# Scoliosis
## Nomenclature and Measurements

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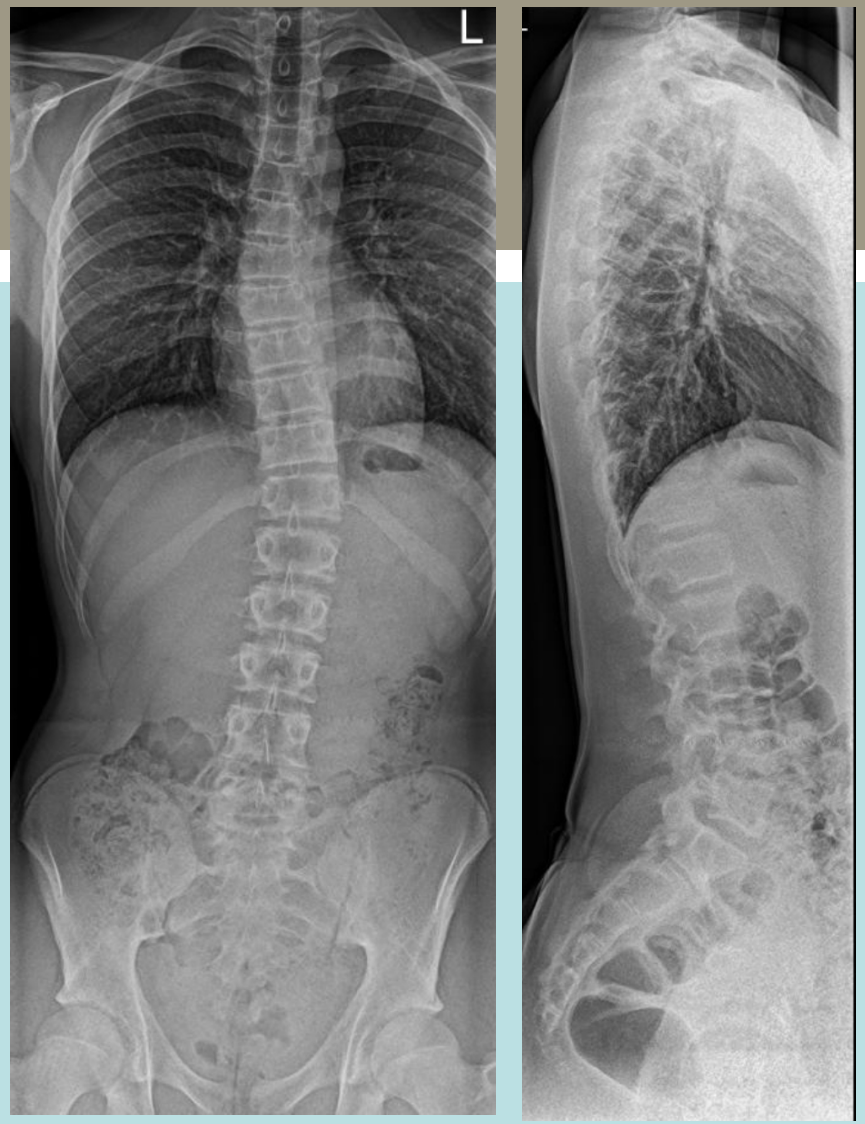
Nothing to disclose

# Scoliosis
# Nomenclature and Measurements

1. Definitions
2. Classification by etiology
3. Classification of idiopathic scoliosis
4. Basic measurements (follow-up)
5. Advanced measurements (surgical planning)
    a. Classification of Adolescent Idiopathic Scoliosis (AIS)
    b. Assessment of sagittal balance

# Definition of Scoliosis

- Lateral curvature > 10°
- Vertebral body rotation
- Abnormal balance
- 3dimensional!



# Etiology

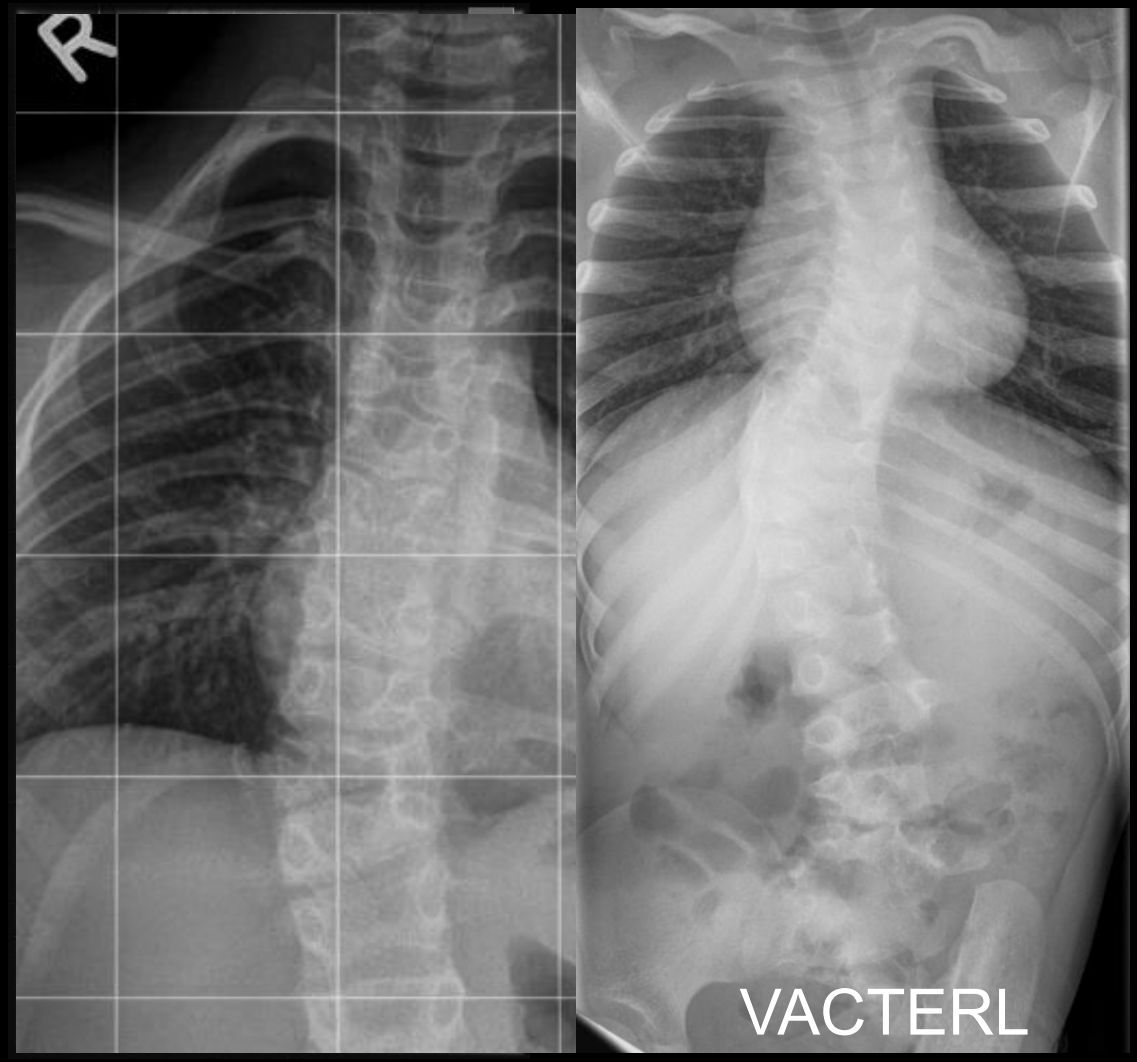
- Idiopathic/primary (80%)
- Secondary (20%)
  - Congenital
  - Neuromuscular
  - Syndromic (connective tissue disease, genetic conditions,…)
  - Neuropathic (spinal tumor, syringomyelia …)
  - Osseous (CRMO, LCH, tumor, trauma, degeneration …)

Khanna Pediatr Radiol 2009, Kim Radiographics 2010

# Congenital Scoliosis

Vertebral anomalies
- Formation defects
  - Hemivertebra → most frequent
- Segmentation defects
  - Unilateral bars/fusions → most severe
  - 75% rate of progression

Underlying Syndrome?

