Disclosure

 ► Speaker Bureau
   - Synthes
   - Smith and Nephew
   - AONA

 ► Consultant
   - Biointraface (unpaid)

 ► Committees
   - METRC executive
   - OTA military
   - OTA classification
   - OTA disaster preparedness
Objectives

► Injury patterns and demographics
► Principles of fracture care
► Rehabilitation implications
► What can we do better
► Perfect surgery
  +
► Unmotivated patient
  or
► Poor rehabilitation
  =
► Bad result
- Imperfect surgery +
- Motivated patient or
- Excellent rehabilitation =
- Good result
Statistics

Life years lost

CDC 2014
Cost

$671 billion/yr

CDC 2015
Falls

- ER visits: $2.5 \times 10^6$
- Hospitalizations: 700,000
- Hip fxs: 250,000

CDC 2015
Disability

► 1 in 4 20 yr olds disabled before retirement*
► 12% Americans disabled, half are working age*
► 8.8 million Americans receive SSDI*
► MSK disorder: 28.5% of disabled**

* Social Security Administration 2013
** Council on Disability Awareness 2009
Mortality vs Disability

Global Burden of Disease, World Bank, 2010
Disability/Age
Disability by Country
Injury Patterns

► Monotrauma: single injury
► Multitrauma: multiple injuries to single system
► Polytrauma: injuries to multiple systems
Injury Mechanism

- **Low energy**
  - Falls
  - Sports

- **High energy**
  - Motor vehicle
  - Industrial
  - Ballistic
  - Falls from height
Fracture Distribution
Evolution of Orthopaedic Surgery
Evolution of Fracture care

► Pre-surgical era: casts, slings, and traction
► Early surgical era: fixation of some “problem fractures”
► 1980’s: Fixation of fractures to save lives and reduce morbidity
  ➢ Early Total Care
► 1990’s-2000’s: Damage control surgery
► Now: Early Appropriate Care
Early Appropriate Care: Definitive Stabilization of Femoral Fractures Within 24 Hours of Injury Is Safe in Most Patients With Multiple Injuries
Correct pH > 7.25 by 8 hrs; tx of femur, pelvis and acetabulum in 24 hrs ↓ complications

EAC vs Clinical Grading scale (Pape) no difference in complications
Treatment options

► Cast/bracing
► Plate and screws
► Rod or nail
► External fixator
  ➢ Simple unilateral
  ➢ circular
Fracture “anatomy”

- Not all are the same
- Bone zones
  - Diaphysis
  - Metaphysis
  - Articular surface
Casts and Braces

► External support
► Temporary
► Definitive
  ➢ Wrist and ankle
  ➢ humerus
  ➢ Nonsurgical candidates
    • Age
    • compliance
  ➢ Many pediatric fractures
    • UE
    • LE
Humeral Fracture Cuff

Figure from Rockwood and Green.
Caveats

► Loss of reduction
► Pressure sores
► Compartment syndrome
► Stiffness/atrophy
Plates and Screws

- Direct control of fragments
  - Excellent for articular fractures
  - May be a reduction tool
- May require more exposure
  - Anatomic limitations
  - May be minimally invasive
- Limited inherent stability
- Advances
  - Locking screw
Common uses

► Fractures around joints
► Diaphyseal fractures
  - Most upper extremity
  - Select lower extremity
    • Deformity precluding IM nail
Elbow Fracture with bone loss

- 52 yo MVC,
- Open distal humerus
- Open segmental femoral shaft with bone loss
Staged reconstruction with iliac crest bone graft
► healed with ROM of 10-135°
► Returned to wt lifting and home improvement
Example of bridge plating in a highly comminuted osteoporotic distal radius fracture.
Not perfect…
Rods or Nails

► Fit inside medullary canal
► Interlocking screws provide axial and rotational stability
► Minimal dissection
  ➢ Preserves blood supply
► Mechanically closer to center of force
Biomechanics

Shorter Moment Arm
Rods and Nails

Preferred for diaphyseal fractures
- Tibia and femur
- Rarely for humerus
  - Tumor
  - Long segment of comminution

Newer techniques have extended indications to the metaphysis
Reduction maneuvers

- Length
- Rotation
- Angulation
Can also fail...
External Fixation

► Pins or wires into bone
► External clamps and bars provide support
► Temporary
  - Unilateral frame
► Definitive
  - Circular frame
“Unilateral” Frame
Circular External Fixation
Beltran, et al, Composite Bone and Soft Tissue Loss Treated With Distraction Histiogenesis, J Surgical Advances, 2010
Therapy implications

