CLINICAL INSTABILITY OF THE SPINE

S.J. du Plessis

University of Calgary Spine Program

Overview of Presentation

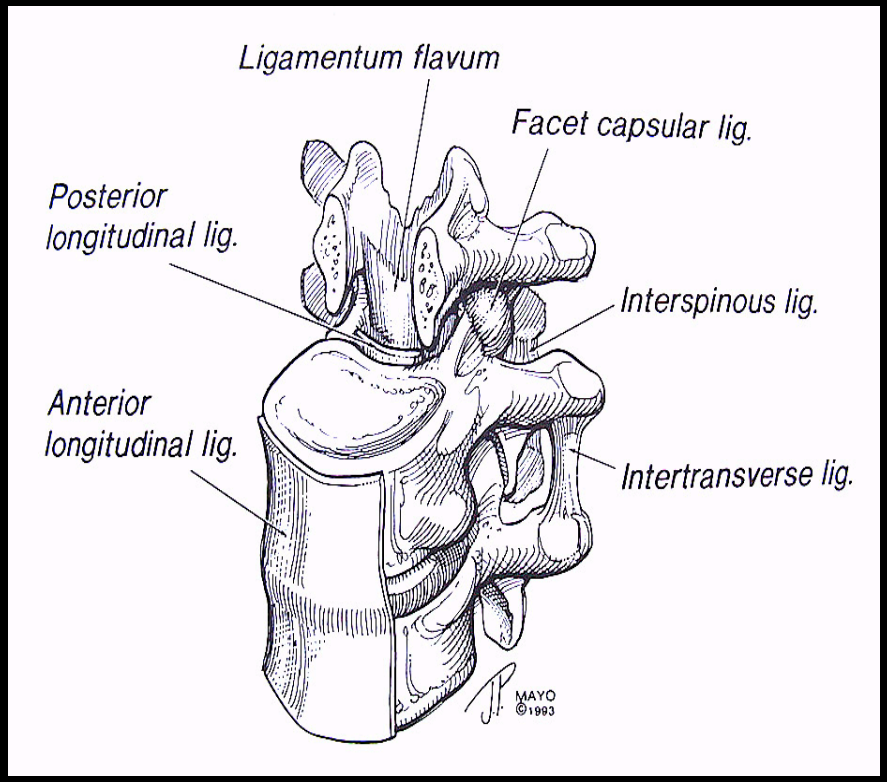
- Biomechanics
- Clinical decision making
- Clearing the spine
  - Clinically
  - Radiologically
- Role of MRI

Spinal Stability

- The ability of the spine to provide a rigid but flexible supporting structure , to allow movement while limiting deformity and preventing neurological compromise.
- “ the ability to limit excessive spinal displacement ”

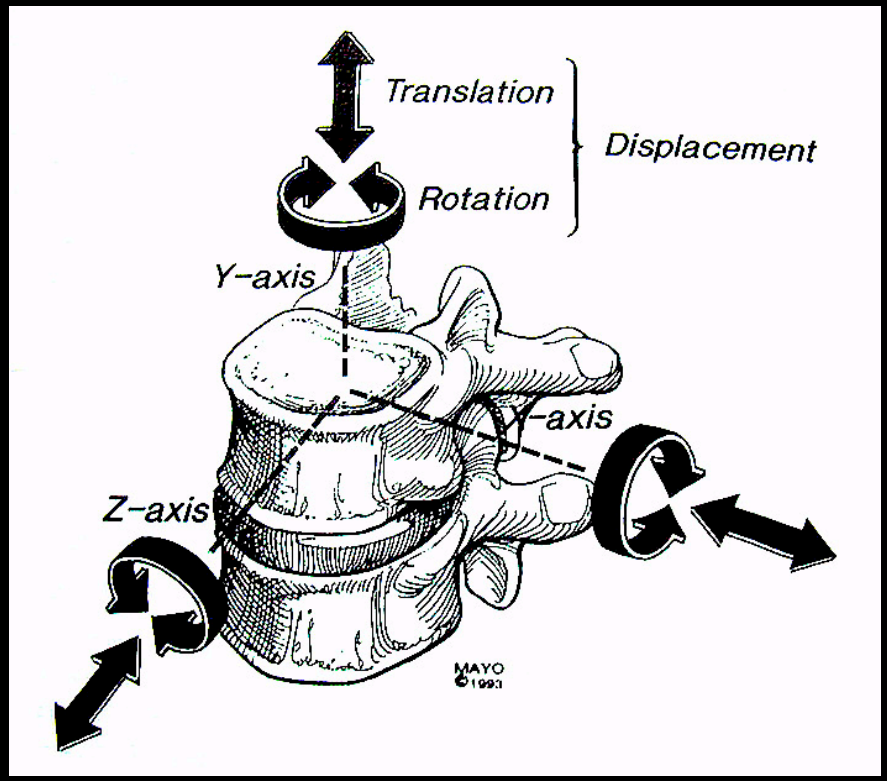
The Functional Spinal Unit (FSU)

