



**Spine Biomechanics:
A Basic Primer Course**

**Johns Hopkins Orthopaedic Surgery
Review Course**

A. Jay Khanna, MD

The Johns Hopkins Medical Institutions
Department of Orthopaedic Surgery
Baltimore, Maryland

University of Virginia
Department of Orthopaedic Surgery


Construct stability is enhanced with posterior spinous process wiring in presence of anterior cervical plating because:

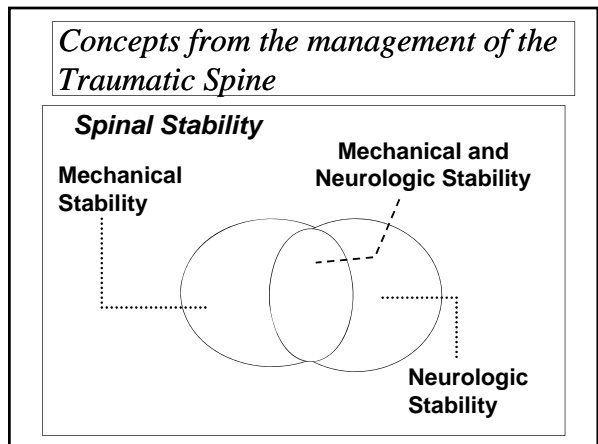
😊

1. Improved rotational stiffness
2. Improved lateral bending
3. Improved extension stiffness
4. Reconstitution of posterior tension band
5. Augmentation of axial load resistance

- Key Points**
1. Understand body weight line / sagittal balance.
 2. Understand theory of anterior column support and posterior tension band
 3. Understand behavior of uninstrumented/instrumented strut graft
 4. Understand implications of shear at the LS junction
 5. Understand why distraction is bad in the L-spine

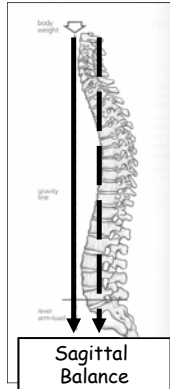
- Biomechanically the best construct for immobilizing C1-2
- 😊😊
1. Gallie-type
 2. Brooks-type
 3. 2 bilateral posterior clamps (Halifax-type)
 4. Anterior odontoid screw
 5. Transarticular (Magerl) screw with midline wiring and grafting

- 60-y.o. Hx of breast cancer has progressive paraparesis. The MRI scan shown to the right. What form of management is most likely to restore or maintain ambulation?
- 1- Radiation therapy and a thoracolumbosacral orthosis
 - 2- Laminectomy alone
 - 3- Laminectomy and radiation therapy
 - 4- Laminectomy and posterior fusion
 - 5- Anterior decompression and stabilization
- 

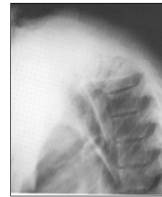


Spinal Biomechanics

- Body weight line is anterior to spinal column
- Vertebral body
 - Anterior column support
- Posterior elements
 - Tension band
- Sagittal balance is important



Spinal Biomechanics

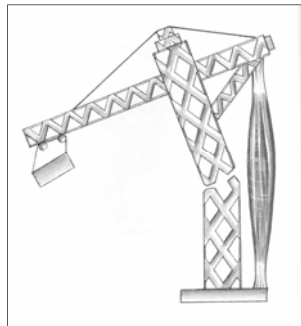


Spinal Biomechanics

Lose anterior column support



Junctional Kyphosis



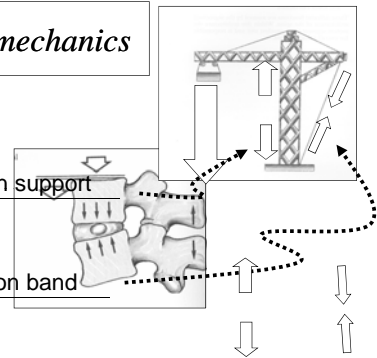
Harms J, Tabasso G. Instrumented Spine. Thieme. 1999

