Story of Lumbar Spine: 1) Variations of Normal

**Goal**

Better understanding structure & function

**Spine**

✓ Lumbar

---

**Objectives**

a) Illustrate anatomy
  - Bones
  - Nerves
  - Canal & Foramen
b) Importance of Radiographs
  - Big Picture
  - Alignment
  - Spondyloysis
  - Spondylolisthesis
c) What Order When
  - ACR

---

**Spine Is at our Core**

Entire skeleton attaches to the spine

- Axial Skeleton
  - Spine
  - Head
  - Ribs
- Appendicular Skeleton
  - Shoulder girdle → Arms
  - Pelvic girdle → Legs

---

**Spine defines our place in the world**

Taxonomy of Life on Earth

- **Kingdoms:** Plants, Animals, Microbes
- **Phylum:** Vertebrates
  - Mammals
  - Birds
  - Reptiles
  - Amphibians
- Arthropods
  - Insects
  - Crabs

---

**Spine has four functions**

- Structural
  - Everything connects to the spine
- Protective
  - Protects spinal cord and nerves
- Hemopoietic
  - Much of the red bone marrow in spine
    - Vertebrae bodies
    - Prone to metastases, multiple myeloma
- Calcium storage
  - Osteoporosis → spinal fractures

---

**Spine Clinically Important**

Back pain 2nd most common neurological ailment (headache most common)

- Most common job-related disability
- American spend >$50 billion annually on LBP
  - “Nearly everyone at some point has back pain that interferes with work, routine daily activities, or recreation”
- Half of what MSK does is the spine
  - Acute trauma (ER, Clinics, Outside studies)
  - Chronic LBP (Spine Clinic, PCPs)
  - Image guided injections for pain

---

**Spine is a structural element**

If I were to build a statue, especially one I’d have to move across an ocean…

I’d start with a central spine (2 columns)

I’d hang a skeletal framework from spine

Cover with skin

Rigid Central Spine

---

© Ken L Schreibman, PhD/MD  9/1/14  www.schreibman.info
Story of the Lumbar Spine:

1) Variations of Normal

Spine as a structural element

If I were to build an imaginary robot…
with a head… and feet…
It might require hinged arms & legs…
With lots of wires…
Rigid central conduit via which wires pass

Robots have rigid spines

Central Structural Flexible Anatomy Radiographs
1. Labeling
2. Body Height
3. Alignment Spondylo…
4. Disc Narrow ACR Approp. Criteria

Humans have a flexible spine

Central Structural Flexible Anatomy Radiographs
1. Labeling
2. Body Height
3. Alignment Spondylo…
4. Disc Narrow ACR Approp. Criteria

Spine as Structural Conduit

If I were to build a real robot…
iPad for a head
Segway-like wheels
Rigid pipe (spine) for the wires to pass
“Ultimate tool for telecommuting”

Spine flexibility from individual vertebrae

Vertebra: [L] vertere “to turn, bend”
➢ Same root as versus
Literally: “Joints in the spine”
➢ Joints between every vertebrae
24(±1) vertebrae between skull/sacrum
Ribs define the parts of the spine:
12 with ribs = Thoracic vertebrae
5 below ribs = Lumbar vertebrae
7 above ribs = Cervical vertebrae

Trivia: All mammals have 7 cervical vertebrae

©Ken L Schreibman, PhD/MD 9/1/14  www.schreibman.info
1) Variations of Normal

### Vertebral Flexion/Extension Not Uniform

![Diagram showing variations in vertebral flexion and extension.](image)

- Most of the spine’s ROM
  - Lower Cervical spine
    - C5-C6
    - “Where DDD Occurs”
  - Lower Lumbar spine
    - L4-L5

### Spine is Straight (from the back)

![Diagram showing a straight spine.](image)

- Vertical line all vertebrae
- Scoliosis: Curved spine
  - Right curve: “Dextroscoliosis”
  - Left curve: “Levoscoliosis”

Note: By convention, scoliosis radiographs are displayed like we’re looking at the patient from the back.