- Two consecutive vertebrae
- Intervertebral disc
- All ligaments
- No muscles



Six Degrees of Freedom

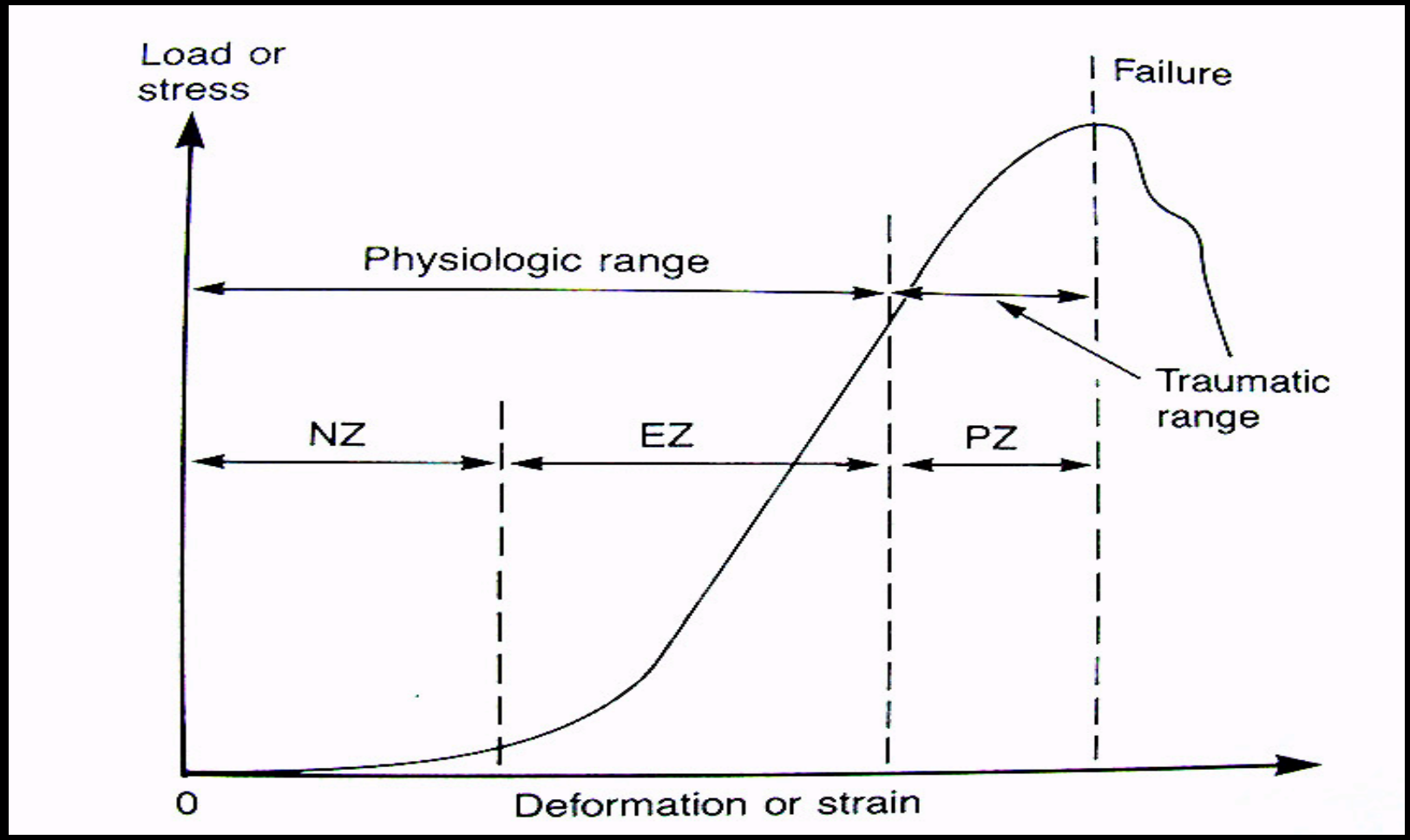
- Axes:
  - Y-AXIS = SAGGITAL
  - X-AXIS = CORONAL
  - Z-AXIS = HORIZONTAL
- Movement:
  - ROTATION
  - TRANSLATION



