AMA
AMERICAN MEDICAL ASSOCIATION

Education Program

Bone Health & Osteoporosis: A Comprehensive Look from Causes to Treatment

Friday, June 7 | 4 – 5:30 pm CDT

Moderator

Edward T. Bope, MD
Chair-Elect, AMA Senior Physicians Section

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Sponsored by the AMA's Senior Physicians Section (SPS)

Learning Objectives

Upon completion of this activity the physician will be able to:

- Review the causes and symptoms of osteoporosis
- Determine the appropriate type of bone scan for specific age groups for optimal bone health
- Explore treatment options for osteoporosis, including lifestyle modifications
- Examine dietary and weight-bearing exercise strategies to prevent osteoporosis

Speaker

Pauline M. Camacho, MD, Professor of Medicine, Loyola University Medical Center

Director, Loyola University Osteoporosis and Metabolic Bone Disease Center

Prevalence of Osteoporosis in the United States

54%

of US adults over age 50

US adults > age 50

10 million osteoporosis

of the femoral neck or lumbar spine

43 million low bone mass

of the femoral neck or lumbar spine

By 2030

> 13 million

with

osteoporosis

expected

Wright NC, et al. *J Bone Miner Res*. 2014;29:2520-2526.

Burden of Osteoporosis

Hip Fractures

>200% increased likelihood of **hospitalization** over 8 years

83% increased likelihood of **death** over 8 years

30% **died** within 1 year

New Osteoporotic Fractures

Nearly 1 in 5 Medicare beneficiaries that **died within 12 months** of new osteoporotic fracture in 2015

$57 billion **Total costs of care** for osteoporotic fractures among Medicare beneficiaries in 2018

> $95 billion **Projected total costs of care** in 2040

Hansen D, et al. http://assets.milliman.com/ektron/Medicare_cost_of_osteoporotic_fractures.pdf

Treatment Gaps in Osteoporosis

- Percentage of patients receiving a medication for osteoporosis following a hip fracture declined from 40% in 2002 to 21% in 2011[a]
- Estimated probability of medication use after hospital discharge was 29%[a]

Reasons for not prescribing osteoporosis medications*[b]

- Patient and physician concerns about adverse events
- Confusion about osteoporosis medications:
  - When to start bisphosphonates
  - Clinical evidence
  - Which drugs to use for different bone sites
  - Second-line therapies
  - How to treat older patients and those in nursing homes

*Surveys of family physicians

a. Solomon DH, et al. *J Bone Mineral Res*. 2014;29:1929-1937.

b. Jaglal SB, et al. *Can Family Physician*. 2003;49:462-468.

Keys to prevention of osteoporosis

- Ensuring adequate calcium and vitamin D sufficiency lifelong
- Lifestyle measures: avoidance of smoking, excessive alcohol use, maintaining active lifestyle
- Early detection and correction of secondary causes of bone loss

Who Should be Screened for Osteoporosis?

Screening for osteoporosis and fracture risk

- All postmenopausal women ≥ 50 years
- Use tools like FRAX when available

BMD testing

- All women ≥ 65 years
- All postmenopausal women with a history of fracture(s) without major trauma and high risk features
- Secondary osteoporosis

• Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

WHO Diagnostic Criteria for Osteoporosis

Table 5 World Health Organization Criteria for Classification of Osteopenia and Osteoporosis	
Category	**T-score**
Normal	–1.0 or above
Low bone mass (osteopenia)[a]	Between –1.0 and –2.5
Osteoporosis	–2.5 or below
Severe or established osteoporosis	–2.5 or below with fragility fracture
[a]Fracture rates within this category vary widely. The category of "osteopenia" is useful for epidemiology studies and clinical research but is problematic when applied to individual patients and must be combined with clinical information to make treatment decisions.	

Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

AMERICAN ASSOCIATION OF CLINICAL ENDOCRINOLOGISTS/ AMERICAN COLLEGE OF ENDOCRINOLOGY CLINICAL PRACTICE GUIDELINES FOR THE DIAGNOSIS AND TREATMENT OF POSTMENOPAUSAL OSTEOPOROSIS— 2020 UPDATE

Pauline M. Camacho, MD, FACE; Steven M. Petak, MD, JD, FACP, FCLM, MACE, CCD; Neil Binkley, MD; Dima L. Diab, MD, FACE, FACP, CCD; Leslie S. Eldeiry, MD; Azeez Farooki, MD; Steven T. Harris, MD, FACP, FASBMR; Daniel L. Hurley, MD, FACE; Jennifer Kelly, DO, FACE; E. Michael Lewiecki, MD, FACE, FACP, CCD; Rachel Pessah-Pollack, MD, FACE; Michael McClung, MD, FACP, FACE; Sunil J. Wimalawansa, MD, PhD, MBA, FCCP, FACP, FRCP, DSc, FACE; Nelson B. Watts, MD, FACP, CCD, FASBMR, MACE

ENDOCRINE PRACTICE Vol 26 (Suppl 1) May 2020

2020 AACE/ACE Diagnostic Criteria for Osteoporosis

1	T-score −2.5 or below	→	Lumbar spine, femoral neck, total proximal femur, or 1/3 radius
2	Low-trauma spine or hip fracture	→	Regardless of bone mineral density
3	T-score between −1.0 and −2.5	+	Fragility fracture of proximal humerus, pelvis, or distal forearm
4	T-score between −1.0 and −2.5	+	High FRAX® (or if available, TBS-adjusted FRAX®) fracture probability based on country-specific thresholds

• Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

Evaluation for Secondary Causes of Osteoporosis

- Very important in the management of osteoporosis
- Causes of secondary osteoporosis are seen in up to one-third of women with osteoporosis without major risk factors[a]
- Disorders of calcium metabolism and hyperparathyroidism contributed to 78% of secondary causes[a]
- Refer to AACE/ACE guidelines for complete list of secondary causes and recommended lab tests[b]

Most common undiagnosed disorders of bone and mineral metabolism[a]

- Hypercalciuria
- Malabsorption of calcium
- Hyperparathyroidism
- Vitamin D deficiency
- Hyperthyroidism
- Cushing's disease

a. Tannenbaum C, et al. *J Clin Endocrinol Metab*. 2002;87:4431-4437.

b. Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

Laboratory Tests to Consider in Detecting Secondary Osteoporosis

Complete blood cell count
Serum chemistry, including calcium, phosphate, total protein, albumin, liver enzymes, alkaline phosphatase, creatinine, and electrolytes
24-hour collection for calcium, sodium, and creatinine excretion (to identify calcium malabsorption or hypercalciuria)
Serum 25-hydroxyvitamin D

Additional tests if clinically indicated might include (but not limited to):

- Serum intact parathyroid hormone concentration for possible primary or secondary hyperparathyroidism
- Serum thyrotropin
- Tissue transglutaminase antibodies for suspected celiac disease
- Serum protein electrophoresis and free kappa and lambda light chains for suspected myeloma
- Urinary free cortisol or other tests for suspected adrenal hypersecretion
- Serum tryptase, urine N-methylhistidine, or other tests for mastocytosis
- Bone marrow aspiration and biopsy to look for marrow-based diseases
- Undecalcified iliac crest bone biopsy with double tetracycline labeling

    Recommended for patients with bone disease and renal failure to establish the correct diagnosis and direct management
    May be helpful in the assessment of patients with the following:
        Suspected osteomalacia or mastocytosis when laboratory test results are inconclusive
        Fracture without major trauma despite normal or high bone density
        Vitamin D–resistant osteomalacia and similar disorders to assess response to treatment

Genetic testing for unusual features that suggest rare metabolic bone diseases

Nonpharmacologic Management

- Adequate calcium and vitamin D intake
- Weight bearing exercises
- Smoking cessation
- Limiting alcohol and caffeine consumption
- Fall prevention

Calcium:

1200 mg/day for women 51 and older and men 71 and older

Vitamin D:

1000 – 2000* IU/day for adults 50 and older to maintain optimal level of 30-50 ng/ml

*4000 IU safe upper limit for general population

Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

Tu KN, et al. *P&T*. 2018;43:92-104.

Pharmacologic Therapies

Antiresorptive agents

- Bisphosphonates
- Selective estrogen agonists/antagonists
- Estrogens
- Calcitonin
- Denosumab

Parathyroid hormone analogues

- Teriparatide
- Abaloparatide

Romosozumab

- Humanized monoclonal antibody against osteocyte-derived sclerostin

Camacho PM, et al. Endocrine Practice. 2020;5:1-37.

Tu KN, et al. P&T. 2018;43:92-104.

Who Needs Pharmacologic Therapy?
AACE/ACE Recommendations

1	T-score between –1.0 and –2.5	→	In the spine, femoral neck, total hip or 1/3 radius and history of fragility fracture at hip or spine
2	T-score of –2.5 or less	→	In the spine, femoral neck or total hip, or 1/3 radius
3	T-score between –1.0 and –2.5	→	If FRAX 10-year probability for major osteoporotic fracture is 20% or greater or 10-year probability for a hip fracture is 3% or greater

Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

Risk Stratification – AACE/ACE 2020 Updates

Examples of Very High Fracture Risk:

- Recent fractures (eg, ≤ 12 months)
- Fracture while on approved therapy
- Multiple fractures
- Fractures while on drugs causing skeletal har
- T-score < –3.0
- High risk of falls
- High fracture probability by FRAX

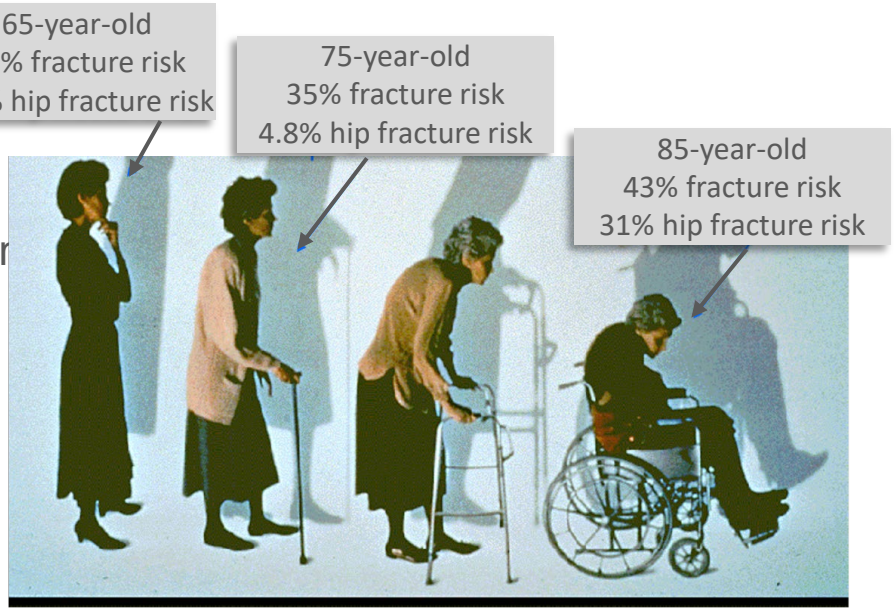

Image courtesy of Pauline Camacho, MD

Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

AACE/ACE 2020 POSTMENOPAUSAL OSTEOPOROSIS TREATMENT ALGORITHM

Lumbar spine or femoral neck or total hip T-score of ≤ -2.5, a history of fragility fracture, or high FRAX® fracture probability*

Evaluate for causes of secondary osteoporosis

Correct calcium/vitamin D deficiency and address causes of secondary osteoporosis

- Recommend pharmacologic therapy
- Education on lifestyle measures, fall prevention, benefits and risks of medications

High risk/no prior fractures**

- Alendronate, denosumab, risedronate, zoledronate***
- **Alternate therapy:** Ibandronate, raloxifene

Reassess yearly for response to therapy and fracture risk

Increasing or stable BMD and no fractures

Consider a drug holiday after 5 years of oral and 3 years of IV bisphosphonate therapy

Resume therapy when a fracture occurs, BMD declines beyond LSC, BTM's rise to pretreatment values or patient meets initial treatment criteria

Progression of bone loss or recurrent fractures

- Assess compliance
- Re-evaluate for causes of secondary osteoporosis and factors leading to suboptimal response to therapy

- Switch to injectable antiresorptive if on oral agent
- Switch to abaloparatide, romosozumab, or teriparatide if on injectable antiresorptive or at very high risk of fracture
- Factors leading to suboptimal response

ABBREVIATIONS GUIDE

BMD – bone mineral density
LSC – least significant change
BTM – bone turnover marker

Very high risk/prior fractures**

- Abaloparatide, denosumab, romosozumab, teriparatide, zoledronate***
- Alternate therapy: Alendronate, risedronate

Reassess yearly for response to therapy and fracture risk

Denosumab	Romosozumab for 1 year	Abaloparatide or teriparatide for up to 2 years	Zoledronate
Continue therapy until the patient is no longer high risk and ensure transition with another antiresorptive agent.	Sequential therapy with oral or injectable antiresorptive agent	Sequential therapy with oral or injectable antiresorptive agent	• If stable, continue therapy for 6 years**** • If progression of bone loss or recurrent fractures, consider switching to abalopa-ratide, teriparatide or romosozumab

* 10 year major osteoporotic fracture risk ≥ 20% or hip fracture risk ≥ 3%. Non-US countries/ regions may have different thresholds.
** Indicators of very high fracture risk in patients with low bone density would include advanced age, frailty, glucocorticoids, very low T scores, or increased fall risk.
*** Medications are listed alphabetically.
**** Consider a drug holiday after 6 years of IV zoledronate. During the holiday, an anabolic agent or a weaker antiresorptive such as raloxifene could be used.

2020 Initial Treatment Algorithm
High Risk, No Prior Fractures

- Alendronate, denosumab, risedronate, zoledronate***
- Alternate therapy: ibandronate, raloxifene

Reassess yearly for response to therapy and fracture risk

* 10 year major osteoporotic fracture risk ≥ 20% or hip fracture risk ≥ 3%. Non-US countries/regions may have different thresholds.

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2020 Initial Treatment Algorithm
Very High Risk, Prior Fractures

- Abaloparatide, denosumab, romosozumab, teriparatide, zoledronate***
- Alternate therapy: alendronate, risedronate

Reassess yearly for response to therapy and fracture risk

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Who are candidates for bisphosphonate holidays?

- Patients who are no longer high risk for fractures
- Patients should have stable or increasing BMD on serial DXA's
- No fractures
- Fracture risk is not increasing due to co-morbid conditions
- No new medications that cause bone loss

How long should patients be treated?

Duration of therapy for high risk patients

Oral bisphosphonates	→	5 years
IV zoledronate	→	3 years

Duration of therapy for very high risk patients

Oral bisphosphonates	→	Up to 10 years
IV zoledronate	→	Up to 6 years

When to resume therapy after bisphosphonate holiday

- If with new fragility fractures
- Significant decline in BMD
- Bone turnover markers have risen to pretreatment levels

Case 1

- 58 year old Caucasian female who was referred to the bone clinic due to a screening DXA which showed osteoporosis
- Lumbar spine T score -2.8, Femoral neck T score -1.8
- No prior fractures
- Personal and family history of recurrent kidney stones
- Normal vitals, physical exam
- Has been taking calcium supplements intermittently after she got the diagnosis

What's important to note about this case?

- Her bone loss is inappropriate for her age
- Z scores are lower than -1
- Ensure a thorough workup for causes of secondary osteoporosis
- Most common cause given her scenario would be idiopathic hypercalciuria
- Less common but also a possibility is familial primary hyperparathyroidism
- 24 urine calcium was 450 mg/24 hours (8 mg/kg/24 hours)
- PTH was mildly elevated at 68 pg/ml

How would you approach this case?

- Would ensure calcium and vitamin D sufficiency
- Treat the secondary cause- thiazide diuretic
- She is high risk but not in the very high risk category
- Would start her on oral bisphosphonate- alendronate or risedronate
- Serial DXA's and annual follow up
- Treat for 5 years and then initiate a drug holiday
- When BMD declines significantly, resume therapy

Romosozumab

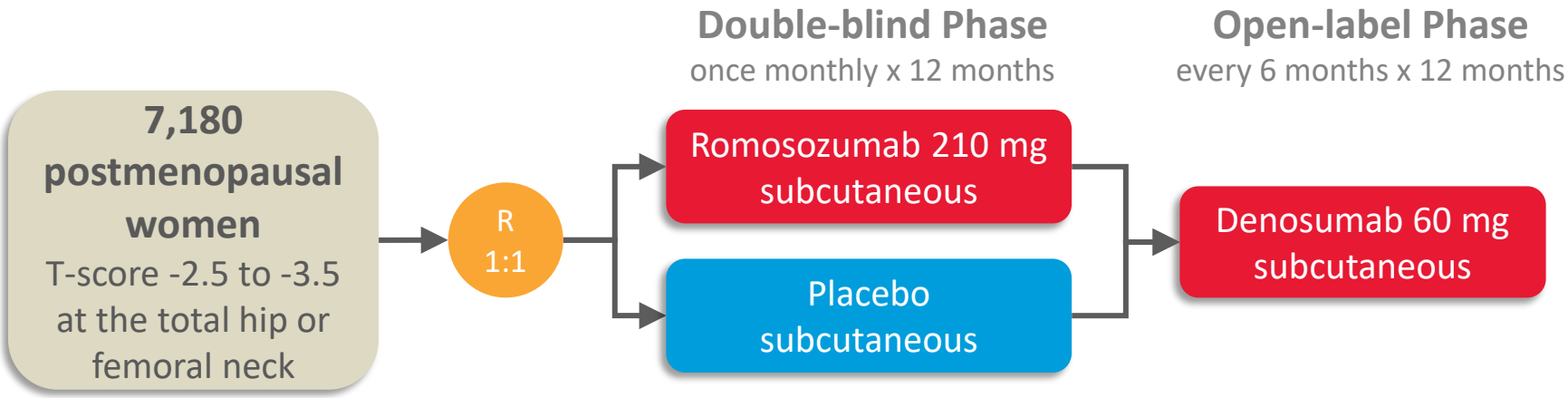
- Humanized monoclonal antibody that inhibits sclerostin, a protein secreted by osteocytes to reduce bone formation
- Approved in the USA in April 2019
- Indicated for osteoporosis in postmenopausal women at high risk high risk of fracture or who failed or are intolerant to other therapies
- Duration limited to 12 months

Black Box Warning

- Potential risk of myocardial infarction, stroke and cardiovascular death
- Should not be used in patients who had an MI or stroke in previous year

- Romosozumab-aqqg injection (for subcutaneous use) prescribing information.

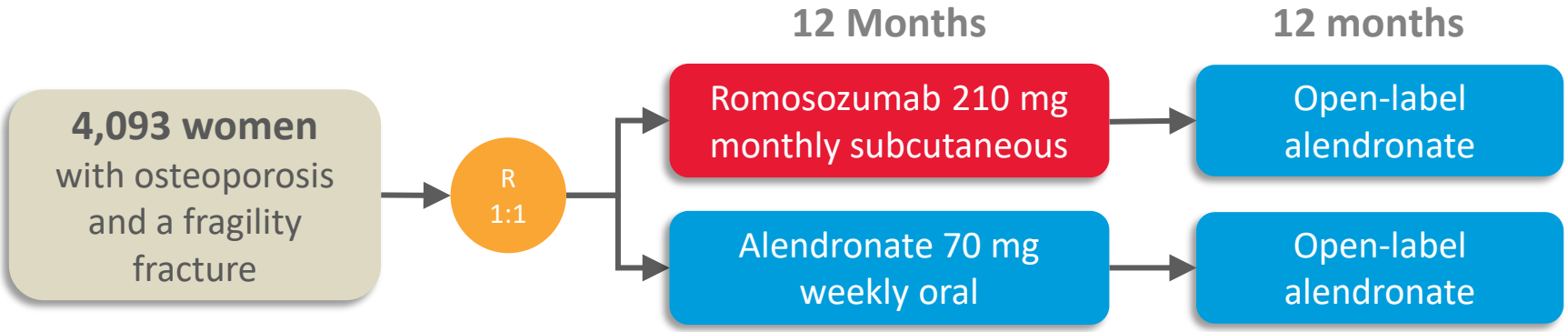
Romosozumab for Osteoporosis
The FRAME trial



- 73% lower risk of new vertebral fracture at 12 months with romosozumab vs placebo
- No significant difference in nonvertebral fracture at 12 months
- At 24 months, 75% decrease in risk of vertebral fractures after transition to denosumab

Cosman F, et al. *N Engl J Med*. 2016;375:1532-1543.

Romosozumab or Alendronate for Fracture Prevention
ARCH Trial



- 48% lower risk of new vertebral fractures in romosozumab → alendronate arm (6.2% vs 11.9%)
- Nonvertebral fracture risk lowered by 19% and hip fractures by 38% in romosozumab arm
- Overall adverse events were similar between arms
- Positively adjudicated serious CV events: 2.5% romosozumab vs 1.9% alendronate in year 1
- 1 event of jaw osteonecrosis in each arm during open-label phase

Saag KG, et al. *N Engl J Med*. 2017;377:1417-1427.

What Is the Role of Romosozumab in the treatment of osteoporosis?

- Patients with very high fracture risk
- Patients previously treated with teriparatide or abaloparatide but still need additional anabolic effect
- Patients who were on oral or injectable antiresorptive therapy but need anabolic therapy or have had rare adverse events (ONJ, AFF)

Case 2

- 85 year old Caucasian female in a wheelchair was referred for second opinion
- She had lost 6 inches in height and had multiple vertebral compression fractures
- She was treated with alendronate for at least 5 years
- She reported recent worsening of chronic back pain and a new fracture was found prior to consult
- Lumbar spine T score -4.0, Femoral neck T score -3.5
- History of celiac disease, currently compliant with her gluten free diet

How would you approach this case?

- Patient is definitely in the very high risk group
- She fractured while on oral therapy
- She has a new fracture - will benefit from anabolic therapy
- Ensure calcium and vitamin D sufficiency
- Switch to anabolic therapy- teriparatide/abaloparatide for two years
- After two years, can consider romosozumab vs switch to injectable antiresorptive therapy
- Serial DXA's and annual assessment of fall and fracture risk

Transitioning from Denosumab

- Discontinuation of denosumab is not recommended without a proper transition plan
- Rapid decrease in BMD with discontinuation of denosumab after 2 or 8 years
- BTM increase to values above baseline by 12 months after discontinuation
- Case reports of multiple vertebral fractures upon stopping denosumab
- They occurred 8 to 16 months after stopping- some as early as 3 months

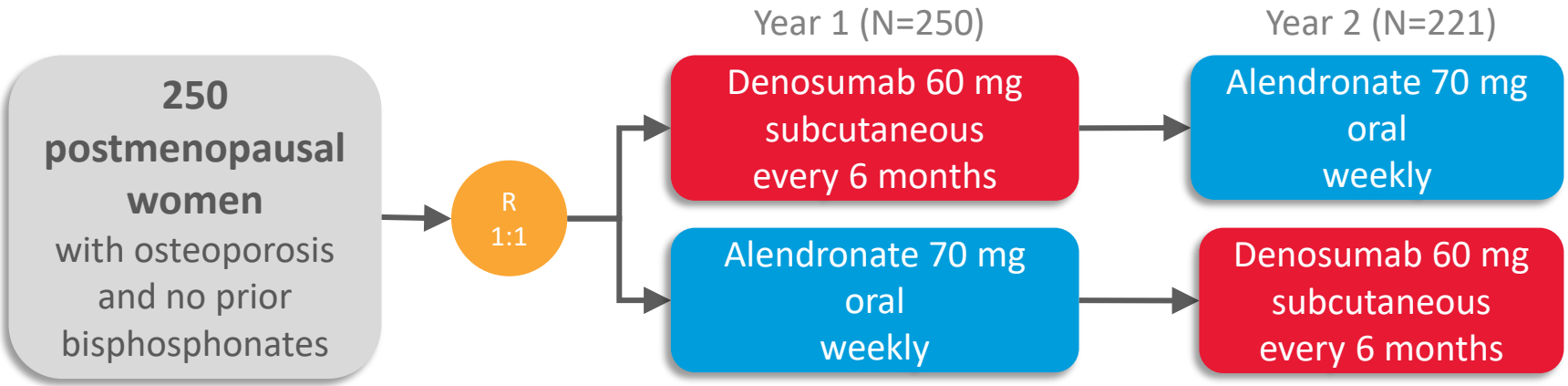
Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

Lamy O, et al. *J Clin Endocrinol Metab*. 2017;102:354-358.