Spinal Biomechanics

- Goal

- Restore: anterior column support
- Restore: posterior tension band

CTQ



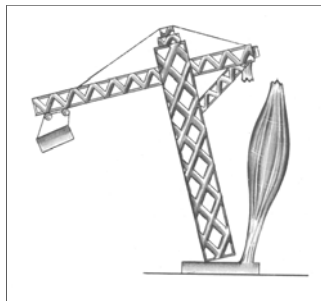
Harms J, Tabasso G. Instrumented Spine. Thieme. 1999

Spinal Biomechanics

Lose posterior tension band

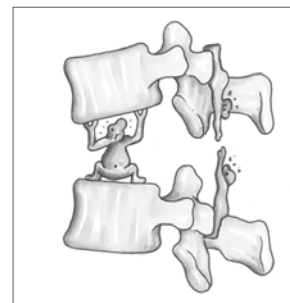


Junctional kyphosis



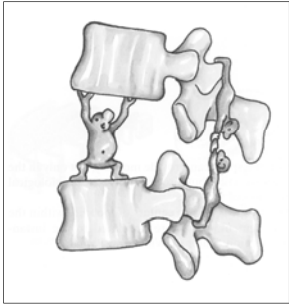
Harms J, Tabasso G. Instrumented Spine. Thieme. 1999

Spinal Biomechanics



Harms J, Tabasso G. Instrumented Spine. Thieme. 1999

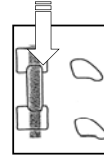
Spinal Biomechanics



Harms J, Tabasso G. Instrumented Spine. Thieme. 1999

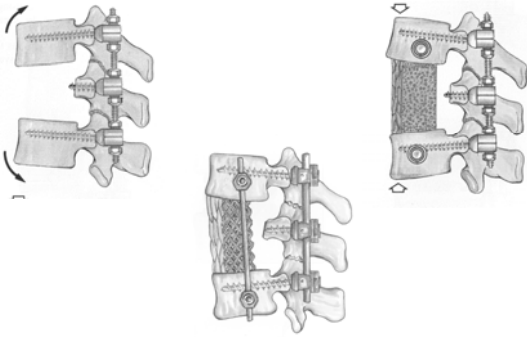
Anterior Column Interbody Support

- Axial compression
 - Loads graft
- Flexion
 - Loads graft
- Extension
 - Unloads graft
- Translation
 - Unstable
 - "Pole vaulting"



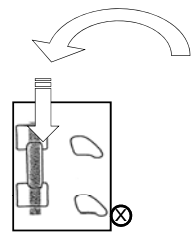
Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

Spinal Biomechanics



Anterior Column Interbody Support

- Axial compression
 - Loads graft
- Flexion
 - Loads graft
- Extension
 - Unloads graft
- Translation
 - Unstable
 - "Pole vaulting"



Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

What are our "Devices" ?

Common Anterior Column Devices

- Structural Support
 - Bone graft
 - Autograft / Allograft
 - Cages
 - Arthroplasty

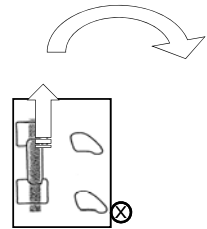
Interbody Devices
applied between
vertebral bodies

- Cantilever Beams
 - Plates
 - Rods

Tension Band
applied on
vertebral bodies

Anterior Column Interbody Support

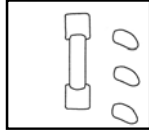
- Axial compression
 - Loads graft
- Flexion
 - Loads graft
- Extension
 - Unloads graft
- Translation
 - Unstable
 - "Pole vaulting"



Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

**Anterior Column
Interbody Support**

- Axial compression
 - Loads graft
- Flexion
 - Loads graft
- Extension
 - Unloads graft
- Translation
 - Unstable
 - "Pole vaulting"

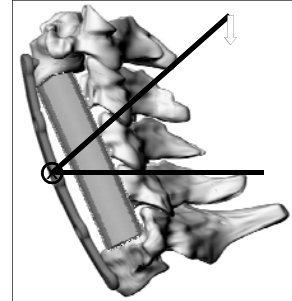


Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

Anterior Cantilever Beam

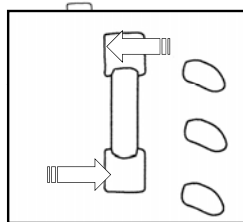
Isolated Anterior Plating

Moves
axis of rotation
anterior



**Anterior Column
Interbody Support**

- Axial compression
 - Loads graft
- Flexion
 - Loads graft
- Extension
 - Unloads graft
- Translation
 - Unstable
 - "Pole vaulting"