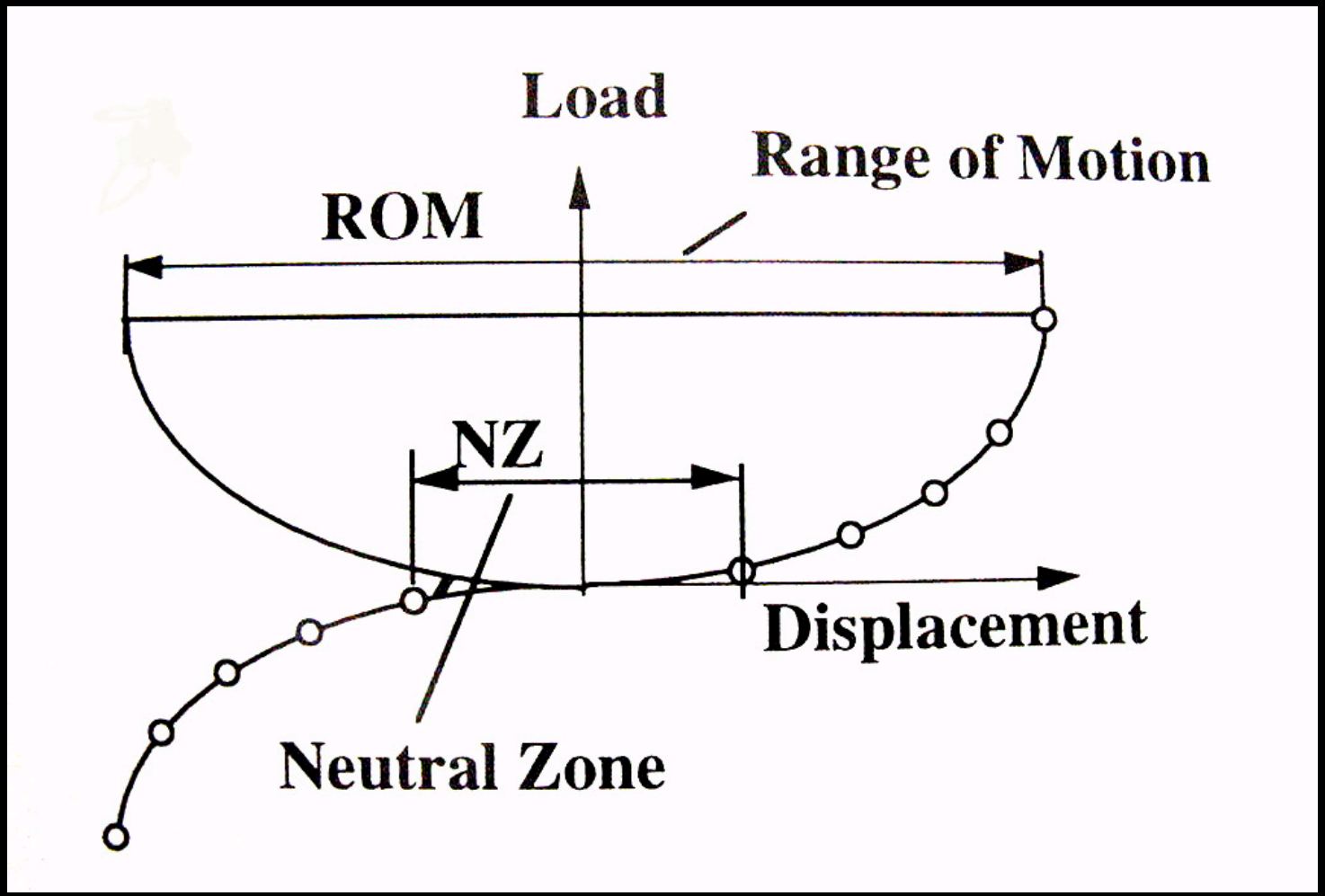
Viscous and Elastic Elements

- DISC = Viscous element:
  - Resistance to loads that increases with increasing force , and energy is dissipated.
- LIGAMENTS = Elastic element:
  - Stores energy which is released during the return to the original position.
- BONE = Weight-bearing element:
  - Transfer of a load from vertical pressure to transverse tension = resilience.

