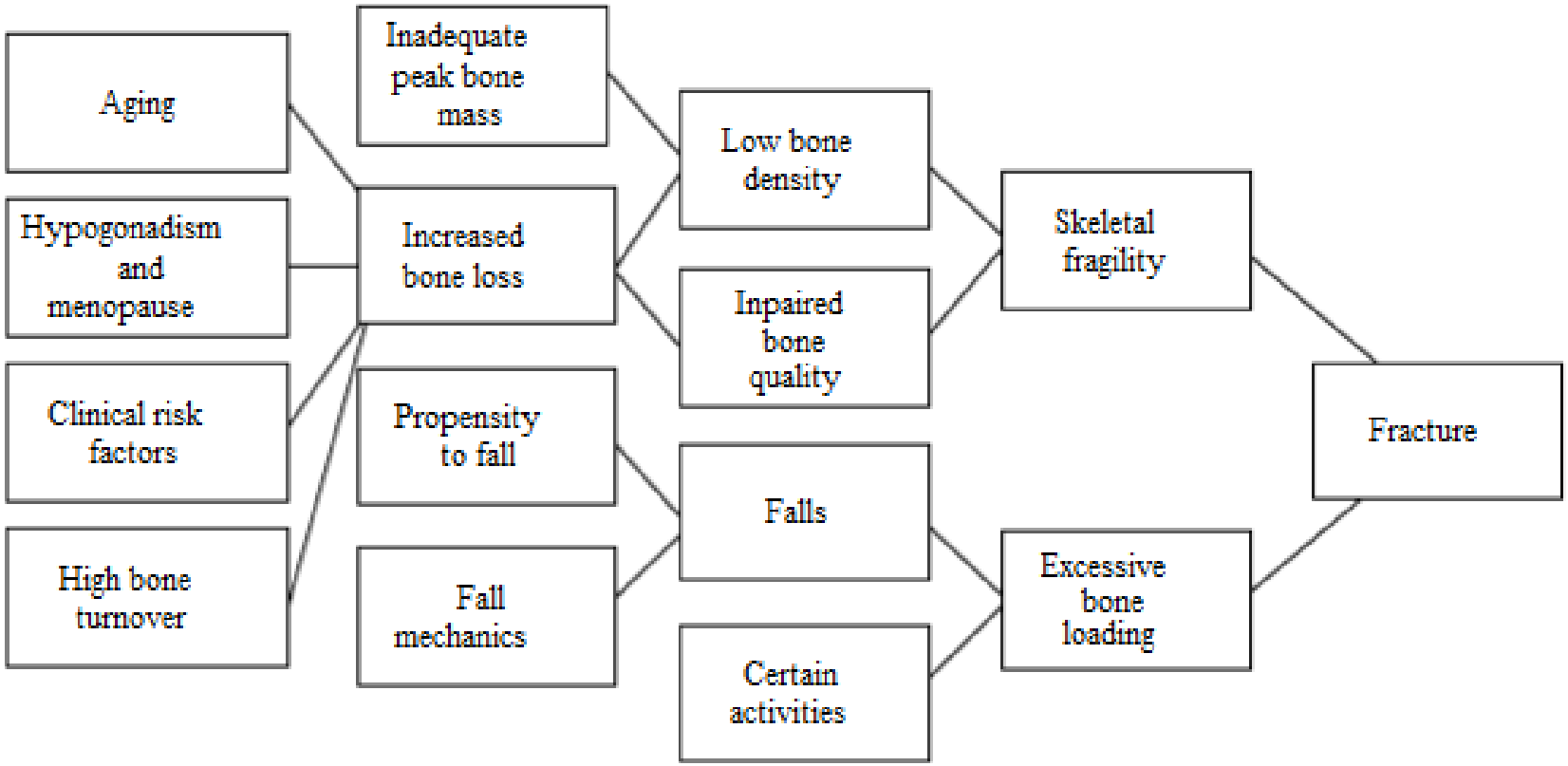
Prevention

- Adolescence (ages 9-19) is the most critical time to build bone
  - Make sure they have adequate calcium
- Throughout life, keep healthy diet with adequate amounts of calcium and vitamin D
- Exercise

Fall Proofing a House

- Make sure all carpet and rugs are secured to the floor
- Don't use slippery wax on floors
- Install bars to grasp near the toilet, bathtub, and shower
- Clean up spills immediately
- Keep stairways and hallways well lit
- Mark the top and bottom steps with a bright tape
- Keep furniture in normal place
- Remove lose wires, cords, and throw rugs
- Is a non-slip rug in the shower/tub or a plastic chair to sit in
- Keep the house clean and clear from clutter

FiGurE 2. pathogenesis of Osteoporosis-related Fractures



From: Cooper C and Melton LJ [7], with modification.

