

Bone Health Management

OTA Core Curriculum

October 2020

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Disclosures

I have no potential conflicts with this presentation.

My disclosures:

Reviewer - Journal of Surgical Education

Objectives

- Review the definition, epidemiology and implications of osteoporosis and fragility fractures.
- Learn how to identify fragility fractures.
- Understand the work-up for osteoporosis.
- Review current the current treatments for osteoporosis.
- Understand our role as orthopaedic surgeons in the identification, work-up and treatment of osteoporosis and fragility fractures.

Case

68 yo caucasian female tripped and fell while taking her trash out.

Presents with left shoulder pain.

PMH: hypertension, rheumatoid arthritis

PSH:

- right distal radius fracture ORIF 2 years ago (sustained after a ground level fall)
- appendectomy

Medications: lisinopril, steroids for RA

Allergies: NKDA

Case

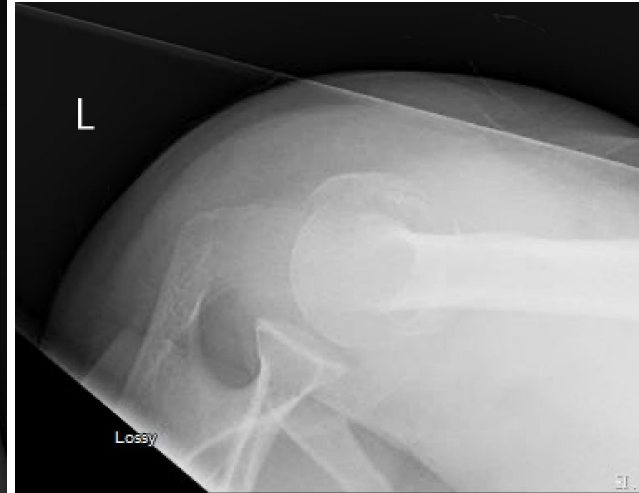
SH: former smoker

FH: mother had a hip fracture shortly before she died

PE:

- BMI 30 (180 lbs; 5'5" tall)
- Left upper extremity swollen and ecchymotic
- NV intact
- Pain with ROM of shoulder

Case



Is this a fragility fracture?

YES!

WHO Definition of a Fragility Fracture:

“A fracture caused by injury that would be insufficient to fracture normal bone; the result of reduced compressive and/or torsional strength of bone.”²⁸

- Fractures from low-energy mechanisms (falls from standing height)
- Fractures with no identifiable trauma.

Why do we care?

What is osteoporosis?

A “bone disease that occurs when the body loses too much bone, makes too little bone, or both.”

-National Osteoporosis Foundation (NOF)²¹

Osteoporosis Epidemiology

- 54 million people in the US have low bone mass¹⁷
- 10 million have osteoporosis in the US¹⁷
- More than 70 million people will be affected by 2030 according to the National Osteoporosis Foundation¹⁷

Osteoporotic Fracture Epidemiology

- ~9 million osteoporotic fractures occur worldwide per year²¹
 - That's a fracture happening every 3 seconds!
- 61% of osteoporotic fractures occur in women²¹
- Lifetime risk of an osteoporotic fracture for a man is more than 2x the lifetime risk of prostate cancer (27% vs 11.3%)!
- 1 in 2 women and 1 in 4 men over 50 years old will sustain an osteoporosis-related fracture.²³

Consequences of Osteoporosis & Fragility Fractures

- “Geriatric fractures threaten independence, cause institutionalization, and increase mortality risk.”¹
- Mortality after a hip fracture = 15-30% within the year!²³
 - 52.4% of deaths occur in the first 3 months
 - 72.5% occur within the first 6 months
 - 1-year mortality is 20% greater in men compared to women²¹
- Fragility fractures cost ~\$19 billion annually in the US²⁷

Why do we care?

Fragility fractures are a huge source of morbidity and mortality!

Osteoporosis & Joint Replacements

- ~60% of patients with a total joint arthroplasty (TJA) have/develop osteopenia or osteoporosis!²²
- 77% of arthroplasty surgeons believe poor bone quality influences the choice of implant yet only 5% test for osteoporosis.¹
- Identifying which patients have osteoporosis or osteopenia prior to joint replacement is helpful!

Osteoporosis & Joint Replacements

- Treatment decreases peri-implant osteoporosis, periprosthetic fractures and need for revisions!¹
 - DXA after TKA and THA shows bone loss around the implants as high as 20%!
 - Limited data exists but a meta-analysis shows bisphosphonates after THA and TKA can prevent osteolysis and stress-shielding around implants → 52-55% decrease in periprosthetic fracture and revision!

Osteoporosis & Spine Surgery

- 69-84% of all patients undergoing elective spine surgery have low vitamin D.¹
 - Low vitamin D is associated with:
 - Increased severity of pain from lumbar spinal stenosis
 - Increased time to fusion after lumbar fusion
 - 3.5x more likely to develop a pseudarthrosis

Osteoporosis & Spine Surgery

- Up to 50% of patients have osteopenia or osteoporosis who undergo elective spine surgery.¹
 - Higher rates of failed fusion
 - 50% of patients with osteoporosis have complications (kyphosis, hardware failure, fracture, screw loosening, subsidence, proximal junction fractures)
 - Treatment with bisphosphonates reduces the risk of these complications and decreases time to fusion¹

Does she have osteoporosis?

