Biomechanics 301

Back Pain
Fusion
Motion Preservation

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DePuy Spine
OrthoMEMS
AxioMed
Computational BioDynamics
The Basics

Lumbar Spondylosis
Practical Applications

Spinal Loads
SPINE BIOMECHANICS

"Seesaw" model

F_{muscles}  F_{disc}  F_{wgt.}

Back Muscles
Suboptimal Leverage

Pyloric sphincter
Rectus abdominis m.
Jejunum
Right crus of diaphragm
Body of pancreas
Back Muscles
Short Moment Arm

\[ \text{F}_{\text{muscles}} + \text{F}_{\text{disc}} - \text{F}_{\text{wgt.}} \]

\(~5\text{ cm}\)

\[ \text{F}_{\text{muscles}} + \text{F}_{\text{disc}} - \text{F}_{\text{wgt.}} \]

\(~60\text{ cm}\)

\[ \text{M} = \text{Fd} = 3000 \text{ Ncm} \]

\[ 60 \text{ cm} \]

\[ \text{M} = 3000 \text{ Ncm} \]

\[ \text{F}_{\text{muscles}} = \frac{\text{M}}{d} = 600\text{N} \]
• Poor leverage of back muscles
  high muscle forces
• Disc, vertebra
  “pay the price”

...but simple models effective for estimating spinal loads

Wgt upper body
Erector spinae tension
Axial compressive disc force
Quiz

...simple models effective for ergonomic analysis
Adaptation

Change in the structure of bone to sustain changes in the external loading

Wolff’s Law (1870):
Bone structure forms to provide maximum strength with minimum mass.
Example: Trabecular bone in vertebral body is aligned in the vertical direction.

Load Transfer

Load transfer thru N+A

www.medscape.com
Load Transfer

Stress Profilometry

Normal

Moderately Degenerated

Significantly Degenerated

Range of Motion

Figure 1-20 A typical load deformation curve depicting the neutral and elastic zones (deformation or strain versus load or stress).

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Range of Motion

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“The treatment of back pain falls primarily in the non-operative domain. Surgery for such a malady should be a relative exception.”
FUSION

Deep, Agonizing Pain
Worsened with Loading
Improved with Unloading
PAIN GENERATOR

DYSFUNCTIONAL MOTION SEGMENT
MOTION PRESERVATION
Interspinous Spacers
(Motion Preservation)

X-Stop (St. Francis Medical)

Wallis (Spine Next, Bordeaux)

Diam (Medtronic)
Dynamic Stabilization
(Motion Preservation or Fusion Enhancement)
Clinical Experience With the Dynesys Semirigid Fixation System for the Lumbar Spine

Surgical and Patient-Oriented Outcome in 50 Cases After an Average of 2 Years

Dieter Grob, MD,* Amoldo Benini, MD,* Astrid Junge, PhD,* and Anne F. Mannion, PhD*1

Conclusion. The results of the present study indicate that both back and leg pain were, on average, still moderately high 2 years after instrumentation with the Dynesys system. Only half of the patients declared that the operation had helped and had improved their overall quality of life; less than half reported improvements in functional capacity. The reoperation rate after Dynesys was relatively high. The results provide no support for the notion that semirigid fixation of the lumbar spine results in better patient-oriented outcomes than those typical of fusion.

Key words: semirigid instrumentation, Dynesys, fusion, patient-oriented outcome, degenerative disorders, back pain, leg pain. Spine 2005;30:324–331
Observation: Reversal of pressure trends with distraction/compression
Clinical Experience With the Dynesys Semirigid Fixation System for the Lumbar Spine

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Pain Generator

????????????
DISCOGENIC BACK PAIN ?
Dysfunctional Motion Segment

Excessive Motion
Fixed Subluxation
Significant Degenerative Changes
Cervical vs Lumbar


Mechanical BACK PAIN

Deep, Agonizing Pain
Worsened with Loading
Improved with Unloading
ATTRIBUTES

Replicates Anatomy
Replicates Motion
Replicates Mechanics
Minimal Complications
Acceptable Revision Strategies
Longevity
Retardation of Degenerative Changes
Symptom Relief

REPLICATES ANATOMY

Disc Interspace Height
Disc Interspace Angle
Replicates Motion

Translation
Angular

Axial
Coronal
Sagittal
In Which Plane?
- Axial?
- Translational?
- Bending?

Along Which Axis?
- Axial
- Coronal
- Sagittal

REPLICATES MECHANICS
- Stiffness
- Shock Absorption
- Creep
Stiffness

Unconstrained
Semiconstrained
Constrained
In Which Plane?

Axial?
Translational?
Bending?

Motion Segment Stiffness

Unconstrained       Semiconstrained       Constrained

Disengagement       Engagement
Clinical Application
Structural Pathology

Anatomic
Mechanical

The Biomechanical Correlate of Mechanical Back Pain

Widened Neutral Zone
FLEXION AND EXTENSION

Unconstrained          Semiconstrained          Constrained

Disengagement          Engagement
FLEXION AND EXTENSION

Unconstrained  Semiconstrained  Constrained

Disengagement  Engagement

Mechanical Back Pain

Begins as Biochemical / Nutrient – Related
then
Becomes Structural
Mechanical Surgery ~ Mechanical Pathology
Mechanical BACK PAIN

Deep, Agonizing Pain Worsened with Loading Improved with Unloading
How do we know ????????????

Imaging Does Not Define An Indication For Surgery
Indications for Surgery

History c/w MLBP
Imaging c/w DSM
+ Objective Data

Mechanical Pathology
??????????????
Cannot Assess Stress / Strain Relationships in Vivo
IAR
Appropriate Loading

Bone
Supporting Soft Tissues
MINIMAL COMPLICATIONS

**Short Term**
- Vascular
- Neurological
- Expulsion

**Long Term**
- Expulsion
- Subsidence
- Failure of Ingrowth
- Osteophyte Formation
Osteointegration

Bony Ingrowth
Large vs Small Pore Size
Short - Long Term Fixation

Short Term Fixation

Intermediate Term Fixation

Long Term Fixation

ACCEPTABLE REVISION STRATEGIES

Dorsal Fusion and Instrumentation Removal?
LONGEVITY

? 

RETARDATION OF DEGENERATIVE CHANGES

?
SYMPTOM RELIEF

Anecdotal Information
Non-Inferiority ~ Inferior Device Bias

Investigator Bias
Patient Selection Bias
Winner-Loser Bias
Back to the Basics
SMOKING
Two Recommendations

#1 Act Like You Are The Patient
#2
Act Like Paying for the Surgery

“Technology” is a Tool
A fool with a tool......

.....is still a fool!!!!!
What Happens in 10, 15, 20 ….. Years?

“A failure of non-operative management should not be construed as implying that surgery will work.”
The art of medicine is amusing the patient until nature cures the disease.

Voltaire
Thank You!!!