Athanasios D, et al. *J Bone Mineral Res*. 2017;32:1291-1296.

Denosumab Followed by Alendronate

2-year, randomized, open-label crossover study



- Exploratory analyses: BMD in year 2 remained stable in denosumab → alendronate arm and increased in alendronate → denosumab arm

Freemantle N, et al. *Osteoporosis Int*. 2012;23:317-326.

Denosumab Followed by Alendronate

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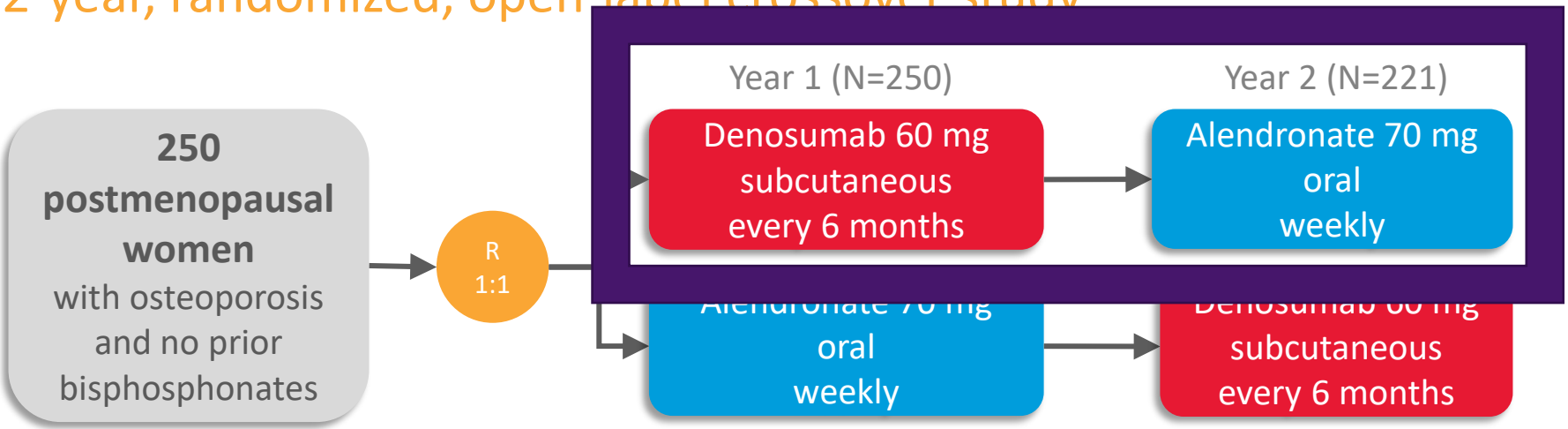

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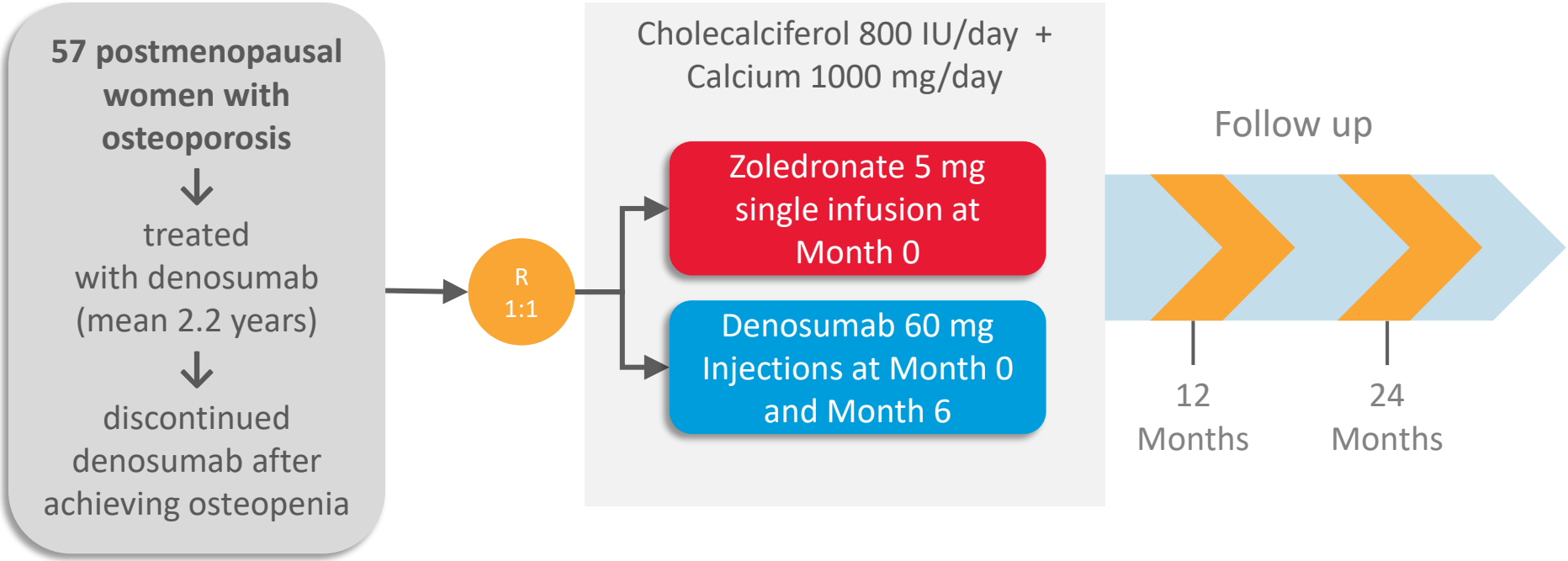
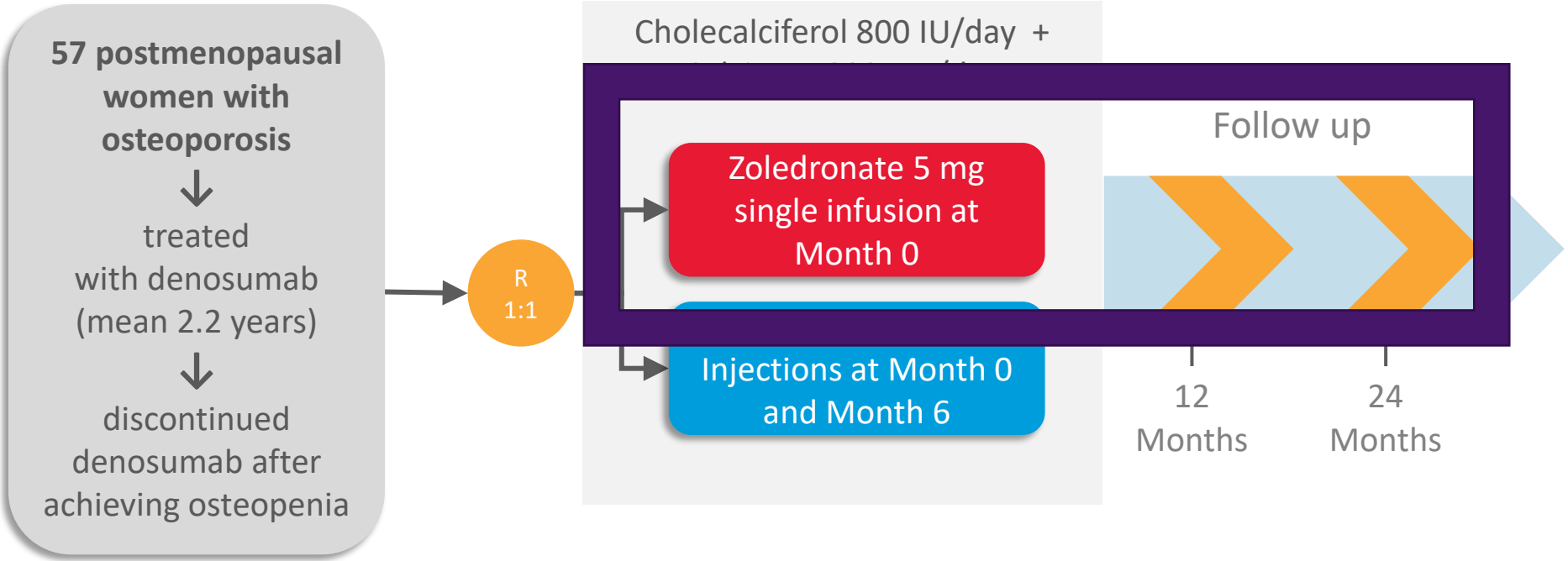
Freemantle N, et al. *Osteoporosis Int*. 2012;23:317-326.

Denosumab Followed by Zoledronate



Anastasilikas AD, et al. *J Bone Miner Res*. 2019;34:2220-2228.

Denosumab Followed by Zoledronate



- Anastasilikas AD, et al. *J Bone Miner Res*. 2019;34:2220-2228.

Denosumab Followed by Zoledronate

Outcomes after 2 years

Lumbar Spine BMD

- Zoledronate arm: same as baseline value
- Denosumab arm: decreased by 5% from the 12-month value

Femoral Neck BMD

- Similar changes in both treatment arms

Bone Turnover

- Denosumab arm increased significantly at 15 months and remained elevated at 24 months
- Changes independent of BMD

Vertebral Fractures

- 2 in denosumab arm
- 1 in zoledronate arm (12 months after infusion)

Anastasilikas AD, et al. *J Bone Miner Res*. 2019;34:2220-2228.

Case 3

- 65 year old Caucasian female was found to have osteoporosis on a screening DXA
- She has no prior fractures and no other high risk features
- Secondary workup was negative, and she was calcium and vitamin D replete
- She reports a history of severe GERD, thus was started on denosumab
- At baseline, lumbar spine T score -2.8, Femoral neck T score -2.5
- After three years on denosumab, her lumbar spine T score was -2.0, and femoral neck T score was -1.8

- Denosumab led to a robust increase in BMD allowing patients to improve to the osteopenia range within a few years of treatment
- If the patient does not develop high risk features, such as fractures, she can be transitioned off
- Would use one infusion of zoledronic acid
- Watch patient closely, follow bone turnover markers and BMD
- After successfully transitioning off, continue to follow and once BMD declines back to the osteoporosis range or patient's risk increases again (clinically), resume therapy

AACE/ACE Algorithm
Switching to Injectable Therapies

Progression of bone loss or recurrent fractures

- Assess compliance
- Re-evaluate for causes of secondary osteoporosis and factors leading to suboptimal response to therapy

- Switch to injectable antiresorptive if on oral agent
- Switch to abaloparatide, romosozumab, or teriparatide if on injectable antiresorptive or at very high risk of fracture
- Factors leading to suboptimal response

Camacho PM, et al. *Endocrine Practice*. 2020;5:1-37.

AACE/ACE Algorithm
Transitions for Very High Risk Patients

Denosumab	Romosozumab for 1 year	Abaloparatide or teriparatide for up to 2 years	Zoledronate
Continue therapy until patient is no longer high risk and ensure transition with another antiresorptive agent	Sequential therapy with oral or injectable antiresorptive agent	Sequential therapy with oral or injectable antiresorptive agent	If stable, continue therapy for 6 years**** If progression of bone loss or recurrent fractures, consider switching to abaloparatide, teriparatide or romosozumab

* 10 year major osteoporotic fracture risk ≥ 20% or hip fracture risk ≥ 3%. Non-US countries/regions may have different thresholds.

** Indicators of very high fracture risk in patients with low bone density would include advanced age, frailty, glucocorticoids, very low T scores, or increased fall risk.

*** Medications are listed alphabetically.

**** Consider a drug holiday after 6 years of IV zoledronate. During the holiday, an anabolic agent or a weaker antiresorptive such as raloxifene could be used.

Camacho PM, et al. Endocrine Practice. 2020;5:1-37.

Conclusions:

- New diagnostic criteria goes beyond just T scores
- Initial treatment choice and duration of therapy based on risk stratification
- Secondary workup is very important and vitamin D and calcium deficiency should be corrected before starting therapy
- Therapeutic agents include antiresorptive and newer anabolic agents and it is important to understand when they are most appropriate to use

Thank you for your attention!