Osteoporosis Workup

Labs:

- CBC
- Fasting comprehensive metabolic panel to evaluate:
 - creatinine
 - LFTs
 - nutritional status via total protein & albumin levels
- Serum calcium, phosphate, magnesium
- TSH
- 25-hydroxy vitamin D level
- 24-hr urine calcium and creatinine
- Intact parathyroid hormone levels (PTH)
- Testosterone levels in men
- Other labs as indicated

Osteoporosis Workup

-25-hydroxy vitamin D level

- normal is between 20 and 40 ng/mL

Fracture Risk Assessment Tool (FRAX)

Estimates the 10-year probability of a hip fracture or combined risk of major osteoporotic fracture (hip, spine, shoulder, or wrist) based on risk factors and femoral neck BMD.

- Validated with and without knowing the femoral neck BMD
- Can be used to determine the need for pharmacologic therapy

Country: **US (Caucasian)** 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/cm²)
Select BMD

<https://www.sheffield.ac.uk/FRAX/tool.aspx>

Fracture Risk Assessment Tool (FRAX)

- Free online calculator at:
<https://www.sheffield.ac.uk/FRAX/tool.aspx>

What are her risk factors for osteoporosis?

68 yo caucasian female tripped and fell while taking her trash out.

PMH: hypertension, rheumatoid arthritis

PSH: right distal radius fracture ORIF 2 years ago (sustained after a ground level fall)

Medications: lisinopril, steroids for RA

Allergies: NKDA

SH: former smoker

FH: mother had a hip fracture shortly before she died

PE: BMI 30 (180 lbs; 5'5" tall)

What are her risk factors for osteoporosis?

68 yo caucasian F tripped and fell while taking her trash out.

PMH: hypertension, **rheumatoid arthritis**

PSH: **right distal radius fracture ORIF 2 years ago (sustained after a ground level fall)**

Medications: lisinopril, **steroids** for RA

Allergies: NKDA

SH: **former smoker**

FH: **mother had a hip fracture shortly before she died**

PE: BMI 30 (180 lbs; 5'5" tall)

Other Risk Factors for Osteoporosis:

- Excessive alcohol use (3+ drinks/day)
- Low body weight
- Limited exercise
- Low calcium and vitamin D intake
- Late menarche
- Early menopause (before age 40) ^{21,23}

Causes of Secondary Osteoporosis

20-30% of osteoporosis in women and >50% of cases in men are due to secondary causes!²⁴

*This is why a laboratory workup is important!

- Hyperparathyroidism
- Thyroid problems
- Hypogonadism
- Diabetes
- Multiple myeloma
- Inflammatory bowel disease
- Inflammatory arthritis
- Malabsorption problems
- Radiation (regional osteoporosis)
- Cushing's disease
- Eating disorders

Causes of Secondary Osteoporosis

Medications:

- Anticonvulsants
- Glucocorticoids
- Aromatase inhibitors
- Androgen deprivation therapy
- Proton pump inhibitors (PPIs)
- SSRIs
- Depo-Provera
- Coumadin¹³
- High-dose statins (low-dose statins may be protective!)¹⁸

What is our patient's FRAX score?

Country: **Canada**

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/cm²)

Select BMD

Clear

Calculate

BMI: 30.0

The ten year probability of fracture (%)



without BMD

Major osteoporotic

48

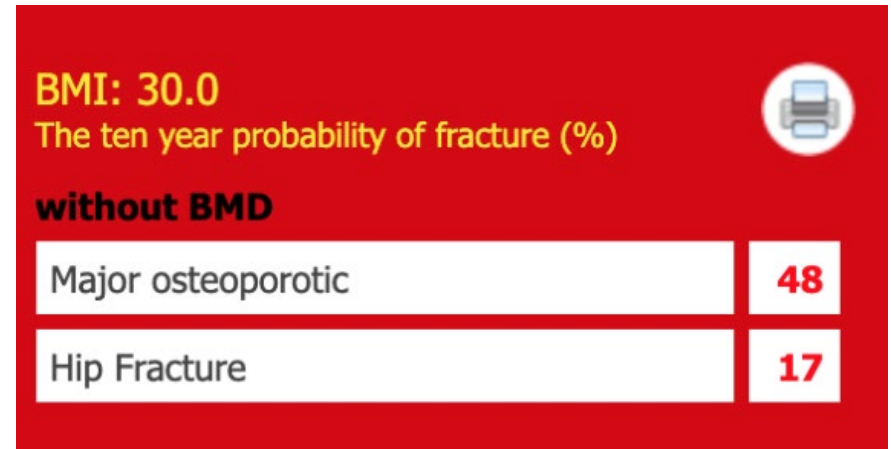
Hip Fracture

17

Fracture Risk Assessment Tool (FRAX)

- >3% risk for hip fracture or greater than 20% for any major osteoporotic fracture → recommend medical treatment in postmenopausal women age 50+.^{21,23}

**Our patient needs
treatment!**



BMI: 30.0
The ten year probability of fracture (%)

without BMD

Major osteoporotic	48
Hip Fracture	17

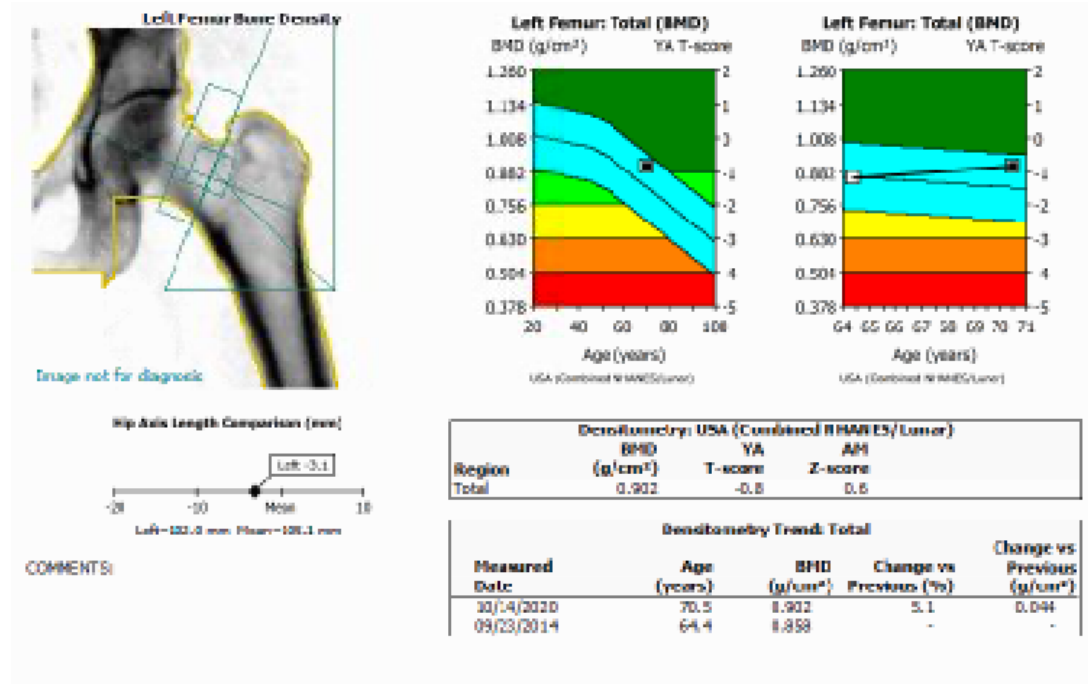
Dual X-ray Absorptiometry (DXA) Scanning

- Determines the bone mineral density at the distal part of the radius, hip, and lumbar spine.
- Indications:
 - Men \geq 70 yo
 - Women \geq 65 yo
 - Younger men and women with risk factors^{21,23, 28}



Dual X-ray Absorptiometry (DXA) Scanning

- T-score: compares the patient's BMD to a 30 y/o woman
- Used to diagnose postmenopausal women and men > 50 yo



Dual X-ray Absorptiometry (DXA) Scanning

	T-Score
Healthy Individual	> -1
Osteopenia	-1 to -2.4
Osteoporosis	≤ -2.5

*standard deviations below the mean

- Severe osteoporosis = the addition of a fragility fracture²³

Dual X-ray Absorptiometry (DXA) Scanning

- Z-score: compares the patient's BMD to a healthy age-matched control of the same sex and race
 - Used in children and patients < 50 y/o
- Z-score ≤ -2.0 in a premenopausal woman or a man < 50 y/o = low BMD for chronological age
 - look for secondary causes of osteoporosis.²¹

DXA scans are important for diagnosing osteoporosis, but...

Osteoporosis can be diagnosed based on low-energy hip or spine fracture, no matter what the DXA scan shows!

Case

The patient's DXA results:

- T-score: -2.5

Does she have osteoporosis and does she need treatment?

Yes! Her T-score indicates osteoporosis and her FRAX scores are high enough to recommend treatment!

Dual X-ray Absorptiometry (DXA) Scanning

- Should be repeated every 3-5 years in at-risk patients.²³
- Changes in DXA scans do not always correlate with fracture risk, even if on treatment.
 - Fracture risk decreases upon starting treatment, even before changes are seen on DXA scans.
 - Therefore, more frequent DXA scans are not indicated.
- There is significant variability among DXA machines. Unless the scan is done on the same machine, results may not be comparable.

Can you tell if she has osteoporosis based on her xrays?

Osteoporosis cannot be formally diagnosed on xray, but osteoporotic changes can be seen on xray if there is at least 30-50% bone loss.¹⁴



Other Imaging Modalities

High-Resolution Peripheral Quantitative CT²¹

- Assesses the microarchitecture of the distal skeleton → volumetric BMD of cortical and trabecular bone
- Need more research on this.

Quantitative Ultrasound of the Heel (QUS)¹⁰

- Predicts future hip fracture risk as well as DXA
- Portable, cheaper, no radiation, & doesn't require specially-trained technicians

Case

“So what do I do about my osteoporosis?”

Osteoporosis Treatment

- Activity modification & lifestyle changes
- Medical therapy

Activity Modification & Lifestyle Changes

- Diet changes
 - Low protein levels are associated with fractures in the elderly.
 - Low vitamin K (in leafy green vegetables, soybean and canola oil) is also associated with osteoporosis.
- Smoking cessation
- Decreased alcohol consumption
- Increased activity
 - Weight-bearing exercise
 - Resistance exercise

Osteoporosis Treatment - Exercise

Weight-bearing aerobic exercise:

- Walking alone probably doesn't improve overall BMD
- \geq 12 months of Tai Chi may improve BMD

Resistance exercise:

- Results in small, but significant localized improvements in BMD.³
 - Example: stair climbing and squats improve BMD in the hip and lumbar spine
- 3x/week x 1 year to be effective³

Why do weight-bearing exercises increase bone mineral density?