Good Sources of:

Calcium:

- Milk
- Yogurt
- Cheese
- Fortified foods
- Fortified juices

Vitamin D:

- Fortified milk
- Fortified cereals
- Liver
- Egg yolks
- Saltwater fish

IOM

Calcium (mg)

Males:

<18: 1100–1300

19–70: 800–1000

>70: 1000–1200

Women:

<18:1100–1300

19–50:800–1000

>50: 1000–12000

Vitamin D (IU)

- 400–600 for all ages and both genders

NOF

Calcium (mg)	Vitamin D (IU)
Men: <70: 1000 >70: 1200 Women: <50:1000 >50:1200	Men: <50:400–800 50–70: 800–1000 >71: 800–1000 Women: <50:400–800 >50: 800–1000

Diagnosis of Bone Health

Terms

- BMC
- Bone Area
- BMD

Tests for Osteoporosis

- Bone Mineral Density (BMD) tests
- X-rays or bone scans
- Lab tests

BMD Tests

- Measure the density of bones
- Detect osteoporosis before a fracture occurs
- Help predict chances of fractures in the future
- Monitor the effectiveness of treatments for osteoporosis

Types of BMD Tests

- DXA (dual energy x-ray absorptiometry)
- pDXA (peripheral dual energy x-ray absorptiometry)
- QCT (quantitative computed tomography)
- pQCT (peripheral quantitative computed tomography)
- QUS (quantitative ultrasound)
- RA (radiographic absorptiometry)

**Most commonly administered*

DXA

- X-rays with two energy peaks that differentiate between bone and soft tissue
- More radiation passing through = lower density
- Most preferred method to diagnose Osteoporosis
- Repeat test annually (compare results)

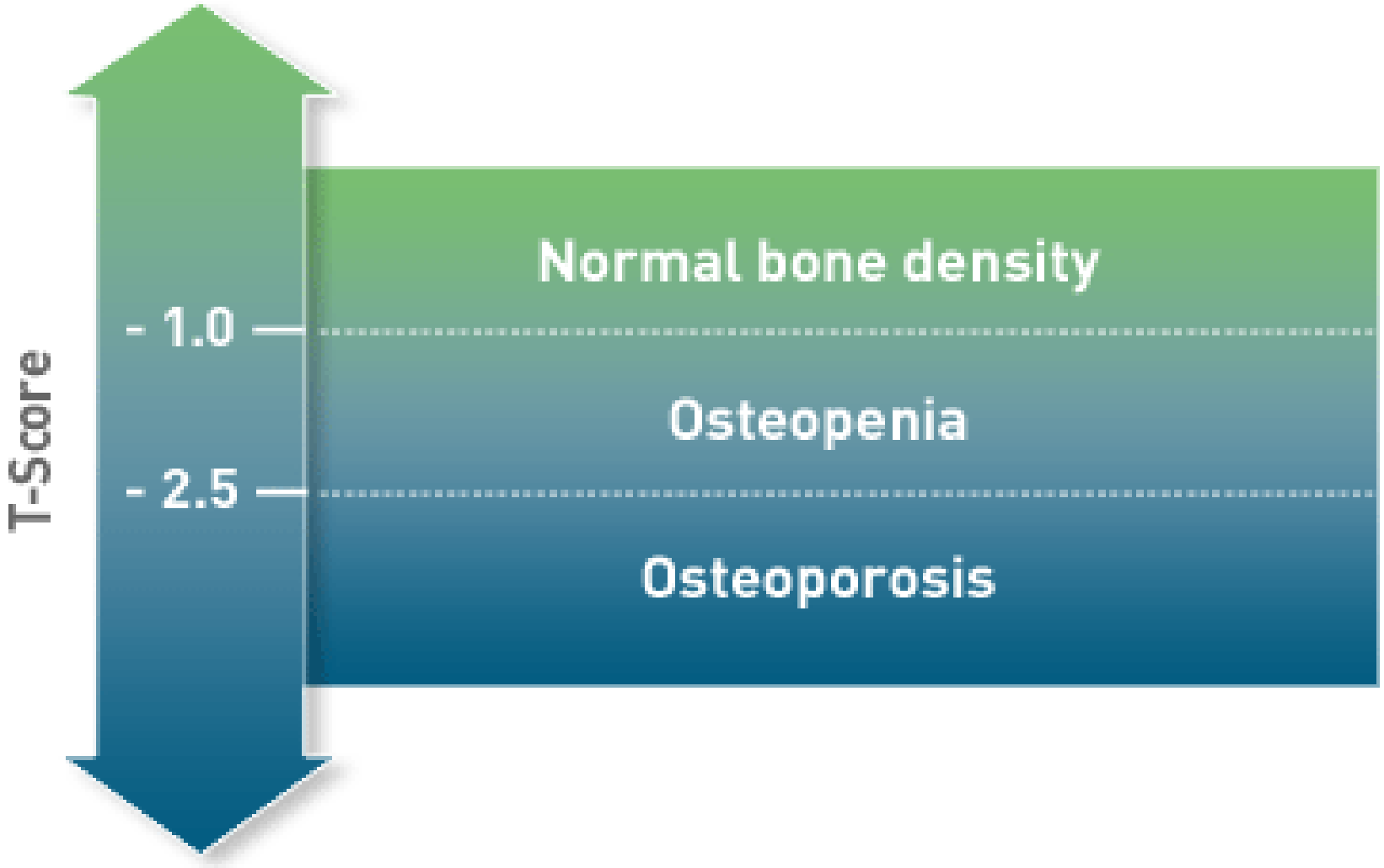
DXA (continued…)

- Measure BMD in the hip and/or spine
- Remain fully dressed
- Takes 5-10 minutes
- Results = T-score

