Clinical Application of Virtual Mechanical Testing Measures Slow Fracture Healing in Patients with Comorbidities

Peter Schwarzenberg¹, Andrea McCarthy², James A. Harty², Hannah L. Dailey¹

¹Department of Mechanical Engineering and Mechanics, Lehigh University, Bethlehem, PA
²Department of Orthopaedic Surgery, Cork University Hospital, Cork, Ireland

Introduction – Secondary Fracture Healing

Risk factors for delayed healing or nonunion include:
- Mechanical factors
  - Stress shielding
  - Increased mobility
- Biological factors
  - Immobility
  - Hypertrophy

Methods – Clinical Study Design

- Tibial Fractures
  - Treated by Reamed Intramedullary Nailing
- Biochemical Correlations
- Mechanical Testing

Methods – Model Construction

- AP and Lateral XR
- Fracture Site
- Model Reconstruction
- Solid FE Model
- Material Properties
- Boundary Conditions
- Solving Iterations

Methods – Virtual Torsion Test

- The simulated torsion test measures the virtual torsional rigidity (VTR) of each tissue:
  - VTR = ML/φ [N-mm/°]
- Normalized torsional rigidity assesses structural healing relative to intact bone:
  - VTR_{N} = \frac{VTR_{FX}}{VTR_{Rec}}

Results – Structural Models at 12 Weeks

- Fractures & Contact Area
- Healing Time
- Normal VTR
- VTR with comorbidities

Discussion & Conclusions

- Virtual mechanical testing detected poor structural bone healing (23% lower VTR compared to normal) in patients with comorbidities with a large effect size even at small N.
- Previous clinical studies have required very large sample sizes (100s or 1000s of patients) to show significant contributions of risk factors to nonunion or delayed healing.
- As an assessment tool, virtual mechanical testing may enable clinical study design with much lower sample size requirements to study the effects of interventions and risk factors.

Results – Morphometric Analysis of Callus

- Callus Density
- Elongation
- Normal vs. Comorbid

More Info

- Corresponding Author Contact: Peter Schwarzenberg, Mechanical Engineering & Mechanics, Lehigh University, peter@lehigh.edu

For additional information on the methods for virtual mechanical testing as an assessment of fracture healing, refer to: