Orthopaedic Trauma

Concept to Reality

– In the beginning
– Vision
– Problems and Changes
– Reality
– Future Challenges
Where did it start?

• Post WWI/II developments in trauma care
  – Shock and blood transfusion
  – Anesthesia
  – Wound care and antibiotics
  – Other specialties: NS, OS, Plastics
• Bohler – centralization of care, ↑result
• Development of trauma systems in the 60s

Result: 1. Need for systematic delivery of care to the injured

2. Best method to assure delivery?
Pre 1960

• Fracture management: delayed
  – Isolated fractures: delayed for union
  – Polytrauma + fractures: too sick, union

• Sporadic attempts at early fracture care
  – Kuntscher with nail in Germany 1950s
  – Allgöwer in Switzerland 1958
ETC – The beginning

• Müller, Allgöwer & Willenegger
  – Easier, better outcomes
  – Polytrauma: fewer pulmonary deaths
  – With femur fracture key to saving life
    Operative Fracturenbehandlung 1963

• Ruedi and Wolff, Riska:
  – ↓ fat emboli syndrome
    Helv Chir Acta 42:507-12, 1975
    Injury 6:110-16, 1976

• Wolff
  – Outlined protocol for ETC, including mechanical ventilation (0.08% vs 30% mortality)
    Unfallheilkunde 81:425-42, 1978
Trauma Care Model

- 1970 - Harald Tscherne began the Hannover Trauma system
- The trauma surgeon developed:
  - General surgeon with fracture treatment skill
  - Team management concept
  - Specialty surgical backup
The Spread

- European success spread 70’s
- AO provided an international interaction
  - Courses and interaction of faculty
- 1973 first NA trauma centers appeared
  - Run by general surgeons with specialty consultation

Result: A need for orthopedic surgeons to start fixing a high volume of fractures with implications on an evolving system of specialization
Border – Buffalo: 1980s

Crucifix position: prolonged immobilization

- Gut origin septic state
- Macrophage damage
  - ARDS, MOF

Early Total Care

- 1982 - Goris
- 1985 - Johnson
- 1985 - Seibel
- 1986 - Meek

<table>
<thead>
<tr>
<th></th>
<th>ETC</th>
<th>Traction</th>
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<tbody>
<tr>
<td>#</td>
<td>179</td>
<td>149</td>
</tr>
<tr>
<td>ISS</td>
<td>49</td>
<td>45</td>
</tr>
<tr>
<td>Mortality</td>
<td>4.9%</td>
<td>26%</td>
</tr>
</tbody>
</table>
Bone and Johnson

• Early vs Delayed Stabilization of Femoral Fractures - JBJS 1989
  – 46 early vs 37 late multiple injury patients
  – Reported higher incidence (non-significant) of pulmonary complications in the delayed group

The injured patient with long bone fractures needed **early total care** but who would do it?
North American

- Trauma system development fragmented
  - General surgery lead
  - Specialties – different priorities
  - Fracture care not a priority but a necessity

Results: Appearance of few orthopaedic trauma programs
Established trauma system in Toronto – interdisciplinary with ortho trauma surgeons as trauma team leaders and running the program

McMurtry, 1980s

Robert Meek

UBC

Vancouver
Orthopaedic Surgery

More fractures
Less interest
Increasing demand
Orthopaedic Traumatologist

- Acute care management of the injured patient
  - Involvement in resuscitation
  - Understands trauma pathophysiology
- Participates in clinical decision making
  - Integral part of team
- Fracture surgeon
- Reconstructive surgeon for complications of MSK trauma
- Full time >75%
Fracture Surgeon

- No acute care involvement
  - Referral base practice
  - Guided by trauma surgeons
- Purely acts a consultant
- +/- full time
- Only fixes fractures
  - sub specialized or general
Relationship

• Orthopaedic Traumatologist
  – at level 1/2 Trauma Centers
  – Involved in trauma program management
  – Involved in acute care trauma aspects

• Fracture surgeon
  – At all levels of Trauma Centers/hospitals
  – Only involved in fracture care
  – Referral based practice
Orthopaedic Trauma

Vision

Excellence in musculoskeletal injury care
Orthopaedic Trauma

• Goals
  – Patient driven
    • clinical relevant - patient’s and injury’s physiology
  – Based on education and research
    • AO, COTS, DGU,OTA, SICOT and others
    • Evidence based driven
  – Cost, resource effective
  – Available to all
Orthopaedic Trauma

• Impediments
  – Dogma and myths
  – Acceptance
  – Resource
  – Lifestyle issues
What were the “principles”?  