► “Life is motion; motion is life”
► Articular cartilage nutrition
► Ligament and tendon healing
  ➢ Orientation of collagen with controlled stress
► Muscle activity prevents contracture and atrophy
► Bone healing responds to load
Man, Bernie, you're a mess!... You ain't itchin' anywhere, are you? Man, I had a cast on my leg years ago and boy did it itch!... Drove me crazy! Y'know what I'm sayin'?... 'Cause you can't scratch it, y'know... Don't think about itching anywhere, Bernie, 'cause it'll drive you nuts!
To weight bear or Not to weight bear

**YES**
- Diaphyseal femur and tibia fx tx with rod
- Humerus shaft fx plate or rod
- Geriatric hip fractures
- Circular frames

**NO**
- Articular fx
- Metaphyseal fx
- Segmental defects
- Compromised fixation
  - Osteoporosis
- Neuropathy/noncompliant pt
Articular fractures
- Tibial plateau fracture: posterior joint is loaded in flexion

Ligament injury
- Elbow

Tendon injury
- Patellar and quad tendon
- Rotator cuff
Amputation

► Traumatic
► Severe trauma
  ➢ Vascular injury
  ➢ Bone loss
  ➢ Loss of skin/muscle
  ➢ Major nerve disruption

Unreconstructible
• Risk to patient
• Poor long term function
Amputation vs. Salvage

Multidisciplinary decision

Based on an overall assessment of all the tissues of the limb:

- Muscle
- Bone
- Vessels
- Nerves
Advances in reconstruction

- Wound management
  - Bead pouch
  - Negative pressure dressing

- Bone stabilization
  - Locking plates
  - Circular frames
  - Minimally invasive techniques

- Bone regeneration
  - Distraction osteogenesis
  - RIA bone graft
  - BMP

- Microvascular reconstruction
  - Free flap coverage
  - Composite tissue reconstruction
  - Limb replant
  - Limb allotransplantation
Advances in Amputation

- Wound management
  - Negative pressure dressing
- Free Tissue transfer to preserve joint

- Gel liners for improved socket fit
- Energy storing terminal devices
- Myoelectric prosthesis
- Microprocessor controlled knee (C-Leg)
- Targeted reinnervation
Societal Factors
LEAP Study
Bosse et.al. 2001-2006

- Prospective observational study -
  - 569 patients
  - 2 and 7 year follow up

- Less complications in amputations
- Less hospitalizations in amputations

- Functional outcomes equal at two years but early cost $ much more money and time with added loss of social, family and work life with salvage group

- Outcome dependent on self efficacy, education, race, insurance
The METALS Study group. METALS: Limb Salvage vs amputation of the lower extremity combat injury outcomes. JBJS-A. 2013

► Military Extremity Trauma Amputation and Limb Salvage Study
► Multicenter retrospective study of severely injured limbs treated with salvage or amputation
► Lower AND Upper extremity
Mean SMFA Dysfunction Score

(Higher Score = Worse Outcome)

Significantly different from unilateral salvage (p < 0.05) after adjusting for covariates
Upper Extremity Results

- SMFA
- Depressive symptoms (%)
- PTSD (%)
- Pain score

Salvage amputation
14 yo m run over by bus
Ankle fx dislocation
Skin loss from knee to ankle
Loss of entire anterior and lateral muscle compartment
IDEO

Intrepid Dynamic Exoskeleton Orthosis
Comparative Effect of Orthosis Design on Functional Performance

Jeanne C. Patzkowski, MD, Ryan V. Blanck, LCPO, Johnny G. Owens, MPT, Jason M. Wilken, PhD, MPT, Kevin L. Kirk, DO, Joseph C. Wenke, PhD, Joseph R. Hsu, MD, and the Skeletal Trauma Research Consortium (STReC)

<table>
<thead>
<tr>
<th>TABLE II Results of Functional Measure Testing*</th>
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<tbody>
<tr>
<td>No Brace (N = 18)</td>
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<tr>
<td>-------------------</td>
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<tr>
<td>Four-square step test (s)</td>
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<tr>
<td>Sit-to-stand 5 times (s)</td>
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<tr>
<td>Timed stair ascent (s)</td>
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<tr>
<td>Self-selected walking velocity (m/s)</td>
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<tr>
<td>On level terrain</td>
</tr>
<tr>
<td>On rocky terrain</td>
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<tr>
<td>40-yr dash (s)</td>
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</table>
"Limb Salvage With Intrepid Dynamic Exoskeleton Orthosis Versus Transtibial Amputation: A Comparison of Functional Gait Outcomes".

