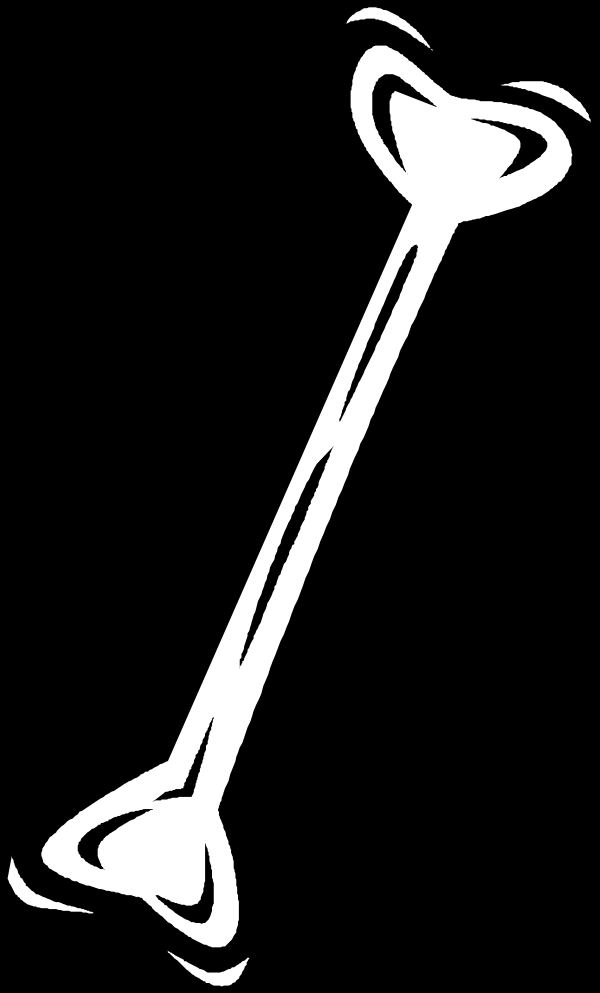


Bone Health and Osteoporosis

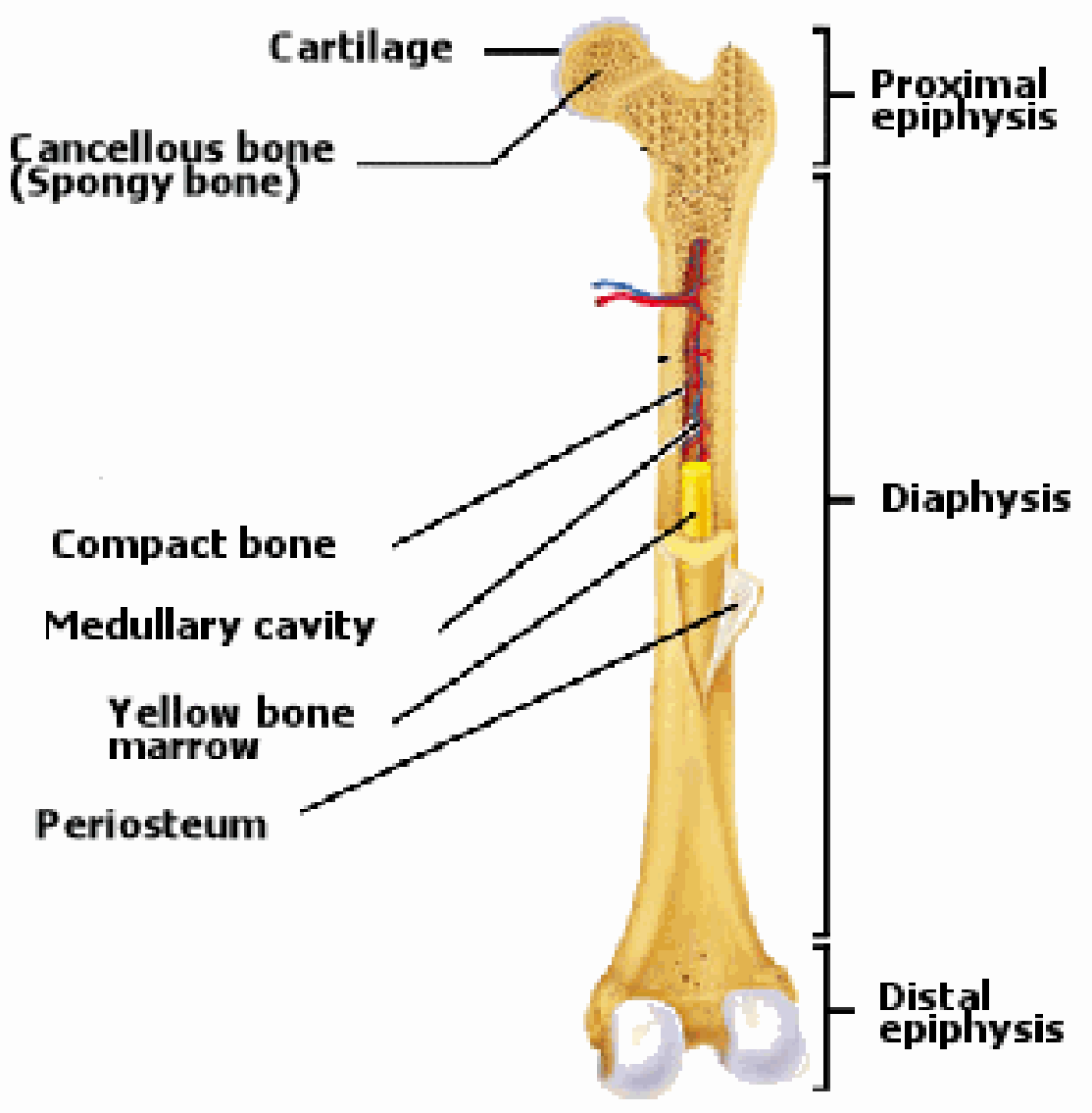
- Katie Garrett
  Jessica Christensen
  Brittney Scott
  McKenzie Smith