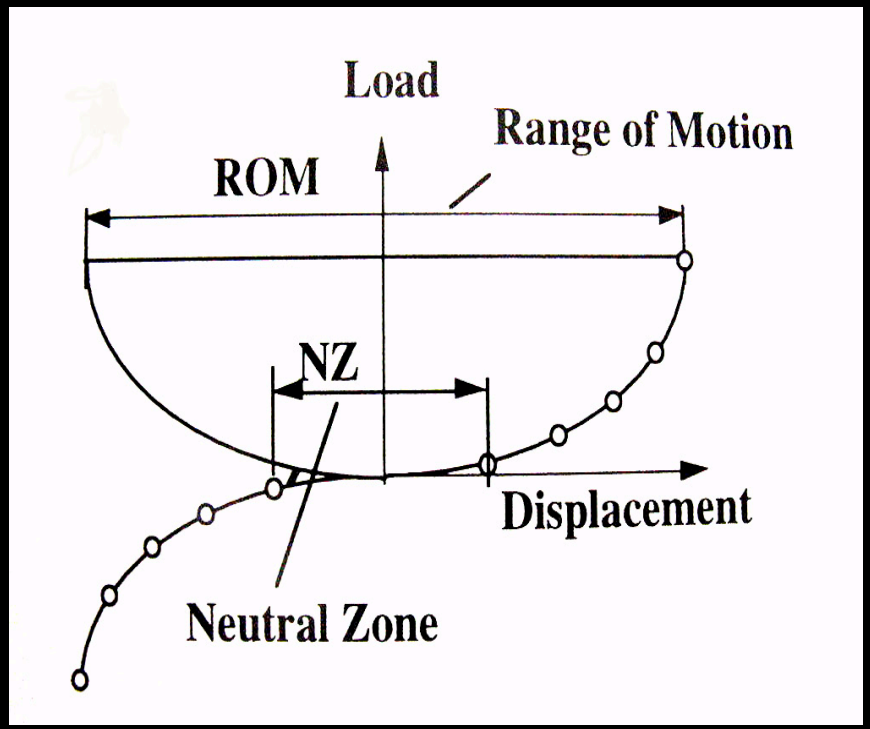
Load - Deformation

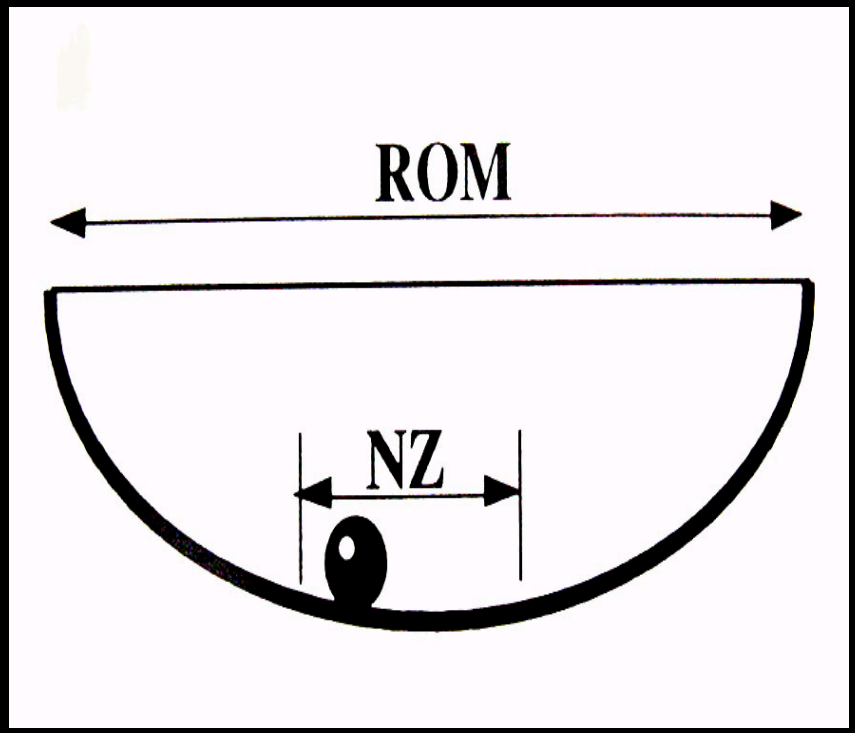


ROM and the NZ



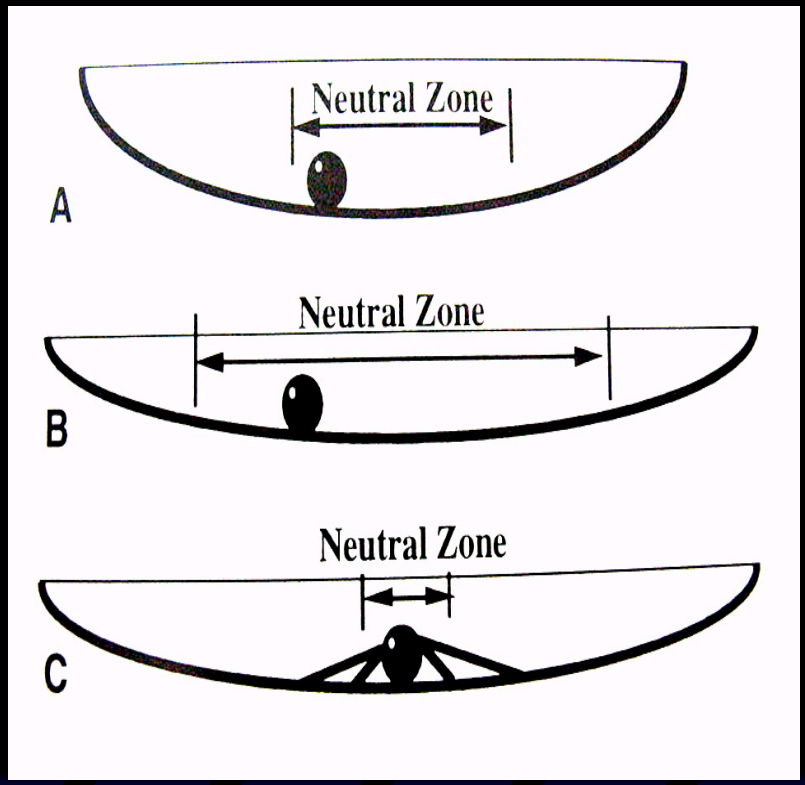
Range of Motion = Neutral Zone





Effect of Fusion on the NZ and ROM

- NZ = ROM
- Normal NZ with normal ROM.
- Unstable spine segment with increased NZ and ROM.