T-Score and Z-Score

- T-Score
  - Compares bone density to optimal peak bone density of young adults (age 20-30)
  - Used for:
    - Postmenopausal women
    - Men age 50+
- Z-Score
  - Compares bone density results to others the same age, weight, ethnicity and gender
  - Used for:
    - Females prior to menopause
    - Males younger than age 50
    - Children

T-scores



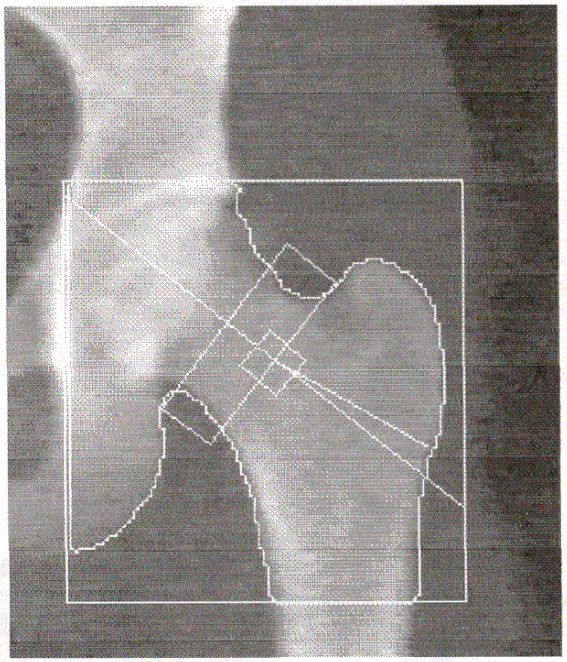


Image not for diagnostic use
92 x 98

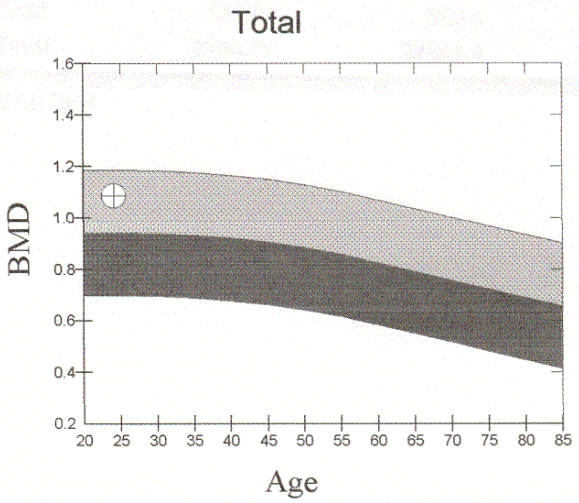
Scan Information:

Scan Date: October 22, 2002 ID: A1022020F
Scan Type: f Left Hip
Analysis: December 28, 2002 09:22 Version 10.0
Left Hip
Operator: es
Model: QDR 4500W (S/N 49485)
Comment:

DXA Results Summary:

Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - Score	Z - Score
Neck	5.04	4.75	0.942	0.8	0.8
Trochanter	10.61	8.95	0.843	1.4	1.4
Inter	18.07	22.94	1.269	1.1	1.2
Total	**33.72**	**36.63**	**1.086**	**1.2**	**1.2**
Ward's	1.27	1.33	1.046	2.7	2.7

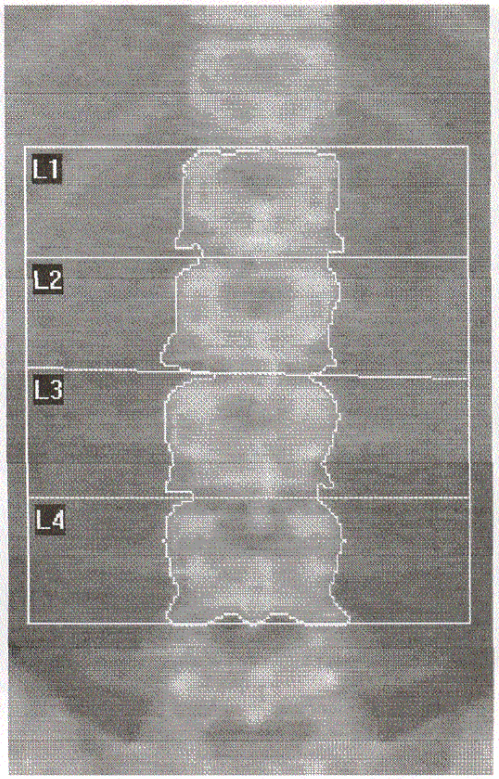
Total BMD CV 1.0%
WHO Classification: Normal
Fracture Risk: Not Increased



24 year old female

68” 167#

Physician's Comment:



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116 x 126

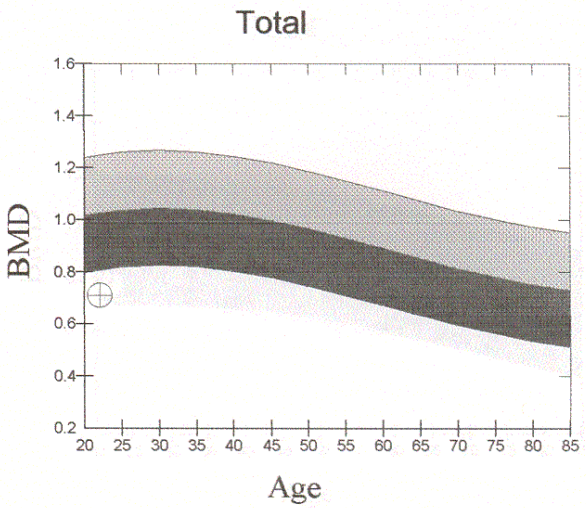
Scan Information:

Scan Date: October 21, 2002 ID: A1021020T
Scan Type: f Lumbar Spine
Analysis: December 28, 2002 09:57 Version 10.0
Lumbar Spine
Operator: es
Model: QDR 4500W (S/N 49485)
Comment:

DXA Results Summary:

Region	Area (cm^2)	BMC (g)	BMD (g/cm^2)	T - Score	Z - Score
L1	11.52	7.51	0.652	-2.5	-2.3
L2	13.10	8.80	0.672	-3.2	-3.1
L3	13.59	10.15	0.746	-3.1	-2.9
L4	14.73	11.17	0.758	-3.3	-3.1
Total	**52.95**	**37.63**	**0.711**	**-3.1**	**-2.9**

Total BMD CV 1.0%
WHO Classification: Osteoporosis
Fracture Risk: High



22 year old female

62” 101#

Physician's Comment:

pDXA

- Same as DXA, but measured in peripheral areas, such as (but not limited to):
  - Heel
  - Wrist
- Used for screening
- NOT used for diagnosis
- Portable

QCT

- Multi-purpose CT scanner
- Common sites are hip and spine
- Differentiates between:
  - Cortical bone
  - Trabecular bone
- Not as widely used because of:
  - heightened radiation levels
  - high cost
  - limited availability

pQCT is used for the peripheral sites.

Can identify density better.

QUS

- Speed of sound waves increases through porous bone
- Common sites:
  - Heel
  - Tibia
- Measurement is not as precise as DEXA or QCT
- Used for screening
- Portable

RA

- Bone mass measurement from radiographs from peripheral sites
  - Most common
    - Hand
    - Heel
- Con:
  - Bone density lost is undetectable until 40% bone loss

Who needs BMD test

- Anyone being treated for Osteoporosis
- Anyone age 50+ with a fracture due to a minor incident
- Women
  - Postmenopausal < age 65 with one or more risk factors
  - Postmenopausal who have stopped taking estrogen therapy or hormone therapy
  - Age 65+ regardless
- Men
  - Age 50-69 with one or more risk factors
  - Age 70+ regardless

When not to administer BMD test

- Patient's hip or spine cannot be measured or interpreted
- Patients with hyperperathyroidism
- Obese patients over DXA table weight limit
  - Can hold up to 350lbs.

X-Rays and Bone Scans

- X-Rays
  - Not used routinely
  - Can identify fractures
  - Can show abnormally-shaped bones
  - Cannot identify Osteoporosis until 25-40% of BMD is lost
- Bone Scans
  - Determines if there are changes that may indicate:
  - Cancer
  - Lesions
  - Inflammation
  - New fractures

Lab Tests

- Monitor bone loss and formation
- Determine if patient is losing bone at a faster rate than normal
- Determine if bones are responding to treatment
- Do not:
  - Detect low BMD
  - Diagnose Osteoporosis

Types of Lab Tests

- Samples of blood & urine
- Evaluation of vitamin D levels
- Evaluation of bone turnover markers

FRAX (Fractured Risk Assessment Tool)

- Developed by WHO (World Health Organization)
- Computer-based algorithm used to estimate patients 10-year fracture probability based on clinical risk factors
- Information needed:
  - Number of clinical risk factors
  - BMD
  - BMI (can be used if BMD is unknown)
  - Age
  - Ethnicity

Example of FRAX

- *Ten-year probability of osteoporotic fractures (%) according to BMD T-score at the femoral neck in women aged 65 years from the UK.*

Number of CRFs	BMD T-score (femoral neck)					
	-4.0	-3.0	-2.0	-1.0	0	1.0
0	27	15	9.7	7.1	5.9	5.0
1	37 (33-41)	22 (18-26)	14 (10-18)	10 (7.1-14)	8.5 (5.7-12)	7.3 (4.8-10)
2	49 (42-58)	30 (23-40)	20 (13-29)	15 (8.6-23)	12 (6.8-19)	10 (5.6-17)
3	62 (53-72)	41 (30-55)	27 (17-42)	20 (11-34)	17 (8.7-29)	15 (7.2-26)
4	73 (63-81)	52 (42-65)	36 (26-51)	27 (18-41)	23 (14-36)	20 (11-32)
5	83 (79-87)	64 (58-72)	47 (40-57)	36 (28-47)	31 (22-41)	27 (19-36)
6	89	75	58	46	40	35

[FRAX website link]

- http://www.shef.ac.uk/FRAX/

Osteoporosis vs. Osteopenia

- Diagnosed by performing a BMD test
- Osteopenia
  - Bone density lower than normal
  - T-score -1.0→-2.5 standard deviations
  - Not guaranteed to develop into osteoporosis
- Osteoporosis
  - “pore bone”
  - T-score > -2.5 standard deviations

Osteoporosis Medications

Medication

- Osteoporosis has no cure, but medication can be used to help *treat* osteoporosis
- Only used after diagnosed with Osteoporosis
- Two main categories:
  - **Antiresorptives**- slow the breakdown of bone
    - Goal of treatment: prevent further bone loss and to reduce the risk of breaking one or more bones in the future
  - **Anabolics**- speed up the rate of bone formation
    - Goal of treatment: build new bone, increase bone mass, repair tiny defects in bone, and reduce the risk of fractures