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

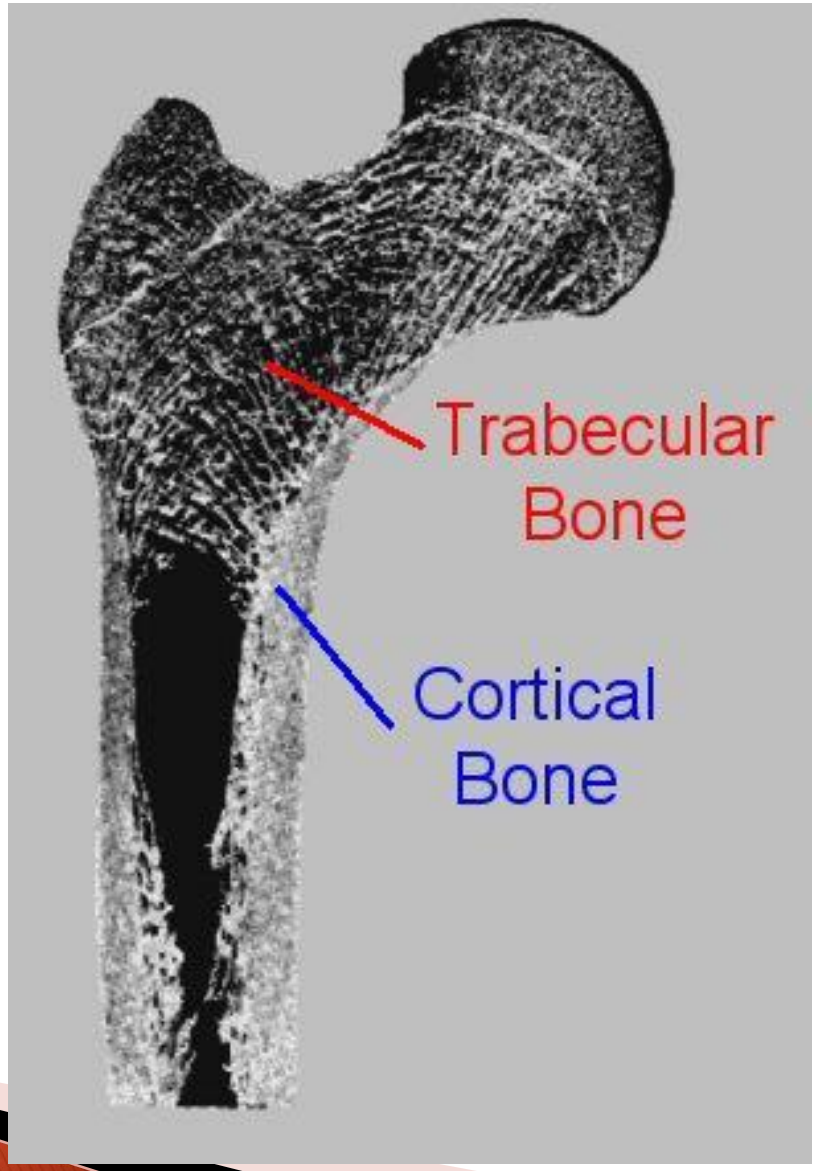
Cortical:

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

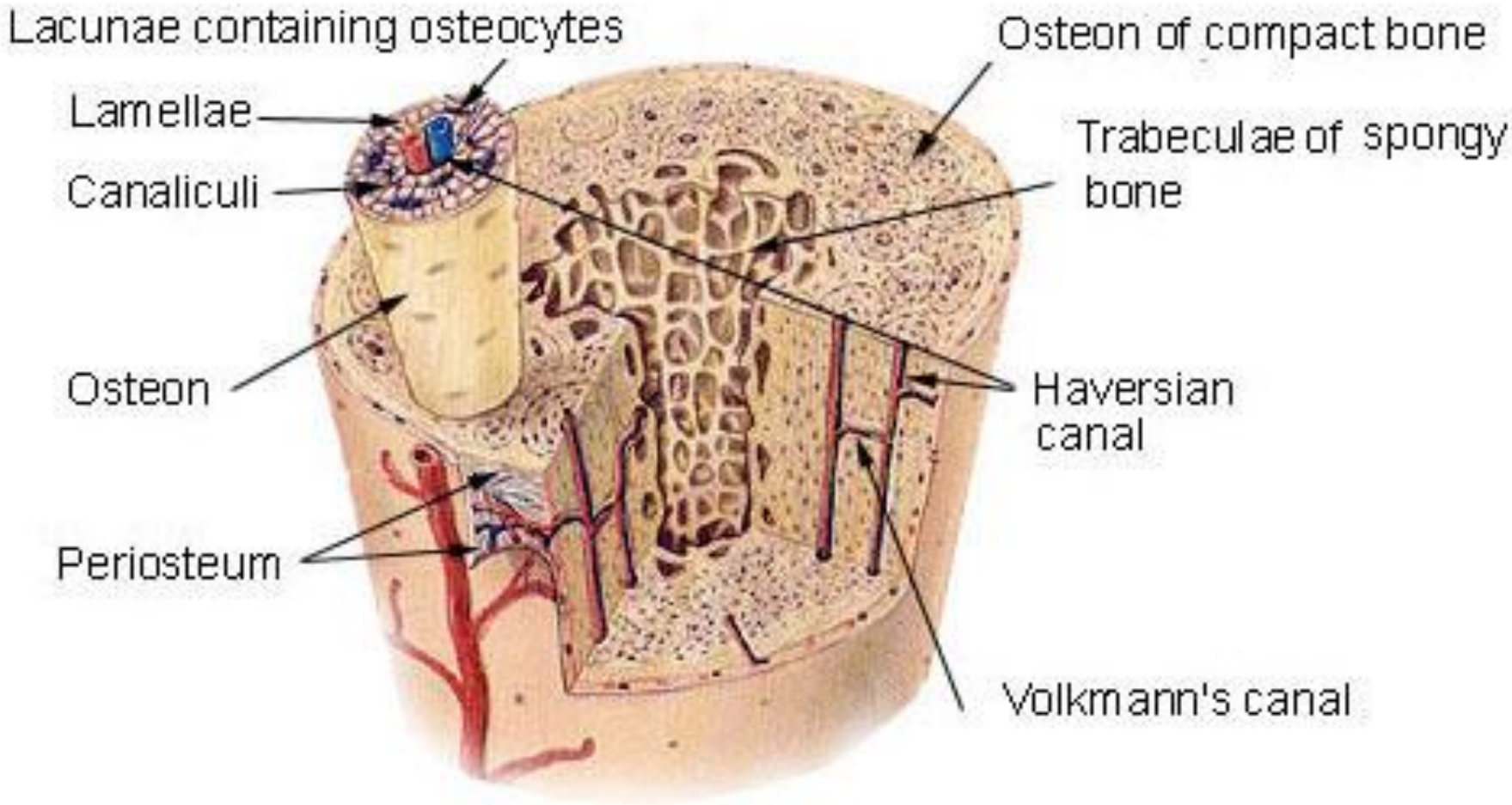
Trabecular:

- 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

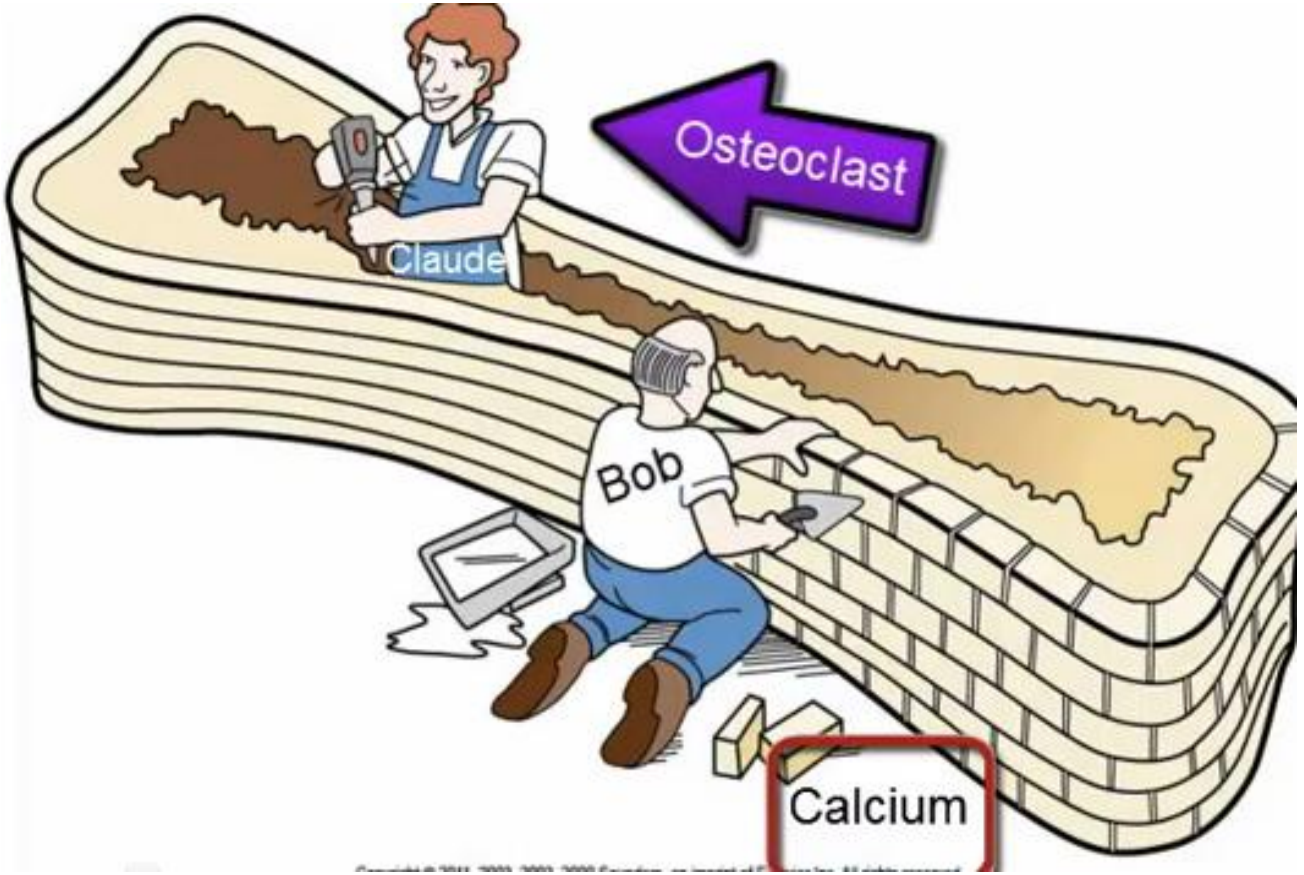
- Bob the builder
- Matrix protein synthesis
- Secretion of cytokines that act on osteoblasts
- Osteocytes and bone-ling cells derived

Osteoclasts

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

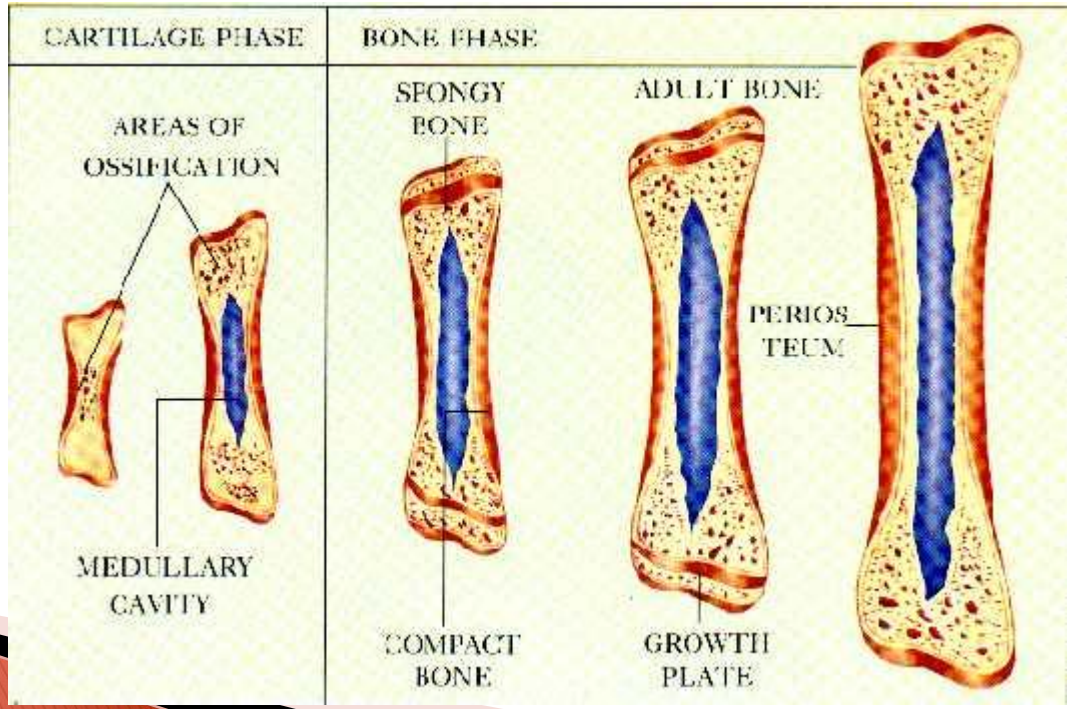
Both made in bone marrow, stimulated by hormones and growth factors