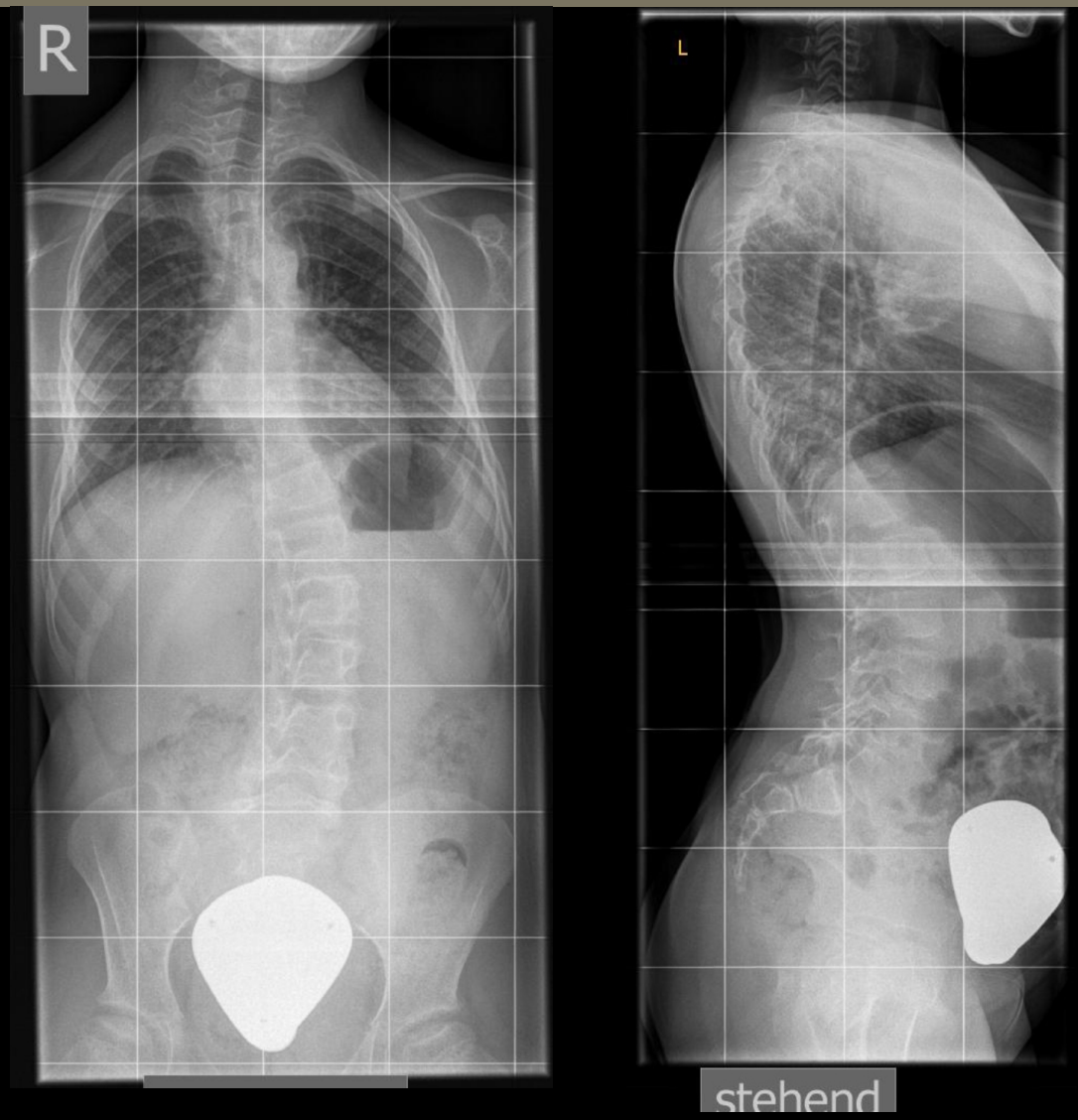


# Neuromuscular scoliosis

Spinal Muscular Atrophy Type 1

C-shaped with
severe kyphosis or lordosis


# Skeletal Dysplasia



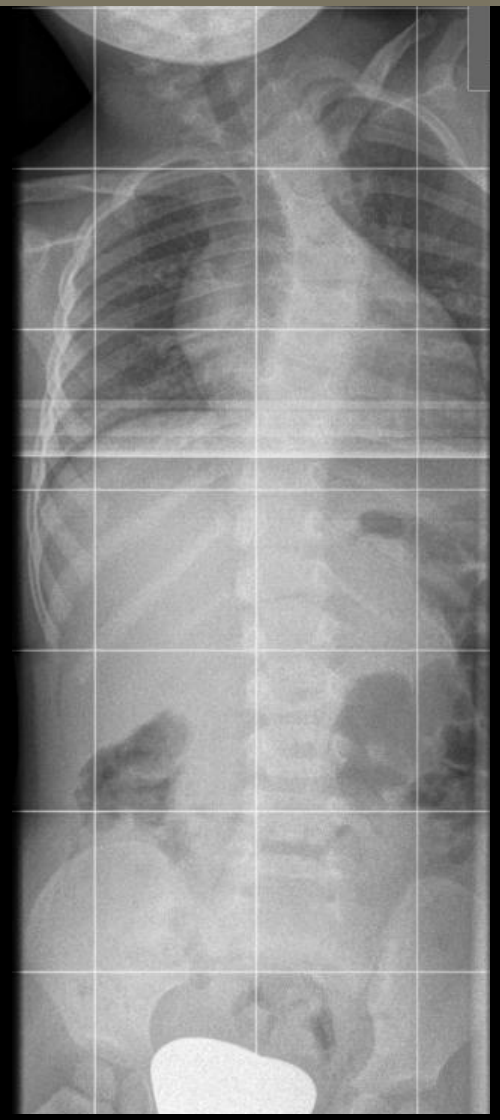

Spondyloepiphyseal Dysplasia

7 years

# Neuropathic Scoliosis

## Spinal Astrocytoma

- Neurological symptoms!




weakness of arm


# Idiopathic Scoliosis

Most common (80%)

Ca. 90% Adolescent Idiopathic Scoliosis (AIS)
Overall prevalence 0.47-5.2 %
♂:♀ = 1:3

# Timing of idiopathic scoliosis

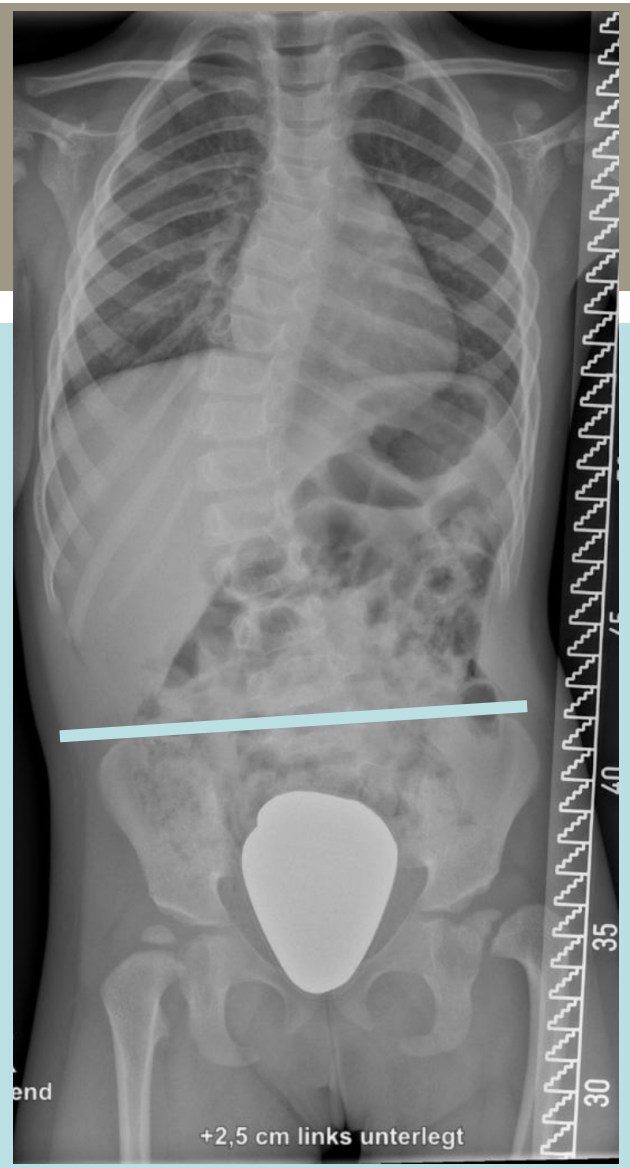
- Early onset (EOS) < 10 years of age
  - Infantile (0-3 years) – levoscoliosis ♂
  - Juvenile (4-10 years)
    - Late infantile or secondary?
- Late onset > 10 years of age
  - Adolescent – dextroscoliosis
- Cobb > 50° and/or progressive early onset
  - ➢ High risk of cardiopulmonary complications

Kim et al. Radiographics 2010, Ridderbusch et al. Dtsch Arztebl Int 2018

# Imaging

- Upright p.a. and lateral radiograph (2D) including C7 and hips (prox. femur)
- E.O.S. scanner (2D/3D)
- Low dose (ALARA!)

