The spine

*Surgical & Clinical Anatomy*

*Kinematics*

*Biomechanical principles*

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Clinical Anatomy

Anatomic Fact

Clinical Application
Anatomical alignment of vertebral column

- Thoracic kyphosis is 20-45 deg.
- Lumbar lordosis is 20-60 deg.
- Cervical spine is highly mobile.
Anatomical alignment of vertebral column

**Sagittal balance:**
C7 plumb line cross @ the middle or posterior part of the L5-S1 disc
Spinal deformities

- Scoliosis - coronal.
- Hyperkyphosis/hypokyphosis - sagittal.
Basic Osseous Anatomy Lumbar Spine

Key Words

- Body
- Pedicle
- Lamina
- Articular proc.
- Transverse proc.
- Spinous proc.
- Spinal canal
Basic Osseous Anatomy Lumbar Spine

Key Words
- (Intervertebral) Foramen
- Facet joint
- (Intervertebral) Disc
Radiographic Anatomy
Lumbar Spine

Key Words

- Body
- Pedicle
- Lamina
- Articular proc.
- Transverse proc.
- Spinous proc.
- Pars
- Foramen
- Disc
Basic Osseous Anatomy  Lumbar Spine

Pars interarticularis

Lumbar Vertebrae [L3-L4] - Assembled
Posterior View
Pars interarticularis defect = Spondylolysis
Disc & Facet joint

Separate lecture
Basic Osseous Anatomy Thoracic Spine

Key Words

- Transverse costal facet
- Inf. & sup. costal demi facet
- Pedicle
Radiographic Anatomy
Thoracic Spine

Key Words

• Transverse costal facet
• Inf. & sup. costal demi facet
• Pedicle
Pedicle Screws

Instrument for reduction & stabilization of the spine during spinal fusion
Basic Osseous Anatomy Cervical Spine C0-C2

- Ant. & post. Arch
- Lateral mass
- Dens = odontoid proc.
Basic Osseous Anatomy  Cervical Spine C3-C7

Key Words
- Intervertebral foramen
- Vertebral foramen
-Facet joint
- Uncinate process & the oncovertebral joint of Luschka
Radiographic Anatomy
Cervical Spine

Key Words
• (Intervertebral) Foramen
• Facet joint
• Uncinate process & the oncovertebral joint of Luschka
Spinal Motion Segment

The Spinal Motion Segment is the functional unit of the spine.

- 2 vertebra
- Joints
- Ligaments & joint capsules

Motion & Stability
Spinal Motion Segment

7 spinal ligaments – from C1 to sacrum
Traumatic injury to the Spinal Motion Segment

Chance fracture
Spinal Motion Segment

Lumbar spine - 3 joints
SPINAL STENOSIS

Canal measures less than 10 mm
Spinal Motion Segment

Thoracic spine – costovertebral articulation

- Costotransverse
- Costocorporeal

- Less motion
- High stability
Thoracic spine – less motion

- Only 1% of intervertebral disc herniation occur at the T - spine
Spinal Motion Segment
Cervical spine - 5 joints

- 1 x Disc
- 2 x facet joints
- 2 x Luschka joints
Oncovertebral joint of Luschka & Cervical Spinal Stenosis
Vascular Anatomy of the Spine

Key words

• Intercostal A. (segmental A.)
• Ant. Radicular A.
• Post. Radicular A.
• Ant. Spinal A.
Vascular Anatomy of the Spine

- Anterior spinal A.
- Adamkiewicz’s A. arises from intercostal A. of T8 to L2 (LT>RT)
- Vascular supply to T spine is sparse.
Spinal cord infarct

- Ligation of Adamkiewicz’s A. during surgery
- T – spine is “at risk” for vascular injuries
Vascular Anatomy of the Spine

C - spine

Vertebral arteries
Origin: subclavian A.
Supply: Basilar A.
Ant. Spinal A.
Spinal A. (enter foramina)

