Fragility Fractures- the problem, advances & treatment

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What is covered

• Demographics
• Bone issues
• Mechanisms
• Basic Surgical considerations
• Avoiding failures
• Post fracture management
Fragility Fracture

- Caused by a fall from a standing height or less
- Osteoporosis is most common cause
- 33 to 50% of women will get a fragility fracture
- 15 to 33% of men get a fragility fracture
- Likelihood increases with age
Fragility Fractures- Risk Factors other than osteoporosis

• Women: Diabetes
  Previous fractures
  High BMI - ankle and prox humerus

• Men: Diabetes
  Mental Health hospitalizations

Holmberg et al; Osteoporosis Int. 2006
## Incidence of Osteoporotic Fractures (United States)

<table>
<thead>
<tr>
<th>Fracture Site</th>
<th>Annual Incidence</th>
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</thead>
<tbody>
<tr>
<td>Hip</td>
<td>350,000+</td>
</tr>
<tr>
<td>Vertebral (Morphometric)</td>
<td>750,000</td>
</tr>
<tr>
<td>Wrist</td>
<td>200,000</td>
</tr>
<tr>
<td>Other</td>
<td>300,000+</td>
</tr>
</tbody>
</table>

Only 30% of morphometric vertebral fractures are “clinically apparent”. 
Demography: projection of Hip Fractures growth from 1950 to 2050

<table>
<thead>
<tr>
<th>Location</th>
<th>1950</th>
<th>2050N</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>378,000</td>
<td>742,000</td>
</tr>
<tr>
<td>South America</td>
<td>100,000</td>
<td>629,000</td>
</tr>
<tr>
<td>Europe</td>
<td>400,000</td>
<td>668,000</td>
</tr>
<tr>
<td>Asia</td>
<td>600,000</td>
<td>3,250,000</td>
</tr>
</tbody>
</table>

What is Osteoporosis?

Skeletal disorder with

- Compromised bone strength
- Increased risk of fractures
- Deterioration of micro-architecture
- Most common bone disease
- Genetic basis (under study)
- Uncoupling of osteoblastic & osteoclastic activity
Current Problem in US

- >5 million older women at high risk of fx
- 1/3 of these have osteoporosis diagnosis
- ¼ of these are on appropriate treatment

Gehlbach et al; Osteoporosis International 2007 June
Osteoporosis

Loss of critical bony inter connections, thinner internal support

Trabecular bone loss and thinning of remaining bone is seen above

Osteoporosis is loss of bone mineral density and critical reduction in strength of bony architecture
Bones change during Life

- Modeling as a child and adolescent
- Remodeling throughout life
- Peak bone mass reached in your 20’s
- Remodeling allows bones to heal
- Resorption in later years
Bone mass changes during life

- Peak bone mass is reached at age 25
- Heredity
- Medications
- Diet, tobacco and alcohol
- Race / Weight
Bending Stiffness / Cross section

Cross section of normal bone

Inner and outer
Diameters increase

Cross section through
Osteoporotic bone
Issues with Osteoporotic Bone Fixation in surgery

- Poor screw purchase
- Fragile cortices
- Difficult or impossible to get rigid fixation
- Initial deformity prone to recurrence
Conventional plate / screw failure

Screws pull out of bone sequentially
Locked plate failure
all screws fail at once

Plate-screw connection
Is solid
Screw-bone interface
Fails as a unit
Mono- vs. bicortical screw fixation
Monocortical screw fixation is not good in fragility fractures

With thin cortices

- Choose screw diameter as large as possible
- Bi-cortical fixation
“Working length“ of bicortical screws

3x More Stable
Mono locked
Std Bicortical
Torsional stiffness

10 months postop. 5 days later
Bridging with Locked Implant
Concepts of Plate Fixation in Osteoporotic Bone

- Tough to employ compression technique
- Bridge plating useful
- Neutralization plates useful
- Long plate for bone protection

Imperfect reduction--but the fracture has Gone on to heal
Why is osteoporotic Bone a problem?