Mangan, Katharine I. MD; Kingsbury, Trevor D. MA; Mazzone, Brittnay N. DPT; Wyatt, Marilynn P. MA, PT; Kuhn, Kevin M. MD

- Slower cadence, shorter stance
- Kinetic and efficiency data equivalent
Can an Integrated Orthotic and Rehabilitation Program Decrease Pain and Improve Function After Lower Extremity Trauma?

Katherine M. Bedigrew MD, Jeanne C. Patzkowski MD, Jason M. Wilken PhD, MPT, Johnny G. Owens MPT, Ryan V. Blanck LCPO, Daniel J. Stinner MD, Kevin L. Kirk DO, Joseph R. Hsu MD, Skeletal Trauma Research Consortium (STReC)

► 41/50 preferred retained limb
► No difference < or > 2yrs post injury

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Week 0</th>
<th>Week 4</th>
<th>Week 8</th>
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<tbody>
<tr>
<td>Short Form Musculoskeletal Assessment</td>
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<tr>
<td>Daily activities</td>
<td>36</td>
<td>35</td>
<td>23</td>
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<tr>
<td>Emotional status</td>
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<td>46</td>
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<td>Mobility</td>
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<td>Function</td>
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<td>Arm</td>
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<td>Visual analog pain scale</td>
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<tr>
<td>Pain scale rating</td>
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<td>3.8</td>
<td>2.7</td>
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<td>Veteran Rand 12-item Health Survey</td>
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<tr>
<td>Mental component score</td>
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<td>51</td>
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<tr>
<td>Physical component score</td>
<td>27</td>
<td>29</td>
<td>37</td>
</tr>
</tbody>
</table>
Post-traumatic arthritis

- Not just related to reduction of fracture
- Cellular apoptosis
- Pilon fx vs plateau
- Upper vs Lower extremity

Viability and apoptosis of human chondrocytes in osteochondral fragments following joint trauma


BJJ, 2007
38 yo tourist
Fell jumping on beach rocks
Open pilon (ankle) fx
Other Factors

- Pain
- PTSD
- Depression
Pain

► Multiple factors
  ➢ Genetics
  ➢ Societal
  ➢ Psychologic

► Management
  ➢ Expectation of control not elimination
  ➢ Early effective tx affects long term outcome
Pain Management

► Pharmacologic
  ➢ Opiates
    • Long acting
    • Contracts
  ➢ NSAID
    • Short term use does not affect bone healing
    • Ketorolac
  ➢ Acetaminophen
  ➢ Gabapentinoids
  ➢ Tricyclics
  ➢ Other
Other management

► Blocks
  - Single shot
  - Continuous

► Counseling
  - Patient engagement
    • Return sense of control
  - Consistent message among providers
Rates of Prescription Opiate Use Before and After Injury in Patients with Orthopaedic Trauma and the Risk Factors for Prolonged Opiate Use

Joel E. Holman, MD; Gregory J. Stoddard, MPH; Thomas F. Higgins, MD

► Preinjury narcotic prescription 15.5% (9.5%)
  ➢ Multiple prescriptions 12.2% (6.4%)

► Multiple pre injury: 6 X >12 wks
  ➢ Opiates multiple providers: 3.5 X
PTSD

- Prevalence up to 50% trauma victims
  - War veterans
    - 36% w TBI; 16% w/o TBI
    - 18% amputee and limb salvage

- Predictor: wishful thinking

- Treatment: Behavioral therapy
  - Pharmacologic: SSRI, α-blocker
Depression

► Prevalence:
  - up to 45% moderate; 3.7% severe
  - LEAP:19% severe

► Treatment
  - Recognition
  - Pharmacologic
  - Psychotherapy
  - Electroconvulsive therapy
- Imperfect surgery
  +
- Motivated patient
  or
- Excellent rehabilitation

= 
- Good result
83 yo
Fell
Bilat elbow fx
► 3 months later…
► Traumatic hemipelvectomy
► Knee dislocation
► Open tibia
► Arrested 3 times in first day
Boneless Chicken Ranch