- NZ and ROM after fusion.

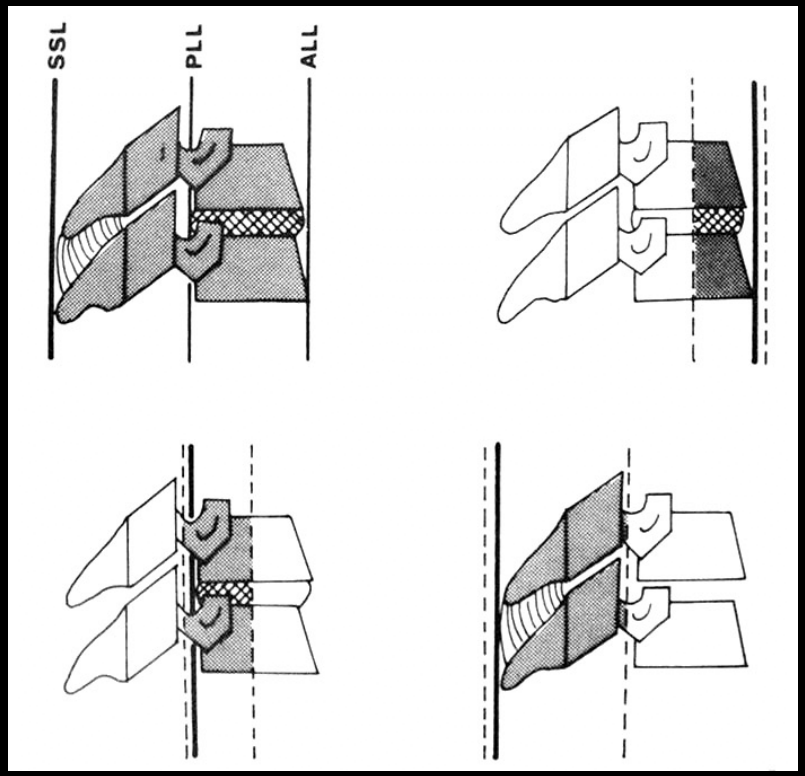


Definition of Spinal Instability

- Clinical instability is the loss of the ability of the spine under physiological loads to maintain its pattern of displacement so that there is no initial or additional neurological deficit , no deformity and no incapacitating pain.