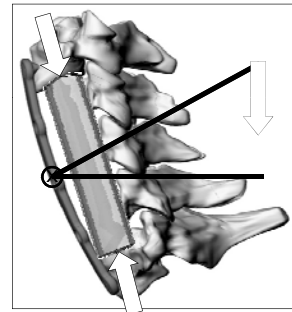


Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

Anterior Cantilever Beam

Isolated Anterior Plating

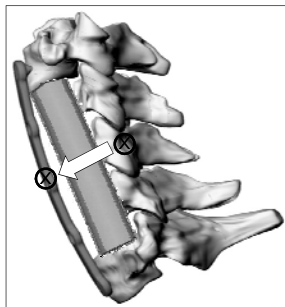
**Isolated Anterior
Fixation loads the
graft in extension**



Anterior Cantilever Beam

Isolated Anterior Plating

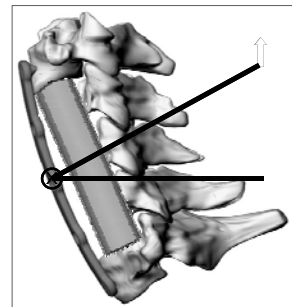
Moves
axis of rotation
anterior



Anterior Cantilever Beam

Isolated Anterior Plating

Moves
axis of rotation
anterior



Anterior Cantilever Beam

Isolated Anterior Plating

Isolated Anterior Fixation unloads the graft in flexion

Terminal Bending

What is it?

- Moments created at the ends of a long construct with insufficient intermediate fixation points

How do you fix it ?

- Place intermediate fixation points

What are our "Devices" ?

Common Posterior Column Devices

- Structural Support
 - Clinically not used much
 - ?? Brooks C1-C2 fusion
- Cantilever Beams
 - Plates / Rods
 - Pedicle and lateral mass fixation
 - Spinous process wiring

"Interprocess Devices" applied between spinous process

Tension Band applied on spinous process

Modified Gallie Fusion

Brooks Fusion

Posterior C1-C2 Fusions

Transarticular Screws

Facet Anatomy and Spinous Process Wiring

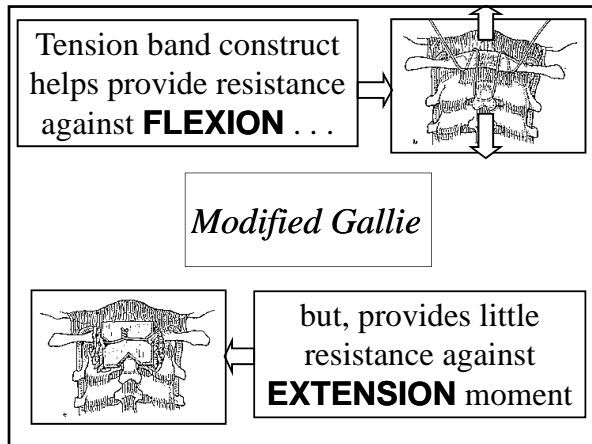
- Cervical facet orientation augments posterior tension band efficiency
- Compression facilitates facet reapproximation
- Facet approximation helps resist flexion and translation

Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

Biomechanical Studies of C1-C2 Posterior Techniques

	Flexion	Extension	Rotation
Modified Gallie	Good	Poor	Poor
Brooks	Good	Better	Better
Transarticular Screws	Best	Best	Best