Wolff's Law - bone remodels in response to mechanical stress

Osteoporosis Treatment - Exercise

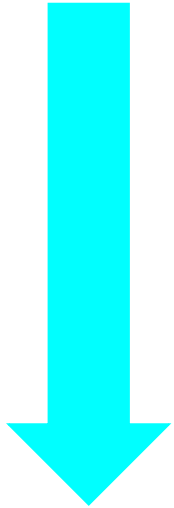
- Reduces the risk of falls.⁸
- Exercise results in femoral neck and lumbar spine BMD improvements which reduce fragility fracture risk by 10%!⁸
- 120-300 minutes of moderate or higher intensity activity per week was associated with fewer hip fractures in older adults.
 - Adding in resistance and balance exercises → fewer falls²¹

Vitamin D & Calcium Supplementation

- **1 billion** people are deficient or insufficient in vitamin D worldwide!!²⁶
 - 77% of Americans
- >50% of patients sustaining a fragility fracture have low vitamin D levels.⁶

- 1000-1200 mg calcium citrate
 - easier on the stomach and to digest
 - divided in 2 doses
- 2000 units vitamin D3
 - Improved absorption when taken with fat
 - Ergocalciferol is no longer recommended (due to issues with accurate laboratory measurements)!¹

Vitamin D & Calcium Supplementation



Risk of hip fractures by 30%²¹

Risk of all fractures by 15%²¹

Risk of hip fractures in a nursing home environment by 23%¹

Medical Treatment

Indications:

- Low risk for future fractures → activity modification & vitamin D/calcium supplementation
- High risk → above + medical therapy

Medical Treatment

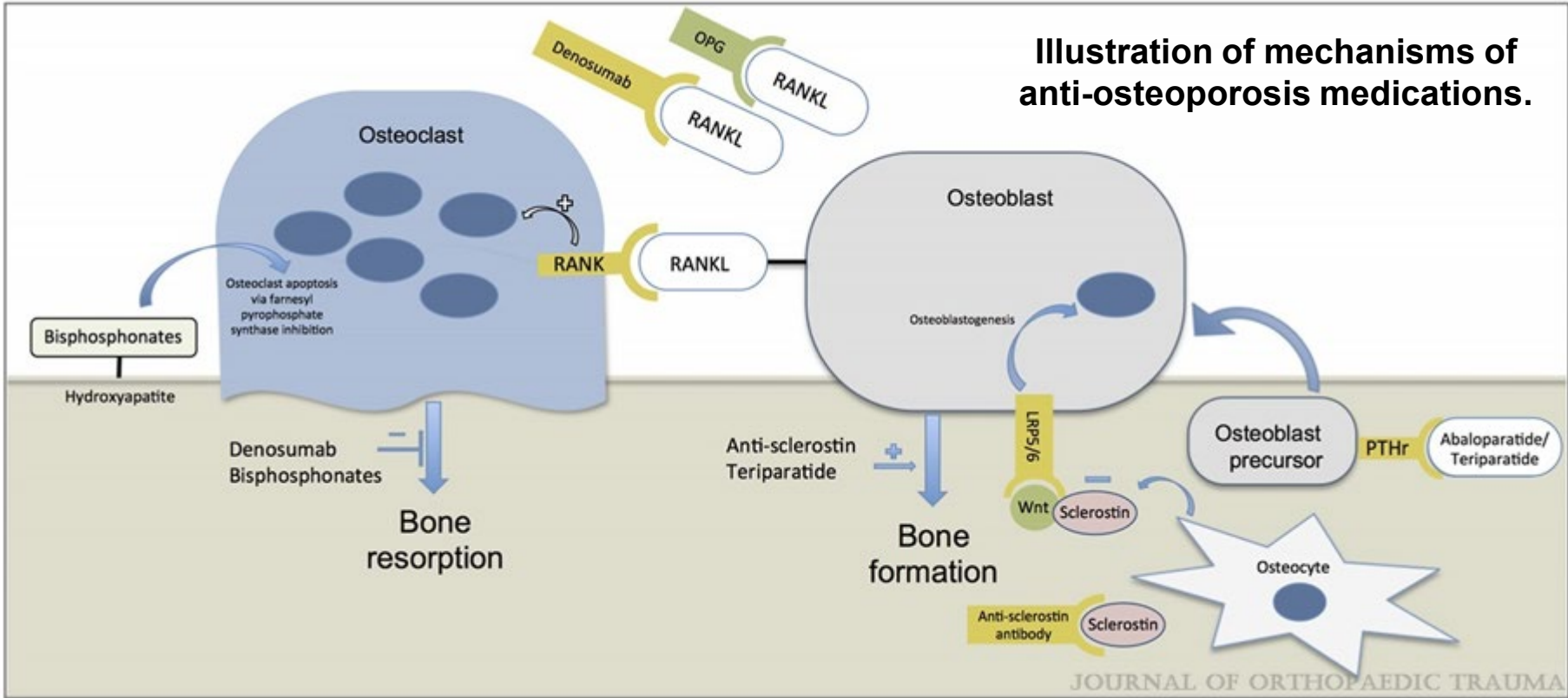
Antiresorptive Drugs (Catabolic Agents):

- *Bisphosphonates*
- *Denosumab*
- Calcitonin
- Estrogen
- Selective estrogen receptor modulators

Bone Stimulants (Anabolic Agents):

- *Recombinant parathyroid hormone*
- *Romozosumab*
- Strontium ranelate

Illustration of mechanisms of anti-osteoporosis medications.