- Leg length discrepancy > 2cm
  → compensate in order to level pelvis




Hansen et al. Pediatr Radiol 2003, Melhem et al. J Child Orthop 2016

# Landmarks and Measurements
## p.a.

BASIC

- Apex (apical vertebra or disc) – *most deviated & rotated*
- End vertebra (cephalad & caudad) – *most tilted*

ADVANCED

- Neutral vertebra – *not rotated*
- Central sacral vertical line (CSVL)
- Stable vertebra – *most cephalad, bisected by CSVL*

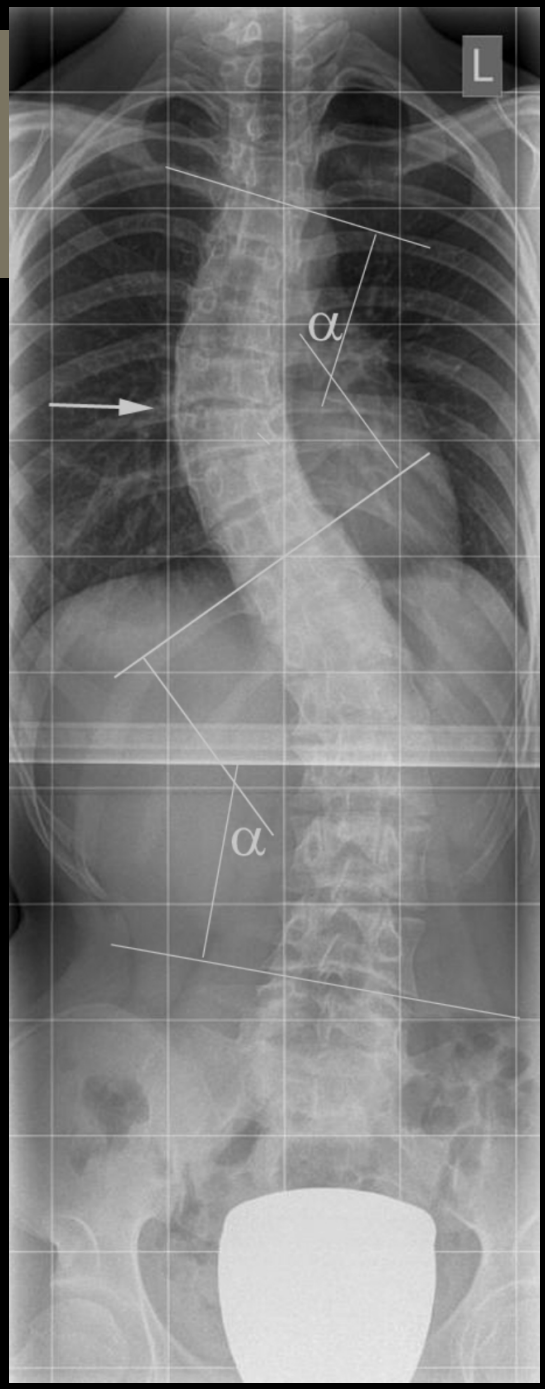
Glossaries: www.srs.org, sauk.org.uk

# Cobb angle

p.a., upright, pelvis levelled

Apex – *most deviated & rotated*
End vertebrae – *most tilted*

Surgical intervention:
Cobb > 35°
Cobb + 10°



# Coronal Balance
## frontal view

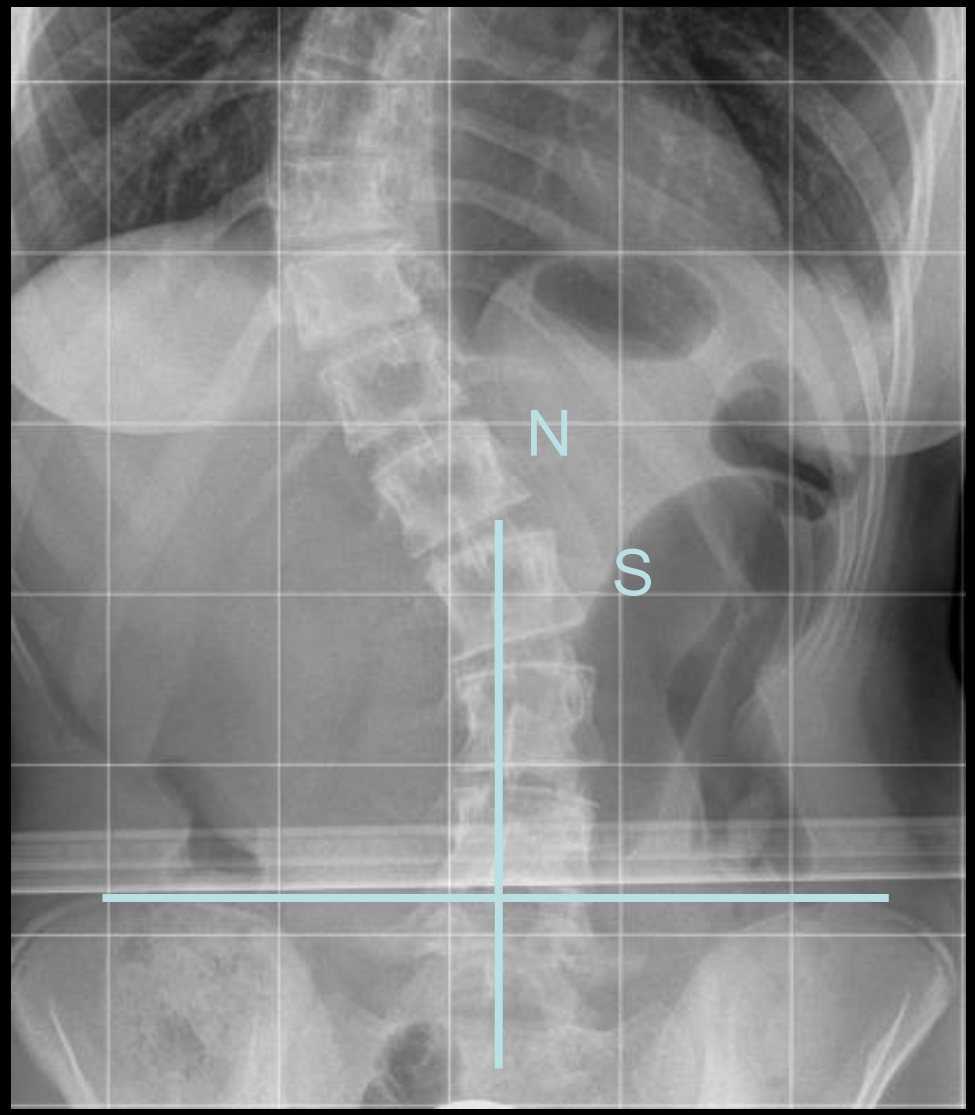
- Central sacral vertical line (CSVL)
  - Parallel to edge of radiograph (pelvic obliquity < 2cm!)
- Plumb line (from centre of C7)

- Normal distance < 2cm

# Surgery planning

Determining the lower fusion level
→ spinal balance

Neutral vertebra – *not rotated*
Stable vertebra –
*most cephalad, bisected by CSVL*
*(central sacral vertical line)*




Potter et al. Spine 2005

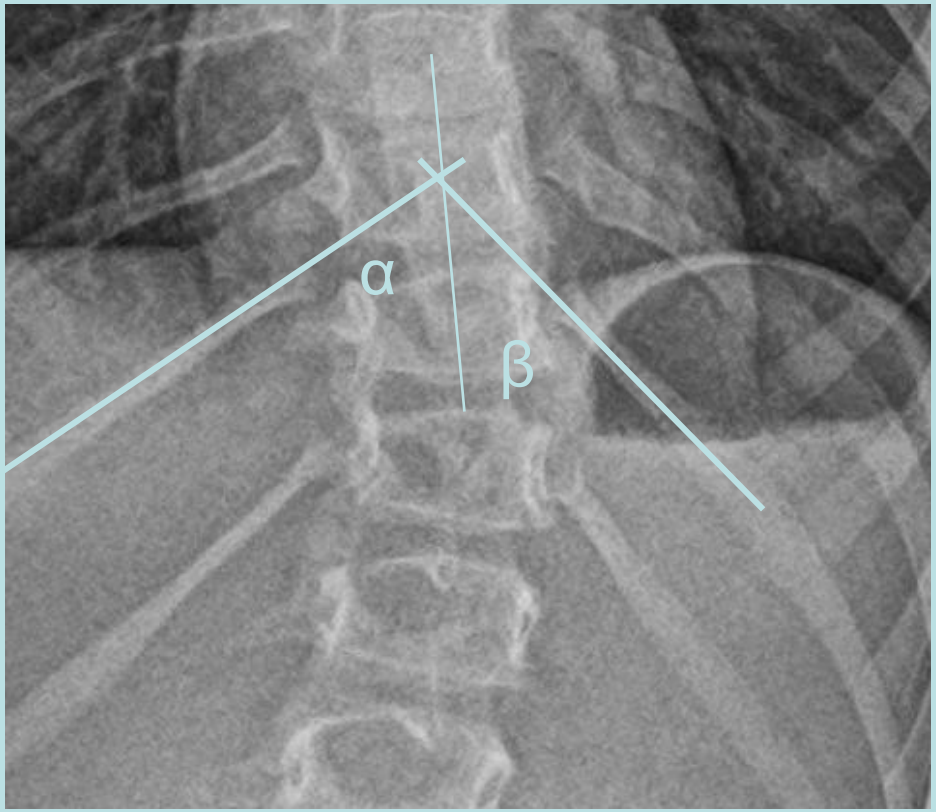
# Limitations and pitfalls

- Cobb angle
  - Interobserver variation ≈ 3-8°(95% CI)
  - Diurnal variation ≈ 5°
  - Vertebral rotation → underestimation of angle by 20%

➢ Follow-up
  - ➢ Use same vertebral level
  - ➢ Consistent patient position
  - ➢ Progression/regression if difference **≥ 5°**

# Early Onset (idiopathic) Scoliosis
## Risk of progression

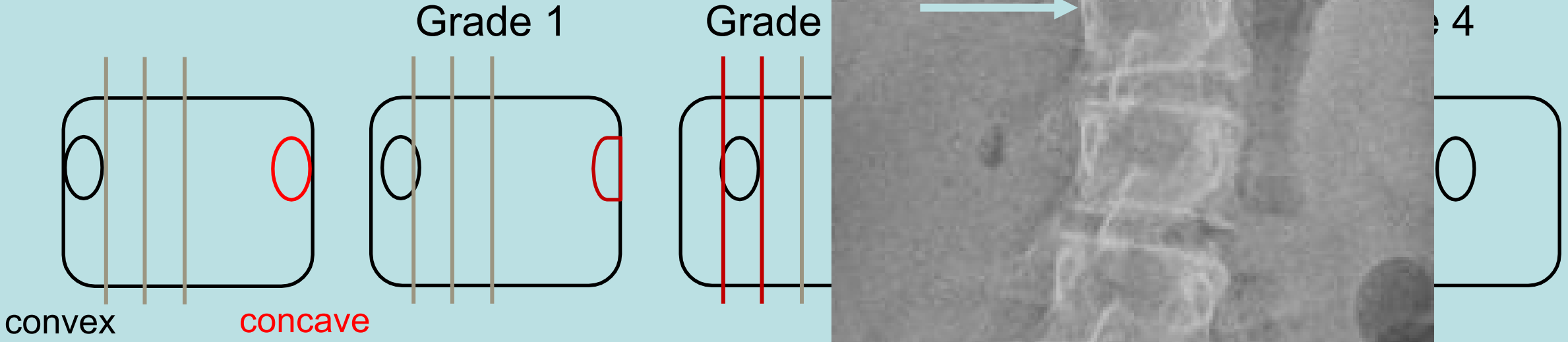
- Rib phase 1 & 2
- Rib-vertebra angle
- RVAD = α – β
- Rib phase 2 <u>and</u>
  RVAD > 20°
  Risk of progression 85%




Mehta, J Bone Joint Surg Brit 1972, Guglielmi et al. Sem Musculoskelet Radiol 2021

# Vertebral

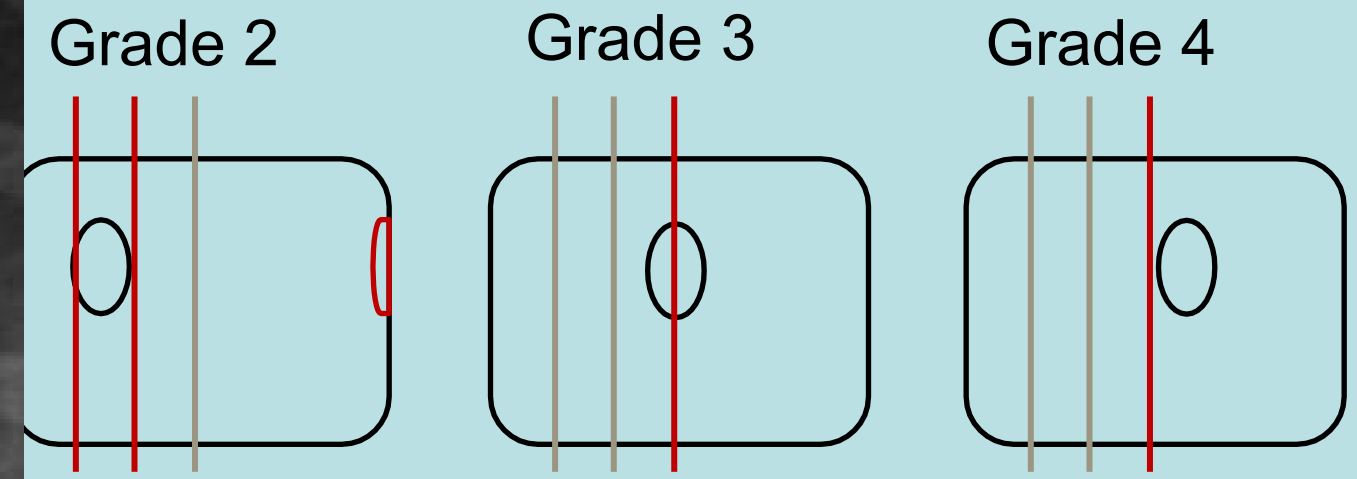
Nash & Moe: Pedic




Guglielmi et al. Sem Musculoskelet Radiol 2021

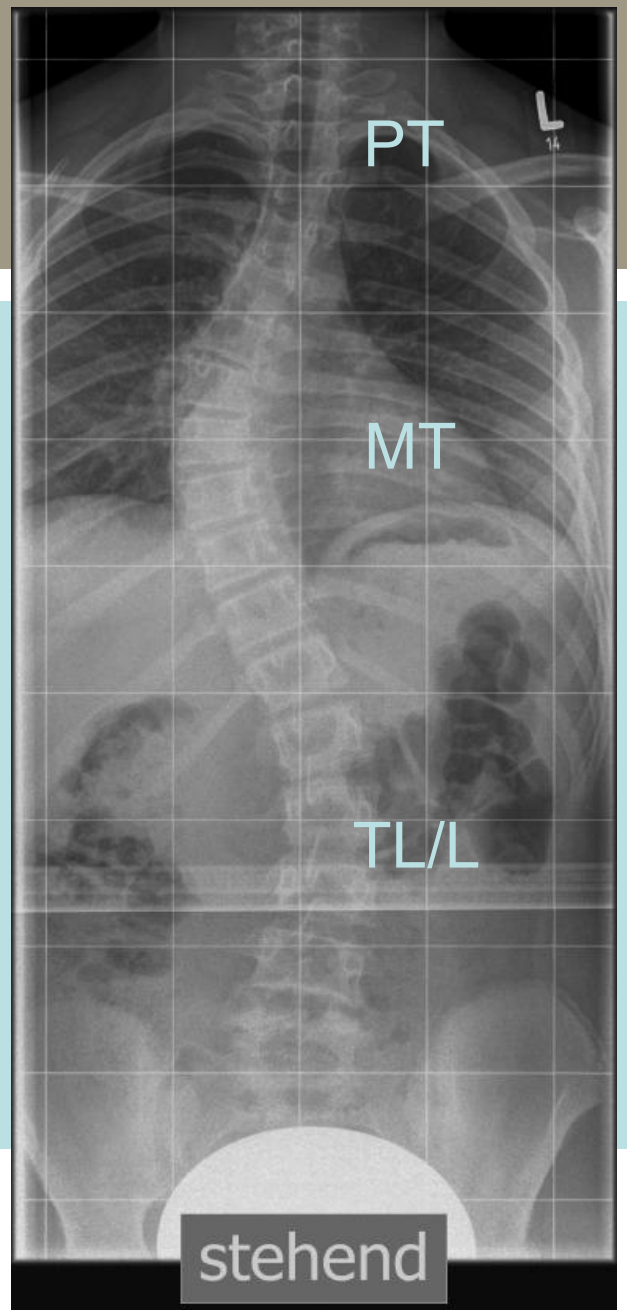
# Vertebral Rotation

les on frontal view




con

# Curve type and extent




| Curve type | Apex | Lenke | Apex |
|---|---|---|---|
| Cervical | C2-C6 | | |
| Cervicothoracic | C7-T1 | Proximal thoracic (PT) | T1-T3 |
| Thoracic | T2-T11 | Main thoracic (MT) | T3 –T12 |
| Thoracolumbar | T12-L1 | Thoracolumbar to Lumbar (TL/L) | T12-L4 |
| Lumbar | L2-L4 | | |
| Lumbosacral | L5 | | |

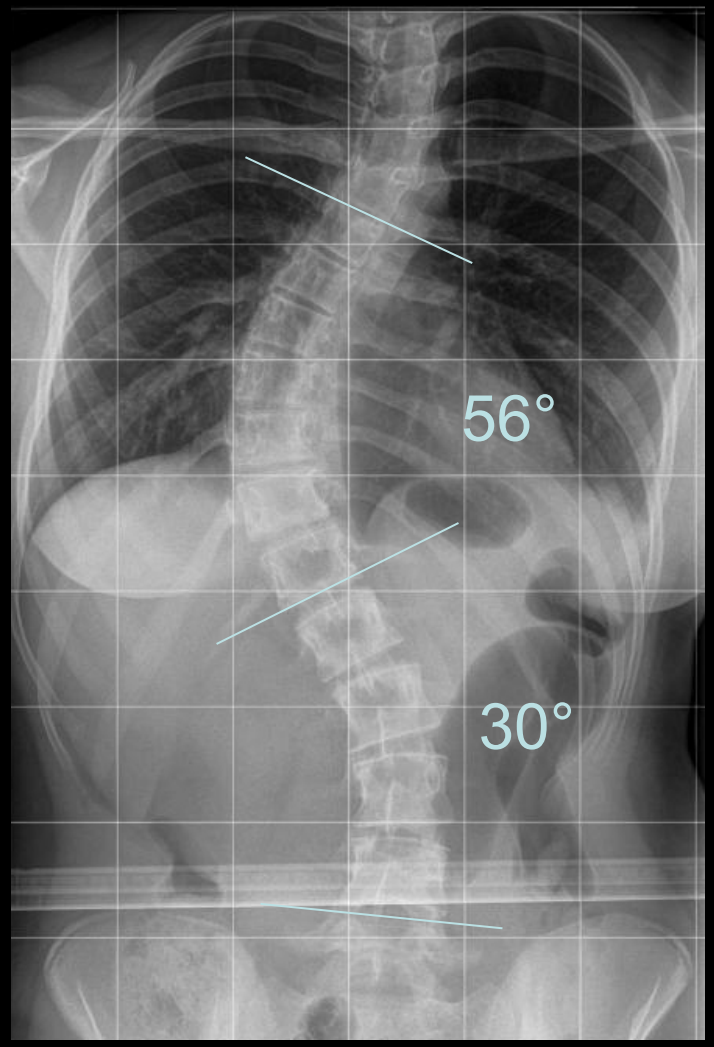
# Lenke Classification of AIS

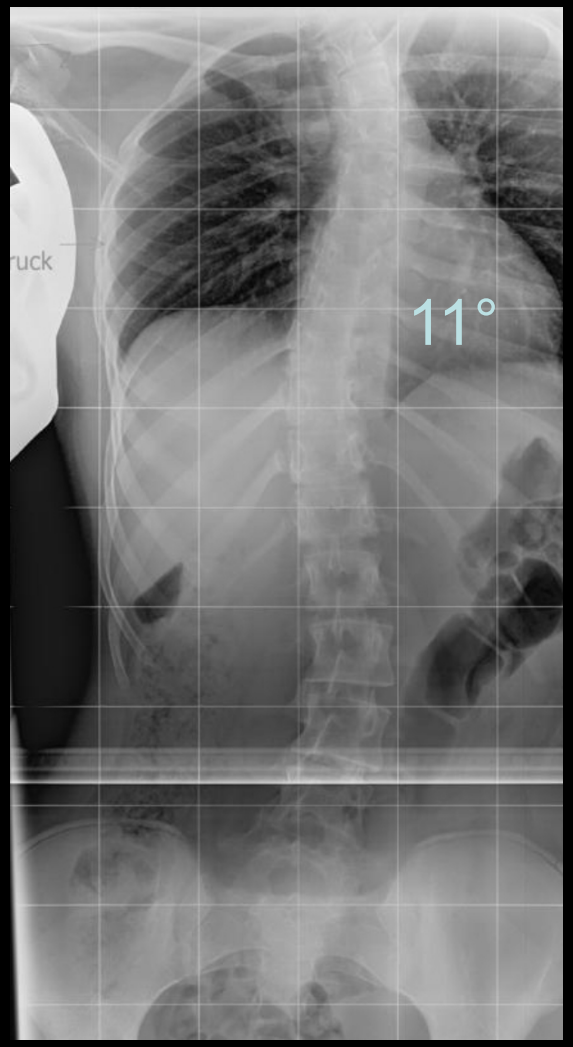
- Major curve („primary“)
- Minor curve („secondary“, compensatory)

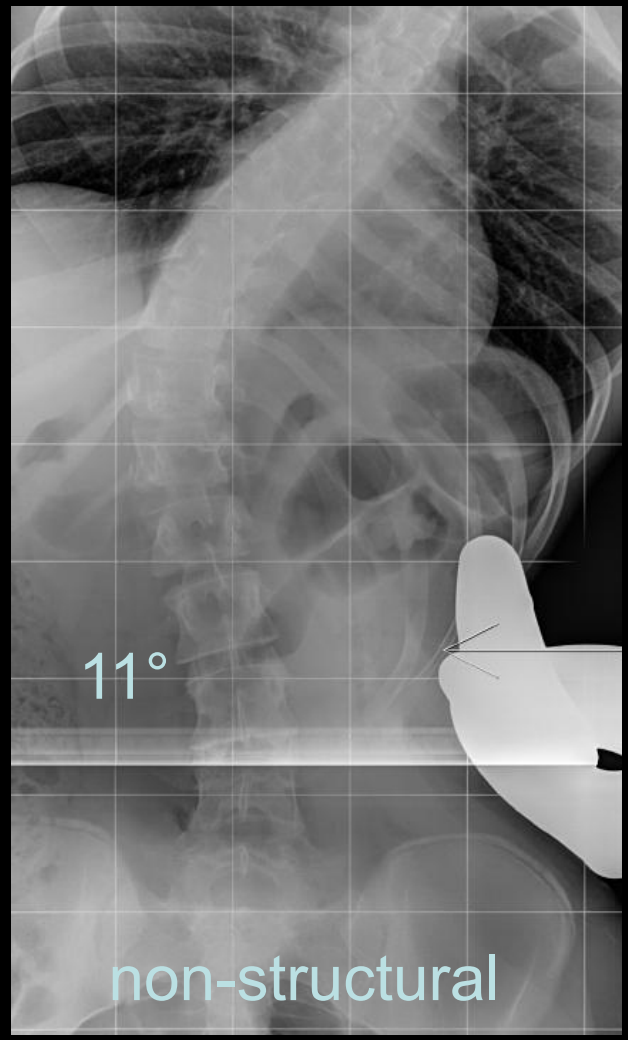
- Non-structural curve
- Structural curve - Cobb ≥ 25°
  - Bending view - Cobb ≥ 25°and/or
  - Kyphosis >20°at levels T2-T5 (PT) or T10-L2 (TL/L)

