

# Treatment of spinal deformities

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# The most common spinal deformities

scoliosis



kyphosis



# SCOLIOSIS

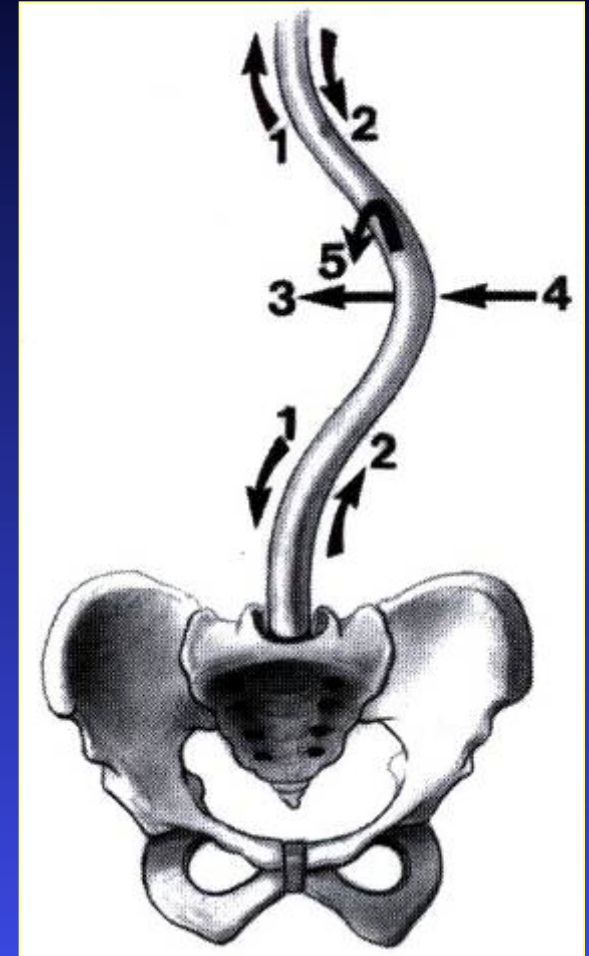
# Scoliosis is three-dimensional deformity

- in frontal plane - scoliosis
- in sagittal plane – hypo, hyperkyphosis
- in transversal plane – rotation, torsion

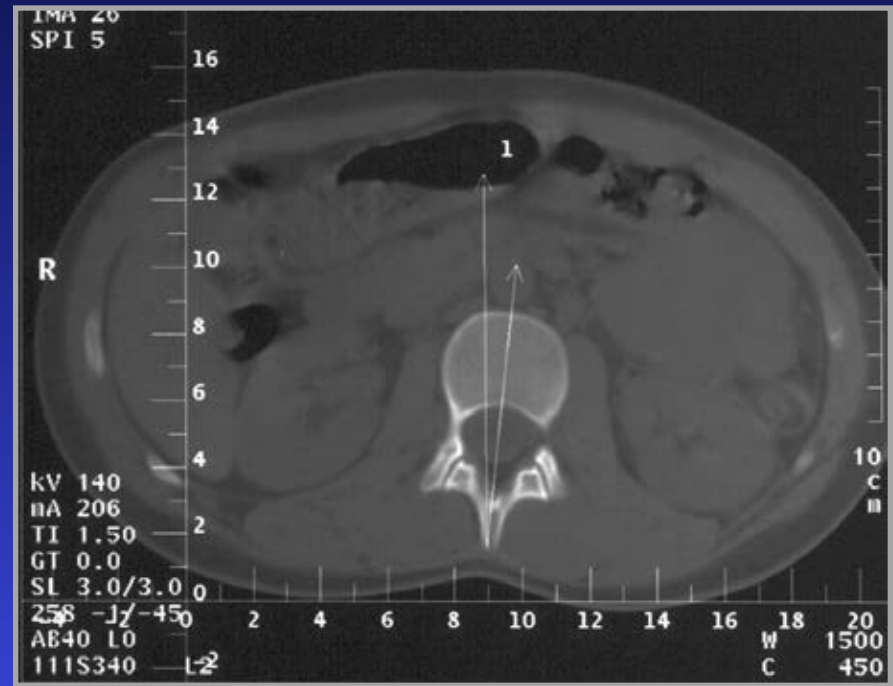
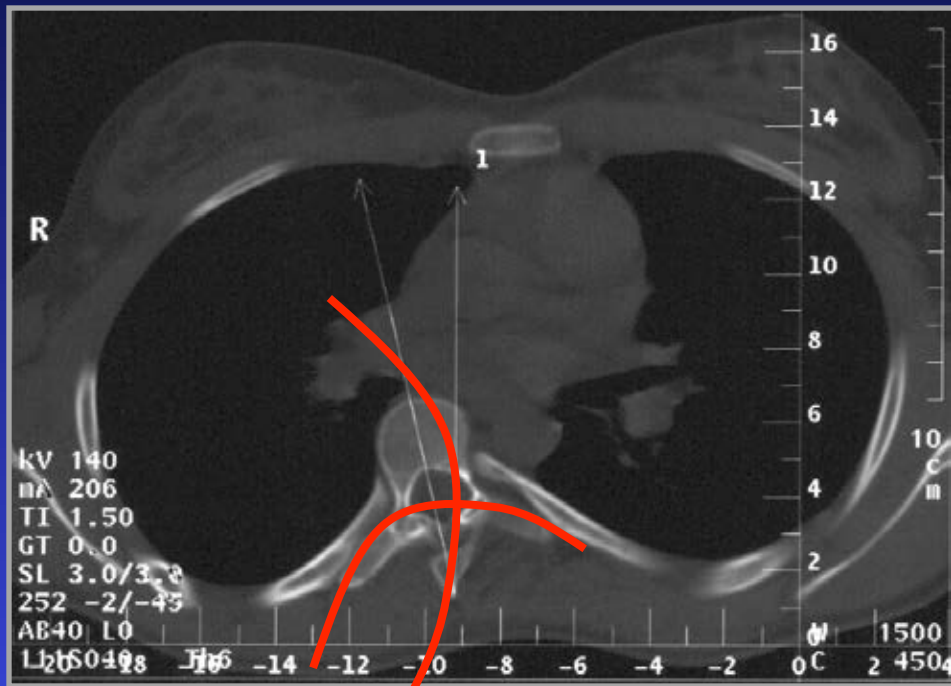




# Scoliosis: 3-D deformity



# Torsion



# Elementary primary evaluation

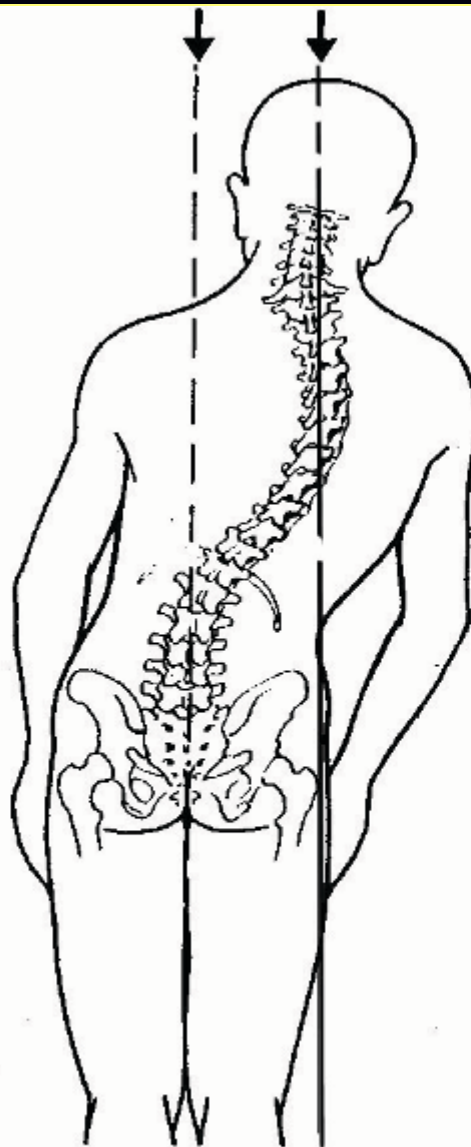
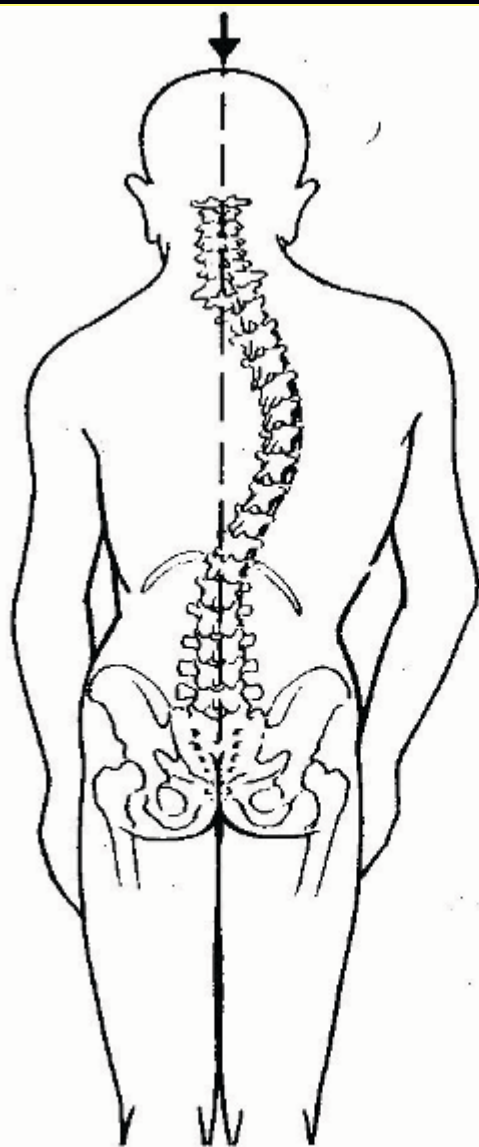
- anamnesis
- clinical examination
- X-ray evaluation
- treatment