JOURNAL OF ORTHOPAEDIC TRAUMA

Image from: Cohn MR, Gianakos AL, Grueter K, et al. Update on the Comprehensive Approach to Fragility Fractures. Journal of Orthopaedic Trauma 32(9):480-490, September 2018. doi: 10.1097/BOT.0000000000001244

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Core Curriculum V5

Bisphosphonates

Pyrophosphate analogs that bind to calcium in bone and prevent bone loss due to osteoclast inhibition.²³

Bisphosphonates

Non-nitrogen-containing:

- Make ATP analogs that build up in osteoclasts → osteoclast apoptosis
- Older, less potent
- Examples: etodronate

Nitrogen-containing:

- Inhibit farnesyl transferase in osteoclasts → osteoclast apoptosis
- More potent
- Less frequent dosing
- Examples:
 - alendronate (Fosamax)
 - zoledronic acid (Reclast & Zometa)
 - ibandronate (Boniva)
 - risedronate (Actonel)

Case

“I don't know doc. I've heard a lot of bad things about these drugs and I'm worried about the side effects.”

Bisphosphonates



Risk of vertebral compression fractures by 45-70%¹

Risk of hip fracture by 40-45%¹

Risk of other fractures by 15-25%¹

- Shown in multiple randomized controlled trials²³
- Cost-effective!
- **Treating 1000 patients x 3 years prevents 100 fractures!**
 - **NNT: 10!**

Bisphosphonate Risks

- The most common side effects are upper GI symptoms.^{21, 23}
 - 20% to 30% will experience these side effects from oral medications
 - Increased risk in older individuals
 - Reduce the risk by avoiding NSAIDS, taking with plenty of water and remaining upright for 30 minutes after ingestion
 - Can avoid with IV administration (30% get flu-like symptoms)

Bisphosphonate Risks

Atypical femoral fractures:

- 1.74 fractures per 10,000 patient-years
- Risk goes up with duration of treatment with bisphosphonates
- Risk factors = Asian race, glucocorticoid use, decreasing height and increasing weight
- Risk goes down rapidly with discontinuation!

Bisphosphonate Risks - Atypical Femur Fractures (AFF)

- In a study in the NEJM, after 5 years of bisphosphonate treatment in white women:
 - 286 hip fractures were prevented!
 - 859 fragility fractures were prevented!
 - 8 atypical femur fractures occurred!

The benefit far outweighs the risk of AFF!

Bisphosphonate Risks

Jaw osteonecrosis:

- RARE!
- 0.7 per 100,000 persons per year
- Reduce the risk by completing any possible dental work prior to starting the medication.

Bisphosphonate Therapy Duration

- Bisphosphonates can last in bone for 30-60 years!!¹ → “bisphosphonate holidays”
 - Stop oral bisphosphonates after 5 years.
 - Stop IV bisphosphonate after 3 years.
- Can be resumed with modified dosing when bone mass decreases on DXA scanning again.²³
- “Bisphosphonate holidays” decrease the risks of bisphosphonates²³

Can bisphosphonates will delay fracture healing?

Probably not.

Some conflicting studies regarding this exist but the majority of studies do not show a negative effect on fracture healing.

