New Materials in Fixation

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Disclosures

• Consultant
  – Acumed, CarboFix, Citieffe
• Editorial Board
  – Journal of Orthopaedic Surgery and Research
  – Trauma Cases and reviews
• Royalty
  – Citieffe
• Speakers Bureau
  – Acumed
• Stock Options
  – CarboFix
• Some of the slides courtesy of Bruce Ziran, MD

Objectives

• Discuss new materials in internal fixation

• Discuss future directions
Internal Fixation

- Carbon Fiber
- Bioabsorbable materials

Evolution – Improved Modulus

- Stainless Steel
- Titanium
- CarboFix: Composite Materials

Modulus of Elasticity

- Cortical Bone
- CF Composite (PEEK)
- Titanium (Ti-6Al-4V)
- Stainless Steel (Steel 316)

CarboFix:
Composite Materials
Potential Effect on Healing

- Lower modulus may enhance callus formation
- "Bone-phillic"

Immediate Post-OP

2 Weeks Post-OP

4 Weeks Post-OP

Carbon Fiber Reinforced (CFR) PEEK

- CFR PEEK biocompatibility: USA guidelines
- Clinical experience/safety of CFR PEEK > 10 yrs

Why carbon fiber? Problems with metal

- High elastic modulus compared to bone
- Radiopaque (can’t see through X-rays)
- Artifacts with CT & MRI
- Potential allergic response
- Potential barometric symptoms
- Cold welding with Ti
Fatigue Properties

• Can withstand > 1,000,000 cycles without failure or damage

Radiolucency

• Better evaluation of healing
Radiolucency

- Better evaluation oncologic lesion
  - 51yo F
  - Breast Ca
  - Path fracture

Radiolucency – advantage in CA

- Less scatter for XRT

Limitations

- Interlocking holes (perfect circles) are challenging
  - Can enhance with changing kVP and mA
- Plates are not bendable
  - Can “over-reduce”
  - Plates can crack
- “Can’t hide”
- Wear debris?
Plate can overpower reduction/lag screw
Slight fracture gap (A)
Deformed lag screw (B)

With more screws...
Further deformation of the lag screw (C)
More fracture gap (D)
More deformation (E)
Potential problems with compression
Wear debris?
- Inflammatory reaction similar between CFR-PEEK and UHMWPE
  - CFR-PEEK superior mechanically and chemically

Bioabsorbable materials
- Impetus: ORIF with "absorbable rods"
  - Pediatrics
  - Arthrodesis
  - Metal-sensitive areas
    - Prominence
    - Radiolucent

Materials available
- PGA – poly-glycolic acid
- PLA – poly-lactic acid
- PDS – poly-dioxanone
- PLLA – poly-levo-lactic acid
- PLLA – slowest degradation, least reactive
Advantages

• Radiolucency and lack of artifact
• Lack of “stress shielding”
• Biodegradable
• Gradual load transfer
• No need for ROH

Applications

• Femoral head fractures
• Various pediatric applications
• Challenging articular fractures
Limitations

- Not contourable
- Poor shear tolerance (after 5 weeks)
- Subject to creep and stress-relaxation
  - Compressive screws lose 20% within 20 minutes
- Reactivity
  - Aseptic inflammation
  - Sinus tract formation
  - Osteolysis
  - Synovitis

Limitations

- Bioabsorbable, but not osteoconductive
  - Debris is typically left behind (inert)
  - Reaction (Walton, J. Biomater Appl 2007):
    - Sequestration first 3 months
    - Inactivity until 1 year
    - Gradual disintegration and fragmentation 1-3 years
      - NOT replaced by bone
Future direction

• Bioabsorbable materials that permit
  – Osteoinduction
  – Osteoconduction
  – Osteogenesis

• Able to modulate cellular signals at molecular level

• Able to modulate mechanotransduction

Current avenues

• Tissue engineering and scaffold development
  – Problems
    • Angiogenesis
    • Cellular longevity
    • Delivery
  – Development focused primarily for spinal and arthroplasty options

Summary

• Alternative implants both possess strengths and weaknesses
• Radiolucency and ability to evaluate for healing
• Reactivity and strength profile differ
• Next generation: molecular and cellular level
Thank you