# Anamnesis

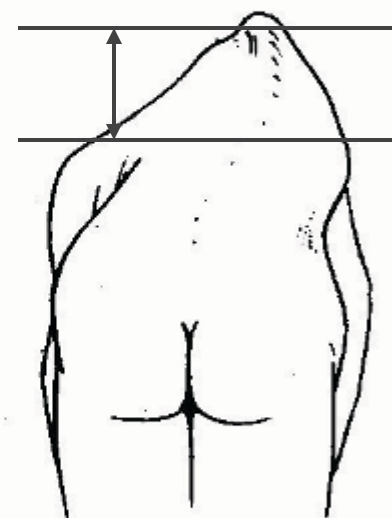
- complex health status
- motorical development
- capture and present treatment
- familiar anamnesis

# Clinical evaluation

- trunk compensation – plumb line
- shoulder height
- waist asymmetry
- pelvic balance
- curve flexibility in bending position
- prominence in bending forward
- others - laxicity, sexual development, skin pigmentation, lenght of lower extremities

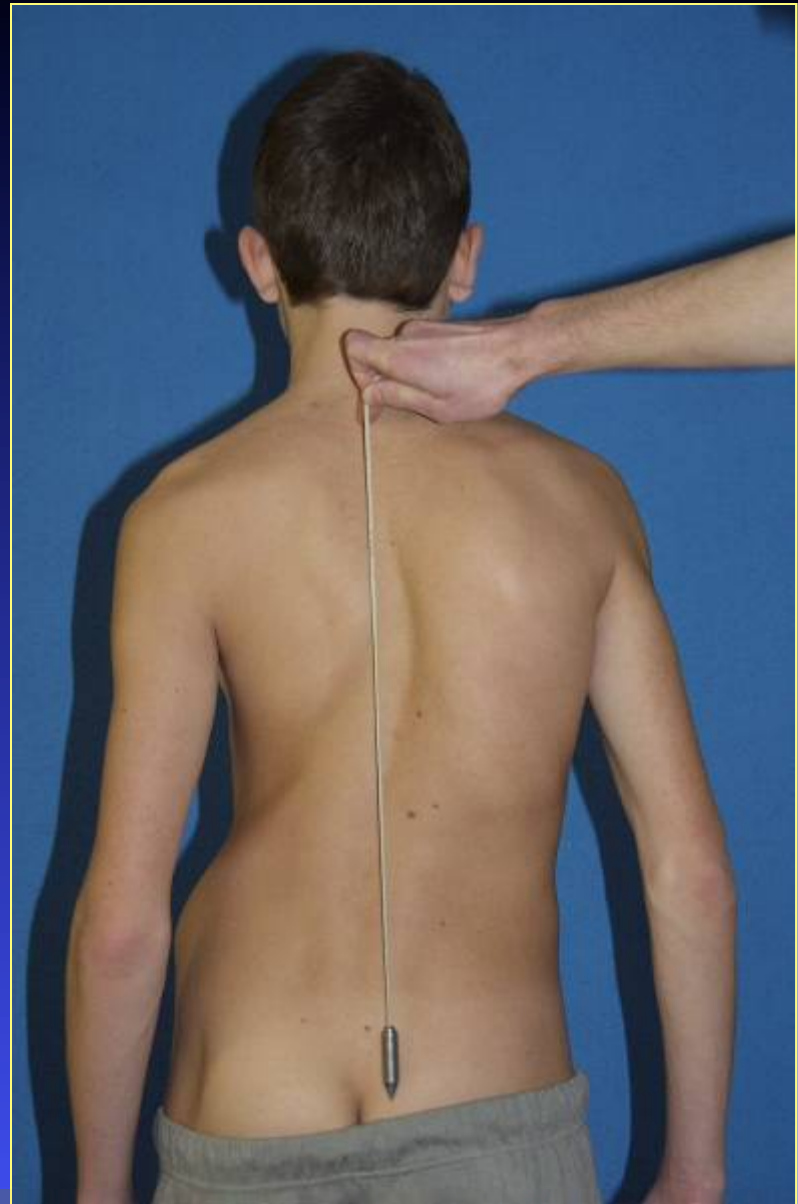


Dekompenzace skoliózy



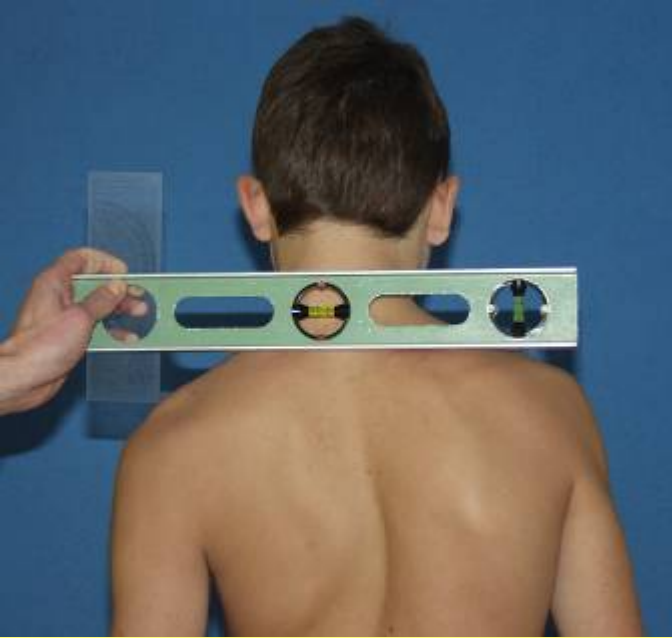
Žeborní prominence (APVZ)