### Spine is NOT Straight (from the side)

![Diagram showing a spine with variations.](image)

- C-spine: Normal forward curve
  - “Cervical Lordosis”
- T-spine: Normal back curve
  - “Thoracic Kyphosis”
- L-spine: Normal forward curve
  - “Lumbar Lordosis”

### Lumbar Vertebrae

- 5 Lumbar Vertebrae (usually)
  - Named: L1-L5
  - Don’t have ribs (usually)
  - Thoracic vertebrae have ribs
  - Lowest is T12 (usually)
- Have Transverse Processes
  - Lowest Lumbar (L5 usually) Articulates with Sacrum
  - S1
1) Variations of Normal

Story of the Lumbar Spine:

1. Radiographs
   - Central
   - Structural
   - Flexible
   - Anatomy
   - Radiographs
1. Labeling
2. Body Height
3. Alignment
4. Disc Narrow
ACR Approp.
Criteria

2. Discs
   - Between "vertebral bodies"

3. Facets
   - Between "posterior elements"

4. Lumbar Articulations

Parts of Vertebra: Processes

1. Vertebral Body
   - Anatomy
   - Radiographs
1. Labeling
2. Body Height
3. Alignment
4. Disc Narrow
ACR Approp.
Criteria

2. Vertebral Body
   - Body: Primary structural component
   - Spine: Old French "spine" "thorn-like"
   - Spinous Process
   - Transverse Process

3. SP → Posterior Elements

4. Criteria

Parts of Vertebra: Canal

1. Vertebral Body
   - Pedicles: Connect posterior elements to vertebral body
   - Body + Pedicles + Lamina = Bony Canal
   - Bony Canal: Protects spinal cord/nerves

2. Lamina
3. Posterior Elements

Parts of Vertebra: Facets

1. Posterior Elements
2. Facets: Sliding joints

Parts of Vertebra: Neural Foramen

1. Lumbar Nerves: Travel thru canal
   - Exit at NP under pedicles

2. Spinal Nerves
   - Spinal nerves exit neural foramen at every level
   - Nerves named relative to bodies
     - Lumbar/Thoracic nerves named for pedicle they pass under
     - L3 nerve passes under L3 pedicle via the L3-L4 neural foramen
     - Cervical nerves named for pedicle they pass over
     - C7 nerve passes over C7 pedicle via the C6-C7 neural foramen (why?)

3. 8 Cervical Nerves

©Ken L Schreibman, PhD/MD 9/1/14 www.schreibman.info
1) Variations of Normal

**Story of Lumbar Spine: Simplified**

**MRI Well Shows Spinal Nerves**

- **Sagittal**
  - Midline
  - Fluid = dark
  - Axial Reference Image
- **T1 Fat Suppressed**
  - Fluid = bright
- **T2 Fat Suppressed**
  - Fluid = bright
- **Axial** (parallel to discs)
  - Fluid = bright

**MRI Well Shows Bones**

- **Sagittal**
  - Thru NF
  - Axial Reference Image
- **T1**
  - Fluid = bright
- **T1+FS**
  - Fat Suppressed
  - Fluid = bright

**MRI Well Shows Bone Marrow**

- **Axial** (parallel to discs)
  - Fluid = bright
  - Axial Reference Image
  - Fx
  - R, R 29yoF

**MRI Well Shows Spinal Nerves**

- **Sagittal**
  - Midline
  - Fluid = dark
  - Axial Reference Image
- **T1 Fat Suppressed**
  - Fluid = bright
- **T2 Fat Suppressed**
  - Fluid = bright

**MRI Well Shows Bone Marrow**

- **Axial** (parallel to discs)
  - Fluid = bright
  - Axial Reference Image
  - Fx
  - L1 & L5 recent & active fractures
  - L2 & L3 old & quiescent fractures

---

©Ken L Schreibman, PhD/MD  9/14  www.schreibman.info
Story of Lumbar Spine: 1) Variations of Normal