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



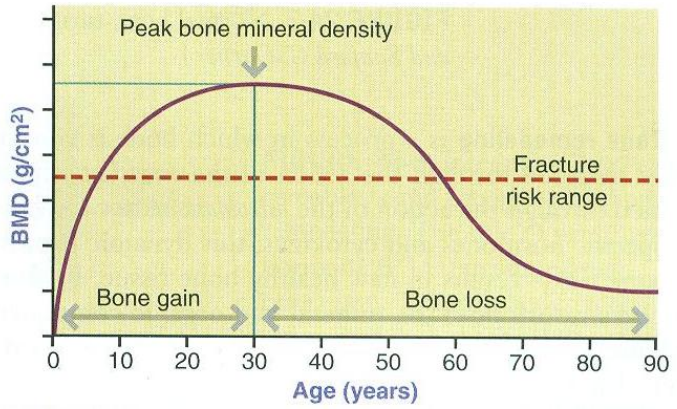
Bone growth, Ca and Vit D

- 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

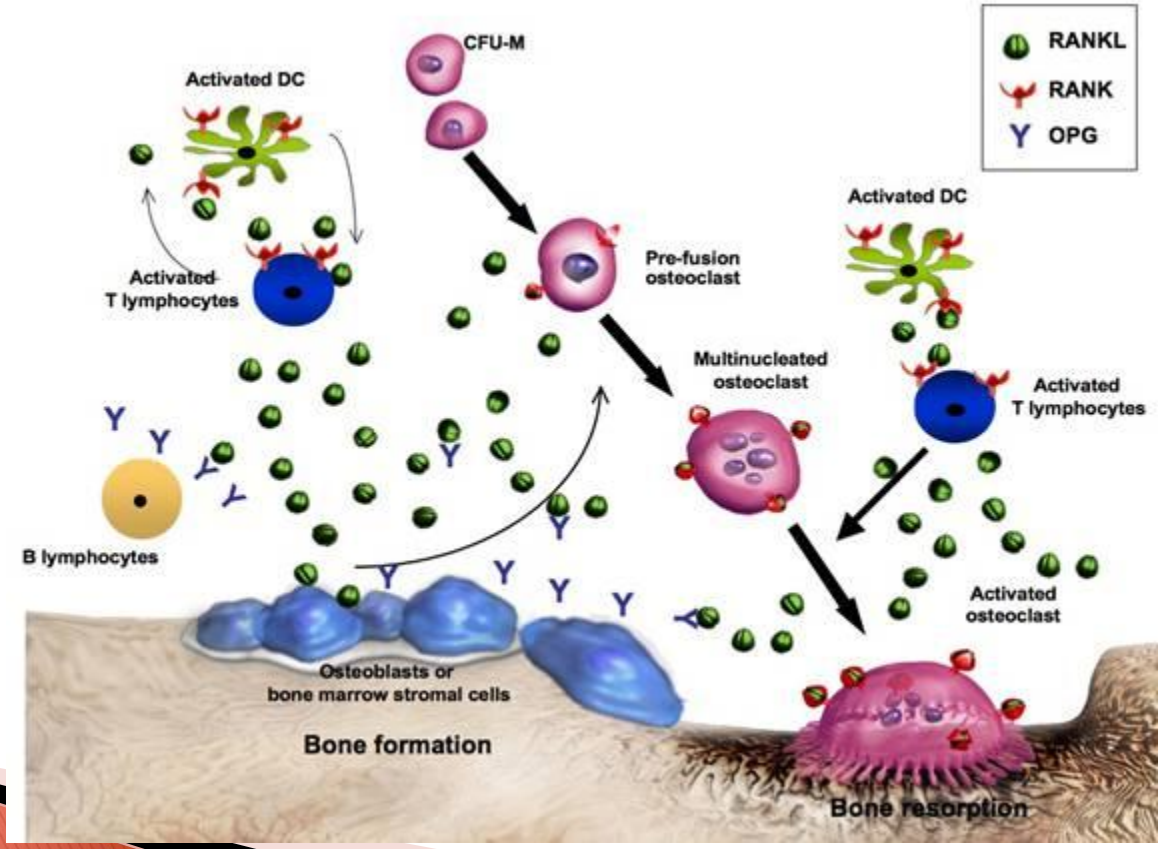
Effects of Low vs. High Vitamin D Intake on Bone

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

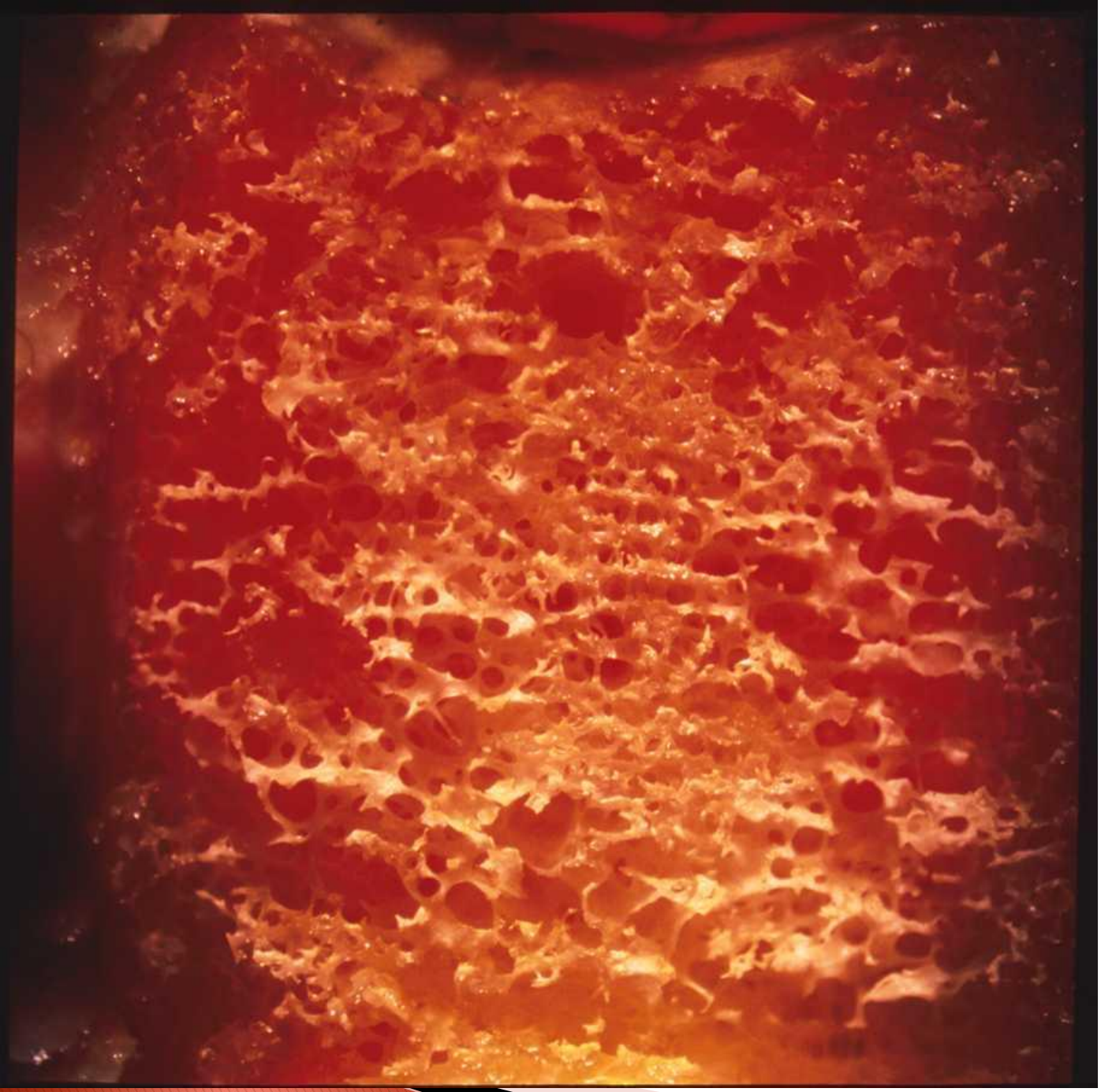


Osteoporosis

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	Modifiable
Age	Not getting enough Ca or vitamin D
Sex	Not eating enough fruits and vegetables
Ethnicity	Too much protein, sodium, and caffeine
Menopausal	Being inactive
Family history	Smoking
Low body weight	Heavy drinking
Broken bones or height loss	Losing weight