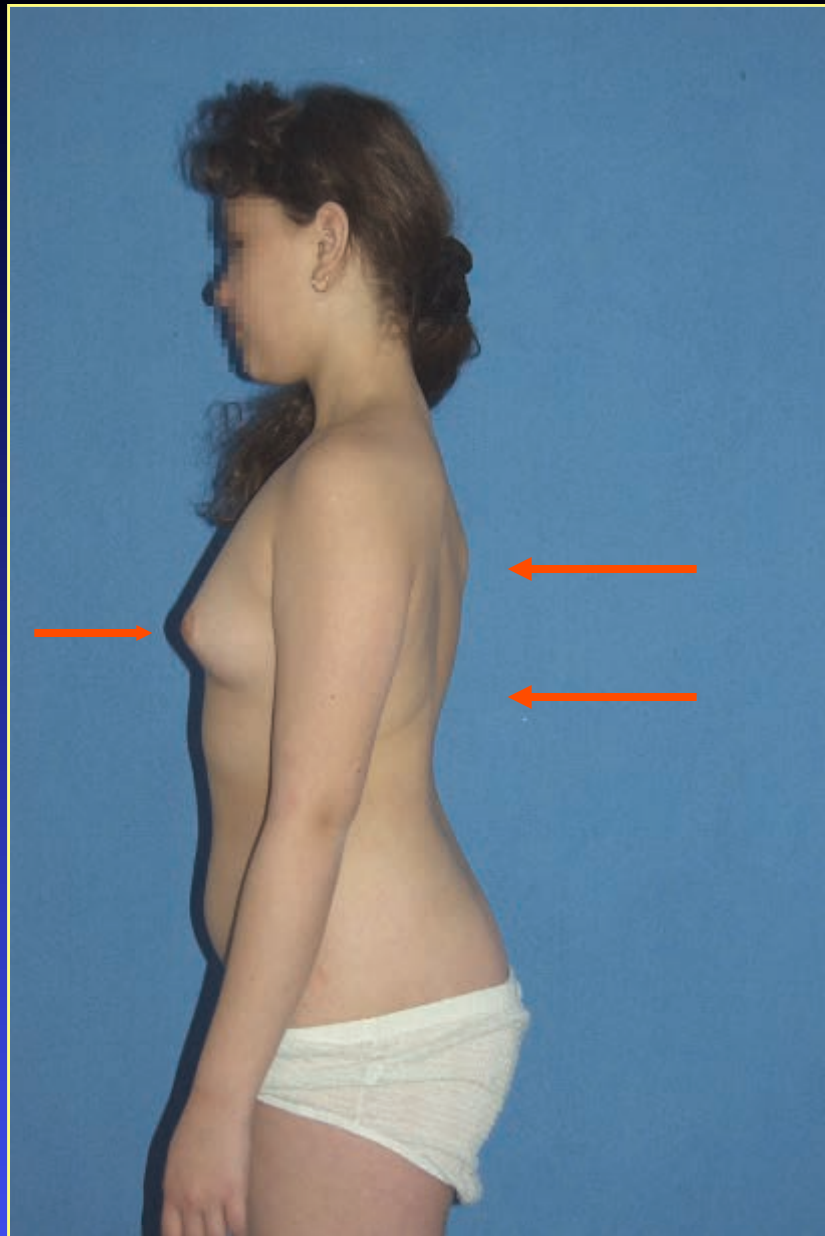


**Measurement of trunk decompensation**

## Measurement of shoulder asymmetry

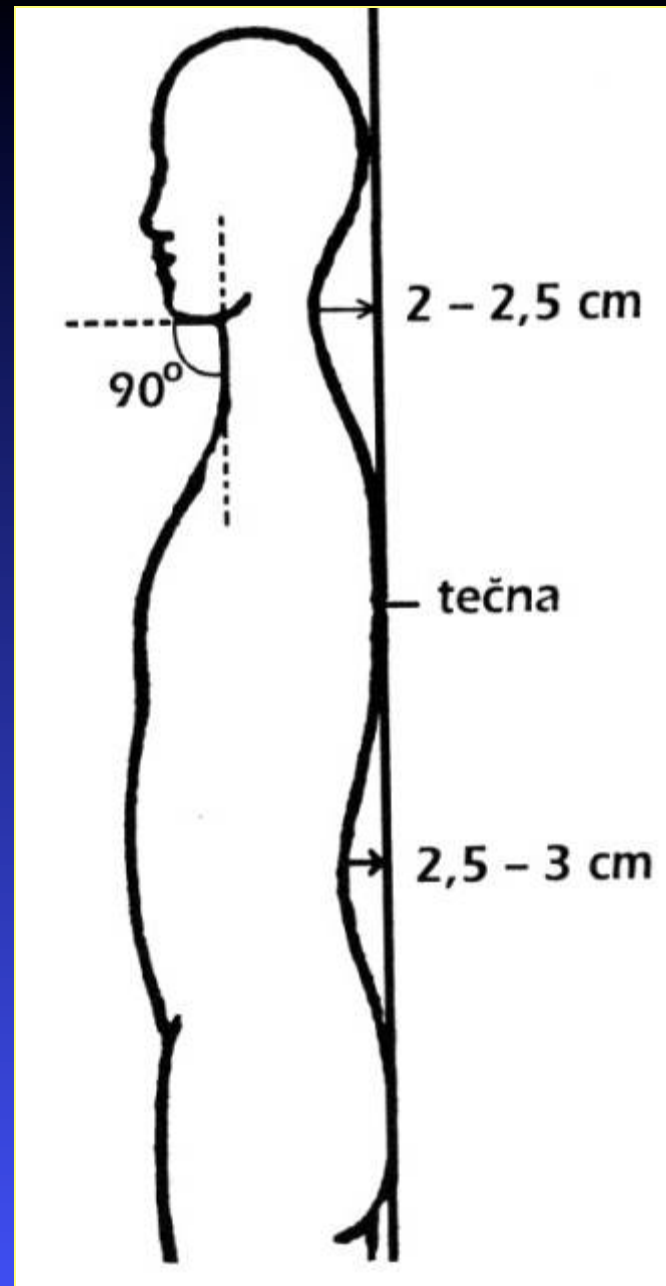


## Measurement of paravertebral gibbus

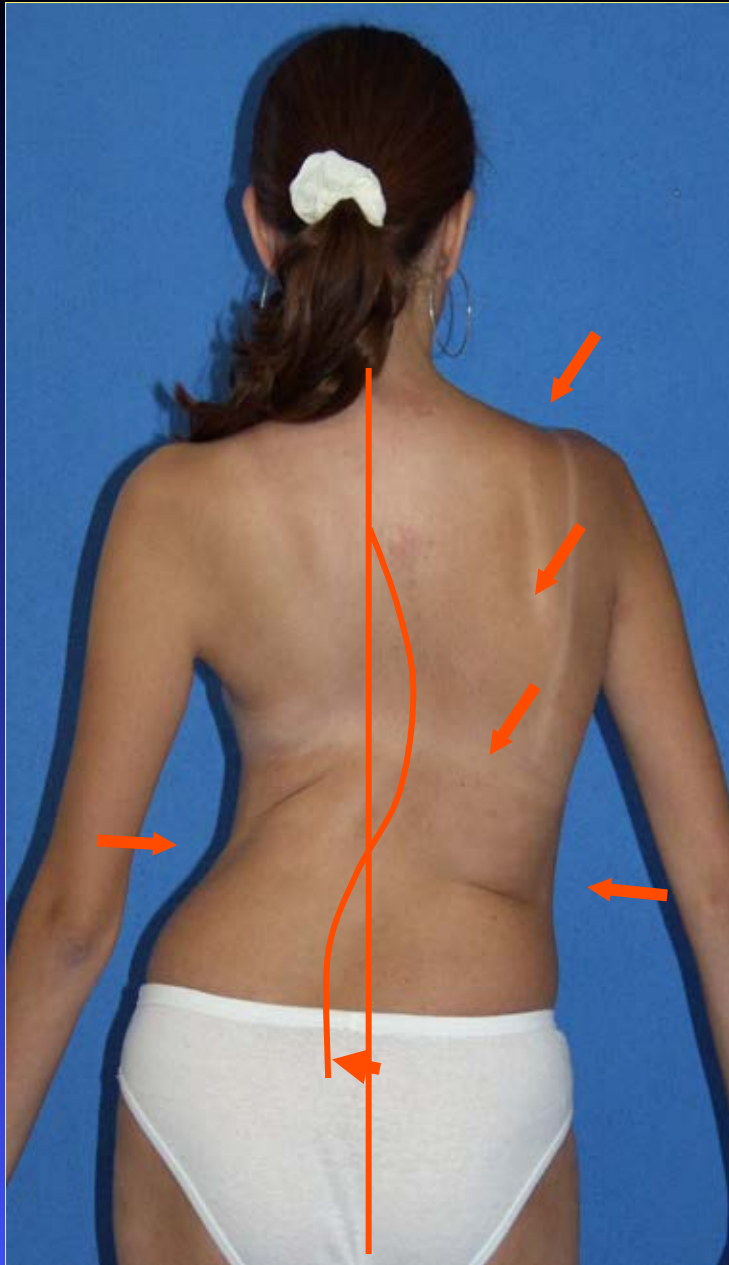


**Measurement of paravertebral gibbus**

# Sagittal balance







**Shoulder height**

**Gibbus**

**Asymmetry of waist**

**Trunk decompensation**

# Neurofibromatosis „café au lait“





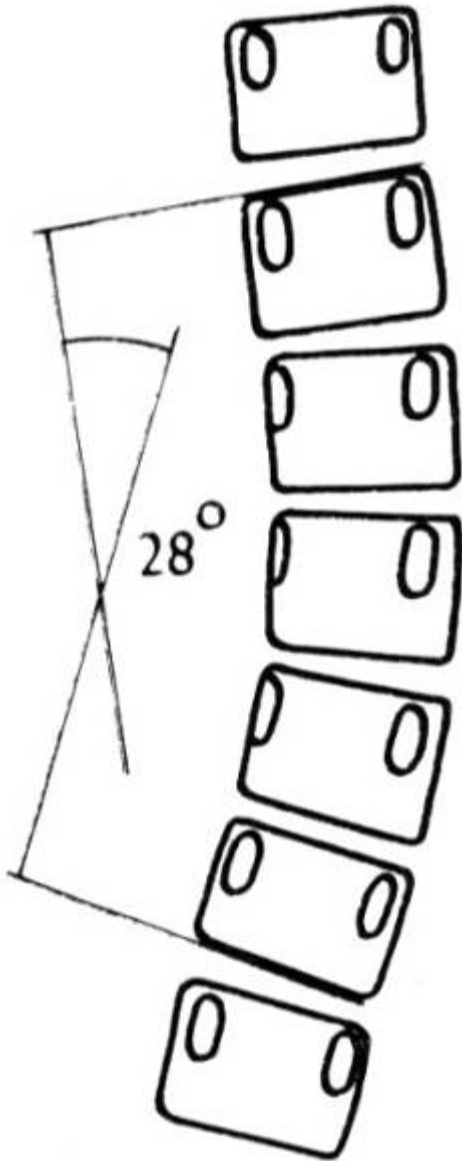