Antiresorptives- Biphosphonates

- Alendronate
  - Approved for men and women
- Ibandronate
  - Approved only for women
  - Increases bone density and reduces the risk of spine fractures
- Risedronate
  - Approved for men and women
- Zoledronic Acid
  - Approved only for women
  - 5 mg by intravenous infusion over at least 15 minutes once a year
  - Increases bone density and reduces the risk of fractures in the spine, hip, and other bones

Antiresorptives- Denosumab (Prolia)

- RANK ligand (RANKL) inhibitor
- Lowers risk of breaking bones in the spine, hip, and other bones
- Injection every 6 months
- Risk of infections

Antiresorptives– Estrogen Therapy (ET) or hormone therapy (HT)

- Postmenopausal women increase BMD and prevent fractures of the spine, hip, and other bones
- HT is required for women who have not had a hysterectomy
- ET and HT can increase the risk of stroke, blood clots, and other problems
- ET and HT should be used in the lowest possible dose for the shortest possible time

Antiresorptives– SERMS

- Selective Estrogen Receptor Modulators
- For women only
- Developed to provide benefits of estrogen therapy without many of the risks
- Raloxifene
  - Increases bone density and reduces risk of spine fractures
  - Reduces risk of breast cancer in postmenopausal women
  - Possible side effects: blood clots, swelling, leg cramps, and hot flashes

Anabolics

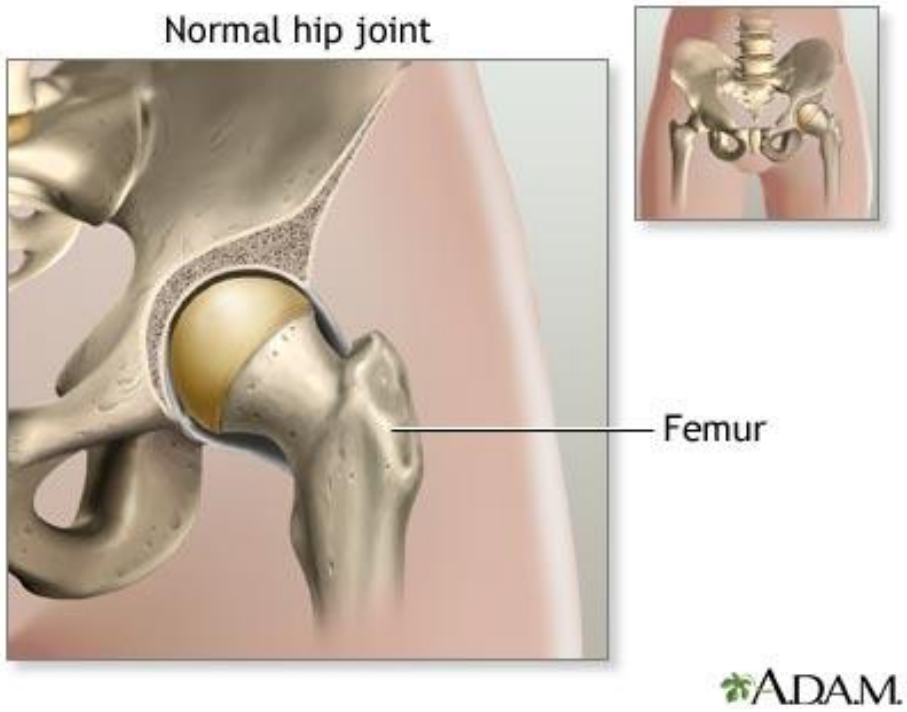
- Teriparatide
  - Piece of parathyroid hormone
  - Causes bone growth, increases bone density, and reduces risk of fractures in spine and other bones
  - Who should not take?
  - Use for 2 years only, after which it is recommended to switch to another medication
- Used for both men and women
- Many people take this medication because they had a fracture while taking another osteoporosis medication

Hip Replacements

Total Hip Replacement

Your hip joint is made up of two major parts. One or both parts may be replaced during surgery:

- The hip socket (a part of the pelvic bone called the acetabulum)
- The upper end of the thighbone (called the femoral head)