Early Total Care – The 80 - 90’s

- Manage all LE long bone fractures (<24Hrs)
- Rapid (< 6 hours) debridement of open fractures
- All open fractures left open
- Emergency ORIF of certain fractures
  - Femoral neck, talus
- Expanding indications for fracture ORIF
  - pelvis, acetabulum
- Increased complexity of instrumentation
  - Locking nails, angular stable fixation
Problems

• Lack of trauma system
  – Inconsistent volumes
  – “cherry picking” in the community
  – Competition between institutions within cities/regions
Problems

• Few orthopaedic traumatologists
  – Over worked
  – No intellectual support
  – Unable to “fight” for their needs as too busy
Problems

• “Standard of care” for community
  – Standard improved in community
  – No support as other surgeons threatened
  – Lost working colleagues as not willingly to try
  – Medical legal implications
Problems

• “No hospital resource”
  – Not a priority in any department
    Ortho, Gen Surgery
  – An orphan
  – Poor reimbursement?
  – Does not fit perceived surgical
    practice model
  – Stresses the infrastructure
Problems

- Not accepted by orthopaedic leadership
  - Not elective
  - Perceived as obnoxious
  - Right of passage as the new surgeon
  - Doing major complex fracture surgery at inappropriate times - bad care
  - Lack of support for equal call schedule
  - Early burnout or disillusionment
Problems

• Increasing population, injury rate, risks
  – Volume increases
  – Compounds other issues
  – Clinic and follow-up support
  – Blood Borne pathogenic disease
  – Malpractice
Problems

- Lack of trauma system
- Few ortho traumatologists
- “Standard of care” for community
- No hospital resource
- Not accepted by orthopaedic leadership
- Increasing population, injury rate, risks

Result: Frustration, poor career opportunities, unacceptable lifestyle
1990s

• Defined a standard of care
• Failed to have the resource and manpower to maintain it
• No evidence to support the “dogma or standards of care”
Change was on the way . . .

- Critical assessment of our dogmas and myths
- Improved acceptance of subspecialty
- Improved resource allocation
- Off hours surgery complications
Dogmas and Myths

• Open Fracture
  – Must be treated with in 6 hours
    JOT. 121, 1995; Plast Recon Surg. 68, 1981; JTrauma, 25, 1983

• Timing of Debridement
  • Debridement most important
  • Wound type drives timing
  • ASAP with stable patient and appropriate OR
    JOT. 484, 2002; JOT 532, 1993; JTrauma 949, 2003
Dogmas and Myths

• Open Fracture
  – Never Closed – packed open
    • At least one more OR session
  – Closure of wound – now allowed
    • No ↑ of infection
    • Still allows repeat debridements
    • Wound debridement driven
    • Allowed better OR time management
    • ↓ costs

Delong; J Trauma 1049, 1999
Gopal; JBJS 82B, 959, 2000
OTA study submitted
Dogmas and Myths

• Fractures requiring Emergency ORIF
  – Young femoral neck fracture
    • Not emergency
    • Must be done ASAP with competent surgeon and team
    • No ↑ AVN, complications

  Jain JBJS 84A, 1605, 2002

  – Displaced Talar neck fracture
    • Not emergency

  Meinberg OTA 2003
32 yr ♂, car vs tree at 80mph
no other injuries vs head injury +pulmonary contusion and liver laceration

Open fractures
2 teams, 4 hours, home in 5 days or ICU → ARDS, MOFS +/- death
Dogmas and Myths