MNT

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

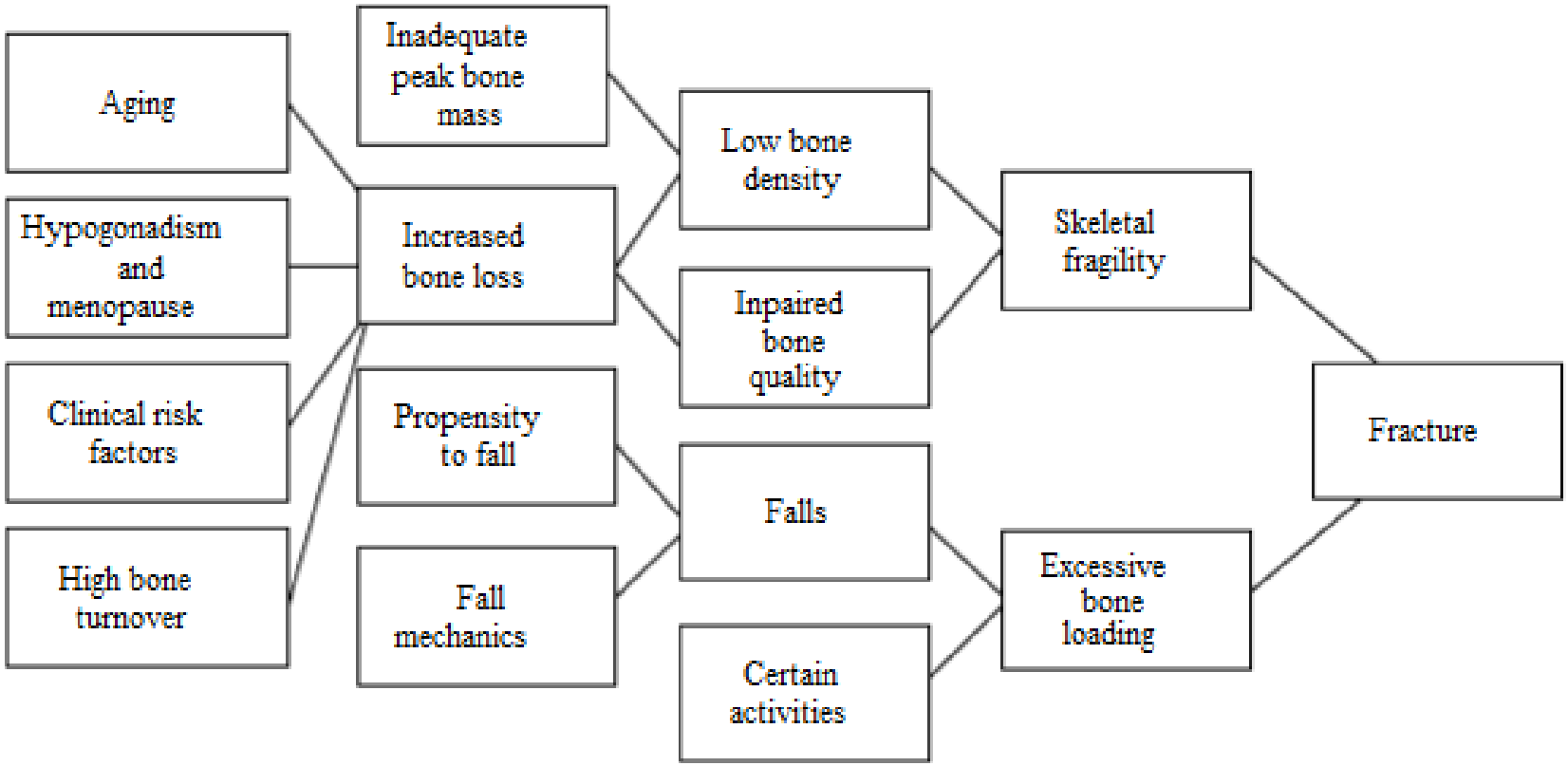
Prevention

- 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)

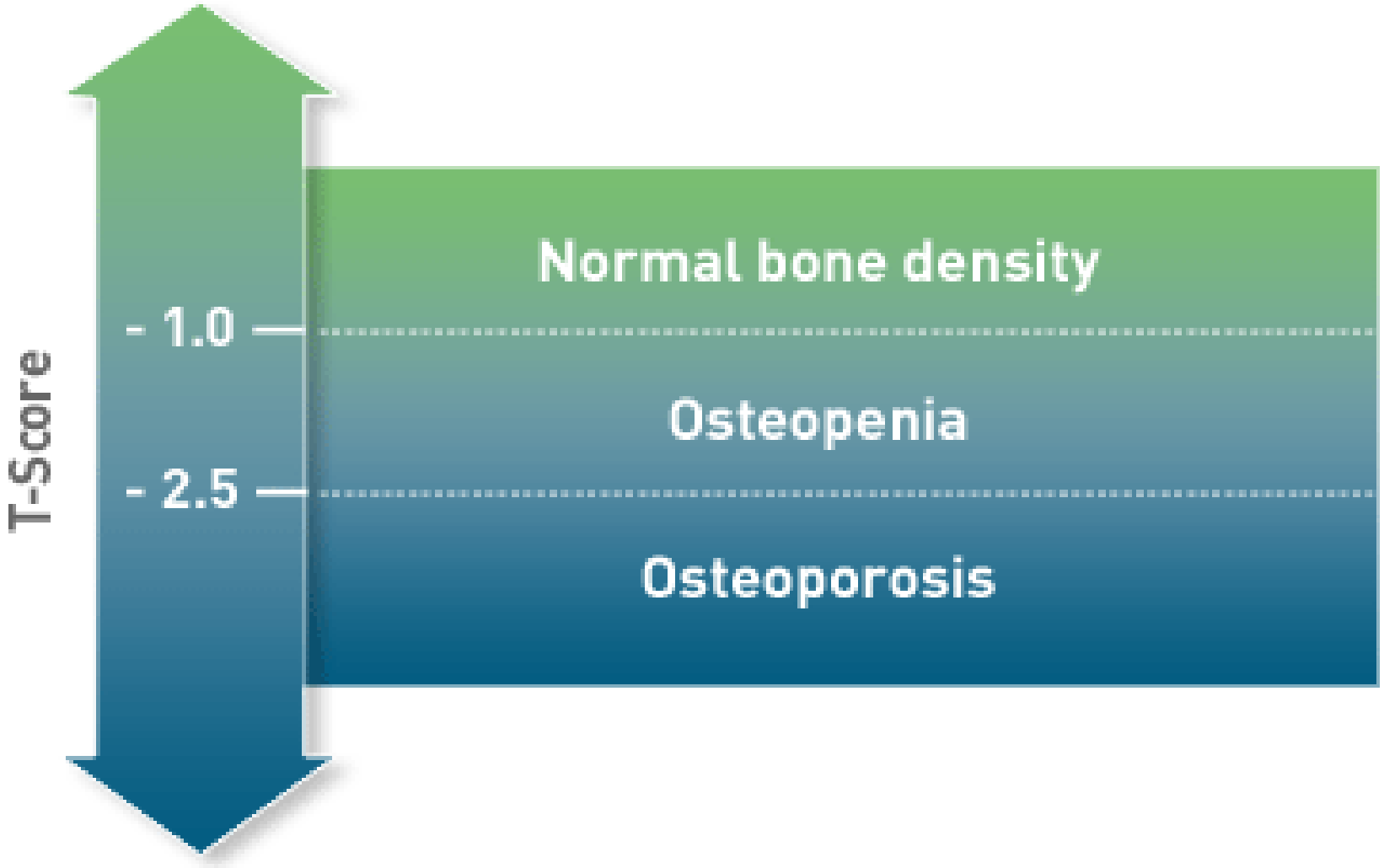
DXA (continued…)