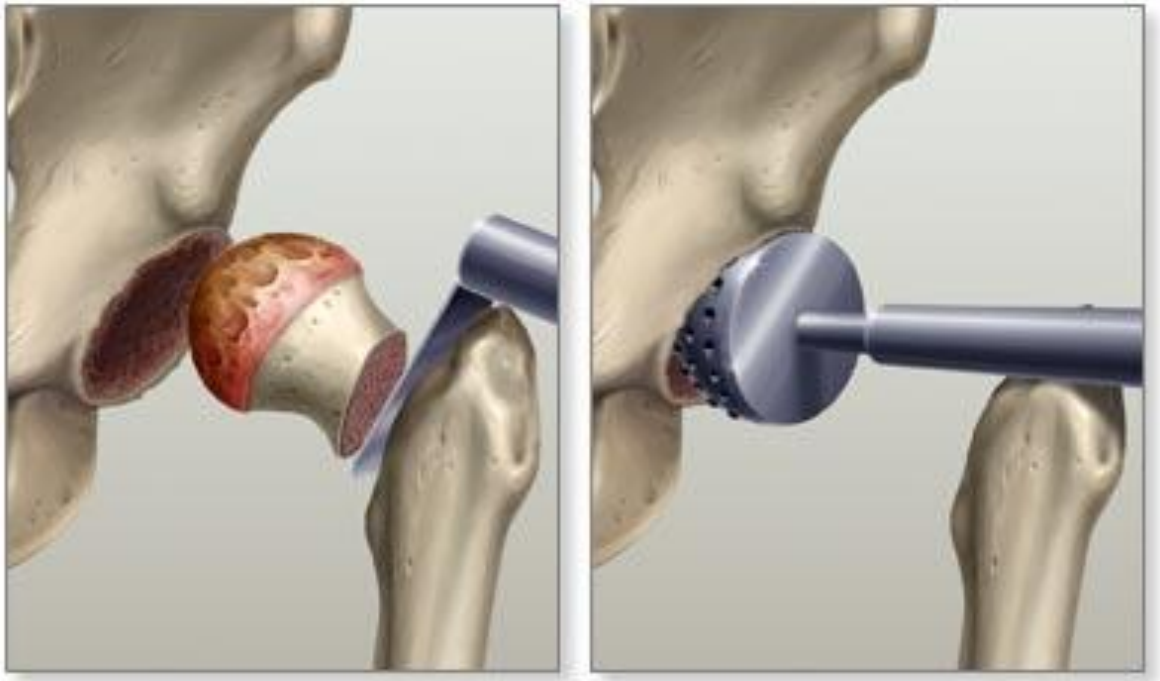
Total Hip Replacement

Hip joint replacement is surgery to replace all or part of the hip joint with a man-made or artificial joint. The artificial joint is called a prosthesis. The artificial hip joint has 4 parts:

- A socket that replaces your old hip socket. The socket is usually made of metal.
- A liner that fits inside the socket. It is usually plastic, but some surgeons use ceramic and metal. The liner allows the hip to move smoothly.
- A metal or ceramic ball that will replace the round head (top) of your thighbone.
- A metal stem that is attached to the shaft of the bone.

Total Hip Replacement

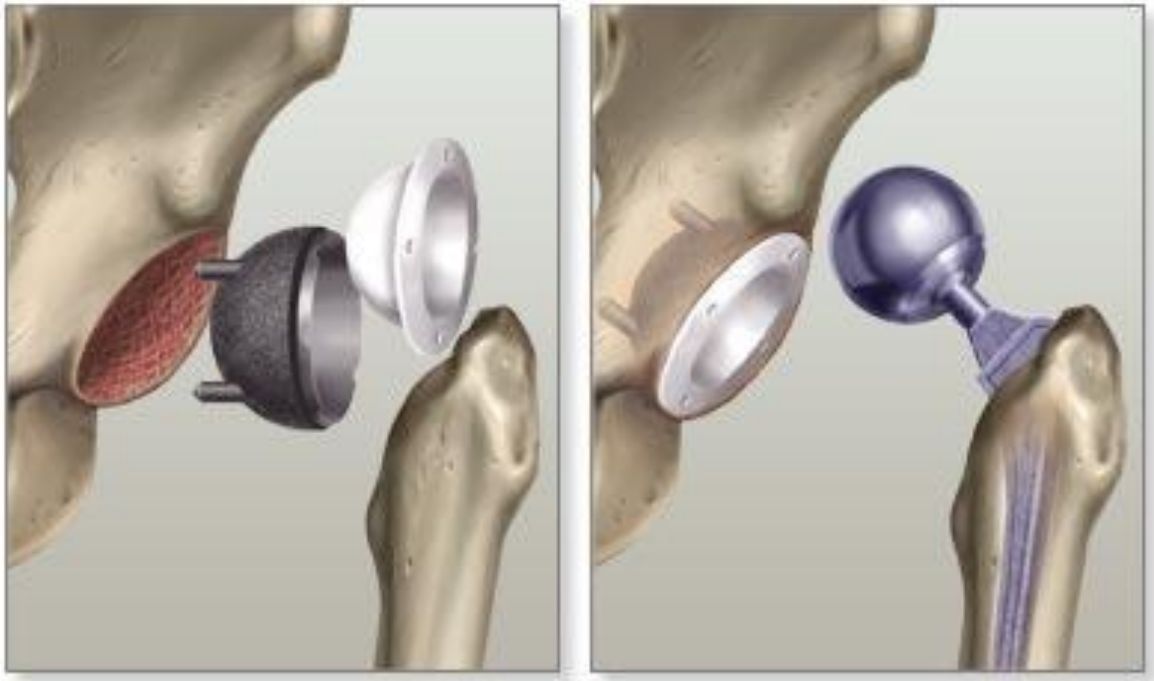
The head of the femur and a layer of the hip socket are removed



A.D.A.M.