Speaker

Jade A. Anderson, MD

Assistant Professor, Musculoskeletal Imaging & Intervention, Department of Radiology; University of Wisconsin School of Medicine and Public Health

American College of Radiology
YPS Delegate for the AMA Radiology Section Council

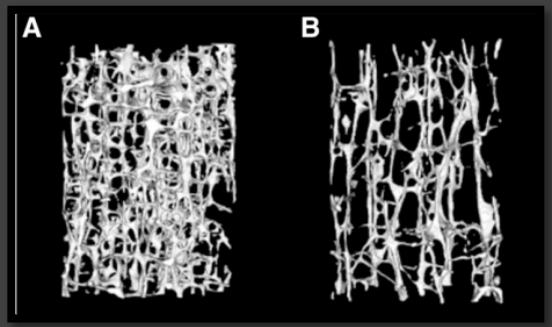
What is a DEXA (DXA) Scan?

- **Definition**: Dual-Energy X-ray Absorptiometry
- **Purpose**: Measure bone mineral density (BMD) and assess fracture risk

Why is it important?

- **Gold standard** for diagnosing osteoporosis and predicting fracture risk
  - Monitor bone health and treatment efficacy
  - Screening is cost-effective
  - Low radiation exposure
  - Non-invasive
  - Quick and easy to perform
  - High accuracy
- We discussed the morbidity, mortality, and costs of fragility fractures previously

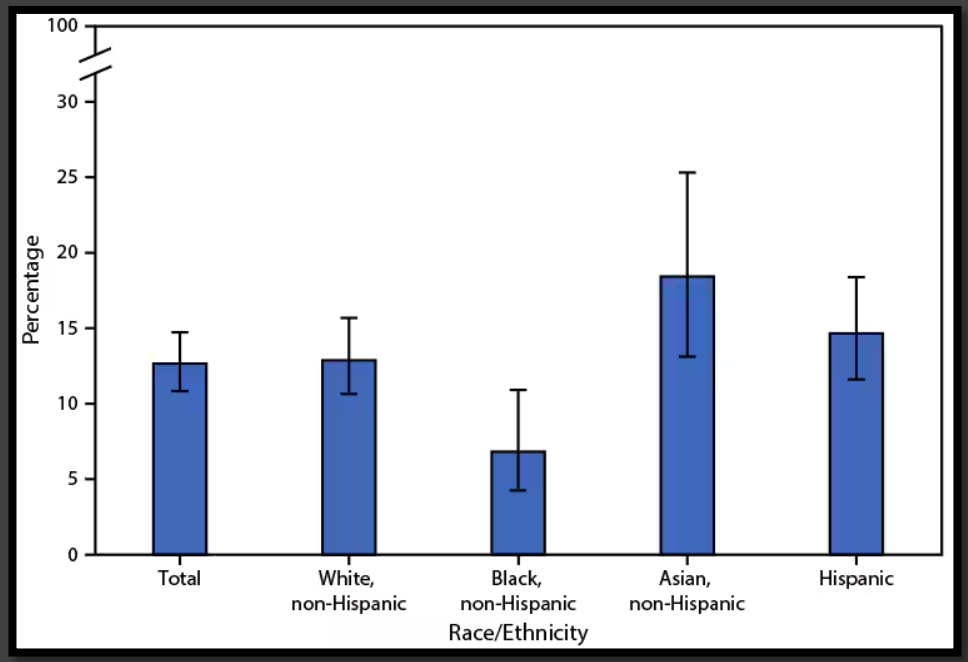
www.froedtert.com/trauma/fall-prevention



Haseltine, K. N. (2021)

Osteoporosis by Race in the USA

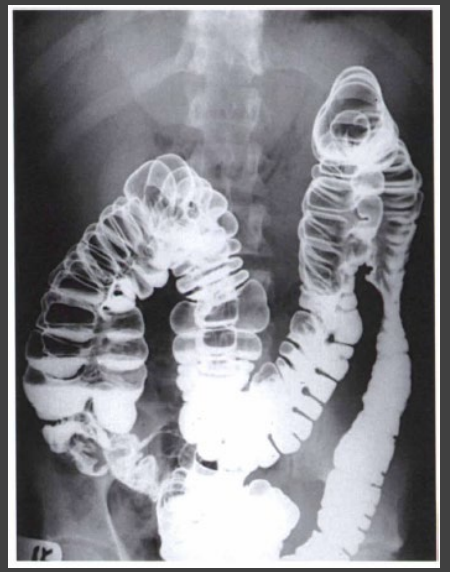
- Percentage of Adults Aged ≥50 Years with Osteoporosis, by Race and Hispanic Origin — United States, 2017–2018
  - **12.6% prevalence**
- Black, Non-Hispanics had lower percentage
- No statistical difference in percentage among Hispanics and Non-Hispanic White and Asian populations



QuickStats. CDC. (2021)

Contraindications

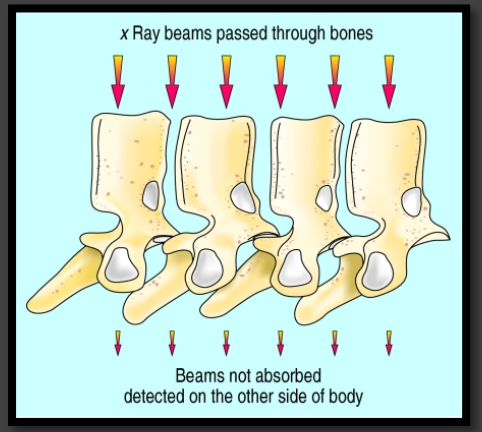
- Indications discussed previously
- No absolute contraindications, but…
  - No recent barium or radionuclides
  - Pregnancy
  - Fx deformity/severe OA/implants/hardware
  - Very high or low BMI/patient motion → needed for reproducibility



www.radtechonduty.com

How does it work?

- Energy (2 different peaks) of x-ray beams passed through bones →
- What is NOT absorbed is detected on the other side
- Therefore,
  - ↑↑↑ bone density =
  - ↑↑↑ beam absorption =
  - ↓↓↓ energy detected



Berger, A. (2002)

How does it work?

- Radiation energy per pixel ("picture element") is detected → converted into an "areal density" measured in g/cm^2
  - number of pixels in the area is summed
  - amount of bone in each pixel calculated
  - = ***calculated bone mineral density (BMD)***

How does it work?

Berger, A. (2002)

$$\bullet T\ score = \frac{patient's\ BMD — population\ peak\ BMD}{standard\ deviation\ (SD)\ of\ population\ peak\ BMD}$$

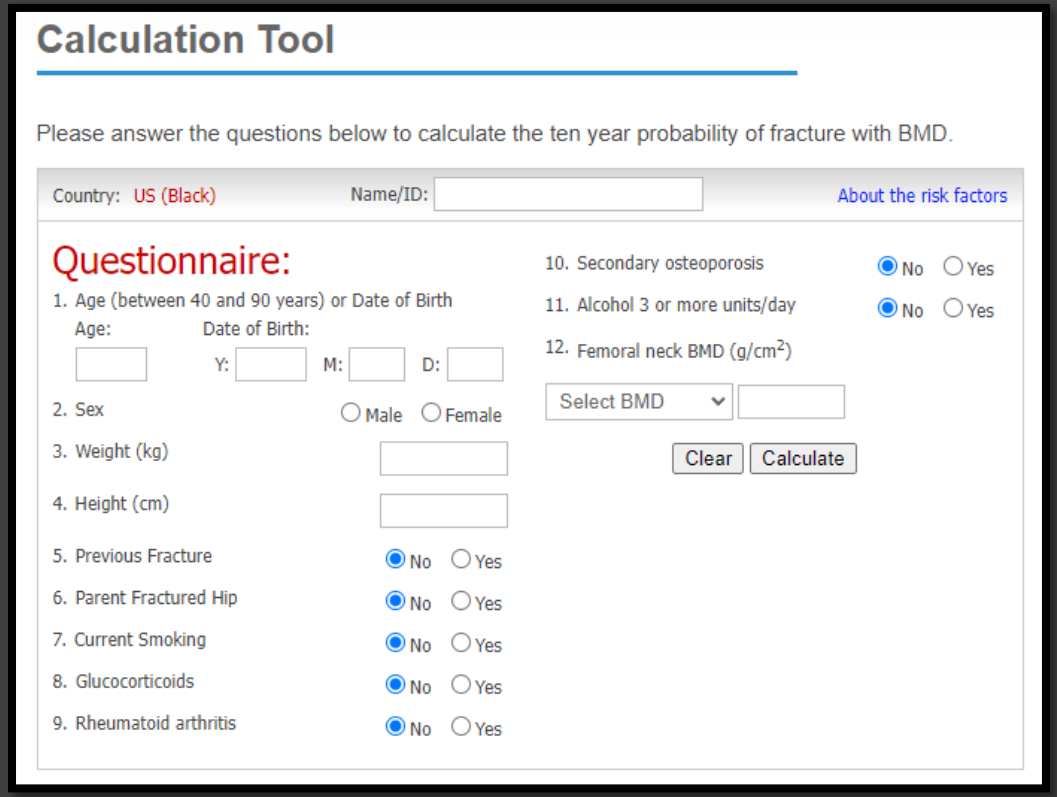
$$\bullet Z\ score = \frac{patient's\ BMD — population\ age\ related\ BMD}{SD\ of\ population\ age-related\ BMD}$$

- **T-score**: patient's BMD converted into values related to the average female/male peak bone mass
  - ***Osteoporosis*** = less than/equal to **-2.5**
- **Z-score**: patient's BMD converted into bone mass related to the patient's age

Don’t forget about FRAX

- Fracture Risk Assessment Tool
- Web-based internationally validated tool used to estimate 10-year risk of fracture
- Good use when DXA not available
  - However, validated mostly from Caucasian cohorts

FRAX



Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

Country: US (Black) Name/ID: About the risk factors

Questionnaire:

1. Age (between 40 and 90 years) or Date of Birth
   Age: Date of Birth: Y: M: D:
2. Sex ○ Male ○ Female
3. Weight (kg)
4. Height (cm)
5. Previous Fracture ● No ○ Yes
6. Parent Fractured Hip ● No ○ Yes
7. Current Smoking ● No ○ Yes
8. Glucocorticoids ● No ○ Yes
9. Rheumatoid arthritis ● No ○ Yes
10. Secondary osteoporosis ● No ○ Yes
11. Alcohol 3 or more units/day ● No ○ Yes
12. Femoral neck BMD (g/cm^2)

Select BMD

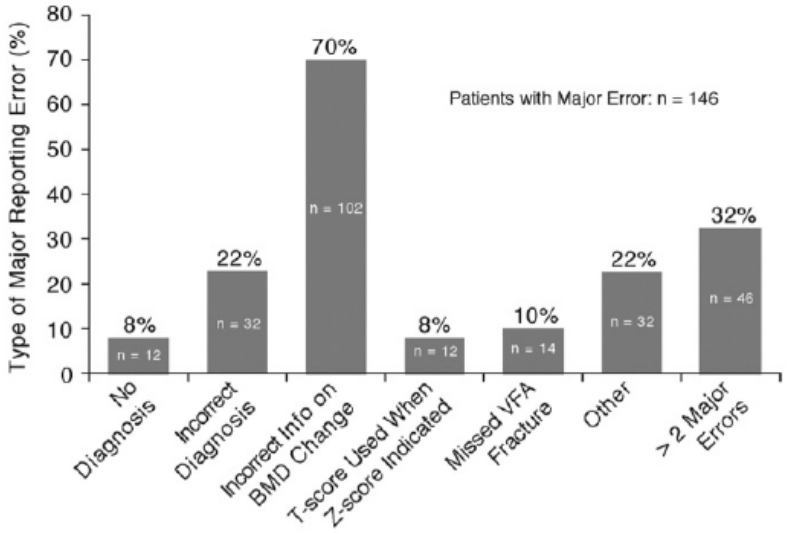
Clear Calculate

Cherian, K.E. (2019)

DXAs Drive Tx…

Despite Driving Rx Decisions, Errors are Common

42% in a UW study



Major error definition:
"Provision of inaccurate information that could potentially lead to incorrect patient care decisions."

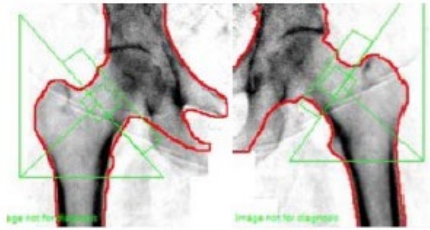
- Excessive workload?
- Low reimbursement?
- Perception that this is a lab test requiring no overview?
- Ageism??
- Other??