Lenke et al., J Bone Joint Surg Am 2001

# Curve types (bending)

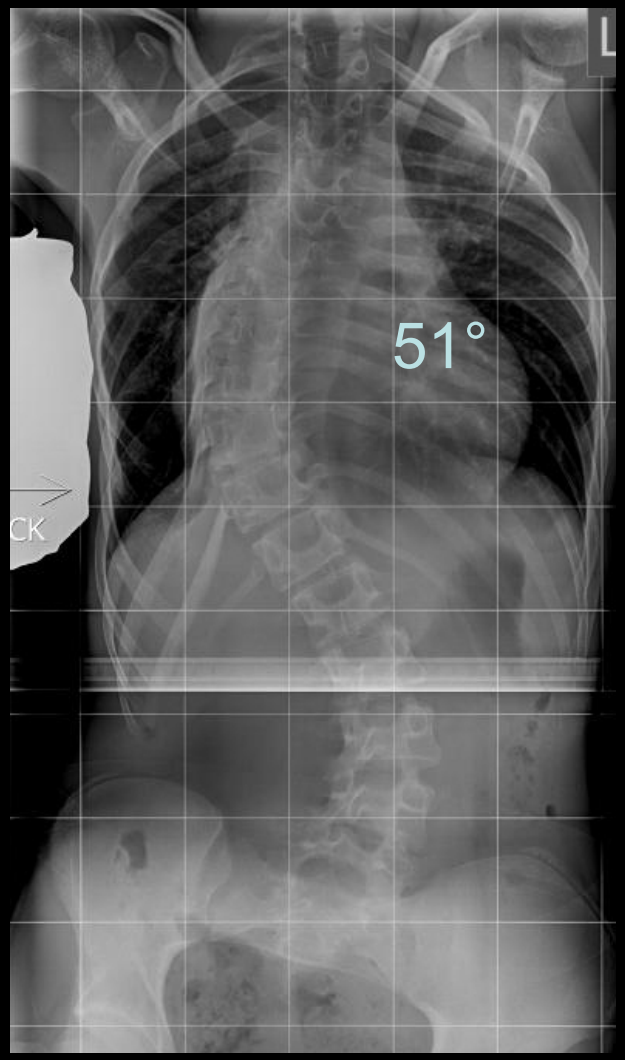


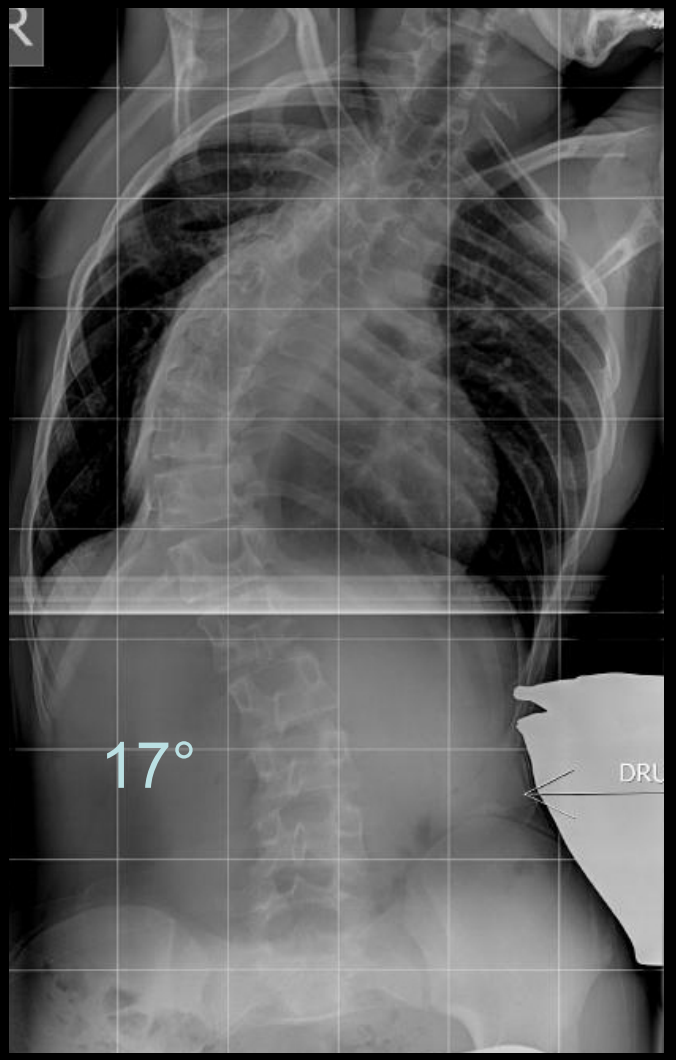



# Curve types (bending)

structural




non-structural

# Curve type and extent

| Lenke | Description | Prox. thoracic | Main thoracic | Thoracolumbar /lumbar |
|---|---|---|---|---|
| | | T1-T3 | T3-T12 | T12-L4 |
| 1 | Main thoracic | Non-structural | *Structural* | Non-structural |
| 2 | Double thoracic | Structural | *Structural* | Non-structural |
| 3 | Double major | Non-structural | *Structural* | Structural |
| 4 | Triple major | Structural | *Structural* | *Structural* |
| 5 | Thoracolumbar /lumbar | Non-structural | Non-structural | *Structural* |
| 6 | Thor./lumbar + main thoracic | Non-structural | Structural | *Structural* |

Slattery et al. Clin orthop Relat Res 2018

# Lenke Classification of AIS

1. Curve type 1 - 6
2. Lumbar modifier

   CSVL in relation to lumbar apex

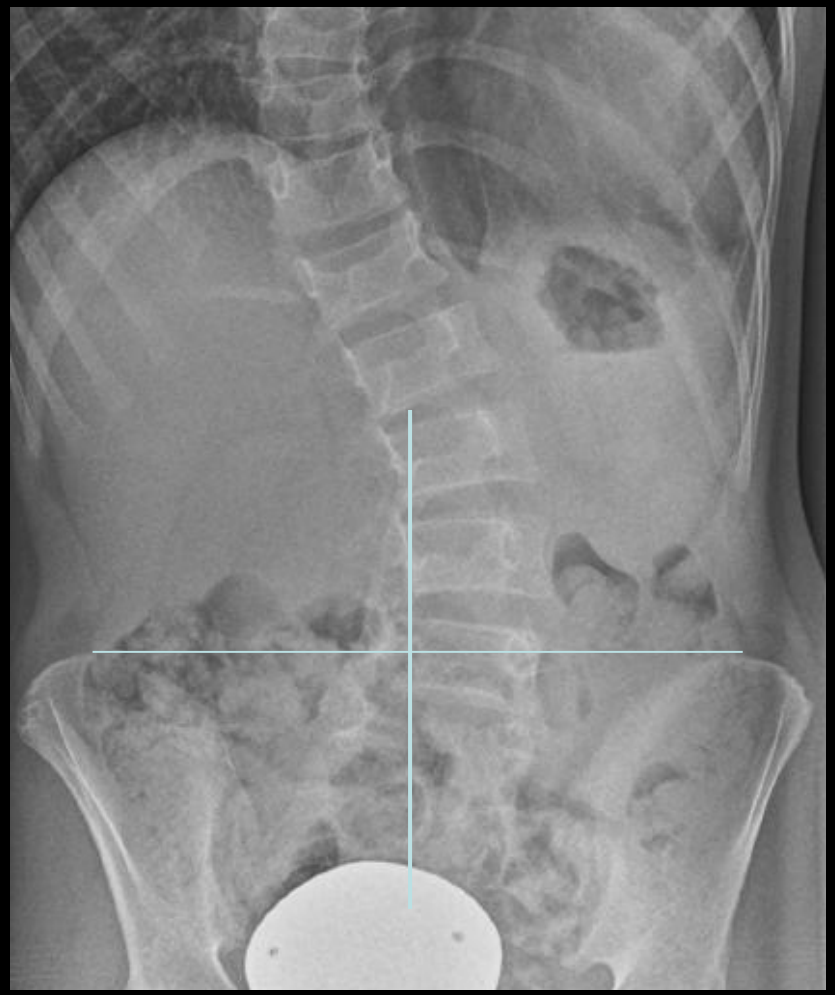
   A. CSVL between pedicles
   B. CSVL touches pedicle
   C. CSVL medial to a pedicle