- 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



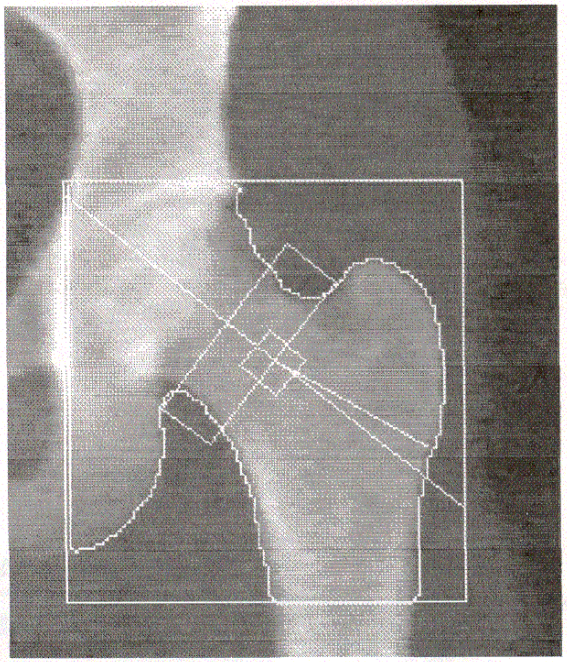


Image not for diagnostic use
92 x 98

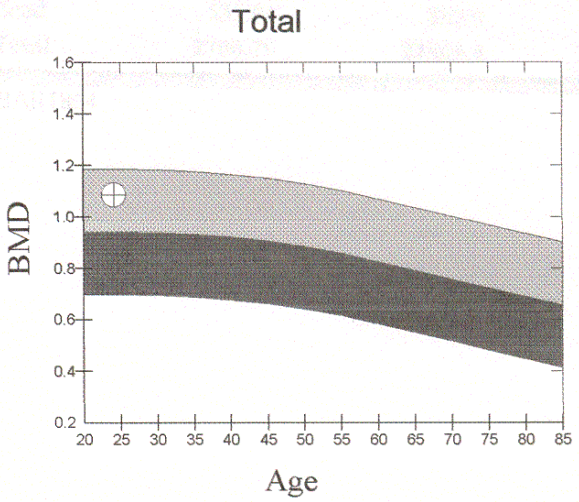
Scan Information:

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 (cm²)	BMC (g)	BMD (g/cm²)	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

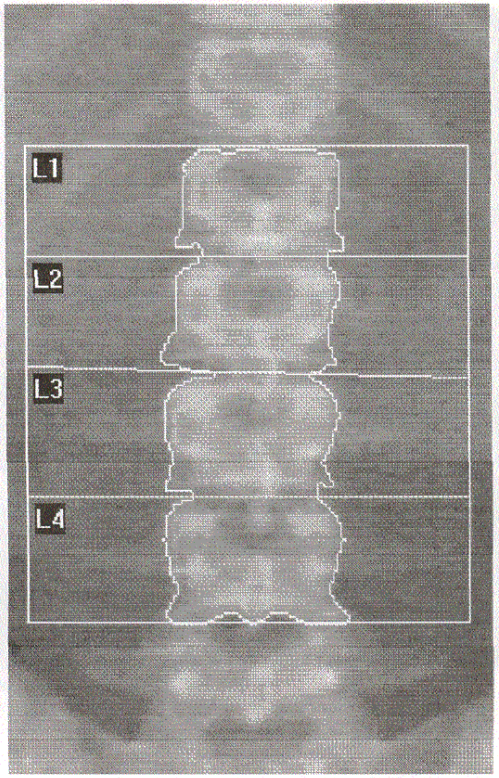
Total BMD CV 1.0%
WHO Classification: Normal
Fracture Risk: Not Increased



24 year old female

68” 167#

Physician's Comment:



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116 x 126

Scan Information:

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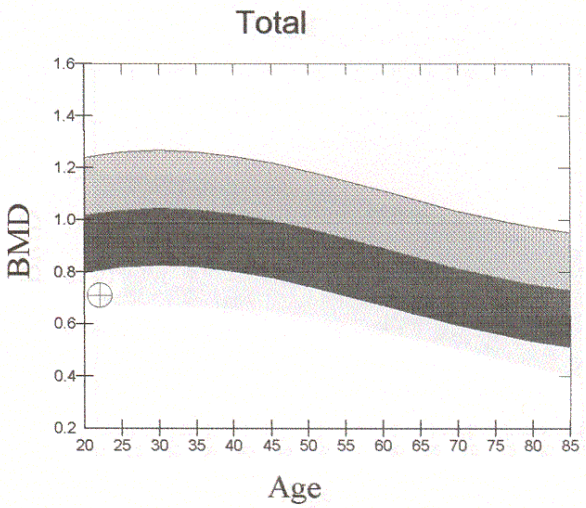
Scan Type: f Lumbar Spine
Analysis: December 28, 2002 09:57 Version 10.0
Lumbar Spine
Operator: es
Model: QDR 4500W (S/N 49485)
Comment:

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

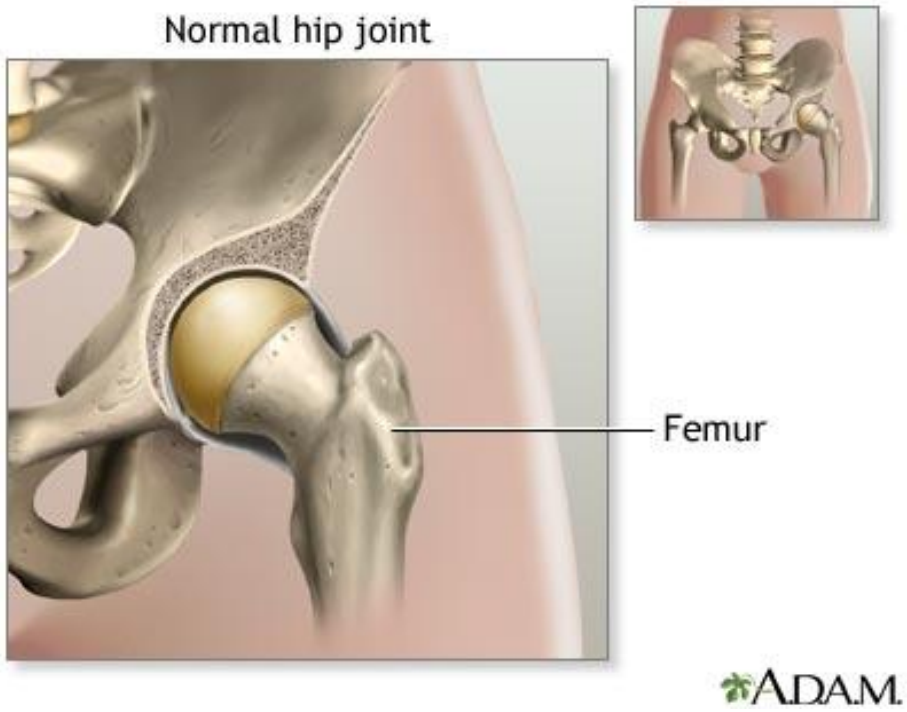
- Teriparatide
  - Piece of parathyroid hormone
  - Causes bone growth, increases bone density, and reduces risk of fractures in spine and other bones
  - Who should not take?
  - Use for 2 years only, after which it is recommended to switch to another medication
- Used for both men and women
- Many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



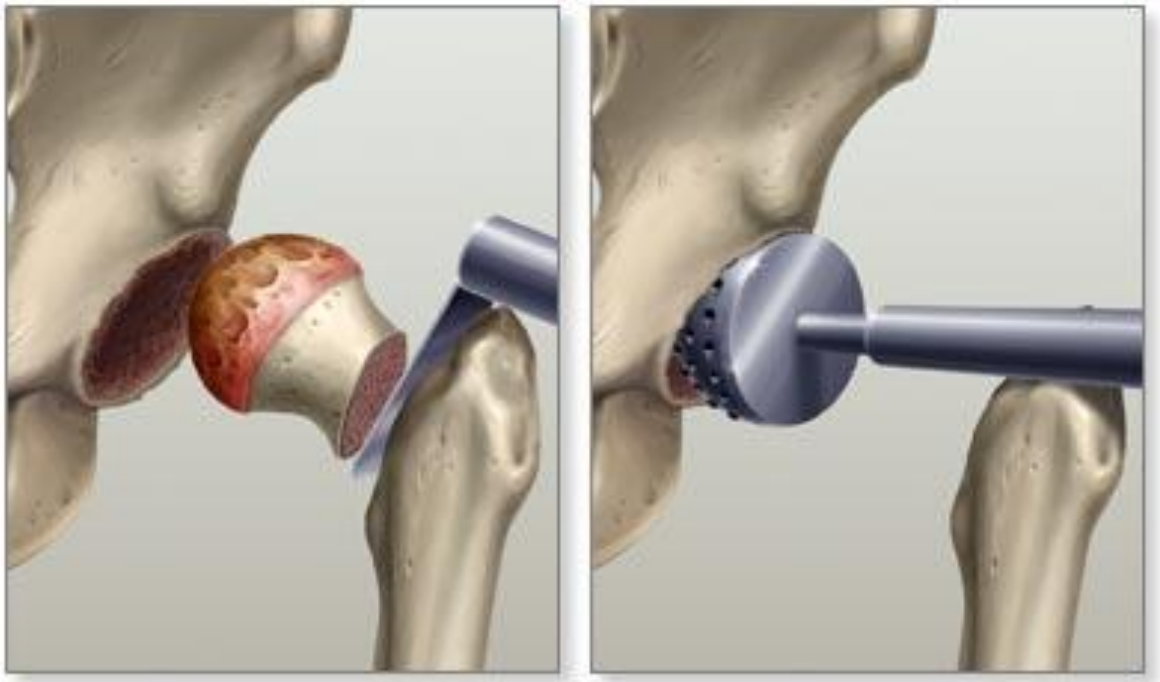
Total Hip Replacement

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

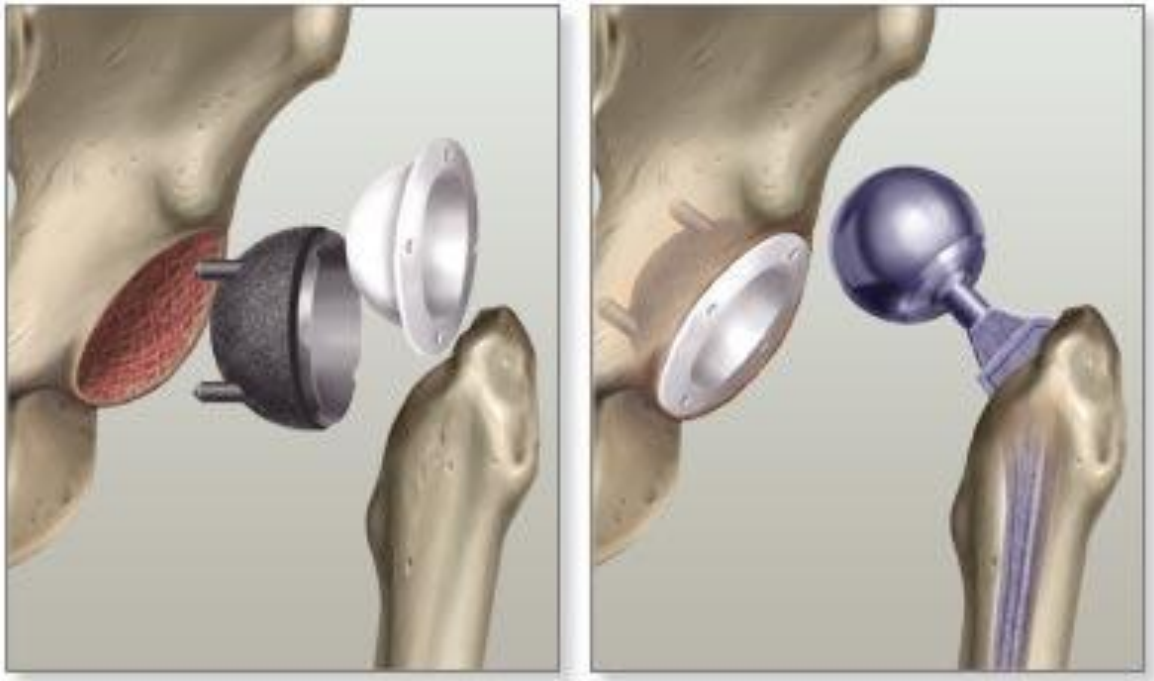
The head of the femur and a layer of the hip socket are removed



A.D.A.M.