Radiographs: Lateral View

Shows the Big Picture
- Well shows vertebral alignment
- Normal Lordosis, smooth curve vs spondylolisthesis
- Well shows vertebral body height
- Parallel superior/inferior end plates
- Slight wedging at T4 junction is common
- Shows Disc space widths
- Widens @ Lower Levels
- L5-S1 variable
- L4-L5 widest
- DDD starts L4-L5

AP & Lateral side-by-side on PACS
1. Label the vertebrae!
   - Iliac Crests @ L4-L5
2. UW MSK Policy:
   - All Lumbar spines get labeled on PACS
   - Why the big fuss? Sometimes it's hard to count...

©Ken L Schreibman, PhD/MD  9/1/14  www.schreibman.info
Variations of Normal

Story of the Lumbar Spine:

1) Variations of Normal

How many LEGS does this elephant have?

How many FEET does this elephant have?

How many shelves are here?

For more PowerPoint enhanced illusions, see my lecture "Pitfalls of the Human Visual System".

Transitional Vertebrae:

Hypoplastic 12th Ribs

Very hypoplastic 12th ribs makes it look like there are 6 lumbar vertebrae:
- Non-rib-bearing vertebrae

Sometimes it's hard to count:

Schreibman’s Rule:
- Iliac Crests @ L4-L5

Transitional Vertebrae: Lumbar Ribs

Lumbar ribs makes it look like there are 4 lumbar vertebrae:
- Non-rib-bearing vertebrae

Lumbar ribs are not uncommon:
- @L4-L5 (9%)

Know more: Lumber Ribs @L4-L5

Iliac Crests @ L4-L5

Criteria

- Approp.
- Narrow
- Height

ACR

- 4.

3.

2.

1.

Radiographs

Anatomy

Flexible

Structural

Central

#Z,#C 30yoF

L5

S1

L1

L2

L3

L4

L5

S1

@L4

Iliac Crests

T12

Ribs

Lumbar ribs

Sometimes it's small

Sometimes absent

Unilateral or Bilateral

M.S. 22yoF

www.schreibman.info

Roger Shepard

37 of 77

38 of 77

39 of 77

40 of 77

41 of 77

42 of 77

© 2014 Ken L Schreibman, PhD/MD

9/1/14

www.schreibman.info
Story of Lumbar Spine: Variations of Normal

1) Variations of Normal

Story of the Lumbar Spine:

Not Everyone Has 12 Ribs

Transitional Vertebrae:

Story of the Lumbar Spine: Variations of Normal

Transitional Vertebrae: Sacralization of L5

L5 is sacralized (fused) to S1 on the right...

Complete sacralization of L5 on the right...

Partial sacralization of L5 on the left...

Story of the Lumbar Spine: Variations of Normal

Final comments on labeling for Radiologists

UW MSK Policy

- ALL LUMBAR VERTEBRAE GET LABELED
  - All: Radiographs/CTs/MRs

Easy to do on PACS

- Single view or entire stack

As easy on AP as Lateral

- Forces me to look at each Pedicle, Spinous Process

©Ken L Schreibman, PhD/MD  9/1/14  www.schreibman.info
Congenital Wedging vs Fracture

Radiologists:
- Measure wedging
- Easy on PACS
- Don’t measure height loss
- Measure local kyphosis
- Cobb
  - Superior end plate level above
  - Inferior end plate level below

2 weeks
- Fracture healing
- 2 months
- Fracture stable
- 6 months
- Fracture solid

Congenital Wedging

- Keystone shaped
- Traumatic wedging
- Right Trapezoid

History Helps: Acute onset, recent trauma
Comparison with old images helps A LOT
May need CT/MRI to determine if acute

©Ken L Schreibman, PhD/MD 9/1/14 www.schreibman.info
Story of Lumbar Spine: 1) Variations of Normal

**How I Look at L-Spine Radiographs**

![Image showing AP & Lateral side-by-side view on PACS]