Bisphosphonates & Fracture Healing

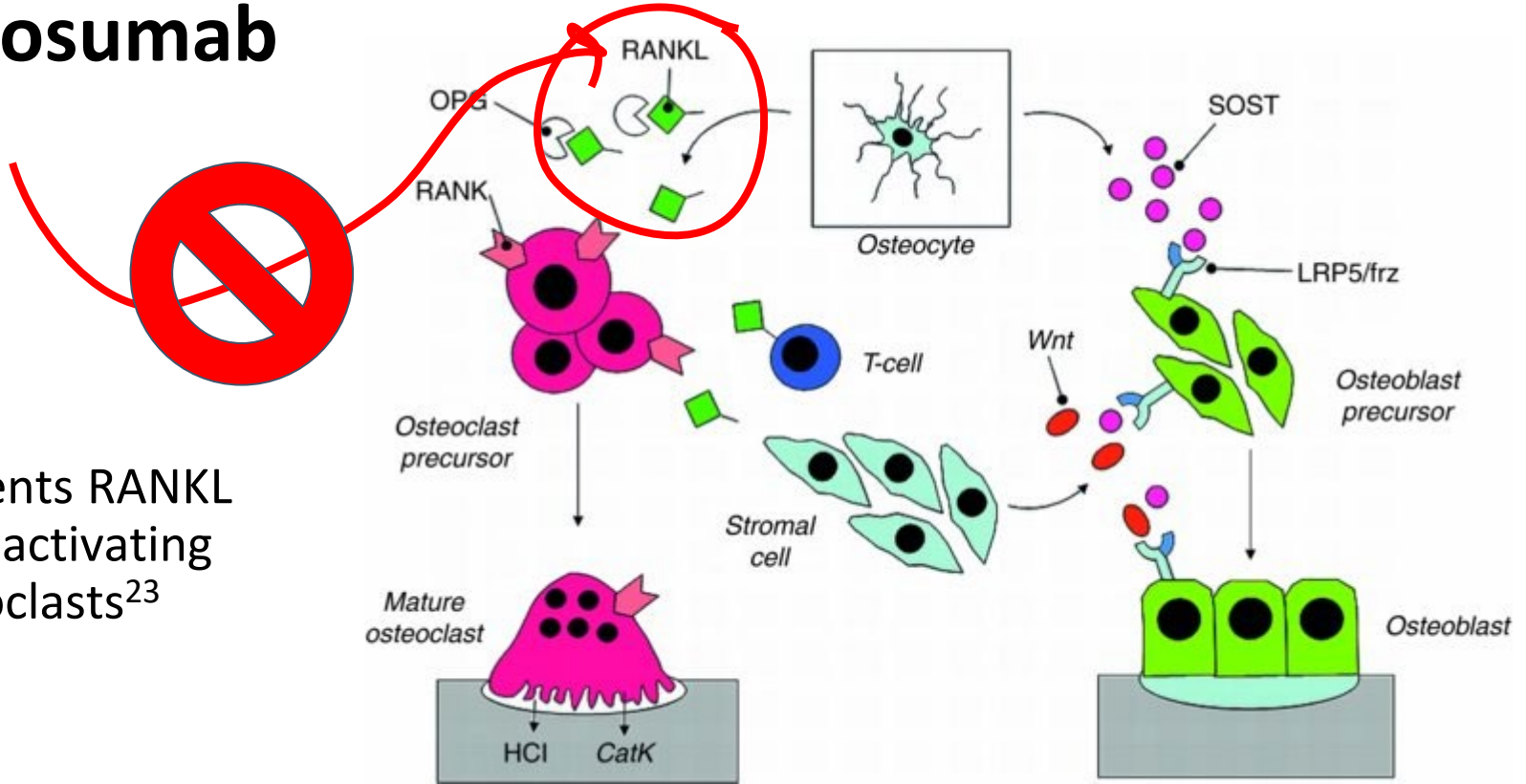
HORIZON Trial⁴

- No difference in fracture healing between zoledronic acid and placebo.
- No difference in fracture healing when zoledronic acid was started within 2 weeks after fracture vs 12 weeks post-fracture.

Denosumab

Monoclonal antibody that inhibits RANKL (receptor activator of nuclear factor kappa-B ligand)

Denosumab



Prevents RANKL
from activating
osteoclasts²³

Image from: Ralston, SH. Osteoporosis and Metabolic Bone Disease. In: Tornetta P, Ricci WM, eds. Rockwood and Green's Fractures in Adults, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.

Denosumab

Randomized controlled trials in women with osteoporosis show that compared to placebo, denosumab showed a significant reduction in:

- vertebral fractures
- non-vertebral fractures
- hip fractures²³

Denosumab

- Useful in renal insufficiency (bisphosphonates are contraindicated in CKD)
- Osteonecrosis of the jaw is a rare side effect.
- Rebound vertebral compression fractures can occur with discontinuation so treatment with a different osteoporosis medication should be considered when stopping denosumab.
- Atypical femur fractures can also rarely occur.

Recombinant Parathyroid Hormone

- When dosed intermittently (once daily), it has an anabolic effect on bone and leads to an increase in BMD.
- More continuous dosing leads to bone resorption.
- Teraparotide and Abaloparatide

Recombinant Parathyroid Hormone

- Uses:
 - Patients with severe osteoporosis
 - Can't tolerate bisphosphonates or need a bisphosphonate holiday
 - Teraparotide reduces the risk of vertebral fractures and other fractures, but not hip fractures²¹
 - Abaloparatide decreases the risk of all fractures²¹
- Results in quicker healing of distal radius and pubic rami fractures

Recombinant Parathyroid Hormone

Risks:

- Most common side effects: nausea, headache, transient hypercalcemia
- **BLACK BOX WARNING:** Long-term use and use in Paget's disease is associated with osteosarcoma.
 - Contraindicated in Paget's disease
 - Max treatment duration = 2 years
 - Not seen with low-dose, short-term use²³