3. Thoracic sagittal modifier

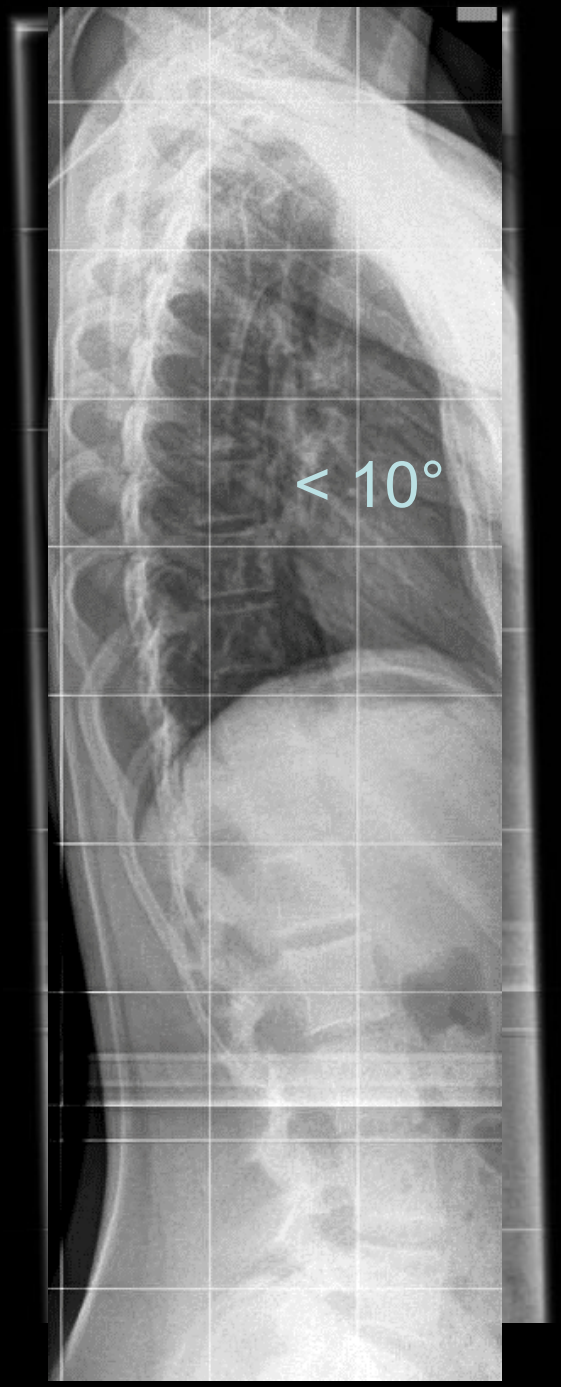
   Kyphosis 10-40°= „N“ // > 40°= „+“ // < 10°= „-“

Trobisch et al. J Am Acad Orthop Surg 2013

# Lenke – lumbar modifier



CSVL touches pedicle = B



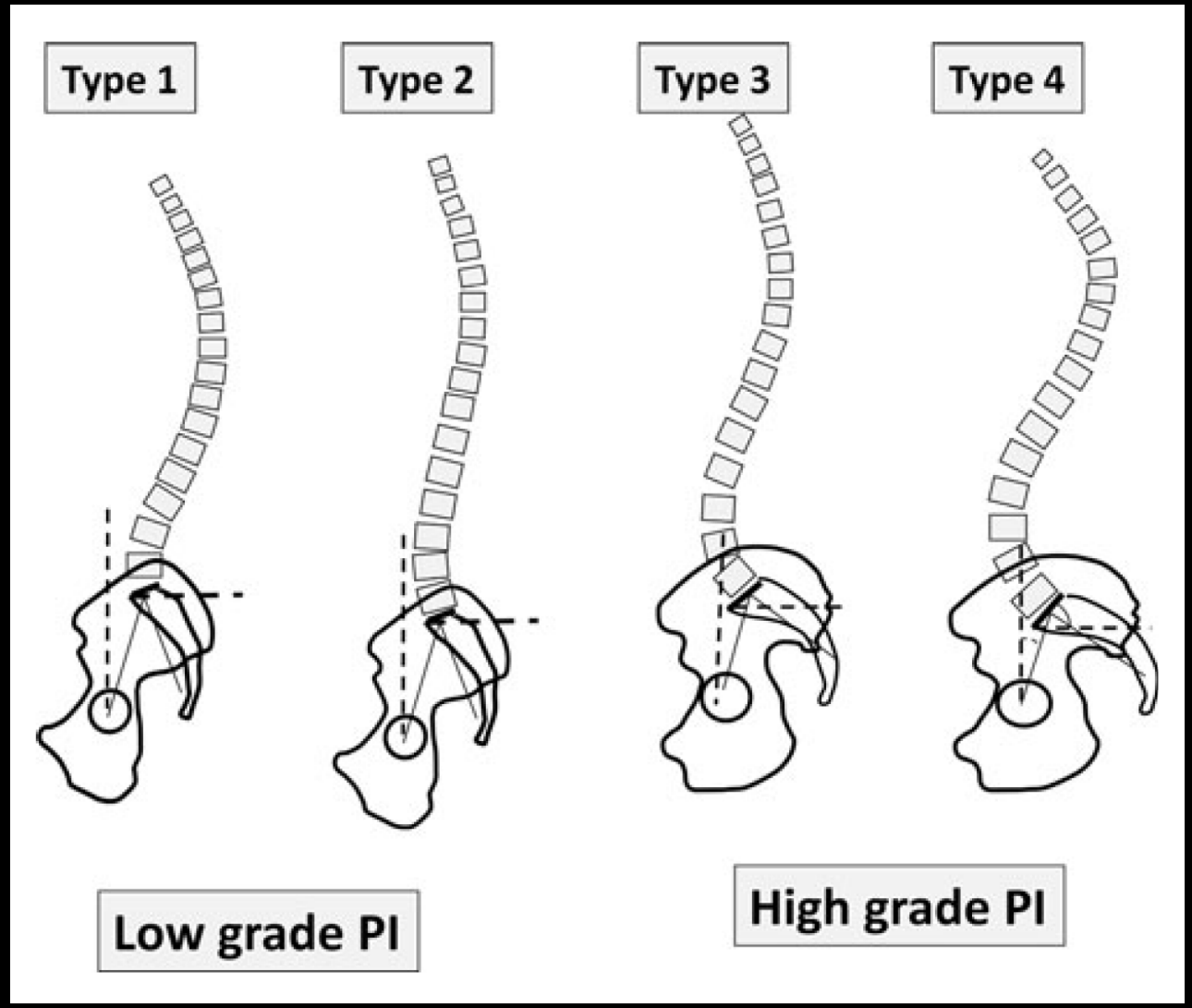

# Lenke – thoracic sag. modifier

Normal thoracic kyphosis (T5-T12)