# Radiological evaluation

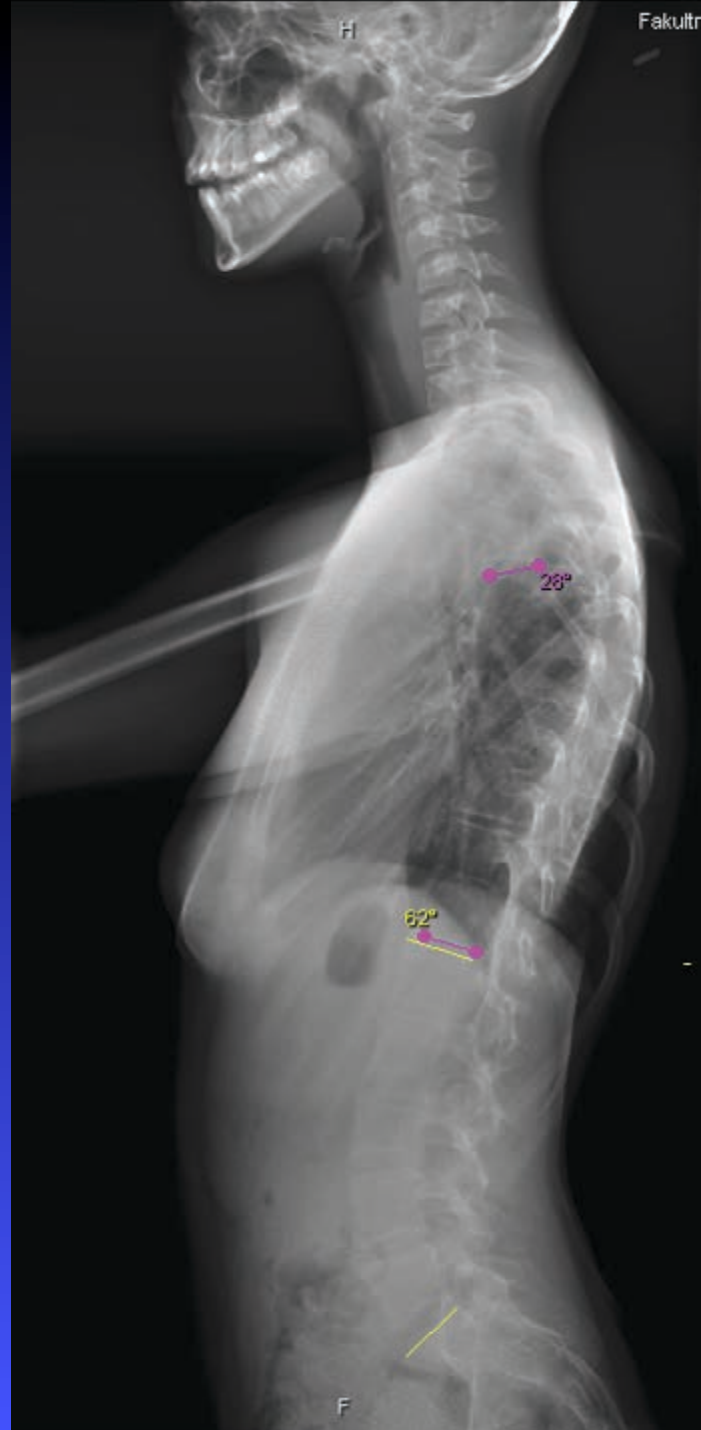
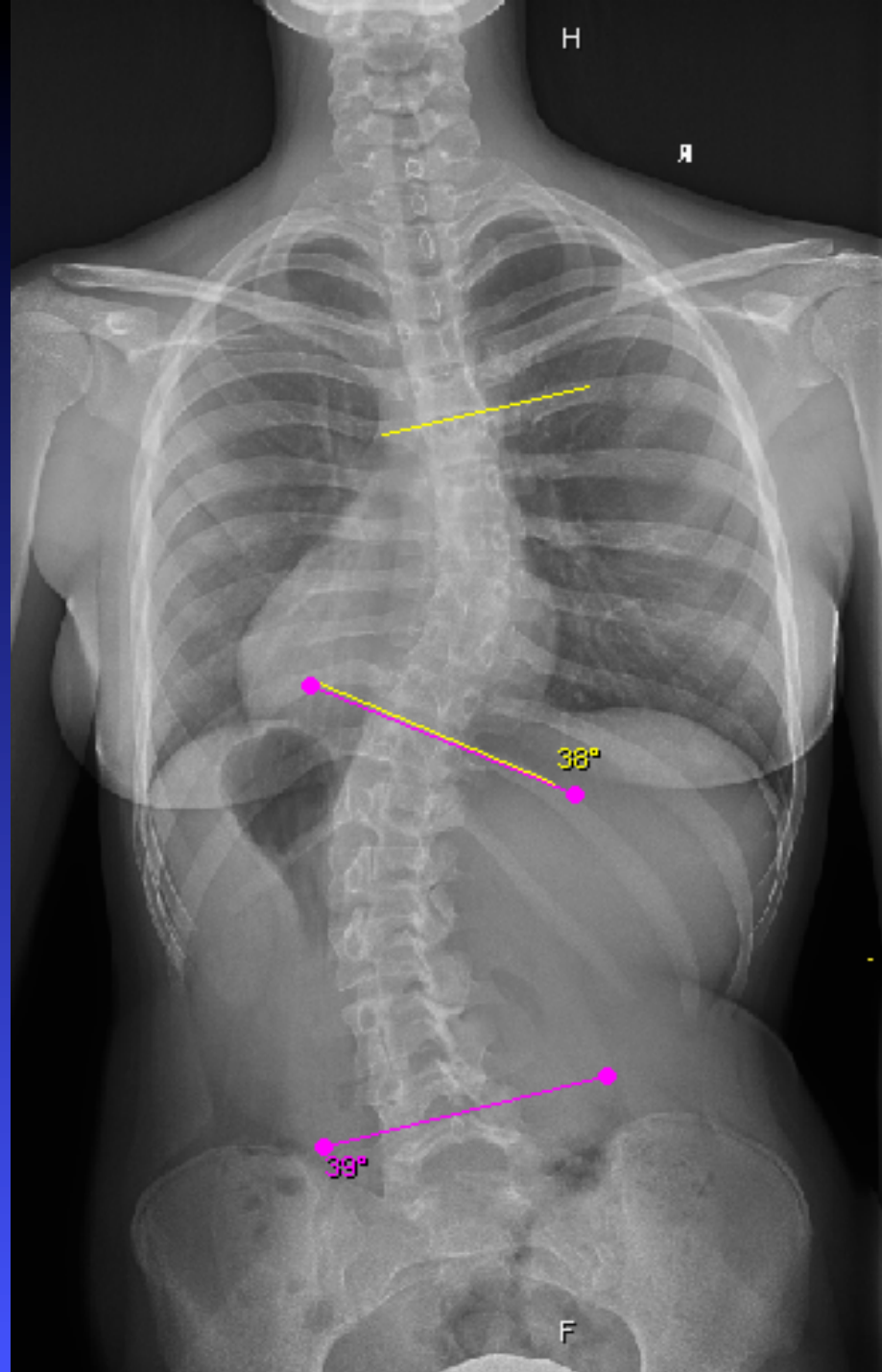
- PA and lateral X-ray in standing position (35x90 cm)
- lateral bending X-rays and traction of 200 N
- Special projections: Fergusson and Stagnara
- wrist X-ray for bone age measurement (Greulich-Pyle 1959)
- CT for measurement of apex vertebra rotation