Recombinant Parathyroid Hormone

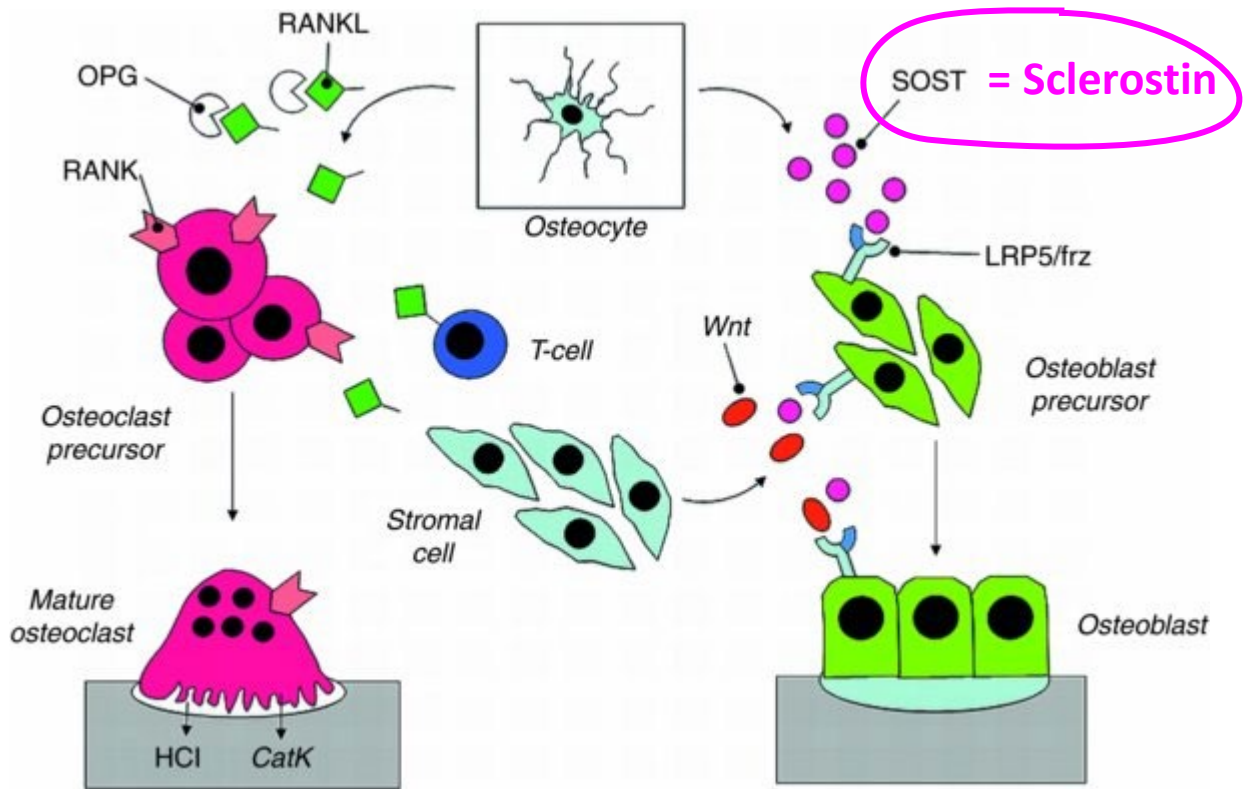
Switch to a bisphosphonate at the end of treatment with rPTH to avoid rapid bone loss.

Romosozumab

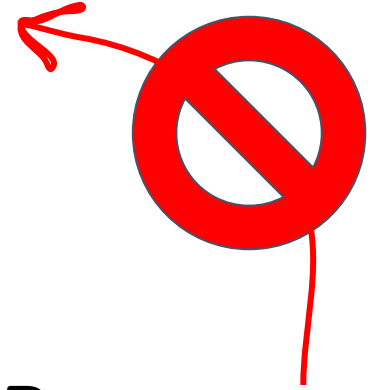
- Monoclonal antibody against sclerostin^{12, 25}
 - Sclerostin = cytokine secreted by osteocytes that inhibits the Wnt signaling pathway that controls osteoblast formation and activity^{12, 25}
- Increases bone formation AND decreases bone resorption!^{12, 25}
- Effectiveness at increasing bone formation decreases after 1

year.²⁵





SOST = Sclerostin



Romsozumab

Image from: Ralston, SH. Osteoporosis and Metabolic Bone Disease. In: Tornetta P, Ricci WM, eds. Rockwood and Green's Fractures in Adults, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.

Romozozumab

- ARCH study showed a 38% relative risk reduction of hip fracture compared to those taking alendronate!¹²
- Indications¹²:
 - Post-menopausal women
 - Patients with contraindications to rPTH (history of previous radiation, CKD) or who have completed their 2-year treatment course with rPTH
- **BLACK BOX WARNING:** may increase the risk of MI, stroke or CV death!^{12, 25}

What is our role as orthopaedic surgeons in the management of patients with fragility fractures?

It's not enough to just treat their fracture!

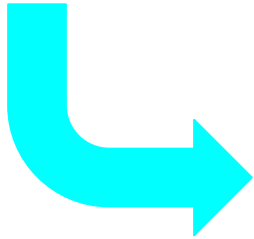
- < 25% of patients with a 1st time fragility fracture receive osteoporosis treatment.¹⁷
- Rate of pharmacologic treatment for osteoporosis is only around 20%!¹
- *Having a fragility fracture is the greatest risk factor for having another fragility fracture!*

It is our responsibility to get these patients the education and treatment they need!

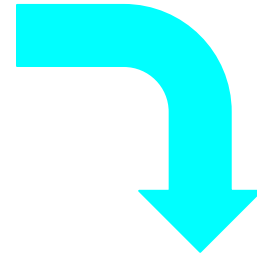
“Own the Bone”

- Nationwide initiative started by the American Orthopaedic Association (AOA) in 2009¹
 - Goals:
 - Set up a Fracture Liaison Service to identify, evaluate and treat patients > 50 yo who are at risk for osteoporosis
 - Prevent additional fractures

Prior to instituting “Own the Bone”, only ~1/3rd of women and 1/6th of men were being worked up & treated post-fragility fracture.