- Loss of cortical thickness
- Loss of bony trabeculae
- Loss of microarchitecture
Signs your patient has bad quality bone

- Poor dentition: Teeth are formed similar to bone
- Multiple vertebral compression fractures
- Previous hip, radius or tibial plateau fracture
- End stage renal disease
- On steroid therapy
- Anticonvulsant use
Osteoporotic Trabecular Bone: Clinical Consequences

- Cut out
- Loss of screw fixation
- Spontaneous fractures
Choice of implant
Many options, reduce the fracture first

One Fixed angle with Blade plate

Multiple fixed angles, longer implant
Varus collapse due to lack of medial buttress
Technique: Impaction intraoperatively
Augmentation in practice
If bone is very poor, consider prosthetic replacement.
Don’t forget the soft tissues

Exposed implant = infection
Incidence of Failures

• Hip: 3 to 5%
• Distal Femur: 5%
• Proximal humerus 30 to 40%
• Ankle 12%
• Distal Humerus 19%

* Srinivasan and Moran; Injury, 2001; ** Korner, J Osteoporosis Int 2004
‘ Oswley, K JBJS 2008; ‘ Smith, TO, Injury 2009
Case Example: Female 82 years

Lag screw cuts out because the screw is not inserted deeply in the head. A 2 hole plate is also good enough, 4 hole plate is not needed.
What areas are at risk for Fixation

• Metaphyseal > Diaphyseal Bone
• Hip
• Distal Femur
• Proximal Humerus
• Ankle
• Proximal Tibia
• Distal Radius
Types of Failure

• Cut-out
• Cut through
• Plate pull –off
• Varus collapse
• Non-union
What Factors contribute to Fixation Failure?

- Poor bone quality
- Metabolic Bone problems
- Fracture Reduction quality
- Implant choice
- Implant Placement
Metabolic Bone Problems - secondary

- Vitamin D deficiency
- Steroids
- Hyperparathyroidism
- Dialysis

- All cause dramatically reduced bone quality and poor healing
Male 70 years, alcoholic

“AP and Lateral”

Fell while intoxicated
Fixed with Strut Graft and Rigid

- Long plate
- And Strut graft
- Short working length of plate
- Reduction
15 months

Knee pain and can’t walk

Nonunion
Broken plate

Causes: Disturbed biology
No metabolic bone assessment
Fracture Reduction Quality matters!

- Bony apposition important – Avoid a gap
- Stable reduction
- Correct rotation
- Angular alignment
Example of Reduction induced failure
Implant Choice

- Correct length and working length
- Correct Principle
- Correct number of screws
- Correct stiffness
Implant choice
A nail is better here
Wrong Implant Choice
Wrong implant
Nail too large for canal

Fracture distal to short nail used for Reverse obliquity sub-trochanteric fracture
Femoral Bow
Nails that are too straight....

- Watch anterior bow*

* Penetration of distal femoral anterior cortex during Intramedullary nailing for subtrochanteric fractures
Ostrum and Levy, J Orthop Trauma April 2006
Haidukewych,G  JBJS 2009
Implant Placement

- Correct placement is often critical
- Tip – Apex distance – Hip
- Correct starting point for IM Nail
- Correct location on the bone
Poor Tip-Apex distance
Starting Point Error

Haidukewych, G, JBJS 2009
Plate on Wrong side of bone
Screws too close to joint
Follow the 4 AO Principles

1. Accurate fracture reduction
2. Stable Fixation
3. Preserve Blood Supply
4. Early mobilization of limb and patient
How to Fix the Failures

- Revision osteosynthesis
- Prosthetic Replacement
- Change Fixation method
Nail Cut-out Revised to Prosthesis

Lateral bow
Makes straight
Stem rubs lateral cortex
Cut out revised to tumor prosthesis
-Too much surgery
Cut through with second fracture

Difficult Initial surgery
Minor re-injury
Revised to Prosthesis
Failed Revision Osteosynthesis Revised to Tumor prosthesis

Third Revision osteosynthesis has failed
Female 83 yrs - Failed Plating
Revised to Nail

14 months post plating
7 months after revision
Inadequate fixation
Revision to prosthesis

Plate pull-off revised to Nail
Male 65 years, alcoholic
Screw Penetration Revised to prosthesis
Early Screw Penetration
Revised by shortening screws

Preoperative

2 weeks, screw in joint

6 months
Failed DCS revised to augmented hip screw

Calcium phosphate cement augmentation
Avoid Failures
correct Guide wire placement
Assess the fracture for stability

Fractured calcar
Varus position
Impact the Fracture for stability

3 months

9 months
Avoid Stress Concentration between implants
Failed Fixation, 4 surgeries

Broken plate
Installed 5 months earlier

Varus deformity

Low Vitamin D level
Correct the deformity.....
and metabolic problem.