Three Column Concept

- Anterior Column:
  - Ant. longitudinal ligament
  - Ant. 1/2 disc and body
- Middle Column:
  - Post. longitudinal ligament
  - Post. 1/2 disc and body
- Posterior Column:
  - Supra spinous ligament
  - Post. bony elements
- 2/3 = Instability



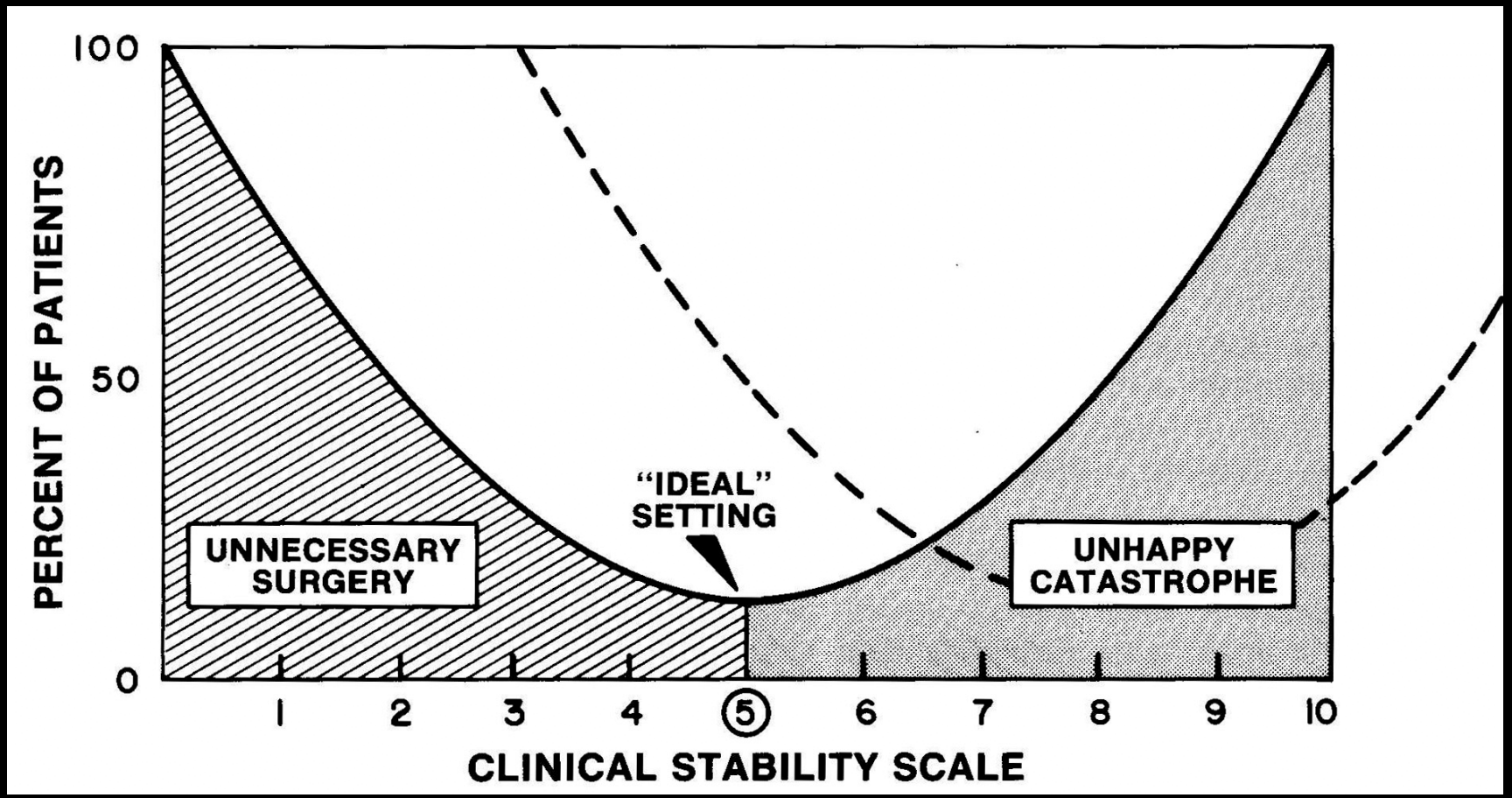
Clinical Groups of Instability

- Acute Spinal Instability:
  - Overt instability
  - Limited instability
- Chronic Spinal Instability:
  - Progressive instability
  - Dysfunctional segment