Variants
Vascular Anatomy of the Spine

Epidural venous plexus
Spinal Column – Nervous sys Relationship

The spinal cord is shorter than the spinal column.
Spinal Column - Nervous sys Relationship

Variations in the conus medullaris location

<table>
<thead>
<tr>
<th>Subjects</th>
<th>T12–L1 disc</th>
<th>Center of L1</th>
<th>L1–L2 disc</th>
<th>Center of L2</th>
<th>L2–L3 disc</th>
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<tr>
<td>Children</td>
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<td>5</td>
<td>6</td>
<td></td>
<td></td>
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</tbody>
</table>
Spinal Column – Nervous sys Relationship

Cauda Equina & Lumbosacral nerve roots
Spinal Column – Nervous sys Relationship

Most disc herniations will compress the transversing N. root.
Spinal Column – Nervous sys Relationship

• The intradural arrangement of nerve roots at the cauda equina
Kinematics

The study of motion
Kinematics

2 types of motion exist:
Translations & rotations = 6 deg. of freedom.
Kinematics

The Instantaneous axes of rotation

- Different for T, L & C spinal segments
- Different under changing loads
Mechanism of traumatic Injury

Instantaneous Axis of Rotation (IAR) dictates the pattern of deformation of a motion segment when a force vector is applied.
Kinematics

The Spinal Motion Segments exhibit a “Coupled Motion” pattern.
(d/t facet orientation)

Cervical Coupling

Left Bending  Neutral  Right Bending
Cervical Facet Dislocation

The mechanism of traumatic unilateral facet dislocation is related to the coupled motion exhibited by the cervical spine.
Motion preserving implants

Total Disc Replacement (TDR)
Kinematics

Facet joint orientation

- Motion pattern
- Coupling
- Biomechanics
Kinematics

- C – spine has the overall greatest ROM
- Rotation is limited in L – spine
- Note: the number of segments!
Predisposition for fracture @ the T-L junction

- Change in stiffness.
- Change in range of motion.
- Change in sagittal alignment.
- An almost 90 degrees change in the orientation of the facets at the T-L junction.
Kinematics

Bending forward is a 2 part motion:

1. L-spine flexion
2. Hip flexion
Spinal Fusion

T12-L5
Biomechanics

Biomechanics is the science of the action of forces on the living body.
Biomechanics

The biomechanical functions of the spine

- Transfer weight of head limbs & trunk to the pelvis
- Allows motion
- Protects the spinal cord
Biomechanics

- Bone
- Joint
- Ligaments
- Muscles and nerves
Biomechanics
The physical properties of the Spinal Motion Segment

Key words
- Stress-strain curve
- Biphasic behavior
- Neutral zone
- Elastic zone

![Graph showing stress-strain curve with key zones: Physiologic range, Neutral zone (NZ), Elastic zone (EZ), and Traumatic range. Failure point is indicated.]
Biomechanics

L – spine in flexion and extension

Motion & Stability

Stress

Strain
Degeneration of the spinal motion segment

- Less total range of motion
- Proportionally larger Neutral Zone
Biomechanics

The intradiscal pressure

(A.L. Nachemson 1976)
Biomechanics

The intradiscal pressure

Clinical applications

(A.L. Nachemson 1976)
Biomechanics

The intradiscal pressure
Clinical applications
Biomechanics

The intradiscal pressure

Clinical applications
Conclusions

Anatomy

• Sagittal and coronal alignment.
• The motion segment: 3 L joints, 5 C joints, T costovertebral articulation, 7 ligaments.
• Vascular anatomy: Adamkiewicz’s A.
• Conus medullaris & anatomical relationships of the nerve roots.
Conclusions

kinematics

• Instantaneous axes of rotation.
• Coupled Motion.
• Facet joint orientation.
• range of motion in C, T & L spine.
• Bending forward is a 2 part motion
Conclusions

Biomechanics

- Stress-strain curve.
- Biphasic behavior.
- Motion & Stability.
- The intradiscal pressure.