CTQ

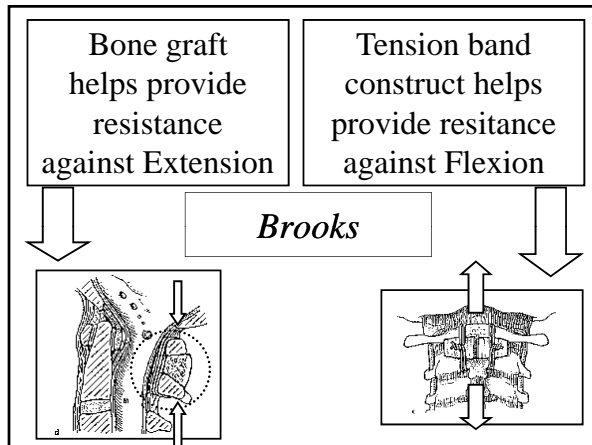


2 Random Lumbar Concepts for the Boards

Anterior: Shear at L5-S1 is bad

Posterior: Lumbar distraction is bad

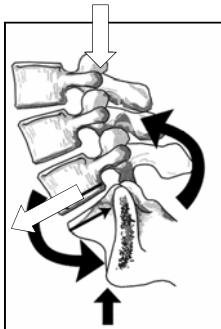
CTQ



Lumbosacral Anatomy and Fusion

Anterior


- Interbody implants work best in compression
- Fusion is best in compression—Wolff's Law **CTQ**
- In an upright posture, the low lumbar / lumbosacral interspace can experience significant shear forces




Benzel EC. Biomechanics of Spine Stabilization. Thieme. 2001.

Transarticular Screws

- Immediate internal fixation
- Rigidly couples facets of C1-C2



- Combined with interspinous wiring and bone grafting provides three-point atlantoaxial fixation



Spinal Deformity

L5-S1 Spondylolisthesis

- Q: Choosing between L5-S1 vs. L4-S1
- A: In low grade slips
 - Grade I / II (0-50%) slip
 - Fairly horizontal L5-S1
 - Fuse from L5-S1 only **CTQ**
- A: In high grade slips
 - Grade III/IV (51-100%) slip
 - L5-S1 often fairly vertical
 - Fuse from L4-S1

Lumbar Distraction

- Lumbar distraction
- Flattening of normal lordotic curve
- Flat back syndrome
- Positive sagittal alignment

Bad, bad, bad, and bad

Benzel EC. Biomechanics of Spine Stabilization. 2001.

- 60-y.o. Hx of breast cancer has progressive paraparesis. The MRI scan shown to the right. What form of management is most likely to restore or maintain ambulation?

- 1- Radiation therapy and a thoracolumbosacral orthosis
- 2- Laminectomy alone
- 3- Laminectomy and radiation therapy
- 4- Laminectomy and posterior fusion
- 5- Anterior decompression and stabilization

Spinal Instability

Does a Laminectomy meet these goals?

NO !

- 60-y.o. Hx of breast cancer has progressive paraparesis. The MRI scan shown to the right. What form of management is most likely to restore or maintain ambulation?

- 1- Radiation therapy and a thoracolumbosacral orthosis
- 2- Laminectomy alone
- 3- Laminectomy and radiation therapy
- 4- Laminectomy and posterior fusion
- 5- Anterior decompression and stabilization

PREFERRED RESPONSE: 5

**THANK
YOU!**

Construct stability is enhanced with posterior spinous process wiring in presence of anterior cervical plating because:

😊

1. Improved rotational stiffness
2. Improved lateral bending
3. Improved extension stiffness
4. Reconstitution of posterior tension band
5. Augmentation of axial load resistance

Construct stability is enhanced with posterior spinous process wiring in presence of anterior cervical plating because:



1. Improved rotational stiffness
2. Improved lateral bending
3. Improved extension stiffness
4. Reconstitution of posterior tension band
5. Augmentation of axial load resistance

Preferred response: 4

Spinal Deformity

Harrington Instrumentation

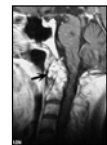
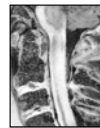
OITE: 45 y.o. Scoliosis 20 years ago with Harrington instrumentation. LBP.

- ANSWER:
 - Flatback
 - Lumbar distractive instrumentation
 - Positive sagittal balance

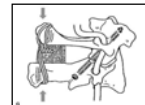
- Biomechanically the best construct for immobilizing C1-2



1. Gallie-type
2. Brooks-type
3. 2 bilateral posterior clamps (Halifax-type)
4. Anterior odontoid screw
5. Transarticular (Magerl) screw with midline wiring and grafting



Thank You



- Biomechanically the best construct for immobilizing C1-2



1. Gallie-type
2. Brooks-type
3. 2 bilateral posterior clamps (Halifax-type)
4. Anterior odontoid screw
5. Transarticular (Magerl) screw with midline wiring and grafting

Preferred response: 5