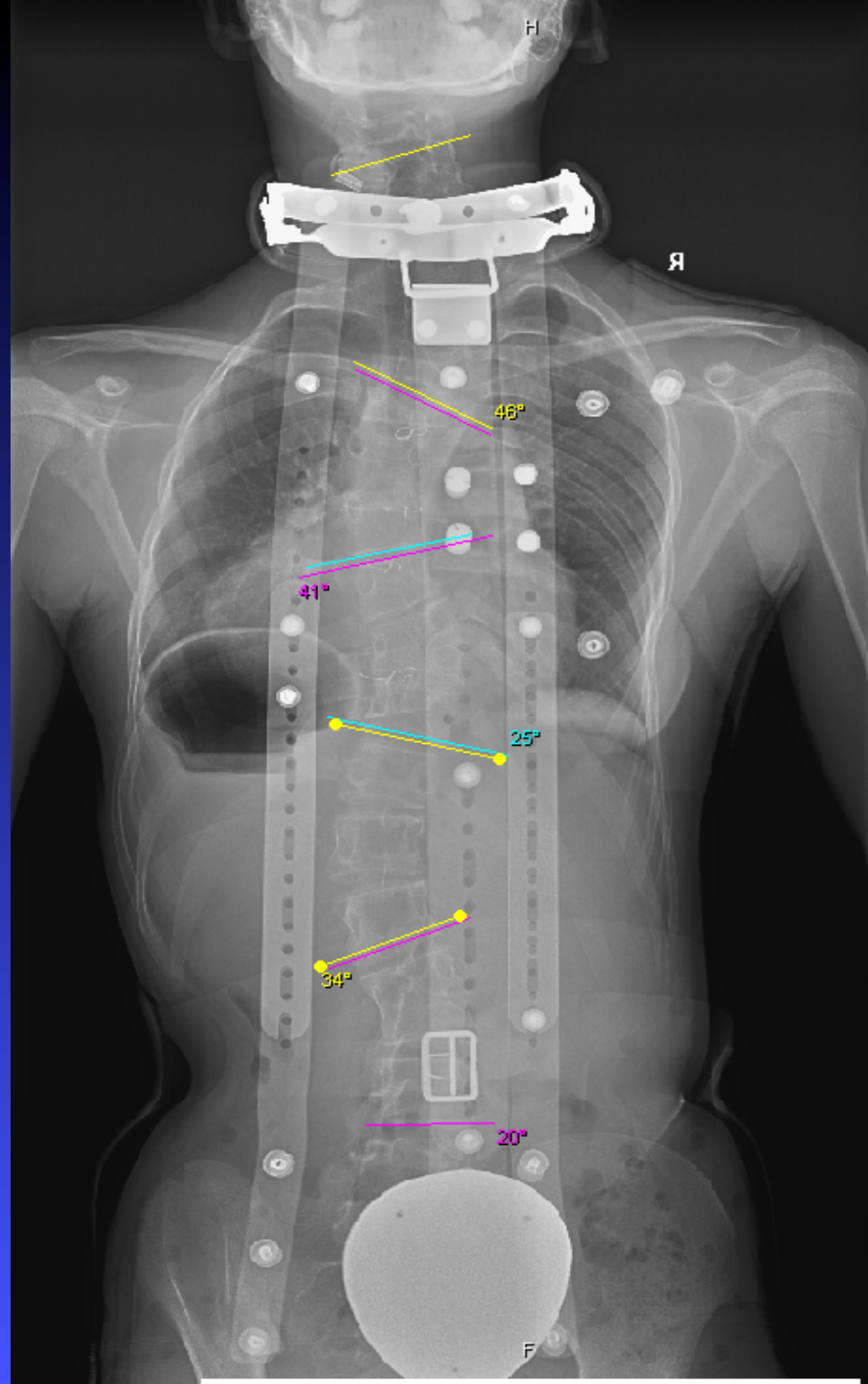
# **Radiological scoliotic measurement**

- COBB – angle of scoliosis and sagittal balance
- MOE – evaluation of vertebral rotation
- RISSER – evaluation of bone age

# Curve gravity evaluation according to COBB

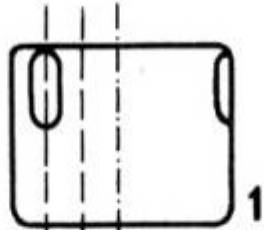
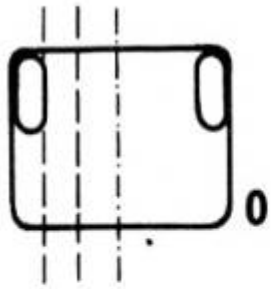




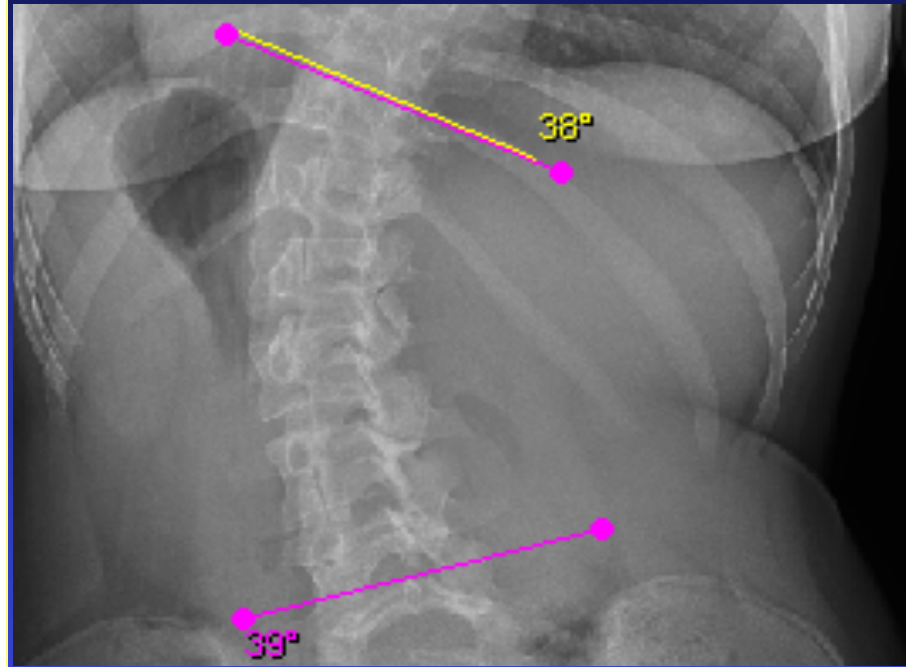
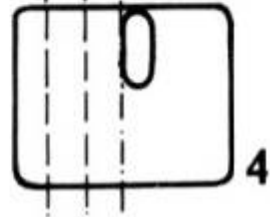
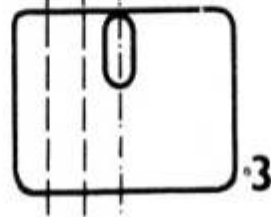
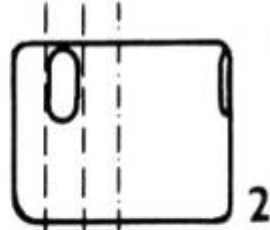


# Rotation evaluation according to MOE

konvexita



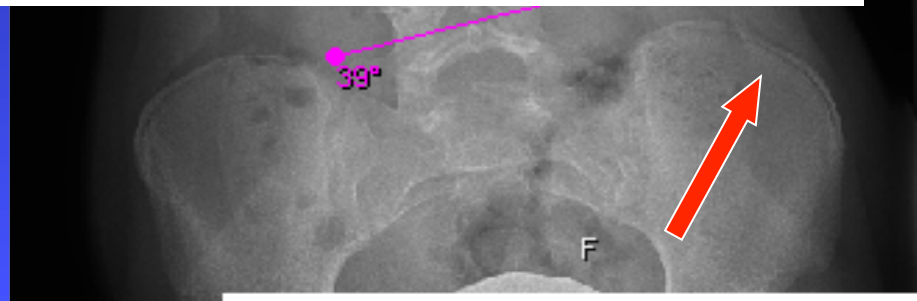
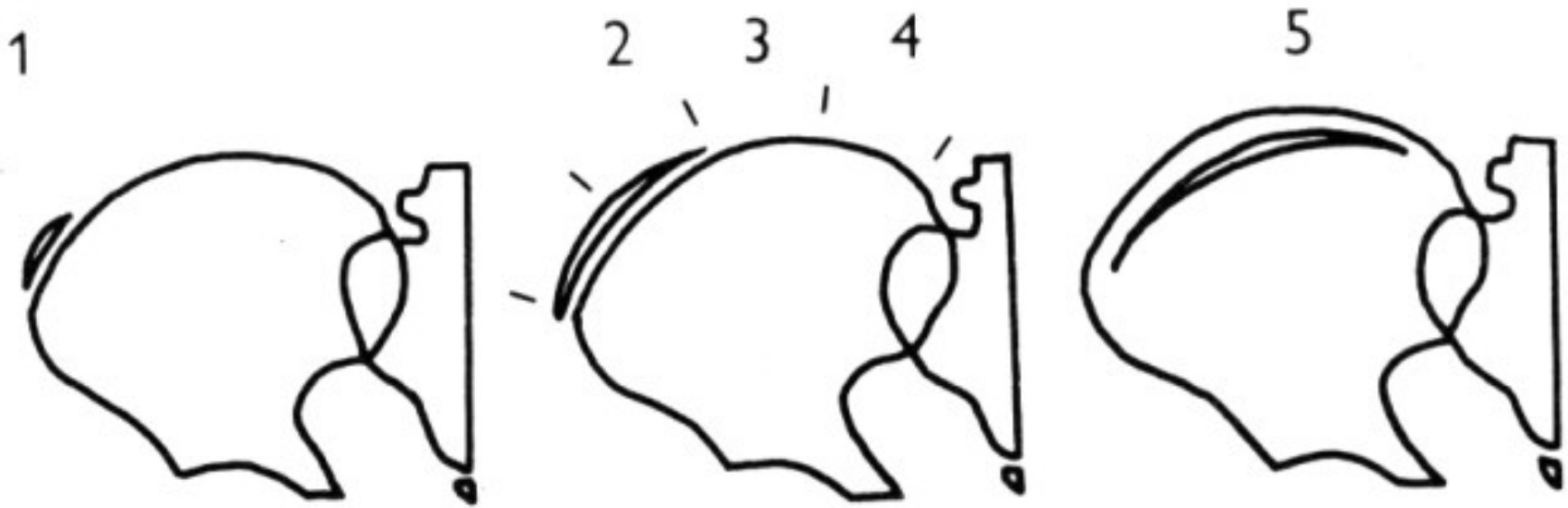
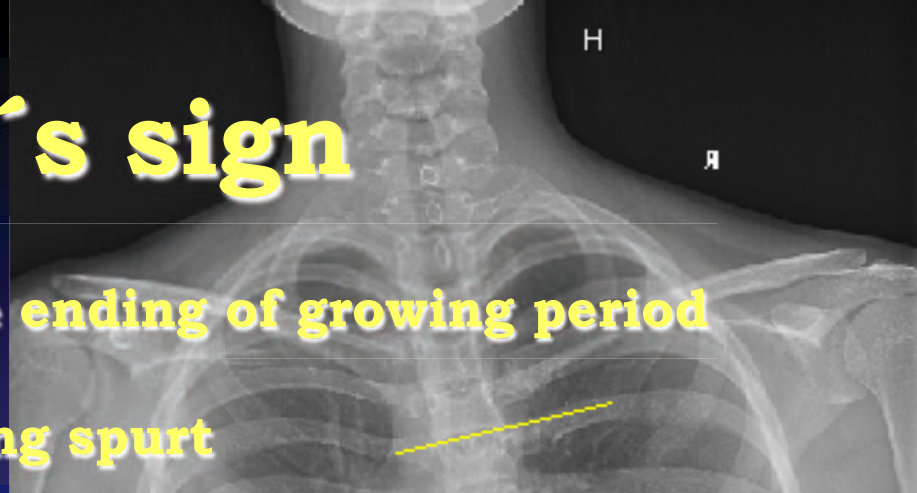
konkavita



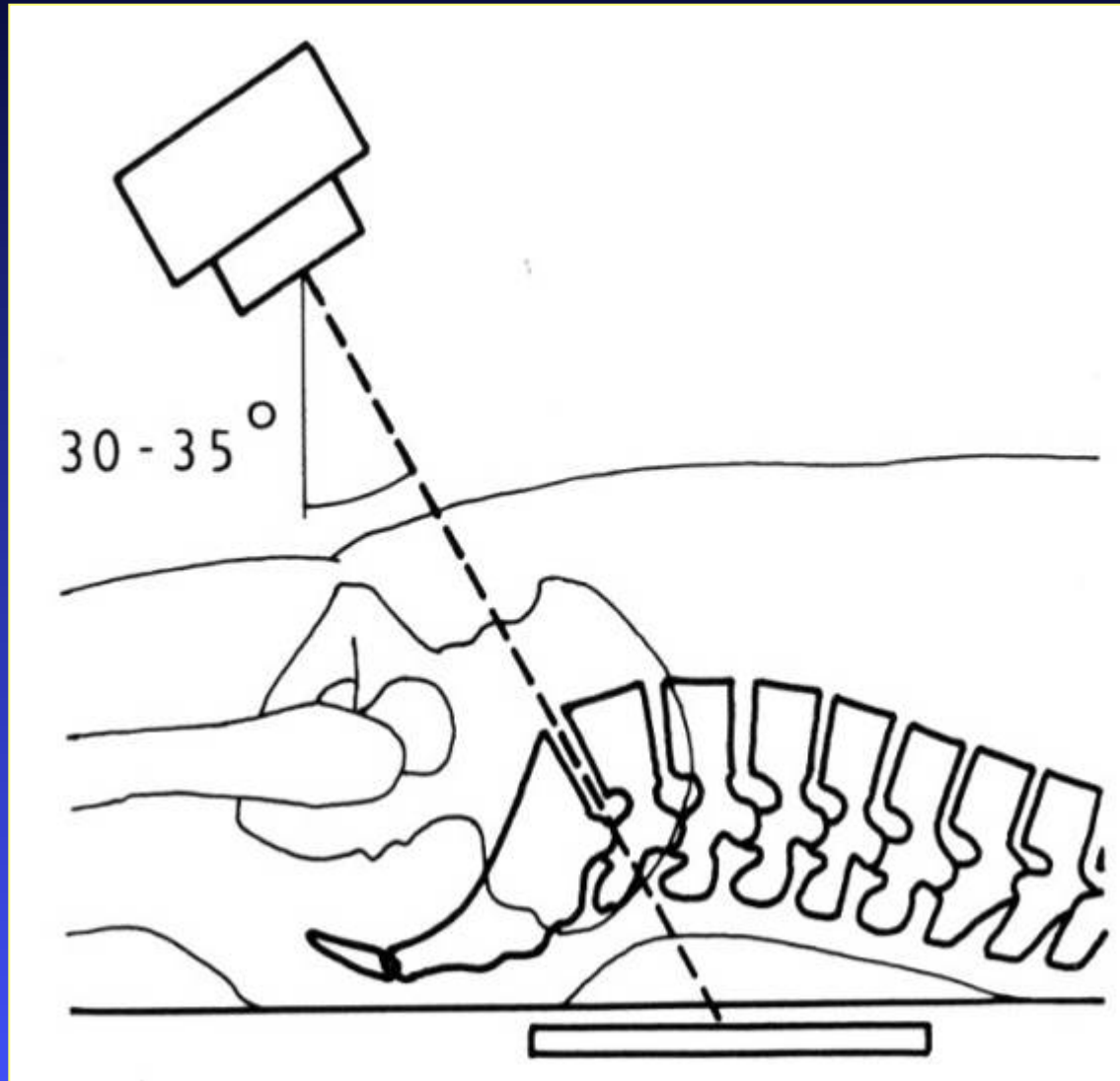


# RISSEY's sign

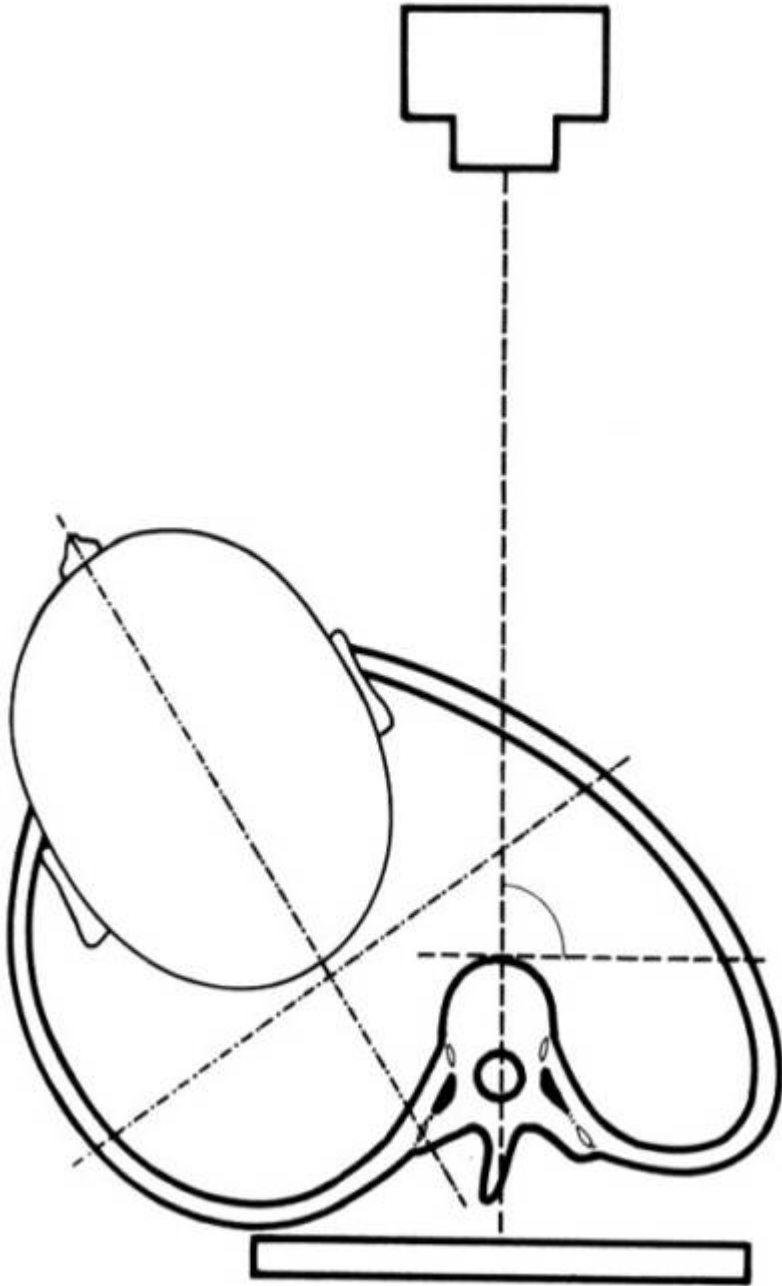
- **STADIUM 1 = 2 years before ending of growing period**
- **STADIUM 3 = peak of growing spurt**



