Nonunions

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Review
Rockwood and Green’s. Fractures in Adults

- 1-2% femur # complication of nonunion
- Delayed union @ 6mths
- Nonunion after this
- Identify cause of delayed union
  Blood supply, soft tissue damage, infection, inadequate fixation, smoking...
Rx - reamed exchange nailing ± lock
lock = stability
reamed = graft, medullary neovascularization

Closed preferable to open to prevent further damage to soft tissues @ nonunion site

Open reserved for broken/loose plates, synovial pseudoarthrosis, displaced nonions

consider autogenous graft
Nonunion Classification

- **Hypertrophic** - prolific callus formation. Vascular, excellent healing potential. Result from inadequate immobilization
- **Atrophic** - absence of callus. Vascular deficient, poor healing potential. Require grafting
- **Normotrophic** - share both. Moderate healing potential
Consensus in the assessment of healing among orthopaedic surgeons

- 444 (77%) survey of orthopaedic surgeons
- Delayed union 1-8 mth, nonunion 2-12 mth
- 90% heal - 6 mth; 75% heal, shorter

**TABLE 1. Frequency of use in the assessment of fracture healing**

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callus size on roentgenogram</td>
<td>39.7</td>
<td>33.4</td>
<td>20.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Cortical continuity on roentgenogram</td>
<td>45.8</td>
<td>33.5</td>
<td>18.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Progressive loss of fracture line on roentgenogram</td>
<td>45.4</td>
<td>32.5</td>
<td>18.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Ability of patient to bear weight</td>
<td>42.4</td>
<td>28.8</td>
<td>19.0</td>
<td>9.8</td>
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<tr>
<td>Pain at the fracture site to palpation</td>
<td>37.2</td>
<td>27.3</td>
<td>19.7</td>
<td>15.9</td>
</tr>
</tbody>
</table>

Values are %.
Definitions of fracture repair

- **Nonunion** - All healing processes have ceased, and union has not occurred.

- **Delayed healing** - Healing processes continue; union has not occurred in the expected time; outcome is uncertain.

- **Union** - Healing processes have resulted in restoration of bony continuity.
The Accuracy of CT for Dx of Tibial Nonunion

Battacharyyya et. al. JBJS 2006

- 35 patients
- comparison of CT to gold standard (surgical findings or 6 months of clinical observation)
- Sensitivity 100%, Accuracy 90%
- Specificity 62% - misrepresent a healed fracture as a nonunion
Nonunion of diaphysis of long bones

- Retrospective single surgeon 113 patients, 14y
- Iliac crest bone graft (if required)
- Plate, Reamed Nail, Ilizarov
- All # healed avg. 6 mth. (26 required repeat surgery w/ bone grafting)
- Complication - malunion (13%), decr. ROM (30%), shortening (4%), donor pain (4%)

Babhulkar et. al. CORR 2005
Indirect reduction and plating of distal femoral nonunions

- 20 consecutive pt. single surgeon
- Nonunion - 6 months or no progress in healing on 3 consecutive monthly X-ray
- Compression plating - minimal ST dissection, shingling/petaling, debridement medullary canal, ostectomy bone ends ± autologous bone graft

Bellabarba et. al. JOT 2002
Postop - immediate ROM, TTWB 6wk, FWB between 12-20wk based on clinical/xray

Union - absence of local tenderness/pain on WB with bridging callus/trabecular bone

Result - All healed ~ 14wk, no malunion/shortening, ↑ ROM from 95-111°

Comp - 1 infection - Rx successfully
Nonunion treatment iliac crest bone graft techniques

- 10% major comp - deep infection, osteomyelitis, hematoma, neurologic injury, vascular injury, iatrogenic wing/SI joint injury, cross contamination, abdo/lumbar herniation

- 39% minor comp - superficial infection, superficial seroma, small hematoma, persistent short term pain (40%), or long term (19%), excessive blood loss, pelvic instability, cosmetic defects

Jones, Mayo. JOT 2005
Estimated as high as $4154

Bone harvest from inner portion of pelvic cortex - not external or along crest

Jones, Mayo. JOT 2005
Infected Nonunion of Long Bones

- 42 consecutive patients 1990-2002
- Type A - infected nonunion of long bones w/ nondraining (quiescent infection)
- Type B - infected nonunion with draining (active) infection
- Sub 1 - bone gap < 4cm
- Sub 2 - bone gap > 4cm

Jain, Sinha. CORR 2005
A1 - 1 stage debridement + bone graft + fracture stabilization

B1 - adequate debridement, # stabilization, 2nd stage bone grafting

A2/B2 - distraction histiogenesis, nonvascularized fibular graft...

All healed - (A1: 4-6mth, B1:8-12mth, A2/B2: 12-15mth)

Compl - B1: 4 repeat bone graft, 2 double repeat; B2: 1 refracture
Vascularized fibular grafting in Rx of MRSA osteomyelitis and infected nonunion

20 patients - ~4 prior surgical procedures

- extensive debridement of lesions and local Abx therapy -> usual secondary fib graft
- external fixation (18), plate fixation (2)
- Revision surgery for vascular graft (6)
- 90% union at 7 month
- No fibular complications

Yajima et. al. JRM 2004
Bone Graft Substitutes

- Autograft - progenitor cells, osteoconductive, osteoinductive

  - donor site morbidity, limited quantities, varying quality, ↑anesthetic time, blood loss, cost, postoperative complications
Bone Graft Substitutes

- Human Allograft - osteoconductive (= autograft), osteoinductive (<autograft)
  - disease transmission (2 cases HIV)
  - pressure washed/frozen, freeze-dried, radiation
Bone Graft Substitutes

- Demineralized Bone Matrix (DBM) - human cortical and cancellous allograft process to remove minerals and leave growth factors, collagen, noncollagenous proteins

- Marked variability in osteoinductive properties, no regulations/guidelines on processing, distribution, quality
Calcium-based ceramics

- Hydroxyapatite - osteoconductive
- Tricalcium phosphate - more soluble, degrades 10-20x faster than HAPT
- Calcium Sulfate - plaster of paris - Osteocet
- Calcium phosphate cement - Norian - injectable paste hardens within minutes in nonexothermic crystallization rxn
Composite Grafting

- Autogenous - volume expanders for autogenous bone graft (BM aspirate with DBM, calcium ceramics)
- Collagraft - Type 1 bovine dermal collagen and TCP, HAPT
- BMP7, 2