Intramedullary Strut Fixation for Rib Fractures

Rib Fixation Colloquium
• No Disclosures
Common Rib Fracture Patterns

Transverse  Oblique  Spiral  Comminuted  Segmental
Biology of Bone Healing

- Primary bone healing
  - Requires intimate cortical contact
    - absolute stability
  - Minimal callus formation
  - Cannot tolerate fracture gap
  - Best with Inter-fragmental compression
  - Relies on Haversian remodeling with bridging of small gaps by osteocytes
Stages of Fracture Healing

1. **Inflammation & Hematoma**
   - Osteoprogenitor cells, Fibroblasts

2. **Callus Formation**
   - Periosteal and Endosteal
   - Fibro-cartilage differentiation

3. **Woven Bone**
   - Substitution of avascular and necrotic tissue
   - Haversian remodeling

4. **Remodeling**
   - Lamellar or trabecular bone
   - Restoration of continuity and ossification
   - Bone union

**When compression is applied via implant, these stages are minimized**
Practically Plate vs IM Strut...

Primary Bone Healing
- Simple fracture patterns
- See the fracture during surgery:
- Apply Compression
- Approximate with:
  - Lag screws
  - Plates and Lag screws

Secondary Bone Healing
- Complex fracture patterns
- Incomplete approximation
- Unable to compress fragments
- Stabilize with:
  - IM Rods
  - Bridge plate fixation
  - External fixation
Orthopedic Perspective on IM Struts

- Relative stability
- Intramedullary splint
- Less likely to break with repetitive loading
- More likely to be load sharing
- Secondary bone healing
Spectrum of Stability

Relative
(Flexible)

Absolute
(Rigid)
Fixation Stability

IM Strut

Plating

Callus

No Callus

Relative (Flexible)

Absolute (Rigid)
Potential Benefit of IM Strut For ORIF Rib Fx

- Indirect or minimally open reduction techniques
- Greater preservation of soft tissues as compared to ORIF
- IM reaming stimulates fracture healing

• Potential To Be Technically More Challenging
Treatment

• When to use Intramedullary Strut?
  – Location
  – Quicker Mobilization (Decreased Pain)
    • Smaller Incisions ?
  – Better Long Term Pulmonary Function ?
  – Occupation
    • Manual Laborer +/-
    • Athletes +/-

• Currently
  – Location, location, location…
Posterior or Behind/Under the Scapula
Destination Not on My Vacation List
IM Struts
• 29 ribs from 3 donors

• 62, 65 yo males: ribs 4-9 (n = 11)
• 82 yo female: 18 ribs
Relative Rib Strength With Loading

<table>
<thead>
<tr>
<th>Construct</th>
<th>Failure Bending Moment (Nmm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate Construct</td>
<td>10703</td>
</tr>
<tr>
<td>Splint Construct</td>
<td>933</td>
</tr>
<tr>
<td>Osteoporotic Rib</td>
<td>769</td>
</tr>
<tr>
<td>Normal Respiratory Load</td>
<td>40 Nmm</td>
</tr>
</tbody>
</table>
IM Strut Mis-adventures
IM Strut Mis-adventures
Summary

• Primary Indication for IM Strut
  – Location

• Need additional Studies to Investigate
  – Short Term Benefits
  – Long-term Benefits
  – Best indications
Reduction Technique - Clamp and Plate

- Place clamp over bone and the plate
- Maintain fracture reduction
- Ensure appropriate plate position proximally and distally with respect to the bone, adjacent joints, and neurovascular structures
- Ensure that the clamp does not scratch the plate, otherwise the created stress riser will weaken the plate

Figure from: Rockwood and Green’s, 5th ed.
Principles of fracture fixation

• Obtain and maintain alignment
  – Reduction

• Transmission of compressive forces
  – Minimum motion across fracture site
  – Achieve stability

• Avoid tensile/ shear/torsion forces
  – Across fracture site

• Prevent motion in most crucial plane
Biology of Bone Healing

- Indirect/Secondary Bone Healing = CALLUS
  - Divided into stages
    - Inflammatory Stage
    - Repair Stage
      - Soft Callus Stage
      - Hard Callus Stage
    - Remodeling Stage
      3-24 mo
      - Relative stability

Figures from: OTA Resident Course - Russel