OWN THE BONE



53% of patients after a fragility fracture were tested for osteoporosis and treated!^{2,7}

Fracture Liaison Services

- Improves identification of patients who need to be evaluated and treated.⁶

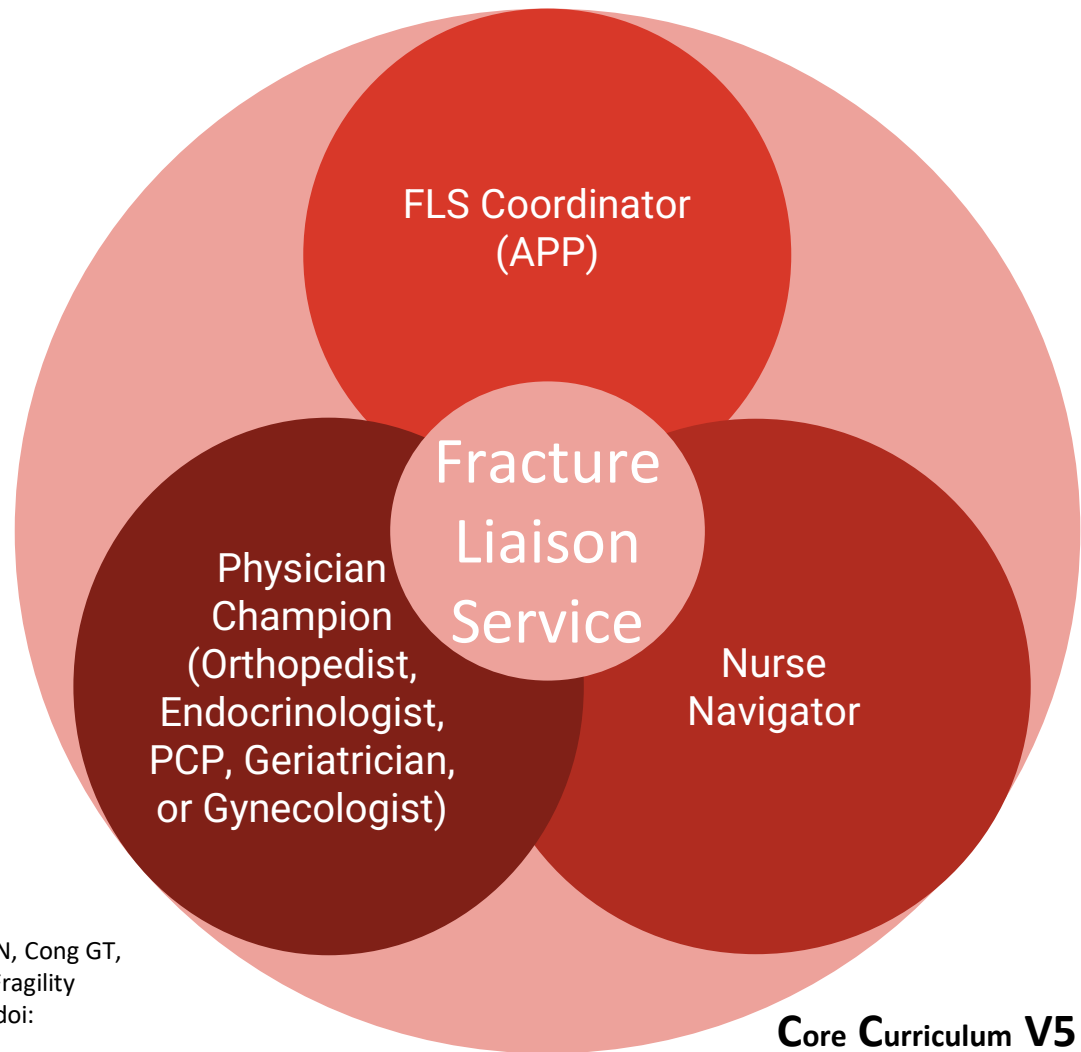


Image from: Cohn MR, Gianakos AL, Grueter K, Rosen N, Cong GT, Lane JM. Update on the Comprehensive Approach to Fragility Fractures. J Orthop Trauma. 2018 Sep;32(9):480-490. doi: 10.1097/BOT.0000000000001244. PMID: 30036208.

Inpatient Stay

FLS coordinator & Nurse Navigator

- Identifies at-risk patients in the hospital
- Performs a Metabolic Bone Health Consult
- Lab ordered and drawn prior to surgery (to ensure accuracy of their baseline health)
- Recommends vitamin D & calcium
- Provides education on lifestyle changes/activity modification
- Outpatient referral

Outpatient Follow-Up

- DXA
- FRAX
- Initiate pharmacologic therapy prn

Long-term Follow-Up

- Work on treatment compliance
 - Adherence to medication therapy is low! 30% at 1 year!¹⁷
- Repeat DXA scan every 3 years
- “Bisphosphonate holidays”



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Our Role as Orthopaedic Surgeons

- Identify at-risk patients & those with fragility fractures
- Educate your patients
- Is there a developed pathway for these patients in your hospital system?
 - If so, get them looped in!
 - If not, order necessary testing & start treatment if indicated.
 - Work to develop a pathway for these patients.

Take Home Points:

- Osteoporosis and fragility fractures are a major source of morbidity and mortality.
- The rate of osteoporosis treatment after fragility fractures is low.
- Bisphosphonates are the first-line pharmacologic treatment of osteoporosis!
- **Identification of fragility fractures and getting these patients evaluated and treated for osteoporosis is our responsibility as orthopaedic surgeons!**
 - In doing so, we can prevent future fragility fractures!

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