OSTEOPOROSIS

Age-related disorder characterized by:

• Decreased bone mass
• Disordered microarchitecture
• Inferior bone quality?
IS OSTEOPOROTIC BONE ABNORMAL?

- Some evidence of altered crystallinity
- Some evidence of reduced collagen density (ultimate strain)
- Overall, most evidence suggests that osteoporotic bone is normal
- Decreased bone mass and trabecular connectivity
RELEVANCE OF ARCHITECTURE TO STRUCTURAL STRENGTH

Normal Quantity and Architecture

Loss of Quantity

Loss of Architecture
HIGH BONE TURNOVER LEADS TO STRESS RISERS AND PERFORATIONS

- Osteoclasts
- Bone
- Perforations
- Stress Risers
Low bone mass is the single most accurate predictor of increased fracture risk
EASY MEASURES OF BONE MASS

- **DEXA scan**: assesses bone density (aka bone mineral density or BMD)

- **Urinary pyridinoline, NTX**: assesses rate of bone turnover
  
  ➢ High turnover mandates a work-up for cause (1° or 2° hyperparathyroidism)
INTERPRETING BONE MASS MEASUREMENT REPORTS

DEXA Scan T-Score

• The standard deviations (SD) above or below the peak bone mass of young adults

• WHO Definitions

  1. Normal is a T-Score of -1.0 or higher
  2. Osteopenia is defined as -1.0 and -2.5
  3. Osteoporosis is defined as -2.5 or lower

• USE FRAX® to calculate actual fracture risk
  (www.shef.ac.uk/FRAX/tool.jsp)
RELATIONSHIP OF HIP FRACTURE RISK TO BMD AND AGE

Hip Fracture Risk increases predictably with increasing age and lower DEXA T-Score

% Risk per 10 Years for T-Score of -2.5 at the hip

- Age 60  9%
- Age 70  15%
- Age 80  23%
RELATIONSHIP OF BMD AND AGE

The diagram illustrates the relationship between bone mass (in grams of calcium) and age. It shows that bone mass generally increases with age until reaching a peak around the age of 20-30, after which it begins to decline. The graph also indicates that men tend to have a higher bone mass than women.
RELATIONSHIP OF BMD AND AGE
BONE ADAPTATION TO AGING (1 of 2)

• The aging skeleton remodels to adapt to bone loss

• Bone remodeling in osteoporosis appears to be an attempt to maximize strength in the face of reduced bone mass

• The skeleton remodels in response to habitual, normal loads (eg, gait)

• The skeleton does not adapt to non-habitual loads
For the osteoporotic femur:

- **During gait**, the principal stresses are concentrated in the compressive trabeculae

- **During a fall**, the principal stresses are concentrated in the tensile trabeculae and are usually 4× normal

- **Non-habitual loads** are more likely to result in fractures

Hayes et al.
HIP FRACTURE

Impact forces in falls from standing height:

• In young: 20% below failure point

• In elderly: exceed failure point by factor of 2

OSTEOPOROTIC FRACTURES

• Loss of bone mass and loss of trabecular interconnectivity

• Reduced bone density is proportional to increased fracture risk

• Bone adaptation occurs but only to habitual loads

• Falls create large non-habitual loads, causing fracture
OSTEOPOROTIC BONE AND ALTERED MECHANICS OF FRACTURE FIXATION

- Traditional ORIF principles often fail
- Skeletal failure, not implant failure
- Non-operative management often unacceptable
- Special strategies are needed!
BIOMECHANICS OF PLATE FIXATION IN OSTEOPOROTIC BONE (1 OF 3)

• ST = (thread diam) (length) (bone quality)
• Tightest screw carries the most load
• Axial forces are countered by frictional force between bone and plate
• Frictional force is determined by the magnitude of screw torque
• For 3.5-mm screw: 3.5–5 Nm max in osteoporotic bone
• Osteoporotic bone cannot resist the shear forces generated by advancing screw threads

• Osteoporotic bone allows only 3 Nm of torque

• Leads to plate loosening with as little as 500-N loads

• Plate loosening then leads to high gap strains and nonunion
BIOMECHANICS OF PLATE FIXATION IN OSTEOPOROTIC BONE (3 of 3)

Best strategy is to share load with bone, thereby decreasing loads at the bone-implant interface

• Sliding hip screw: dynamic fixation
• IM nails
• Tension band constructs
• Impact or shorten fractures to create stability
HISTORICAL STRATEGIES TO DEAL WITH OSTEOPOROTIC BONE (1 of 4)

• Classic principles of ORIF weren’t working
• Screws had poor purchase; buttress plates failed
• Strategies that worked:
  ➢ Tension bands
  ➢ Antiglide plates
  ➢ Load-sharing constructs
HISTORICAL STRATEGIES TO DEAL WITH OSTEOPOROTIC BONE (2 of 4)

Successful constructs:

• Shared loads between implants and bone
• Used strong soft tissues attached to bone
• Shortened fractures to achieve cortical contact
• Double plates at 90° angles
• Prosthetic replacement
Tension bands using strong soft tissue attachments

• Proximal humerus: rotator cuff

• Medial malleolus: deltoid ligament
Successful plate fixation

- Fixed-angle devices
- Cortical contact; avoid gaps opposite plate
- Shorten
- Antiglide plates
- Double plate for extra stability
STRENGTH OF SCREW FIXATION

Screw insertion torque is the important parameter

- ST = (thread diam) (length) (bone quality)
- Use large thread
- Get cortical purchase
- Bicortical screws even with locking plates
BIOMECHANICS OF LOCKED PLATES (1 of 2)

• In locked plates the axis of the screws is fixed

• This creates a single beam construct between plate, screws, and bone

• 4× stronger than conventional, load-sharing plates

• In locked plates, strength of fixation is the sum of all the screws’ fixation
• Locked plates improve fix in osteoporotic bone

• Provide sufficient stability to reduce fracture gap strain

• Result is healing by callus and endochondral ossification
MORE ABOUT FRACTURES IN THE ELDERLY (1 of 2)

Improve fracture healing biology to maximize rate of healing:

• Indirect reduction/minimal stripping

• Use bone graft or substitutes to replace areas of bone crush or loss

• Take advantage of strong soft tissue attachments to anchor fixation
MORE ABOUT FRACTURES IN THE ELDERLY (2 of 2)

• Use prosthetic replacement:
  - When results of ORIF are poor
  - Fractures into arthritic joints
  - Failed ORIF

• Use cement to replace bone loss and improve screw purchase
DIAPHYSEAL FRACTURES

Intramedullary nails:

• Ideal fixation

• Fulfill all criteria for osteoporotic fractures

• Excellent clinical results of locking IM nails
SLIDING HIP SCREW VS. TROCHANTERIC FIXATION NAIL

The sliding hip screw: the model paradigm

- Fixed angle; broad purchase
- Load sharing
- Allows immediate weight-bearing
- Easy to insert
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