What is the Problem and is There a Consensus?

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Introduction

• Introduction – what is the problem?
• Additional imaging studies – CT, MRI, US
• Objective scores – are there any?
• How do we improve?

Problem

• There is no gold standard for the definition of fracture healing
• Inter- and intra-observer reliability with most measurements is low
• There is considerable variation in scores, methods and technique
• Union, time to union are critical to success or failure
Current Assessment

- Corrales LA et al. “Variability in the assessment of fracture healing in orthopaedic trauma studies” JBJS(A) 2008
- 12 different clinical criteria
- 11 different radiographic criteria
- Bridging at fracture site most common criterion
- Only 2 studies assessed x-ray reliability quantitatively
- “Lack of consensus”
- “ad hoc defn’s of plain x-rays”

Reliability

- Correlated radiographic assessment with stiffness measurements of fractures
- General appearance / cortical bridging (2 or 3 cortices)
- “All groups performed poorly”

Reliability of fracture assessment

- 15 sets (four views) of scaphoid nonunion post ORIF with bone grafting
- 7 surgeons of varying experience graded films as “yes / no” - are trabeculae crossing fracture site
- Inter-observer K: 0.46, intra-observer K: 0.54
- “Radiographic assessment not reliable or reproducible in this setting”
Prospective trial

- “Low-intensity ultrasound accelerates healing of scaphoid fractures” Mayr E et. al. AAOS 2000
- RCT of stable scaphoid fractures treated with cast versus cast + ultrasound
- 30 patients, all healed clinically and by x-ray
- Mean time to union 6.2 weeks in US group, 8.8 weeks in control
- CT every 2 weeks

CT scan

- “Bhattacharyya T et. al. “The accuracy of computed tomography for the diagnosis of tibial nonunion” JBJS(A) 2002
- 35 patients with equivocal findings
- “gold standard” – OR findings or observation
- Scans assessed by 2 radiologists, 1 surgeon
- K value 0.89, sensitivity 100%
- Accuracy 90%, specificity 62%
- 3 “nonunions” found to have been healed at OR

Radiographic outcomes

- Whelan et. al. “Interobserver and intraobserver variation in the assessment of the healing of tibial fractures after intramedullary fixation” JBJS(B) 2002
- 30 tibial fractures Rx with IM nail assessed by 4 orthopaedic surgeons at 2 separate times
  - kappa value
    - Number of cortices bridged by callus: 0.75 0.89
    - Number of cortices with visible fracture line: 0.70 0.82
    - Extent of callus: 0.57 0.83
    - Overall impression of healing: 0.67 0.82
- “Number of cortices bridged by callus a reliable
Radiographic Union Score for Tibial fractures

- Whelan et. al. “Development of the RUST score for the assessment of tibial fracture healing after intramedullary fixation” J Trauma (in press)
- Score of 1, 2 or 3 for each of four cortices (ant, post, med, lateral)
- No callus, fracture line = 1
- Callus, fracture line = 2
- Callus, no fracture line = 3

- Kappa values 0.80 – 0.85
- Reliable and reproducible score

Consensus opinion

- Objective scoring systems
- Union an important outcome
- Adjudication committee examines radiographs