Krueger, et. al, J Clin Densitom, 2019, 22:115-124

Source: Neil Binkley, MD at BMD Peer Learning Conference

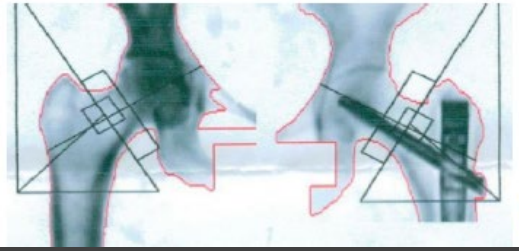
University of Wisconsin-Madison

Error examples…



Region	BMD (g/cm²)	YA T-score
Neck Left	0.509	-3.8
Neck Right	0.000	-
Total Left	0.630	-3.0
Total Right	0.070	-7.4

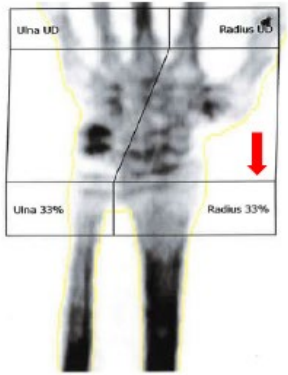
No comment regarding a FN BMD of 0.000 g/cm²



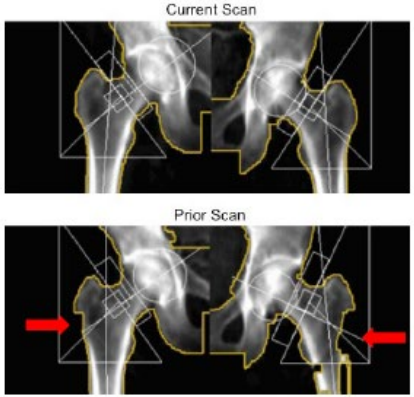
Examples of Errors

(These actually occurred)

Not where the 1/3 Radius ROI goes



Compared mean total hips but not the same regions



Reported a T-score of +19, and 69% BMD increase on teriparatide

Source: Neil Binkley, MD at BMD Peer Learning Conference

University of Wisconsin-Madison

Business → DXA Trends Among US Medicare Beneficiaries: 2005 – 2019

- ***Utilization***
  - DXA use per 10,000 Medicare beneficiaries →
    - Peaked in 2008 at 832
    - Declined to 656 in 2015
    - Increased to 807 in 2019
  - Total number of DXAs performed annually remained stable at around 2.7 million initially → dropped to 2.2 million in 2015 → rebounded to ~2.7 million in 2019

DXA Trends Among US Medicare Beneficiaries: 2005 – 2019

- ***Place of Service***
  - In 2005, 70.7% of DXAs were performed in office settings → declined to 47.2% by 2019
  - During the same period, outpatient hospital (OH) settings saw an increase in DXAs from 28.6% to 51.7%
  - Shift from office-based to hospital-based settings was associated with greater reimbursement reductions in the office setting

DXA Trends Among US Medicare Beneficiaries: 2005 – 2019

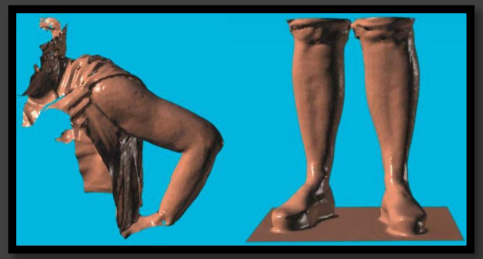
- ***Who's Interpreting?***
  - DXAs interpreted by radiologists ↑ significantly from 43.5% in 2005 to 73.5% in 2019
  - Interpretation by non-radiologist specialties, including primary care, rheumatology, and OB/GYN, declined over the same period
    - *No statistically significant change in endocrinology interpreters*
    - *DXA interpretation increased (0.1 percentage points per year, p<0.001) among NPPs*
  - →→→ Reflects movement of DXA interpretation from office-based non-radiologists to hospital-based radiologists

DXA Trends Among US Medicare Beneficiaries: 2005 – 2019

- ***Reimbursement and Access***
  - Reduction in office-based DXA practices is partly due to reimbursement cuts by CMS
    - → limits access to DXA testing, especially in rural areas
  - ↑↑ availability of Fracture Liaison Services (FLS) in the US may have contributed to the rebound in DXA testing from 2015 onwards

Recent Advances

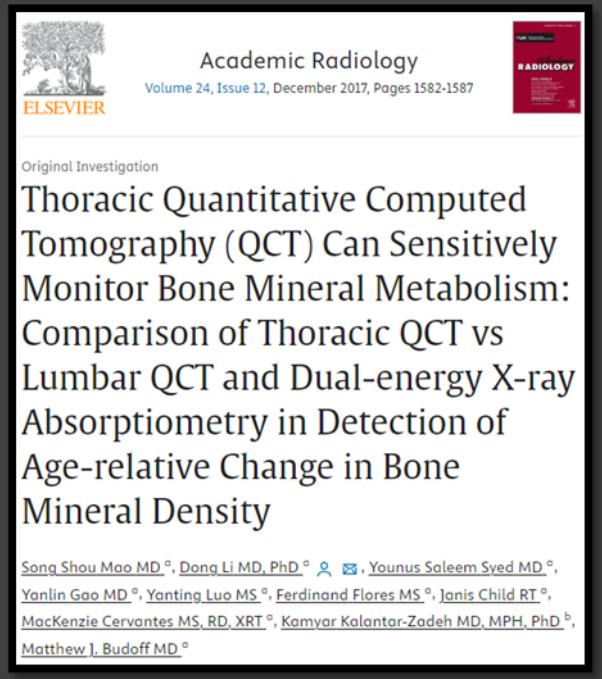
- High-resolution imaging
- 3-D DEXA scans
- Improved software algorithms for better accuracy
  - *Ex*: Trabecular bone score (indirect measure of trabecular microarchitecture derived from DXA images of the lumbar spine)
- AI integration with other diagnostic tools



Arm and Calf 3D Scans.
Maschhoff, C.W. (2024)

Advanced Bone Imaging Technology

- 2017 article compared QCT of both the thoracic and lumbar spines to whole-body DXA
  - QCT → more sensitive in detecting annual rate of bone loss
  - Significant negative correlation between age and BMD for QCT, but not with DXA, except in the legs of women
  - DXA → potential false elevations due to calcifications and osteophytes in the elderly
  - Negative → QCT = larger radiation dose and more expensive



ELSEVIER

Academic Radiology

Volume 24, Issue 12, December 2017, Pages 1582-1587

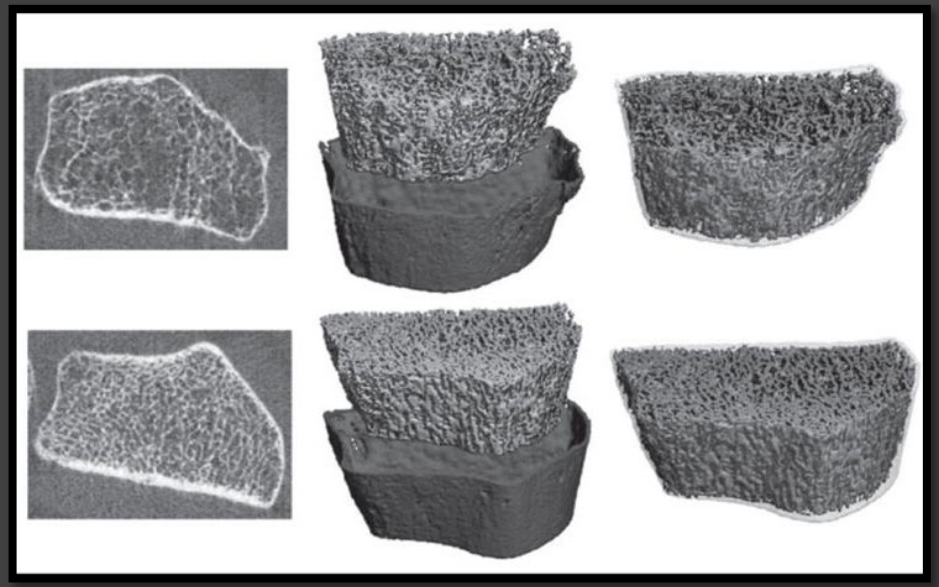
Original Investigation

Thoracic Quantitative Computed Tomography (QCT) Can Sensitively Monitor Bone Mineral Metabolism: Comparison of Thoracic QCT vs Lumbar QCT and Dual-energy X-ray Absorptiometry in Detection of Age-relative Change in Bone Mineral Density

Song Shou Mao MD [a], Dong Li MD, PhD [a], Younus Saleem Syed MD [a], Yanlin Gao MD [a], Yanting Luo MS [a], Ferdinand Flores MS [a], Janis Child RT [a], MacKenzie Cervantes MS, RD, XRT [a], Kamyar Kalantar-Zadeh MD, MPH, PhD [b], Matthew J. Budoff MD [a]

Advanced Bone Imaging Technology

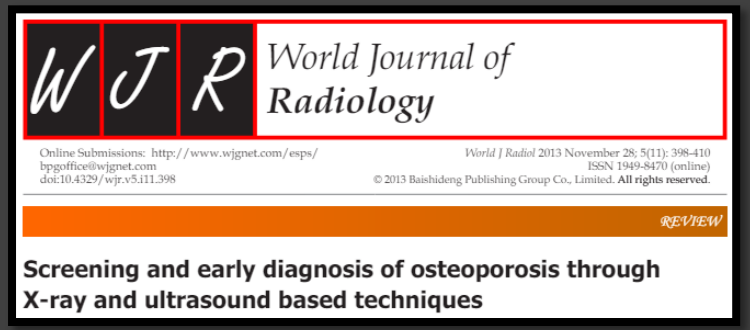
- High-resolution peripheral QCT images of the left radius of a person who suffered a low trauma fracture at the right radius (top row) and a fracture-free, age-matched control (bottom row)
- Depicts 2-D grayscale slices, the segmented cortical and trabecular compartments, and a 3-D rendering with highlighted cortical porosity



Pawlowska, M.H. (2016)

Advanced Bone Imaging Technology

- Quantitative Ultrasound (QUS)
  - Radiation-free, portable, cost-effective
  - Measures bone density, structure, and elastic properties → beyond BMD
  - Mainly for pre-screening, requiring confirmation by DXA for diagnosis
  - Currently limited to peripheral sites and less validated for spine and hip



Advanced Bone Imaging Technology

- Bone Microindentation Testing (BMT)
  - Validated technology that directly measures the ability of bone to withstand fractures
  - Under local anesthesia, a microprobe (1-mm), is inserted under the skin of the mid anterior tibia and locally penetrates the periosteum
    - cycles of indentations, 375-µm across
    - creates microscopic discontinuities that can be extrapolated into measures of resistance

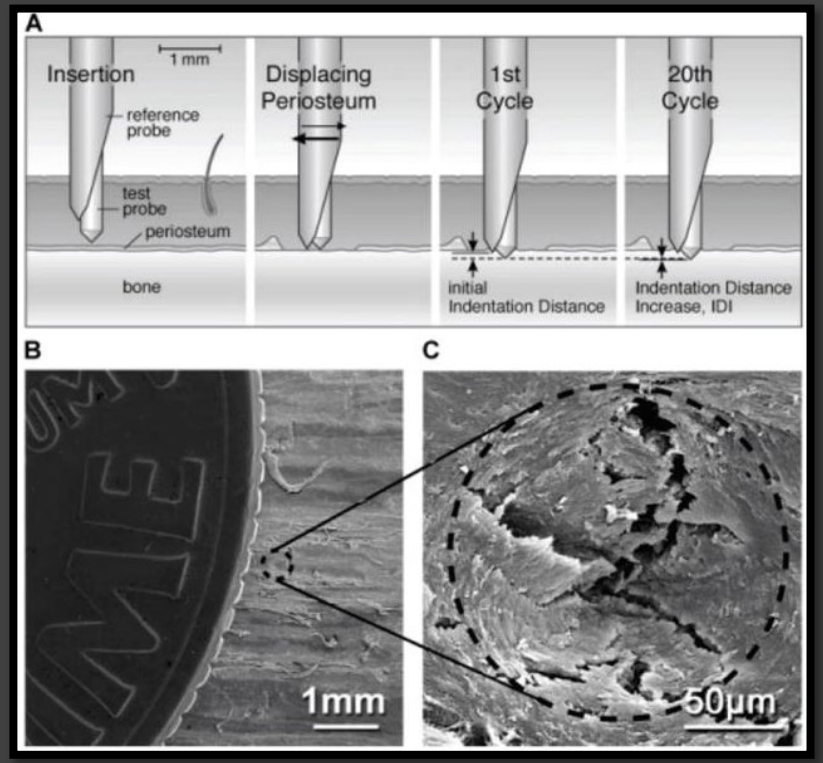
Bone Microindentation Testing (BMT)