Early Total Care

– Created long surgeries at inappropriate times
  • Stressed resource
  • ? Complication rate
– Not for all patients
– Not for all fractures surgeons, hospitals
– Has its place but can be planned
Damage Control - Orthopaedics

• A New “Dogma”
  – Does allow for rapid stabilization for ill patients
  – Does allow for rapid stabilization of soft tissues
  – Does allow surgeons who are not comfortable with injury or patient to provide temporary care and transfer
  – Not for all patients, not an excuse for laziness

Fracture Care is NB

- Stabilization is imperative
  - decrease pain, prevents further injury,
  - ↓ antigenic load, toxic products

BUT

- Type and extent determined by
  - Physiological status of patient
  - Method with least impact on physiology
  - Co-operative team play
Type of Stabilization

- IM nailing – reamed, unreamed
- DCO – External Fixation
- Skeletal Traction
Acceptance

- With increasing Trauma centers and systems
- American College of Surgeons COT recognizes the need for fracture care
- Ortho trauma OR as requirement for Level 1 designations (2006 ACS COT)
- Needed for training residents due to specialization within training programs
- Increasing number of fellowship program
Techniques and Toys

• Percutaneous fracture surgery (MIS)

• Navigation?

• Angular stable fixation/Anatomical Plates
The Future – Cost Effective Care

• Technical aspects well defined
  – Excellent results with conventional surgical techniques and implants

• ??? Need for multiple new implant variations – Evidence for justification of use
  – All cost more
Ideal Development Pathway

1) - Identify a Clinical Need
2) - Develop the concept
3) - Initial design and revision
4) - Dry lab testing – defining mechanical and handling properties
5) - Clinical Studies: Handling/Trials
6) - If “superior” released
## Direct Cost

<table>
<thead>
<tr>
<th></th>
<th>Gold Standard</th>
<th>New Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implant cost</td>
<td>$</td>
<td>$$$</td>
</tr>
<tr>
<td>OR Time</td>
<td>$$$</td>
<td>$$$</td>
</tr>
<tr>
<td>LOS</td>
<td>$$$$</td>
<td>$$$$</td>
</tr>
<tr>
<td>Revisions</td>
<td>$</td>
<td>??</td>
</tr>
<tr>
<td>Removal rate</td>
<td>$</td>
<td>??</td>
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# Implant Cost

<table>
<thead>
<tr>
<th>Implants</th>
<th>List Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral Blade – 9 hole with screws</td>
<td>$550</td>
</tr>
<tr>
<td>Femur distal femur plate – 9 holes with screws</td>
<td>$3250</td>
</tr>
<tr>
<td>Difference</td>
<td>$2700</td>
</tr>
</tbody>
</table>

At my hospital, 6 distal femurs are done a month

Extra cost is $2700 = $16,200

For 1 year = 12 X $16200 = $194,400
## Indirect Cost

<table>
<thead>
<tr>
<th></th>
<th>Gold Standard</th>
<th>New Technology</th>
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<tbody>
<tr>
<td>Company R&amp;D</td>
<td>None</td>
<td>$$$</td>
</tr>
<tr>
<td>Surgeon Education</td>
<td>None</td>
<td>$$$</td>
</tr>
<tr>
<td>OR staff Re-training</td>
<td>$</td>
<td>$$$</td>
</tr>
<tr>
<td>OR re-tooling</td>
<td>None</td>
<td>$$$$</td>
</tr>
<tr>
<td>New Inventory</td>
<td>None</td>
<td>$$$$$$$</td>
</tr>
<tr>
<td></td>
<td>Gold Standard</td>
<td>New Technology</td>
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<tr>
<td>----------------------</td>
<td>---------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Radiology Use</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Radiation Exposure</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Resident Education</td>
<td>+++++</td>
<td>Might be negative</td>
</tr>
<tr>
<td>Learning Curve Results</td>
<td>NA</td>
<td>- - - -</td>
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<tr>
<td>Clinical outcomes</td>
<td>Excellent</td>
<td>Prob Excellent</td>
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### Distal Femur Fractures