1. Label the vertebrae!
2. Vertebral body height
3. **Alignment**
   - Lateral: Normal Lordosis vs Spondylolisthesis
   - AP: Straight vs Scoliosis
   - Scoliosis should be imaged with "Scoliosis" Radiographs

**Criteria**
- Narrow Height

**Spondylolisthesis**

- (Gr) spondylo: "vertebrae" "olisthesis: "slipping"
- Anterior slippage of a vertebra relative to the one below it
- aka "Anterolisthesis"
- 3 causes of spondylolisthesis
  1. DDD (most common)
  2. Spondylolysis
  3. Trauma (least common)

**Spondylolysis**

- (Gr) spondylo: "vertebrae" "lysis: "dissolution"
- Pars Intertubercularis Defect
- PELL disrupted @ L5-S1
- SPL disrupted @ L4-L5
- L5 Spine Process not attached to L5 Body

**Modern CR X-rays use phosphor plates held in cassettes**
- Largest plates are 14x17"
- From the old film days
- Scoliosis cassette hold 2 plates
- Two plates w/one x-ray exposure
- Upper + Lower plates stitched together, automatically
- Fiducial marks → 1-inch overlap
- Yield an image up to 14x33"

©Ken L Schreibman, PhD/MD  9/1/14  www.schreibman.info
Variations of Normal

**Pedicle**

Other Oblique

### 1) Variations of Normal

#### Story of Lumbar Spine:

**Spondylolysis: Prevalence**

- **Japan:** 2,000 CTs (20-92yo) not for back pain
  - **6% Spondylolysis** (M:F = 2:1)
  - **80% Bilateral**
  - **75% of these had spondylolysis**
  - **20% Unilateral**
  - **8% of these had spondylolisthesis**

- **90% @ L5**
- **Probably a stress fracture**
- **Due to vertical sheer**
- **Vertical sheer greatest at L5 pars interarticularis**

#### Spondylolysis: CT Gold Standard

- **Dx:** Unilateral spondylolysis without spondylolisthesis
- **6 months later...**

#### Spondylolysis: Lateral View

- **May be able to see on lateral view if there is enough spondylolisthesis to separate body from spinous process**

#### Spondylolysis: Oblique Views

- **Shot laying on X-ray table**
  - **Unlike standing AP & Lateral**
  - **See scotty dog**

#### Radiographs Show the Big Picture

**For Alignment:** Get Standing Views
- For alignment of entire Lumbar spine:
  - **Get Lumbar spine radiographs**
- For alignment of entire Thoracic spine:
  - **Get Thoracic spine radiographs**

**For Stability:** Get Flexion/Extension
- For alignment of Thoraco-Lumbar Junction
- For alignment of ENTIRE SPINE (C+T+L)
- **Get Scoliosis radiographs**

---

©Ken L Schreibman, PhD/MD 9/1/14  www.schreibman.info
Story of Lumbar Spine: 1) Variations of Normal

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension Views**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Good ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Limited ROM**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.

**Flexion/Extension: Spondylolysis**

- Central Structural
- Flexible Anatomy Radiographs
  1. Labeling
  2. Body Height
  3. Alignment Spondylo...
  4. Disc Narrow ACR Appro.
American College of Radiology Appropriateness Criteria

Low Back Pain

- Acute uncomplicated LBP without red flags is a benign, self-limited condition that does not require imaging evaluation.
- MR has displaced CT and myelography as the initial imaging modality of choice in complicated LBP, with some contraindications.
- CT is useful in patients with surgical fusion, bone structural abnormalities, MR contraindications.
- Other modalities are used in selected patients for problem solving but not routine clinical practice.

NR has displaced CT and myelography as the initial imaging modality of choice in complicated LBP.

Nonspecific lumbar disc abnormalities are common in asymptomatic patients, readily demonstrated on MR. Don’t treat the images; treat the patient.

Any Questions?

Patients with fusions throughout spine (AS, DISH) who have pain after even minor trauma MUST get spine CT urgently for non-displaced fractures!

©Ken L Schreibman, PhD/MD  9/1/14  www.schreibman.info