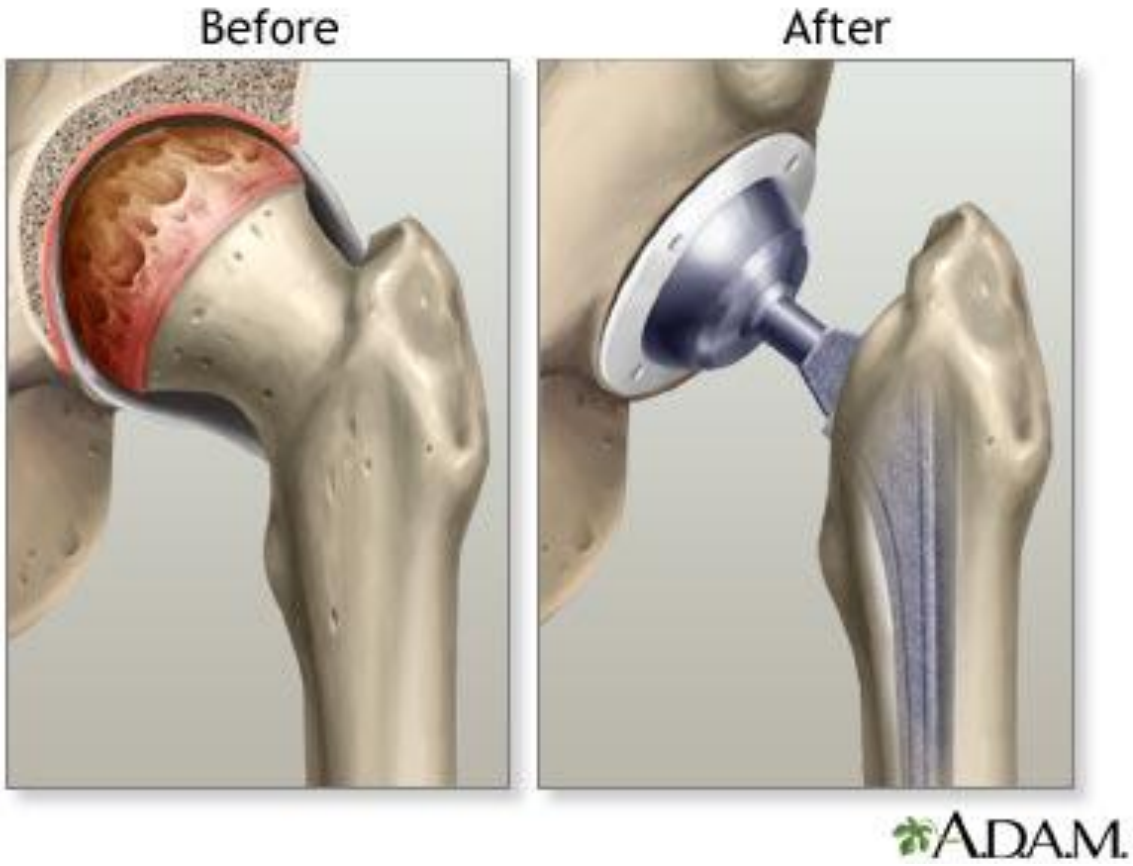
Total Hip Replacement

A metal ball and stem are inserted in the femur and a plastic socket is placed in the enlarged pelvis cup