<table>
<thead>
<tr>
<th></th>
<th>New Technology</th>
<th>95° Blade Plate</th>
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<tbody>
<tr>
<td><strong># fractures</strong></td>
<td>62</td>
<td>57</td>
</tr>
<tr>
<td><strong>ROM</strong></td>
<td>3 - 110</td>
<td>88% &gt;100</td>
</tr>
<tr>
<td><strong>Union (t)</strong></td>
<td>96.8%(13)</td>
<td>96.4%(10.7)</td>
</tr>
<tr>
<td><strong>Other proc</strong></td>
<td>2 bone grafts</td>
<td>2 delayed unions</td>
</tr>
<tr>
<td><strong>Infection</strong></td>
<td>3.2%</td>
<td>0</td>
</tr>
</tbody>
</table>
## Proximal Tibial Fractures

<table>
<thead>
<tr>
<th></th>
<th>New Technology</th>
<th>Conventional</th>
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<tbody>
<tr>
<td>Union</td>
<td>89%</td>
<td>83%</td>
</tr>
<tr>
<td>ROM</td>
<td>1 - 112</td>
<td>1 - 125</td>
</tr>
<tr>
<td>Infection</td>
<td>4.6%</td>
<td>5.7%</td>
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## Level of Evidence Summary

<table>
<thead>
<tr>
<th>Level</th>
<th>#</th>
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<tbody>
<tr>
<td>IV</td>
<td>894</td>
<td>11</td>
</tr>
<tr>
<td>III</td>
<td>346</td>
<td>3</td>
</tr>
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</table>

Analysis: Data only shows that we're probably not hurting the patients.

The Current Status of Locking Plating: The Good, the Bad, and the Ugly

Strauss, Schwarzkopf, Kummer and Egol

JOT 22, 7: 479 -486, August 2008
## Implant Costs

<table>
<thead>
<tr>
<th>Implant</th>
<th>Cost Anat/lock</th>
<th>Cost standard</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal Tibia 6 h</td>
<td>2342</td>
<td>839</td>
<td>1503</td>
</tr>
<tr>
<td>3.5 plate 12 h</td>
<td>962</td>
<td>400</td>
<td>562</td>
</tr>
<tr>
<td>4.5 plate 12h</td>
<td>1224</td>
<td>398</td>
<td>1224</td>
</tr>
<tr>
<td>Volar plate</td>
<td>1317</td>
<td>220</td>
<td>1097</td>
</tr>
<tr>
<td>Hip fracture</td>
<td>CMN 2805</td>
<td>DHS 889</td>
<td>1916</td>
</tr>
<tr>
<td>Distal Humerus</td>
<td>2951</td>
<td>867</td>
<td>2084</td>
</tr>
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</table>
At CMC taking last year’s selected fracture volumes for IT fractures, distal femur fractures, proximal tibia, distal radius and distal humerus, our excess cost for new technology implants = $536,026.00
The Future – Cost Effective Care

• Technical aspects well defined
  – ??? Need for multiple new implant variations –
    Evidence for justification of use
  – All cost more

• Biology will be the future but can it be afforded and done correctly
  – Bone substitutes
  – Growth factors: BMPs etc
  – Cellular based therapy - MSCs
  – Genetic engineering
Bone Graft Substitutes

- Many types – calcium sulphates, calcium phosphates, coral derivatives
- One company has 13 different variations of calcium sulphates/calcium phosphates
- Not inexpensive
- Are they really what we need?
Bone Substitute Properties

CLASSICAL

• **Osteogenic**
  – Living graft cells forming bone

• **Osteoinductive**
  – Transfer of matrix bound growth factors to induce local and derived cells to form bone

• **Osteoconductive**
  – Permanent or temporary scaffold to act as solid base for bone formation
Bone Substitute Properties

NEW

- Promote angiogenesis
- Resorbable
  - variable time frame - ? Best
  - how much
- Delivery Agent
  - morphogens, drugs-antibiotics, cells
- Strength
  - not an issue
- Osteointegration: new bone able to bond to old bone
What do we know????