- Indentation distance from the periosteal surface to the last-cycle indentation = total indentation distance (total ID)
- Difference between the first- and last-cycle indentation is the indentation distance increase (IDI)
- Both total ID and IDI were significantly greater in postmenopausal females **WITH** than without osteoporotic fractures → increased bone fragility
    - Estimates biomechanical skeletal competence, independent of BMD

Bone Microindentation Testing (BMT)

- Insertion of the test probe assembly → displacing periosteum with reference probe → first-cycle indentation → last cycle indentation

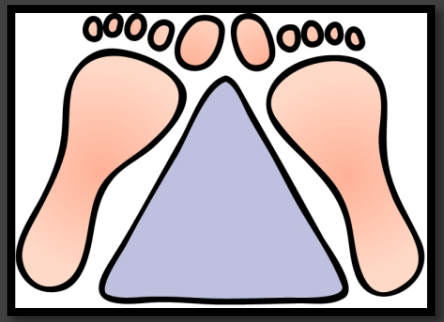
- Determines the IDI with respect to the first cycle



Pawlowska, M.H. (2016)

What to tell your patients

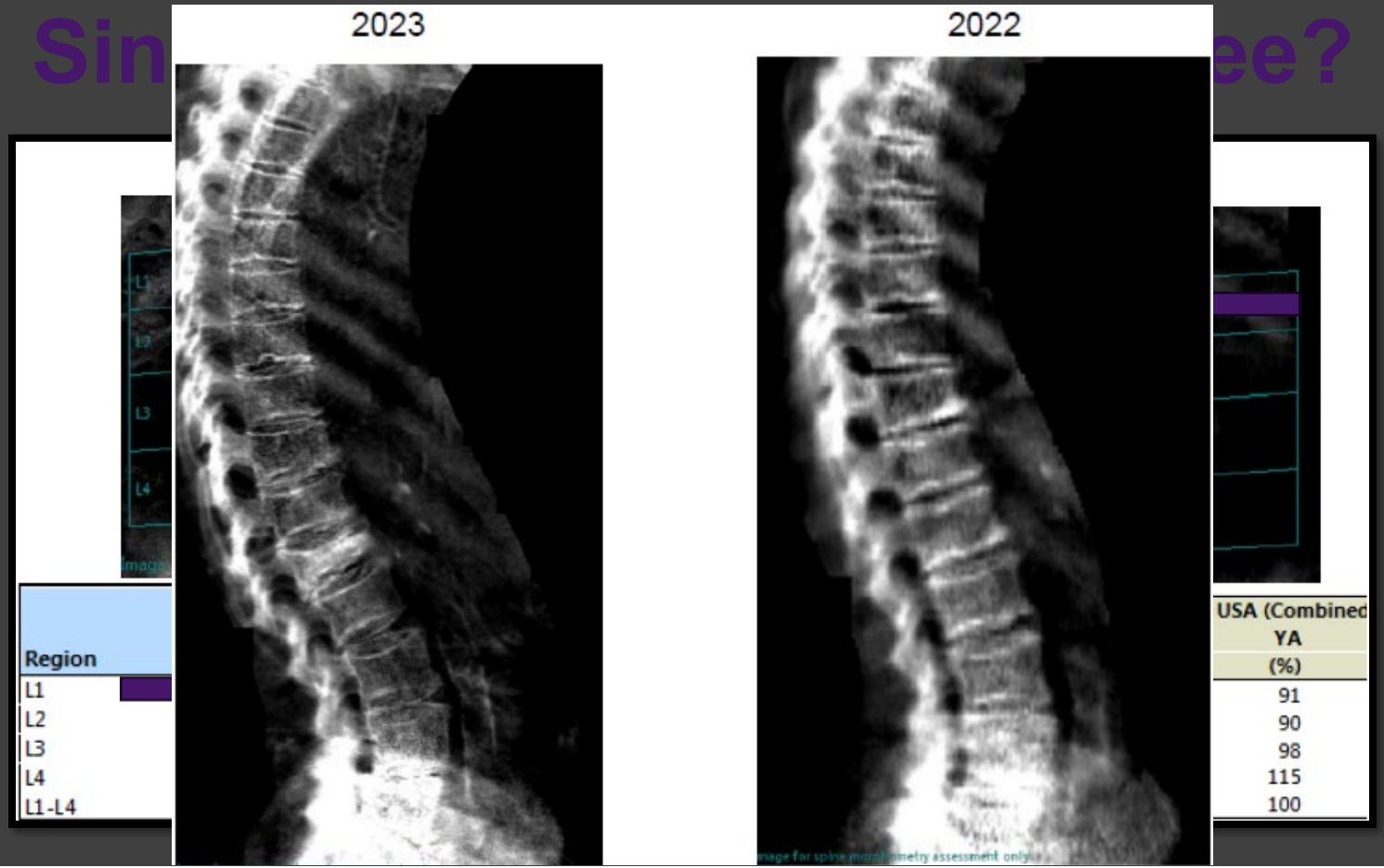
- 10–15-minute exam, no metal
- Supine, open X-ray table
- Only 1/10 radiation of a CXR
- No patient motion!
- No limitations after the exam



Berger, A. (2002)

Choplin, R.H. (2014)

Sin ee?



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Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

Thank You!

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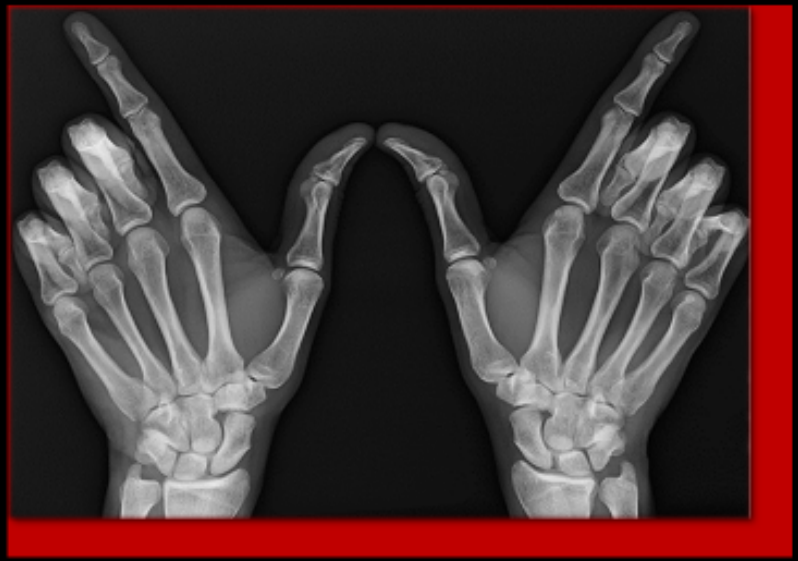
@Ortho2Rads



Speaker

Prakash Jayabalan, MD, PhD

Director of Clinical Musculoskeletal Research &
Attending Physician Scientist, Shirley Ryan AbilityLab

Associate Professor Northwestern Feinberg School of Medicine

Focus of my Presentation

Discuss Diet and Exercise Strategies for Individuals at Risk of Developing Osteoporosis

Case Study

61-year old female
To discuss lifestyle strategies to help prevent osteoporosis (or prevent it getting worse)

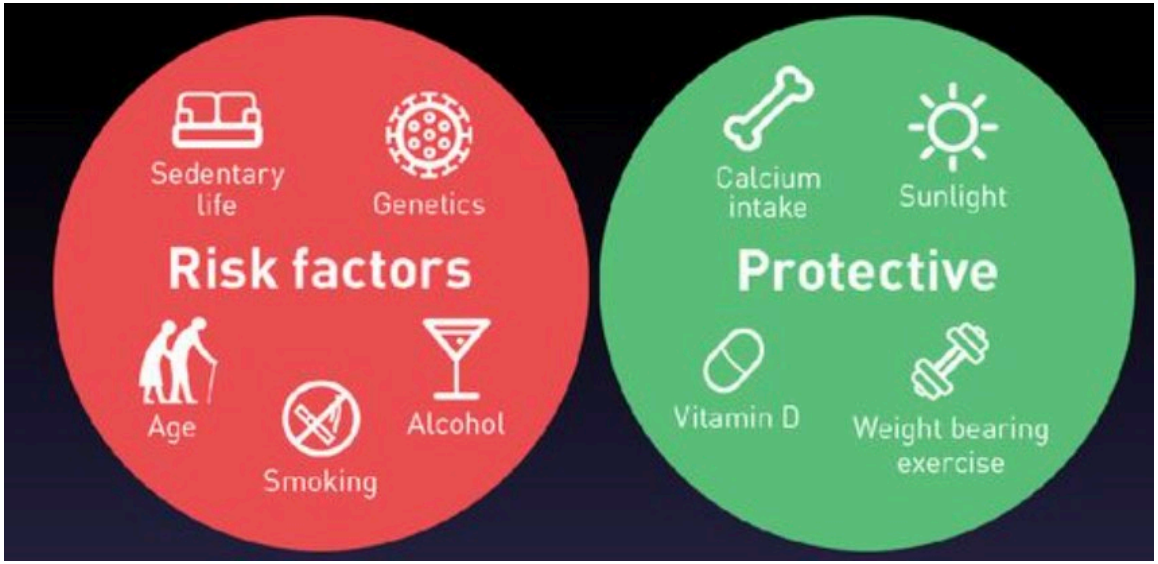
Epidemiology

- Osteoporosis is a skeletal disorder, compromised bone strength leading to susceptibility to fracture

- Fractures occur with forces generated by a fall and most common in:
  - Spine
  - Hip
  - Wrist

- More common in women, but men often undiagnosed

Risk and Protection



Bone physiology

- Bone consists of:
- Crystals of hydroxyapatite (Calcium phosphate)
- Inorganic collagen matrix

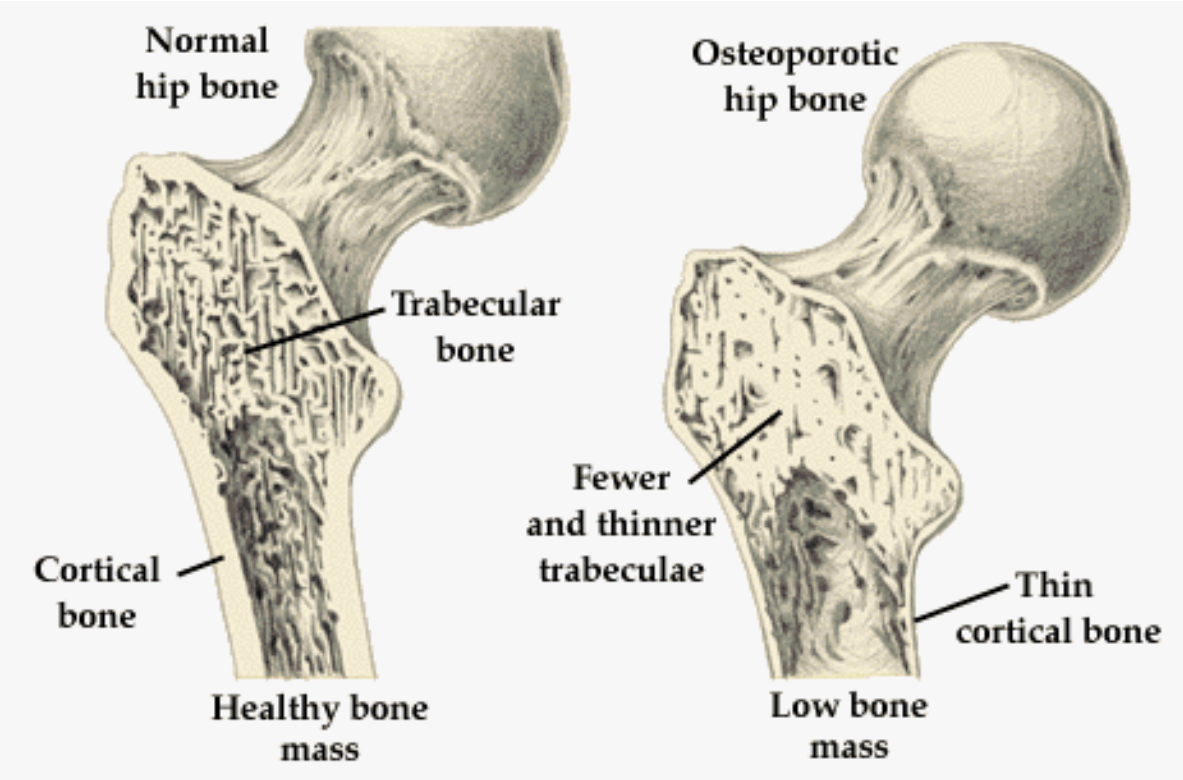
Types:
- Cortical
- Trabecular bone

Bone modeling/remodeling – affects the quality and structure of the bone
- Impacted by:

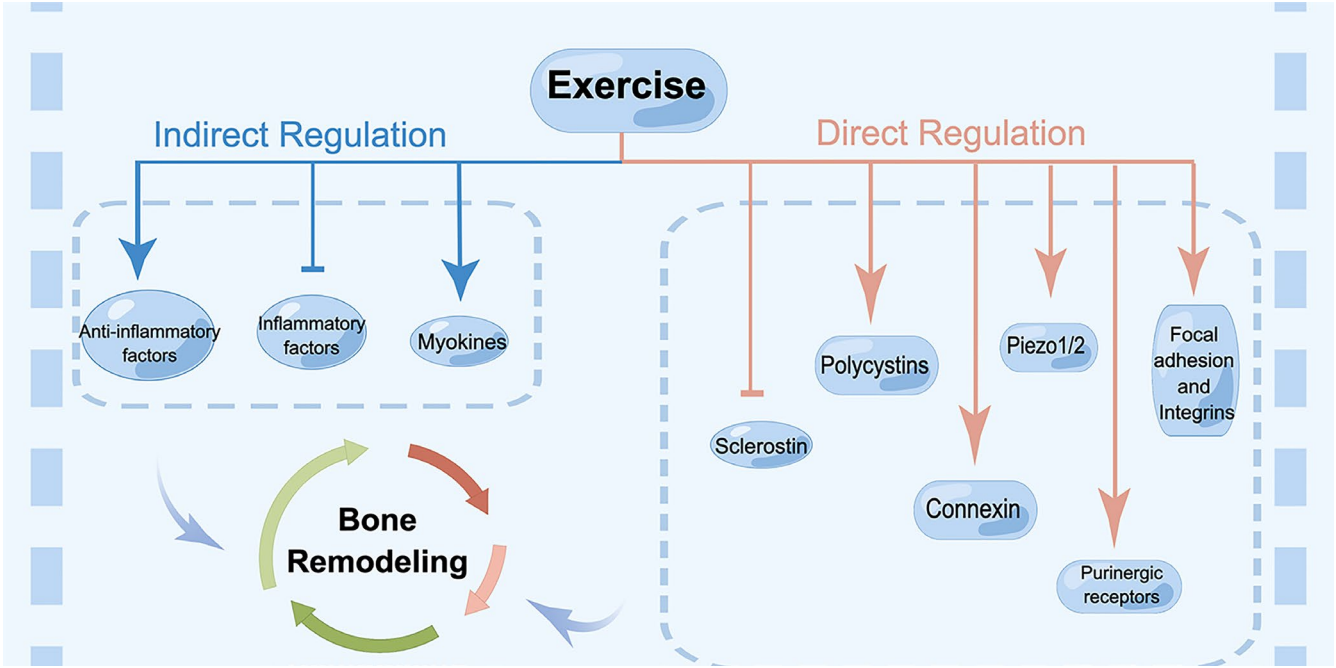
1) Hormonal

2) Mechanical environment

Bone



Impact of Exercise on Bone



Physiologic Response to Exercise

- Acute Response
- Exercise causes compression, tension or torsion of bone
- Ultimately deformation which is basis for chronic adaptations

Chronic response

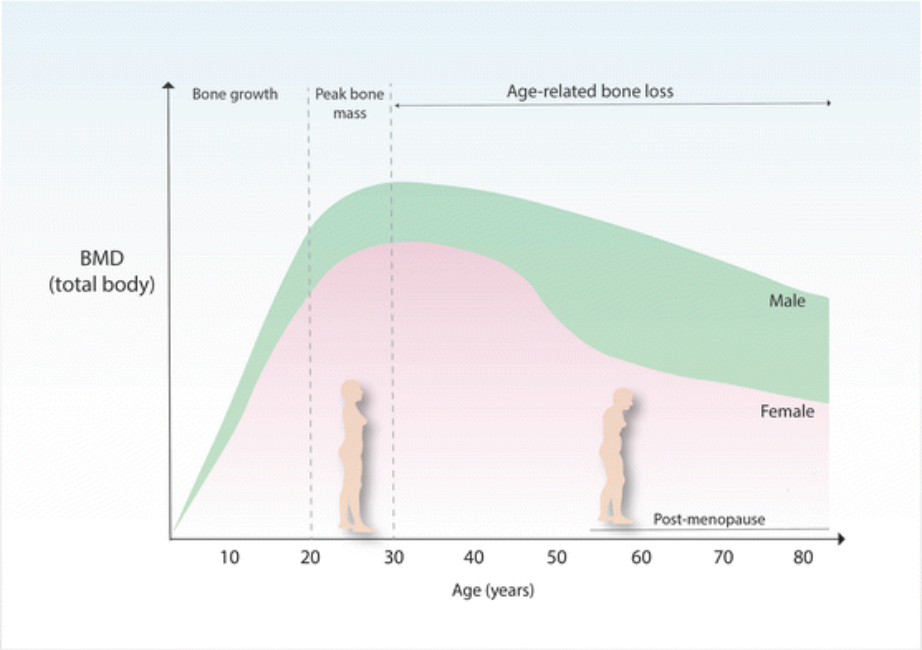
- Remodeling of bone takes several months
- Maintenance of bone quality through targeted remodeling

Exercise for bone health across life

- Exercise during youth builds a strong skeleton

- Period of maximal velocity of height growth most important period of bone mineral accumulation

- Bone response to loading is optimized in pre-puberty and early puberty



Hendrickx et al. (2015)

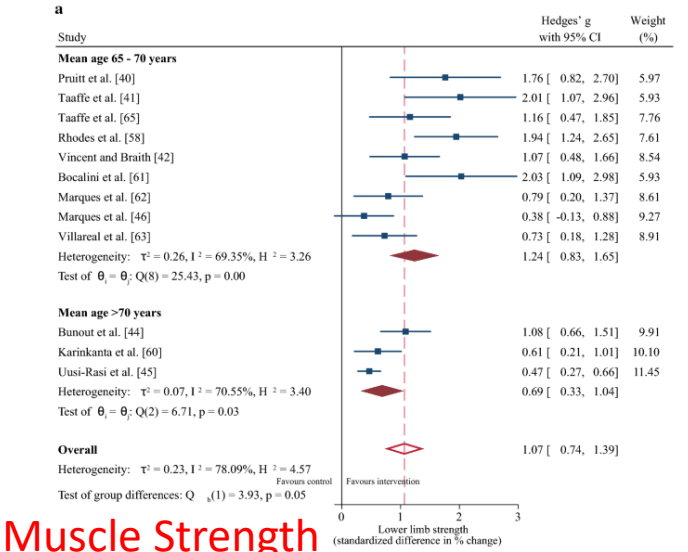
IMPACT of Exercise on Bone Formation

- Weight bearing and resistance activities increase markers of bone formation:

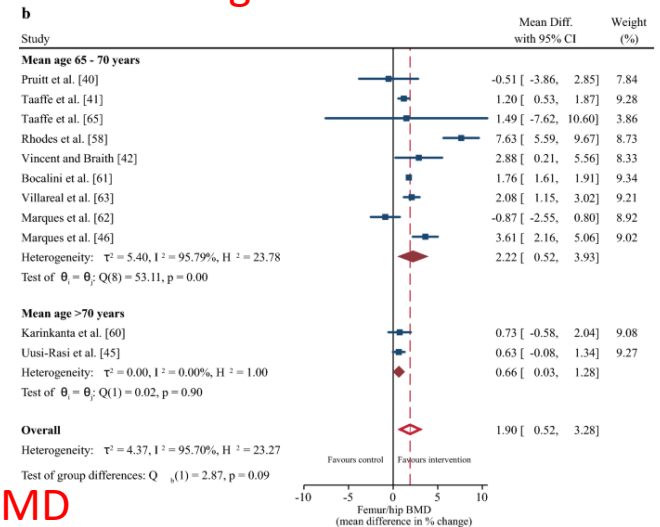
  1) Pro-collagen type 1-N terminal peptide (P1NP)

  2) Osteogenic cells

  3) Decreased markers of bone resorption
  - Increase in BMD in L-spine compared to lower intensity training program.



Muscle Strength



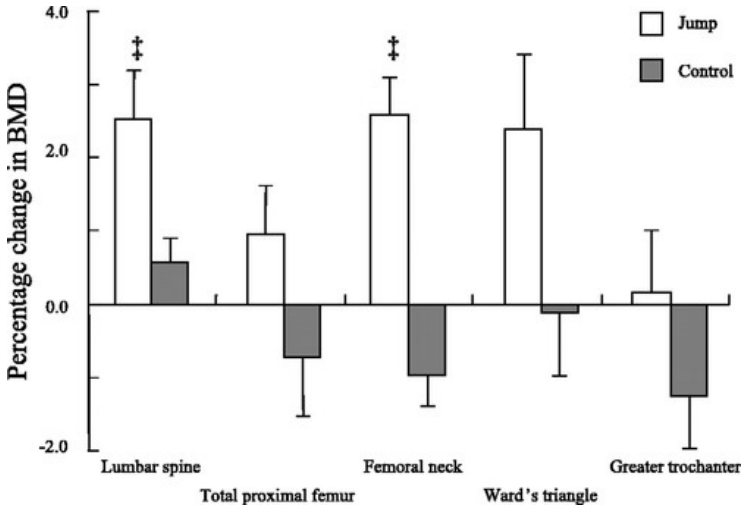
BMD

Exercise for bone health across life

What should we all be doing?

10-20mins, 3days/week – impact activities

- Plyometrics
- Jumping
- Moderate intensity resistance training



Burrows et al, 2007

Ten jumps 3x/day

- Increase BMD in proximal femur and intertrochanteric region

Exercise for individuals at risk of osteoporosis

Exercise testing for those with osteoporosis

- Not contraindicated generally
- Cycle ergometry maybe indicated with severe vertebral osteoporosis
- Vertebral compression fractures may compromise ventilatory capacity….affect balance during treadmill walking
- Maximal muscle strength testing maybe contraindicated in those with severe osteoporosis because of risk of fracture

Contraindicated Exercises

- **Large forces on relatively weak bone**

- Twisting movements
- Dynamic abdominal exercise (e.g. sit ups)
- Jumping, high impact loading
- Trampolines and step aerobics
- Excessive neck and trunk flexion
- Exercises that involve explosive loading

Exercise Prescription

EXERCISE PRESCRIPTION & REFERRAL FORM

Your Prescription for Health
Exercise is Medicine™
www.ExerciseIsMedicine.org

PATIENT'S NAME: _____ DOB: _____ DATE: _____

HEALTH CARE PROVIDER'S NAME: _____ SIGNATURE: _____

PHYSICAL ACTIVITY RECOMMENDATIONS

Type of physical activity:	Aerobic	Strength
Number of days per week:		
Minutes per day:		
Total minutes per week*:		

***PHYSICAL ACTIVITY GUIDELINES**

Adults aged 18-64 with no chronic conditions: Minimum of 150 minutes of moderate physical activity a week (for example, 30 minutes per day, five days a week) ***and*** muscle-strengthening activities on two or more days a week (2008 Physical Activity Guidelines for Americans).
For more information, visit www.acsm.org/physicalactivity.