Quantitation of Acute Instability

- Neural element injury = 3
- Integrity of anterior and middle column = 2
- Integrity of posterior columns = 2
- Resting translation deformity = 2
- Resting angulation deformity = 2
- Dynamic translation deformity = 2
- Dynamic angulation deformity = 2
- Disc narrowing at level of pathology = 1
- Dangerous loading anticipated = 1

Clinical Decision Making



Management options of comatose trauma patients without MRI

- Continue spinal precautions until clinically cleared = Costly option.
- Flexion / Extension radiography = False negative information and may be risky.
- Discontinue spinal precautions = Dangerous.

Cost of spinal precautions in comatose patients

- Prolonged unnecessary spinal precautions.
  - Patient mobilization
  - Respiratory care
  - Extremity fracture management
  - Complicates medical and nursing care
- Cost and risks of early MRI are outweighed by its benefits.
- Difficult to determine cost.

Influence of MRI on Treatment

- Selden et al , Neurosurgery 1999
  - Immediate MRI altered initial clinical management in 49% of patients.
  - Prognostic Value
    - Presence and length of intra-axial hematoma
    - Cord edema
    - Extra-axial hematoma
- MRI also influenced the surgical approach and the timing of surgical intervention.

Restrictions with MRI

- Patient condition
- Transportation to MRI
- Access to patient in MRI
- Monitoring equipment - MRI compatible
- Cost
- Availability

Decision Instrument

- No midline cervical tenderness
- No focal neurologic deficit
- Normal alertness
- No intoxication
- No painful , distracting injury

NEXUS Results

- 818 (2.4 %) patients had radiographically documented C-Spine injury.
- Decision instrument identified 810 patients.
- 2 of the 8 patients “missed” had clinically significant injury.
- Decision Instrument = Sensitivity 99.0%
- Imaging could have been avoided in 12.6%

Radiographic Clearing

- Bone and soft-tissue structures must be evaluated before the spine can be cleared.
- Bone injury = XR and CT
- Soft-tissue injury
  - MRI (direct evaluation)
  - Dynamic views (indirect evaluation)

Limitations of Plain Radiography

- Woodring et al , J of Trauma 1993
  - C-spine trauma series
  - “missed” 67% of fractures and 45% subluxations
- Concluded that the C-spine trauma series cannot be relied upon to determine the extent and severity of cervical injuries
- Liberal use of CT scanning

Dynamic Radiography

- Flexion / Extension views are valuable to determine spinal stability days to weeks after injury - when acute pain has subsided.
- Risky in obtunded or medicated patients where intrinsic guarding mechanisms are not intact.
- May be false negative early on due to voluntary or involuntary guarding.