• The Use of Calcium Phosphate Bone Cement in Fracture Treatment
  – Bajammal, Zlowodzki, Letwica, Tornetta, Einhorn, Buckley, Leighton, Russell, Larsson and Bhandari
  – JBJS 90A, June 2008 pp1186 – 1196
  – Meta analysis of 14 randomized controlled trials suggesting: less pain, ↓ loss fracture reduction, ↓ infection in distal radial fracture and likely improved functional outcomes
  – Methodological limitations and lack of patient relevant outcomes → large size RCT to show effect
Clinical Consequences

- Clinics flooded with products
- No evidence as to what works
- Millions of dollars spent on these products
- Irresponsibility by surgeons and producers
  - Lack of directed research – what is needed, poor interaction between clinician and scientists
  - Producers not wanting to take risk – develop a new concept – they know what sells and the game is market share
Growth Factors/Cells

• Recombinant PDGF
  – Elective hindfoot fusions and distal radius
  – Outcome: time to heal - ? relevance
• BMPs ???? Dose, application, results
  – BMP7 (OP1) good for tibial non unions (Friedlaender)
  – BMP2 good for open tibias (Geesink)
• MSC
  – Bone marrow aspirates
  – Hernigou concentrating MSC from bone marrow
Where are we now?

- Orthopedic Trauma surgery is here to stay
- Orthopedic Trauma is becoming recognized as a legitimate field (specialty)
- Orthopedic Trauma needs resource like other orthopaedic subspecialties in teaching and non teaching hospitals
- Fractures can be treated by all orthopaedic surgeons who are interested and skilled
Lifestyle

• Less emergency surgery
• More controlled schedule
• More fellowships producing more trained ortho traumatologists
• Community based hospital systems developing
• Better reimbursement
• Better understanding of needs on training programs
So if

- Our lifestyle is acceptable
- Our fracture care is better directed and is more effective
- Recognized as a standard

BUT can we deal with

- the creation of this new standard?
- the changing practice of the orthopedist in the ER
- the burden of Indigent, non insured care (46.6m)
THE BURDEN - USA

- 50 million injured in 2000
- Lifetime costs for these injuries = 406 billion
- Fractures ($21b), Sprains ($7.1b) and open wound care ($4.5b) – 3 of the top 10 most expensive diseases
- 3.5 \(10^6\) ER ortho visits in 2004, 885,000 admitted, 8 million office visits
The Future

• Who will look after fractures?
  – Less orthopedist will be interested in treating fractures:
    • subspecialty training – different interests
    • more ortho traumatologists in the community
      – “standard of care issue”
    • practice logistics – time management
    • life style issues
  – Care centralized to larger centers
Perceptions

• Ortho Trauma Side
  – Super specialist
  – No time for simple fractures
  – Works at a tertiary care center
  – Always is being dumped on

• Orthopedist Side
  – Skill level
  – Best for the patient
  – Malpractice issue if expert in community
  – Interest level – should not do something if have no commitment
Solution

• The ideal will never work
• Recognize the need for a “fracture surgeon” or ortho trauma surgeon
• Develop new models for training these individuals
• Remove barriers to taking call
• Alternative payment plans for these surgeons
  – Hospital based practices - all levels
  – Support those who want to take fracture call
The Solution

• Resource
  – Need to assure major level one centers continue to support ortho trauma as hospital based mission
  – Regional referral systems
  – Community hospital have hospital based “fracture surgeons”
  – Training programs and specialty boards develop innovative new ways to address the specialty of ortho trauma and fracture surgery
The Future

• More emphasis on the psychosocial aspects of care
  – Post traumatic Stress, Depression effect outcomes – Starr, Vrahos
  – Outcomes – social/educational status – LEAP Study
  – Better relationships to the community and rehabilitation services to improve return of patients to useful role
Orthopaedic Trauma

• Reality
  – Excellent musculoskeletal injury care - **YES**
  – Accounting for patient’s physiology ?
  – Cost effective - **NO**
  – Resource effective - **Improving**
  – Available - **Improving**
Orthopaedic Trauma

Orthopedic Trauma

It is our heritage
It is now viable and successful
It will only improve