# FERGUSON's projection

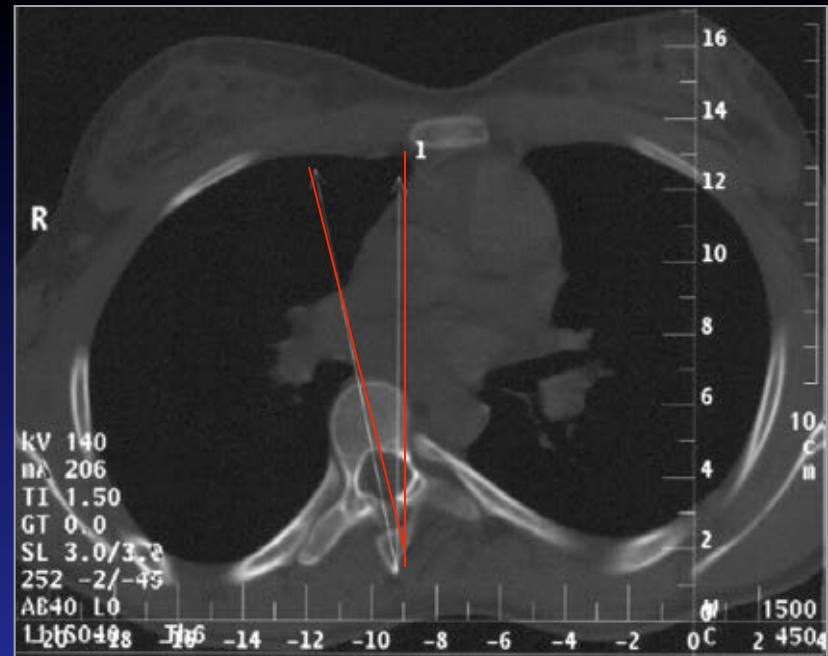


# STAGNARA projection



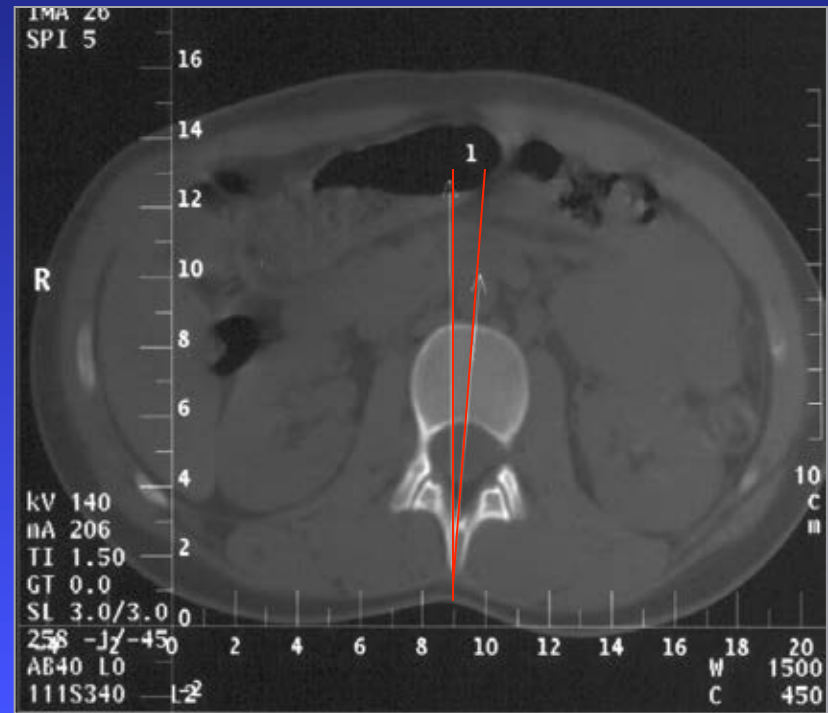
# Rotation vertebra evaluation

Th apical vertebra



*double Th-L curves*

L apical vertebra



# Basic terms

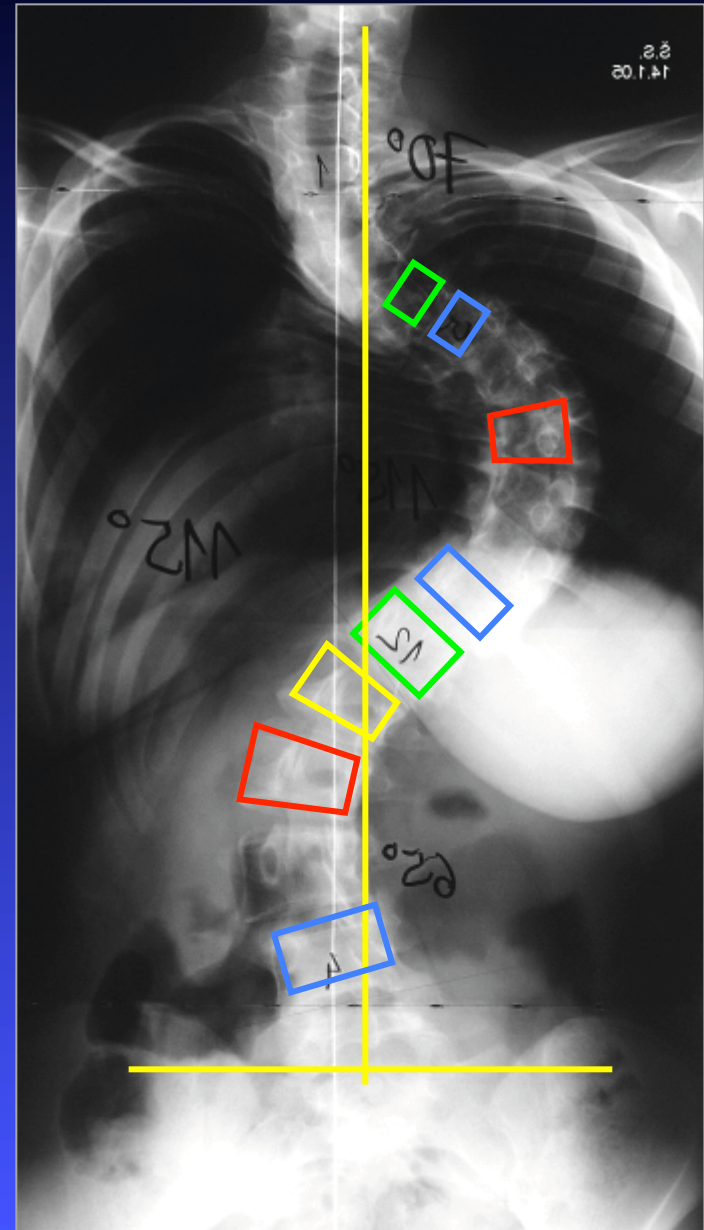
**Apical vertebra**

**Ending vertebra**

**Neutral vertebra**

**CSVL**

**Stable vertebra**



# **Characteristics of the curves**

**Structural**

**Non-structural**



# **Curves terminology**

(according to Cobb angle)