Neutral

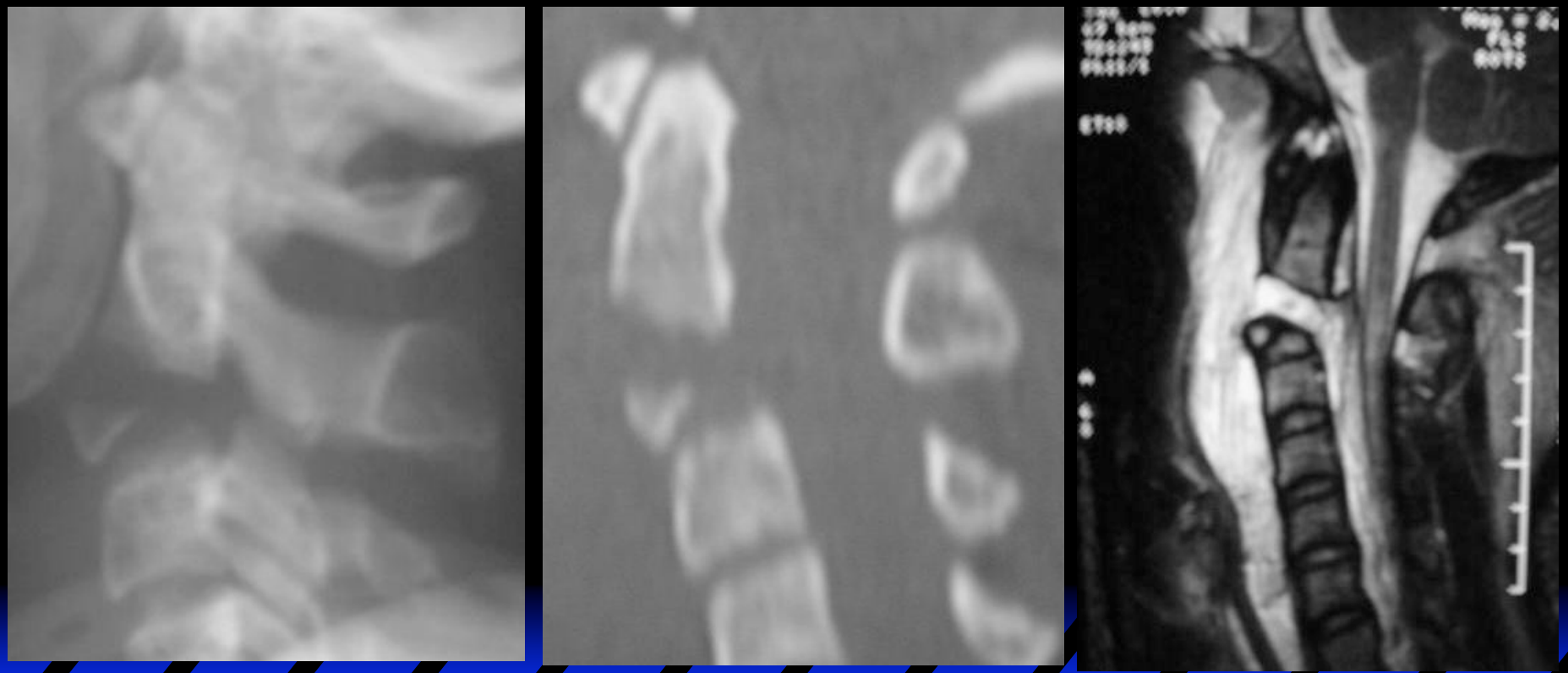
Flexion

Extension

MRI for Vertebral Trauma

- Best imaging modality
  - Spinal cord
  - Vertebral soft-tissue
- Information provided by early MRI in SCI
  - Vertebral body alignment
  - Bony relationships to the cord (bone fragments)

XR CT MRI



Indications for MRI in Trauma

- Comatose or obtunded trauma patient
- Patient with neurological deficit
- Patient with history suggestive of SCI
  - MRI first
  - CT scanning targeted to the area of soft-tissue injury = bony injury evaluation.
  - Limited Imaging
    - Saggital T1 and T2
    - Reduces cost

Comatose Trauma Patient

- D'Alise et al , J Neurosurg 1999
  - MRI identified significant injury in 25.6 % of patients cleared by plain radiography.
  - 25 % of these patients needed surgery.
  - Spinal precautions were discontinued in the rest facilitating medical and nursing care.
  - Limited imaging = Saggital T1 + T2

Management options of comatose trauma patients without MRI

- Continue spinal precautions until clinically cleared = Costly option.
- Flexion / Extension radiography = False negative information and may be risky.
- Discontinue spinal precautions = Dangerous.

Cost of spinal precautions in comatose patients

- Prolonged unnecessary spinal precautions.
  - Patient mobilization
  - Respiratory care
  - Extremity fracture management
  - Complicates medical and nursing care
- Cost and risks of early MRI are outweighed by its benefits.
- Difficult to determine cost.

Influence of MRI on Treatment

- Selden et al , Neurosurgery 1999
  - Immediate MRI altered initial clinical management in 49% of patients.
  - Prognostic Value
    - Presence and length of intra-axial hematoma
    - Cord edema
    - Extra-axial hematoma
- MRI also influenced the surgical approach and the timing of surgical intervention.

Restrictions with MRI

- Patient condition
- Transportation to MRI
- Access to patient in MRI
- Monitoring equipment - MRI compatible
- Cost
- Availability

Conclusion

- Spinal stability = Bone AND Soft-tissue integrity.
- MRI does not replace XR and CT but provides us with very valuable decision making information.