- 10-40° = N
- < 10° = „-“
- > 40° =„+“

Lenke type 1B-

# Normal sagittal alignment (Roussouly)

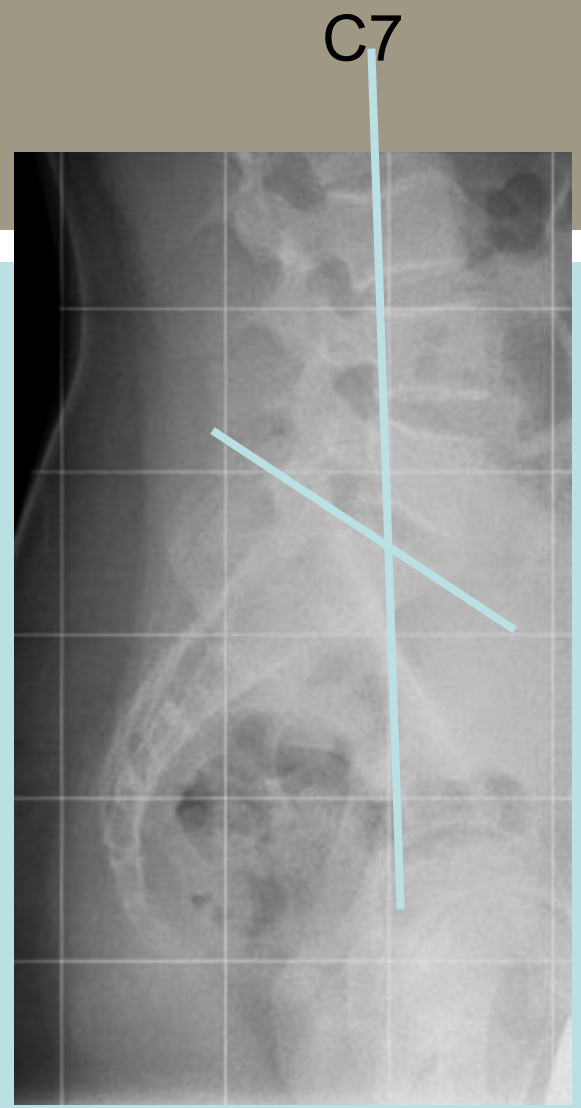



Roussouly, Pinheiro-Franco
Eur Spine J 2011

# Sagittal Balance
## lateral view

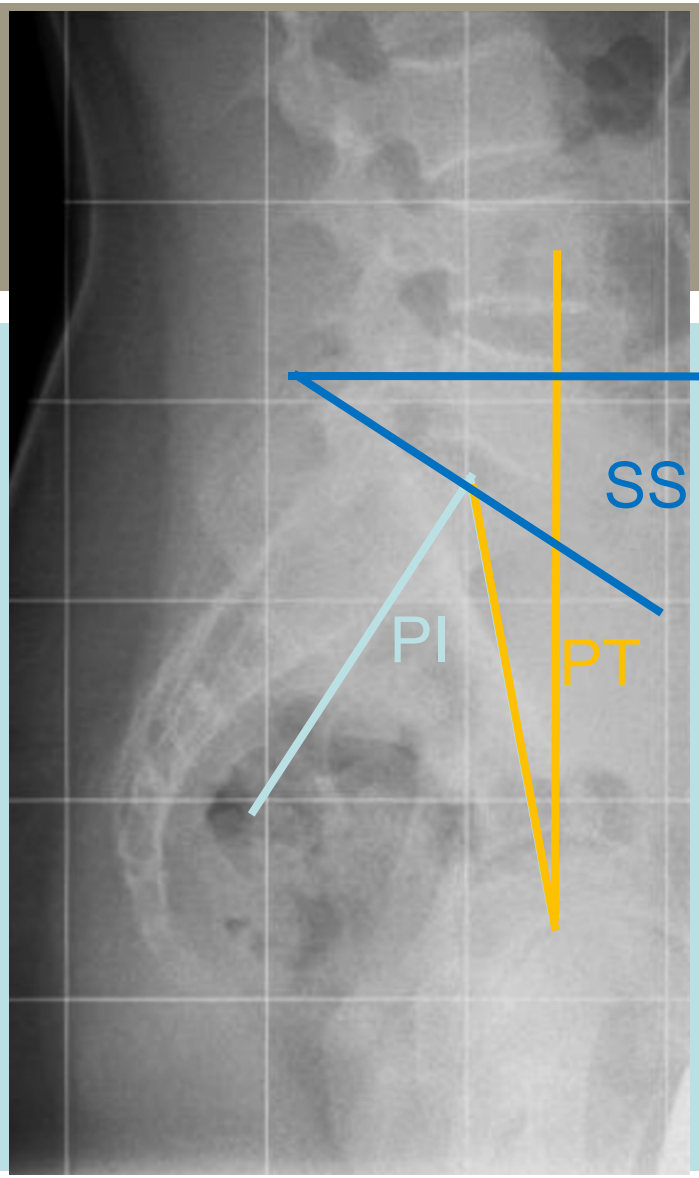

Lateral radiograph: C7 - hip joints

- Kyphosis
- Plumb line (from centre of C7)
  - Posterosuperior corner S1
  - Normal distance < 2cm
- Spinosacral angle
  - Mid C7 – S1 vs. S1 end plate
  - 135°(+/- 8)



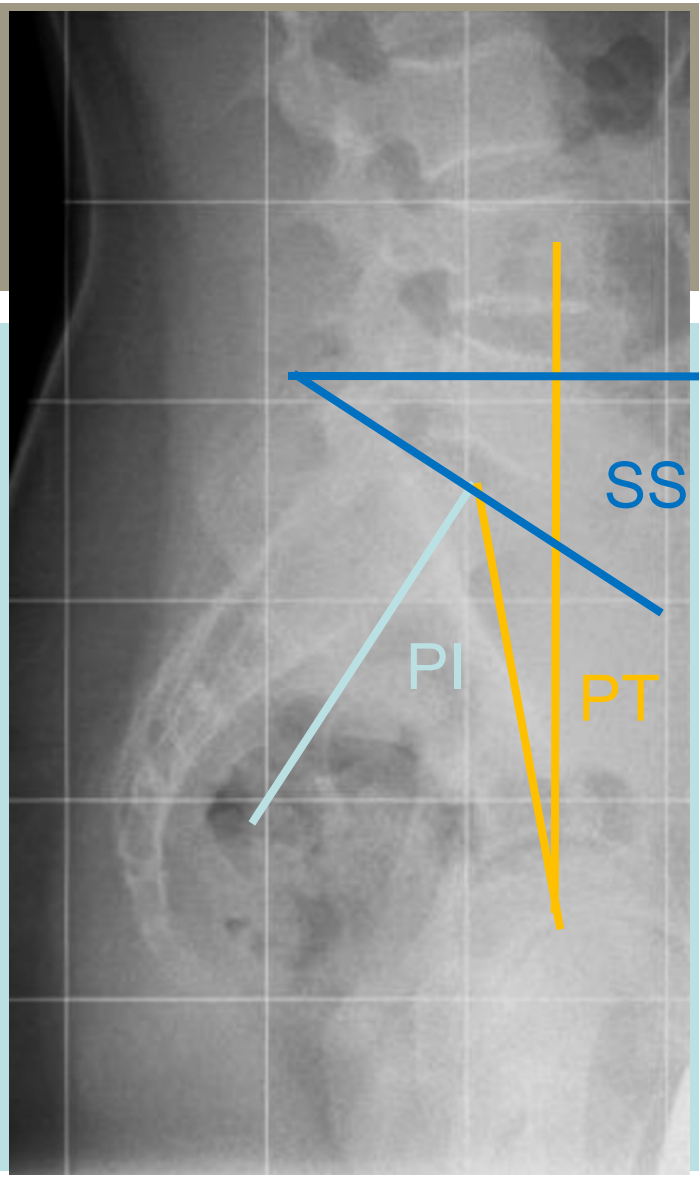
# Sagittal Balance
## lateral view

- Pelvic incidence
  - 1) centre of end plate S1 to
    centre of (axis of) femoral head(s) and
    2) line perpendicular to end plate S1
- Pelvic tilt
  - Angle:  Line 1 and vertical line
- Sacral slope
  - Angle: end plate S1 and horizontal line



# Sagittal Balance
## lateral view

- Pelvic incidence (PI): 30-85°!
  - Individual, sagittal dimension of pelvis
  - Static after growth arrest
- Pelvic tilt (PT)
  - Functional
- Sacral slope (SS)
  - Functional
- PT + SS = PI



# Skeletal Maturity and Growth Spurt

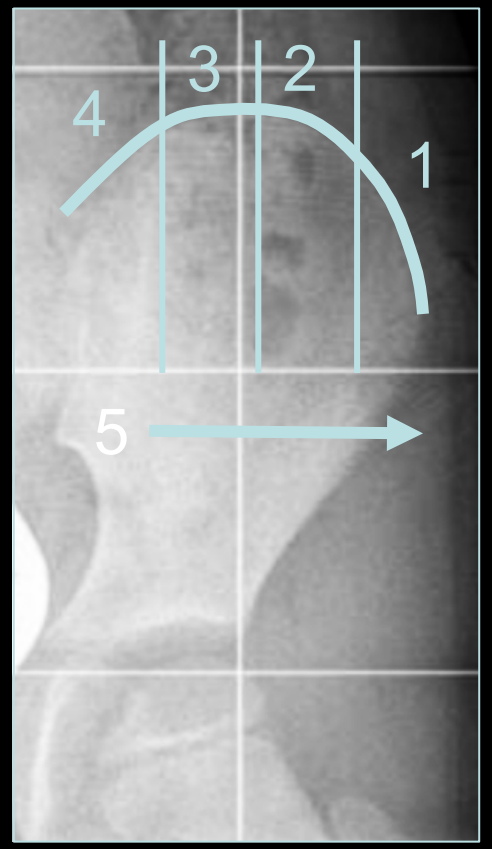
- Triradiate cartilage
- Iliac crest apophysis

- Elbow (Sauvegrain)
- Left hand (Greulich & Pyle, Sanders)

# Skeletal Maturity and Growth Spurt

- Triradiate cartilage
  - Closes at period of maximum spinal growth
  - High probability of progression resp. therapeutic effect
- Iliac crest apophysis
  - Appears after peak of growth spurt

# Risser Index




Growth spurt before Risser
Risser 4 ≈ growth arrest ♀
Risser 5 ≈ growth arrest ♂

Risser ↑
Risser of progression ↓
Therapeutic effect ↓

# Conclusions

- A lot of measurements!

➢ Understand and describe 3 dimensions of scoliosis

➢ Sagittal balance is important (correlates with QoL)

➢ Spinopelvic complex is important

- Basic measurements for follow-up
  - Spontaneous, physiotherapy, cast, braces,…
- Intervals depend on prognosis and expected growth rate

# Conclusions

- Comprehensive measurements for
  - Therapy planning
  - Surgical planning

- Radiographs must depict crucial landmarks
- Skilled technicians
- ALARA!
- Close collaboration with orthopedic surgeons

# Thank you


Literatur: t.vonkalle@klinikum-stuttgart.de