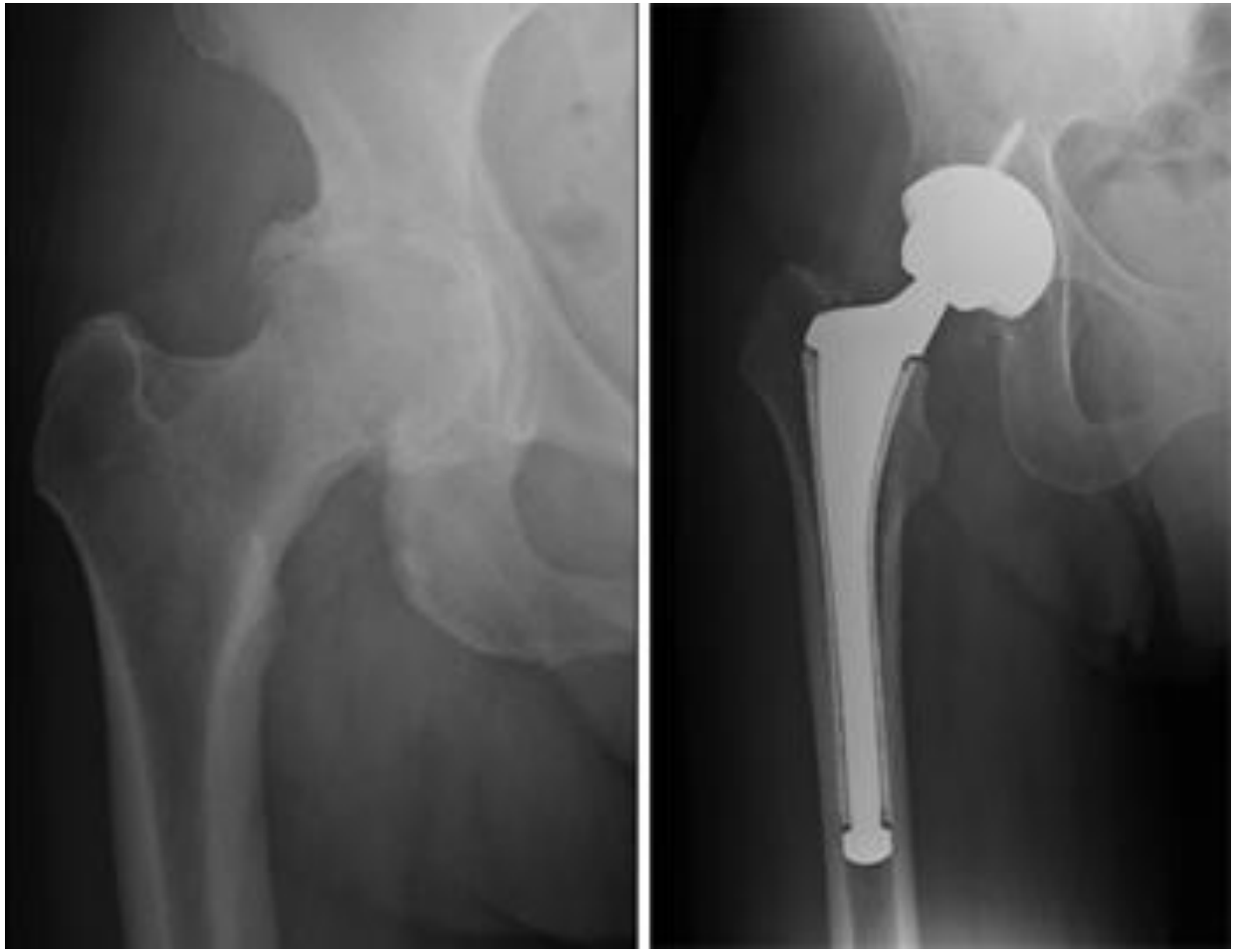


A.D.A.M.

Total Hip Replacement



Total Hip Replacement



After Surgery

Don’t…

- Cross legs at the knees for at least 8 weeks
- Bring your knee up higher than your hip
- Lean forward while sitting or as you sit down
- Pick up something on the floor while you are sitting
- Reach down to pull up blankets when lying in bed
- Don't kneel on the knee on the unoperated leg (the good side)
- Don't use pain as a guide for what you may or may not do

Outlook/Prognosis

- Hip replacement surgery results are usually excellent. Most or all of the pain and stiffness should go away
- Some people may have problems with infection, loosening, or even dislocation of the new hip joint
- Over time, sometimes as long as 15 - 20 years, the artificial hip joint will loosen. Some people may need a second replacement
- Younger, more active people may wear out parts of their new hip. It may need to be replaced before the artificial hip loosens

Lordosis vs Kyphosis

Skull and Spinal Column - Lordosis (Swayback)

Kyphosis (Hunchback) of the Spine

Vertebral compression fracture

Cementing Vertebrae

- Stabilize
- Pain returns after 6 months

Case Study

Case Study

- GS
- Age 73
- Female
- Chief Complaint: hump back, curvatures in upper thoracic and lower spine
- Hx: menopause began at early 50's, menstrual cycle recently stopped, sister diagnosed with osteopenia 2 years ago

Case Study

- Dx: osteoporosis
- Tx: total hip replacement, hormone therapy, calcium and Vitamin D supplementation, 4-6 weeks rehabilitation for recovery, increase exercise

Nutritional Assessment

- Anthropometric
  - Ht 5’5’’
  - Wt 113 lb
  - BMI: 18.7
  - IBW: 125lb (90% IBW)
- Biochemical
  - Low labs for NA, K, Ca, Albumin, Hgb, HCT
  - T-sore: -3.5
- Clinical
  - Right hip fracture
  - Osteoporosis
  - Curvature of upper thoracic and lower spine regions

Nutritional Assessment

- Dietary Assessment
  - Patient states that dairy products are fattening
    - Has not consumed milk since teenage years
  - Usual dietary intake:
    - Breakfast: coffee
    - Lunch/dinner: Salad and Soup
  - When menstrual periods ceased, did not begin hormone therapy treatments
  - Estimated Calorie Needs:
    - Harris-Bennedict: 1099kcal
    - Stress factor: 1.0-1.2: 1099-1318kcal
  - Supplementation:
    - Calcium: 1000-1200mg
    - Vitamin D: 800-1000 IU

Nutritional Assessment

- PES Statement
  - Inadequate calcium intake related to low dairy consumption for 55+ years as evidence by a bone mineral density T-score of -3.5.
- Intervention
  - Increase caloric, calcium and vitamin D consumption
  - Education of the importance of dairy foods
  - Increase weight bearing exercises
- Monitoring and Evaluation
  - Assess healing progress
  - Assess weight gain
  - Assess understanding of dairy foods

Sample 1-Day Diet

Breakfast 8 oz orange juice with calcium and vitamin D
1 cup ready-to-eat cereal fortified with vitamin D
4 oz skim milk

Lunch 2.5 oz extra lean ground beef on bun with
1 slice non-fat American cheese
1 lettuce leaf
2 slices red tomato
1 green salad with
1 hard boiled egg
2 tablespoons low calorie dressing
8 baby carrots
8 oz skim milk

Snack 1 orange

Dinner 2.5 oz chicken breast
1/2 cup broccoli
3/4 cup rice
2 slices French bread with 1 tsp margarine
1 cup strawberries with 2 Tbsp lite whipped topping

Approximate Nutrient Analysis

Calories: 1,500
Protein: 94g
Carbohydrate: 205g
Fat: 33g
Sodium: 1,825mg
Potassium: 3,336mg
Calcium: 1,560mg
Vitamin D: 10mcg (400 IU)

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