Preop Planning
Don’t leave a void if possible
Female, 73 years with osteoporosis
Summary

• Plan your cases
• Assess the bone quality
• Proper implant choice and placement
• Reduce the fracture
• Impact the fracture if needed
• Respect the bone biology
• Bridging construct for comminution
Basic Post Fracture Osteoporosis Workup: Metabolic

- 25-OH Vitamin D level
- Intact PTH Level
- Calcium
- Phosphate
- TSH
- Albumin level
Causes of Osteoporosis

• Primary
• Secondary
• Nutrition
• Lifestyle (Exercise, smoking, alcohol)
• Hormonal problems
• Age
• Medications (steroids, seizure meds)
Keeping the bone healthy

• Genetic factors – unclear transmission
• Moderate Physical activity
• Calcium
• Vitamin D
• Hormones Parathyroid hormone
  Calcitonin
• Estrogen
• Testosterone
Remember Metabolic Health

• Serum Albumin < 3 = higher mortality**
• Vitamin D levels – often low *
• Parathyroid Hormone level
• Calcium level

• Avoid malnutrition and Osteomalacia in your elderly patients!

• Guisti, Barone, Razzano, Pizzonia, Oliveri, Palummmmeri, Pioli; J Endocrinol Invest Oct 2006
• Bukata et al, CORR 2011
Diagnosis of Osteoporosis

• DEXA Scan is best at present

  • T score
    Compares density relative to peak bone mass
    (Normal healthy 25 year old)
    Matched to sex and race

  • Z score
    Compares density to peers
Osteoporosis: a 2-Stage Disease

• With
• Without Fracture
Hip Fracture
Lifetime incidence in women 1:6
Diagnosis of Osteoporosis Using Central DXA
WHO-Definition

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>T-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&gt; -1</td>
</tr>
<tr>
<td>Osteopenia</td>
<td>&lt; -1 and &gt; -2.5</td>
</tr>
<tr>
<td><strong>Osteoporosis</strong></td>
<td>≤ -2.5</td>
</tr>
<tr>
<td>Severe Osteoporosis</td>
<td>≤ -2.5 with Fracture</td>
</tr>
</tbody>
</table>

*Mainly for Spine and Hip in Women*
Who Should be Tested?

- All women aged 65 and older regardless of risk factors*
- Younger postmenopausal women with one or more risk factors (other than being white, postmenopausal and female).
- Postmenopausal women who present with fractures (to confirm the diagnosis and determine disease severity).
- Many women with osteopenia will fracture*

*Pasco et al.; Osteoporosis International, 2006
What Medicare covers DEXA every 2 years

- Estrogen deficient women at clinical risk for osteoporosis
- Individuals with vertebral abnormalities
- Individuals receiving, or planning to receive, long-term glucocorticoid (steroid) therapy
- Individuals with primary hyperparathyroidism
- Individuals being monitored to assess the response or efficacy of an approved osteoporosis drug therapy.
Workup for the Fragility Fracture patient

- Labs: Basic
  - Intact PTH
  - 25 vit D level
  - serum calcium

Advanced
- serum alkaline phosphatase
- 24 hour urinary calcium
- urine N-telopeptide
- TSH
What about Men?

- Higher peak bone mass
- Fragility fracture
- Steroid use
- Forearm fracture
- Vertebral fracture
Osteoporosis is Treatable

- Nutrition
- Exercise
- Lifestyle changes
- Medications
- Fall prevention
- No treatment completely abolishes fracture risk
Nutrition

- Calcium requirements
- Young 1000mg / day in 2 doses
- Older 1500mg /d in 3 doses
- Calcium gluconate
- Calcium Citrate
- Calcium Carbonate
- Whichever is tolerated
Body weight

• Very low weight is a risk factor BMI < 18
• Normal weight best
• Obesity predisposes to falls
Vitamin D3

- Deficiency is common with age
- Lack of sunlight
- Deficiency = Osteomalacia
- Very common in Nursing homes
- May cause fracture not to heal
Vitamin D3

- Vitamin D3 -not D2- is best
- Dose - Young 400 units / d
- Older 800 units / day - maintenance
- If deficient, D2 50,000 units / wk
- 25 OH Vit D level to diagnose deficiency
- Sunlight helps - Essential for bone health!!!
Exercise

- Weight bearing exercise best
- Low impact exercise can help prevent falls
- Weight training
- Tai Chi
- Exercise helps other body systems too
- Patients have control over this!
- Helps to start young
Fall Prevention

• Medications can cause falls
• Poor lighting
• Throw rugs
• Fall proofing the home
• Exercise, balance and strength training
• Correct the vision
• Pets
Lifestyle

- Alcohol in moderation only
- Alcohol can cause osteoporosis
- Alcohol can cause falls
- Cigarette smoking causes osteoporosis
- Slows bone healing
- Smoking cessation is the best plan
Medications

- Many medications harm the bones
- Steroids (Prednisone)
- Seizure drugs
- Elevated Thyroid hormone
- Cancer drugs (Lupron)
- Avoid these if possible
- DEXA scans necessary with these
Osteoporosis Medications

- Antiresorptive drugs
- Anabolic therapies
Osteoporosis Treatments

Stimulators of bone formation
Anabolic

Inhibitors of bone resorption

Stimulators of bone formation
Inhibitor of bone resorption
Anti-resorptive Therapies

Bisphosphonates

• Non hormone compounds
• Bind to Hydroxyapatite crystals
• Inhibit Osteoclastic activity
• Cause Osteoclasts to die prematurely
• Half life 6 to 10 years in bone
• Can be taken by mouth or IV
Oral Bisphosphonates

- Alendronate (Fosamax)
- Risedronate (Actonel)
- Ibandronate (Boniva)
- IV bisphosphonates are used when oral medications are not tolerated
- Work for men and women
- Best treatment for steroid osteoporosis
Bisphosphonates - problems

- Reflux
- Must be upright for one hour
- Mostly GI symptoms
- Rare: osteonecrosis of mandible
- Long term effects not known
- Need to take Ca, Vit D*
- Compliance a problem*

*Adami et al.; J Bone Mineral Research, 2006 Oct
Anti-Resorptive: SERM’s

- Raloxifene and Tamoxifen
- Bind to Estrogen Receptor
- Have a good effect on Bone density
- For women only
- Should be used with Calcium, Vit D
- Reduces risk of breast cancer
- Increases risk of DVT
Calcitonin

- Hormone that regulates calcium, bone
- Synthetic Salmon calcitonin
- Decreases bone resorption
- Reduces pain from Vertebral fractures
- Nasal spray or injection
Teriparatide (Forteo)

- Synthetic hormone like human Parathyroid hormone 1-34
- Builds bone mass
- Improves bone quality
- Increases the life span of osteoblasts
- Injection for 2 to 3 years
- May increase periosteal thickness, activity
Teriparatide (Forteo)

- FDA approved for women with:
  - High fracture risk
  - Multiple fractures
  - Failure of other therapies
- For men with:
  - Hypogonadal osteoporosis
  - High fracture risk men
Teriparatide Contraindications
PDR Black Box

• Previous Radiation therapy
• Paget’s disease
• Young patients open physes

• Very Expensive $$$$$
Treatment following Fragility Fractures

- Published low rates 15 -20%
- Should be much higher - 50% plus*
- Communication between hospital, MD’s and patients essential**
- CMS planning to penalize us for this

*Gidwani et al, Ann RCS Engl, 2007
** Meadows et al; Osteoporosis Int ,2007 Feb
The Orthopaedist’s Responsibility

CMS guidelines

• Diagnose the Fragility Fracture as such
• Obtain Lab tests
• DEXA scan
• Institute Therapy
  or

Refer for treatment to PCP or Metabolic Bone Clinic