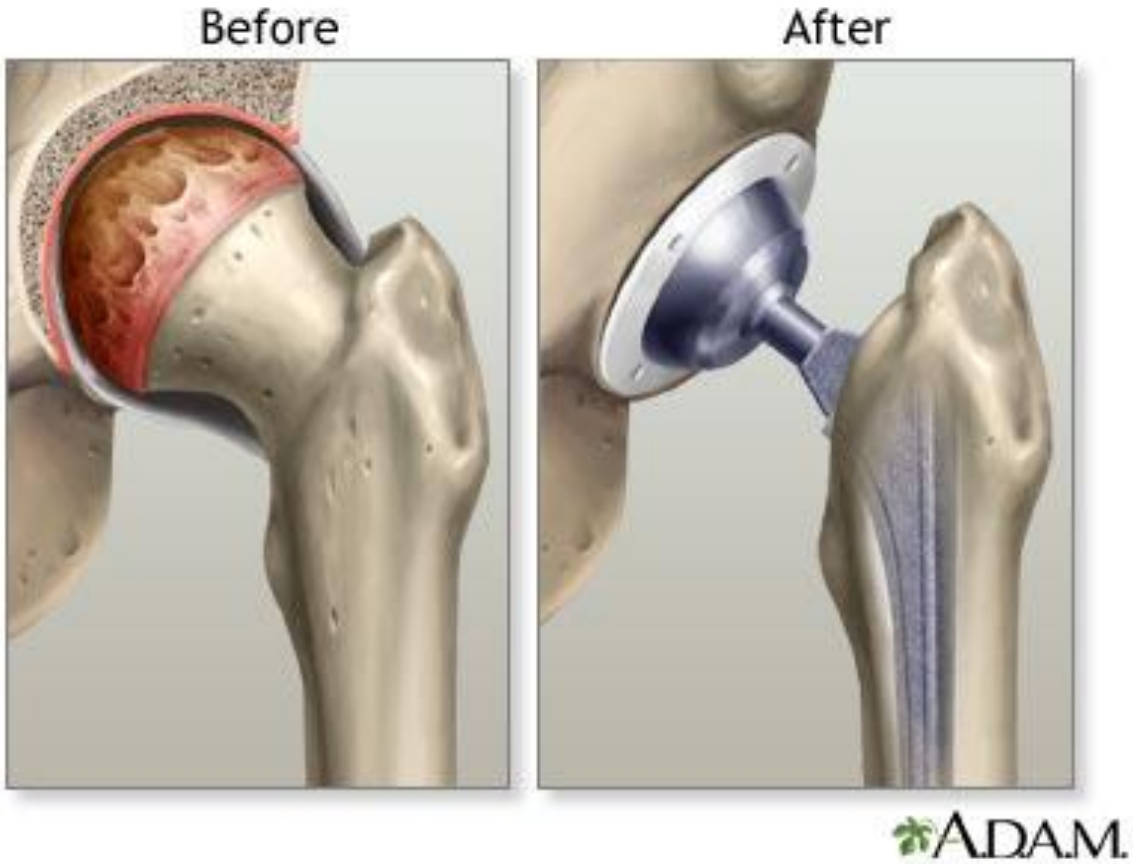
Total Hip Replacement

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

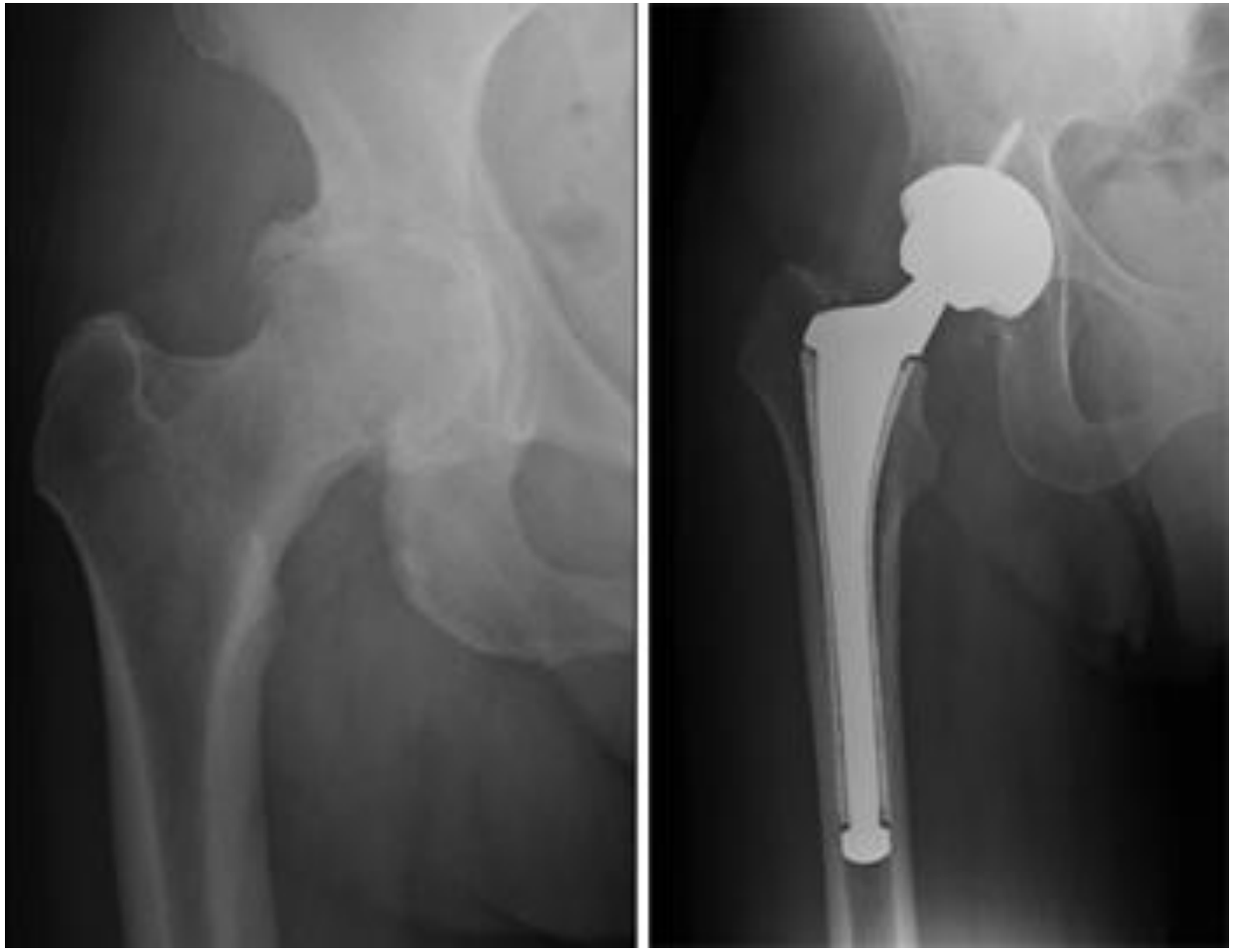


A.D.A.M.

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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