REFERRAL TO HEALTH & FITNESS PROFESSIONAL

Name: _____

Phone: _____

Address: _____

_____

Web Site: _____

Follow-up Appointment Date: _____

Notes: _____

_____

_____

_____

Frequency
Intensity
Timing
Type

Osteogenic Activities

- Response is site specific
- Loading/stress designed to affect the location in which osteoporosis or low BMD identified (e.g. spine, hip etc.)
- Rest is important for bone adaptation

What Exercises Build Bone?

Form of Exercise	Impact on BMD	BMD Sites
Swimming	None or Decreases	None or Decreases at all sites
Walking	Protects against further loss	Hip
Low-Impact Aerobic Exercise	Protects against further loss	Hip, Lumbar Spine
High-Impact Aerobic Exercise	Increases BMD	Hip, Lumbar Spine
Weight Training	Increases BMD	Hip, Lumbar Spine, Radius
Running*	Increases BMD	Hip, Lumbar Spine
Squash	Increases BMD	Hip, Lumbar Spine, Radius

Individuals at risk of osteoporosis

GOAL: Preserve bone health

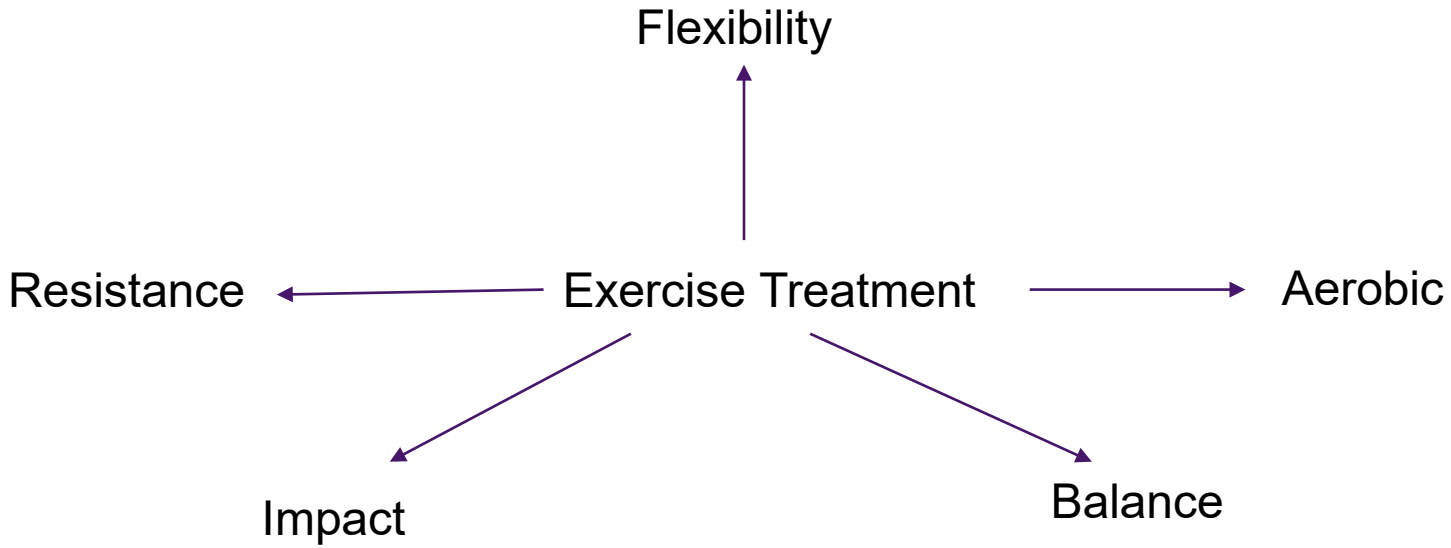
- Moderate to vigorous intensity aerobic exercise 3-5days/week
- Moderate to vigorous intensity RT 2-3 days/week
- Jogging, jumping and plyometric exercises
- Higher intensity strength training (8-RM) most beneficial

Individuals with Osteoporosis

GOAL: Prevent disease progression

- Moderate to vigorous intensity aerobic exercise 3-5days/week
- Moderate to vigorous intensity RT 2-3 days/week
- Jogging, walking, stair-climbing, aquatic and other exercise as tolerated

Types of Exercise for the bones



Flexibility Training

- Increased flexibility can be of benefit (postural corrections)

- Slow and controlled movements

- **Avoid:**
- **Spinal flexion**
- **Ballistic type stretching**

No!

RESISTANCE TRAINING

Frequency – 2-3 days/week 5-12 Rep set

Intensity – >50% 1RM progress to 85% 1RM

Time – 2-5 sets

Type - Combo of free weights, machines focusing on >2 muscle groups

LIFTMOR STUDY (n=101)

- Post-menopausal women
- COMBO high intensity progressive resistance and WB training for 8 months
- Increase in BMD in L-spine compared to lower intensity training program

Watson et al, 2018

IMPACT Exercise

Frequency – 2-3 days/week

Intensity – High

Time – 10-50 jumps/session, 1-2 mins rest every 10-20 reps

Type - Jump drop, jumping chin-ups, jump rope (>6months)

Balance Training

Frequency – >1-3 days/week

Intensity

Time – >15mins/day

Type - Dynamic and static balance

Weight bearing aerobic exercise

Frequency – >3 days/week

Intensity – RPE 11-14, 40-60% HRR, 3-6 METs

Time – >30mins/day

Type - walking, cycling, stepping, stair climbing etc.

Aerobic Training

- **Goals**
- Increase aerobic fitness
- Decreased CV risk factors
- Maintain bone strength
- Improve balance

Prescription:

- Perform 3-5 days/week at 40-60% of HRR

- 20-30 mins/session with slow increase to 30-60mins once tolerated

- Exercise mode should be weight bearing

‘Other’ Physical Activities

Frequency – >2-5 days/week

Intensity – Moderate intensity

Time – >10-60mins/day

Type - Tai Chi, foot stamping activity, Tae Kwon Do

Lifestyle Modifications

- Adequate Calcium (1,000-1,500mg d-1) Intake
- Adequate Vitamin D (600-800IU d-1) intake
- Regular exercise
- Smoking cessation
- Avoid excess alcohol intake
- Visual corrections to decrease fall risk
- Rapid weight loss? (Shahraki et al)

Types of Diet

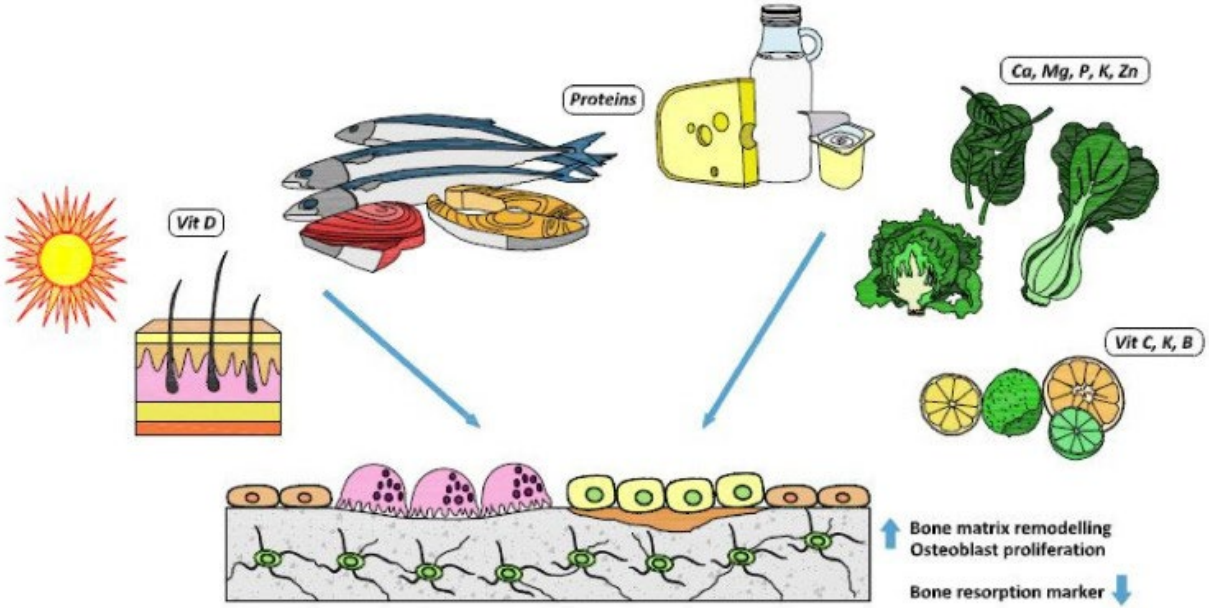
- **Mediterranean Diet**
- EPIC study, 2013 - 7% decreased risk in hip fracture incidence
- Meta analysis - 21% reduced risk of hip fracture (Malmir et al 2018)

- **Asian Diet**
- Adherence to vegetables, fruit, soy diet – 34% reduced risk of hip fracture (Diaz et al, 2018)
- Korean study – dairy and fruit pattern decreased risk of L-spine low BMD by 53% (Shin et al, 2013)
- White rice, kimchi, and seaweed dietary pattern increased risk of low BMD

- **Western Diet**
- Framingham study – higher intake of red meat, processed food → low BMD femur (Sahni, 2015)

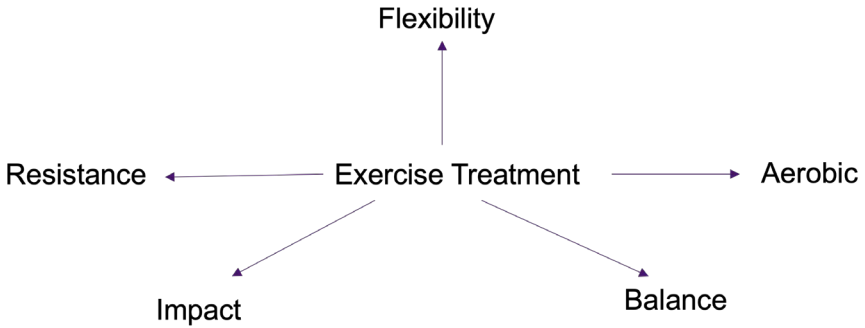
- **Vegetarian Diet**
- Meta-analysis– 4% lower BMD at femoral neck and L-spine (Bayesian et al, 2009)
- Fracture incidence also increased (Epic Oxford Study, 2009)

Diet



Munoz-Garach et al (2020)

Conclusion – Lifestyle Interventions



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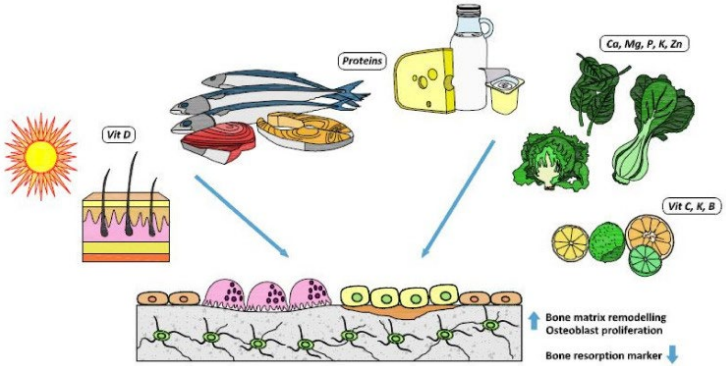

‘Individualized approach’

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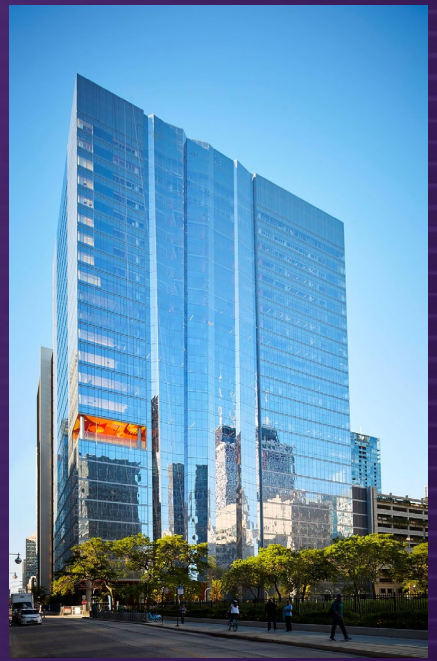
Questions?



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Questions from Audience Members

Physicians' powerful ally in patient care