**Main** (weighty rotation)

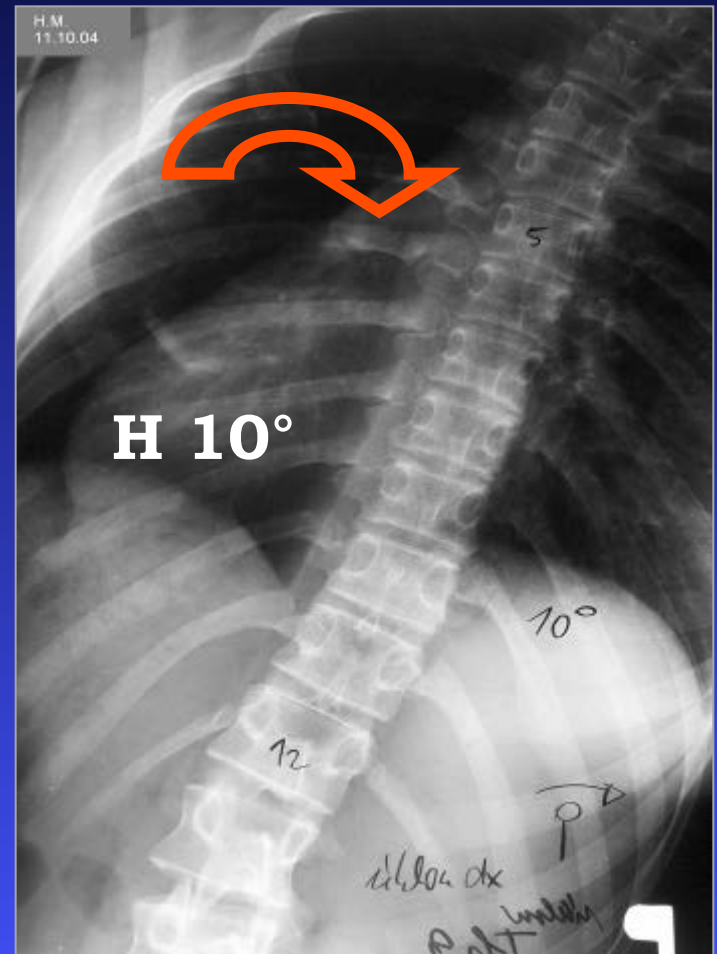
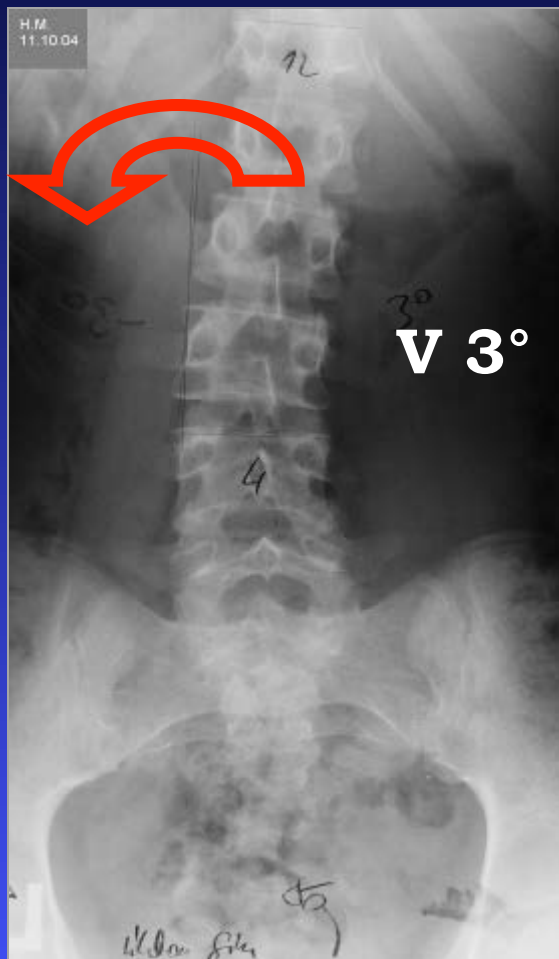
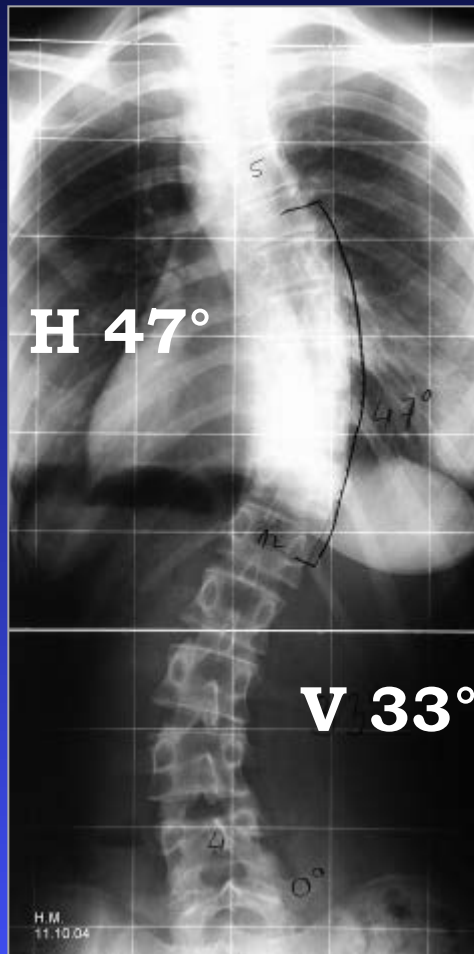
**Adjacent** (compensatory)

# Curve structurality

- **Main – structural**
- **Adjacent – structural, non-structural**

Curve structurality of adjacent curve is important to decide the fusion of adjacent curve in surgical treatment of AIS

# Non-structural curve

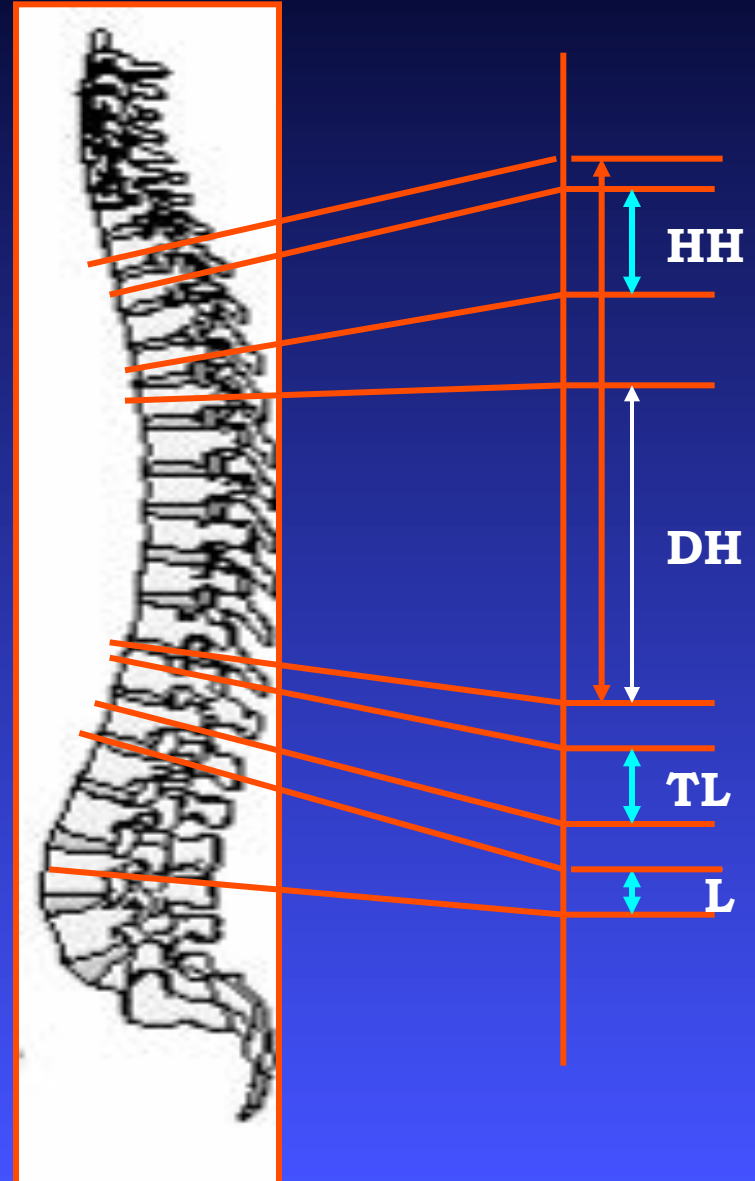


# Classification

- Orientation – right or left convexity
- Localisation – C,CT,T,TL,L,LS
- Gravity of curves – according to Cobb angles
- Etiology

# Localisation of the curve according to position of the apical vertebra

- **Thoracic:** T2- disc T11/12  
    **Upper Th** T3 – T5  
    **Lower Th** T6 – disc T11/12
- **Thoracolumbar:** T12-L1
- **Lumbar:** disc L1/2-L4



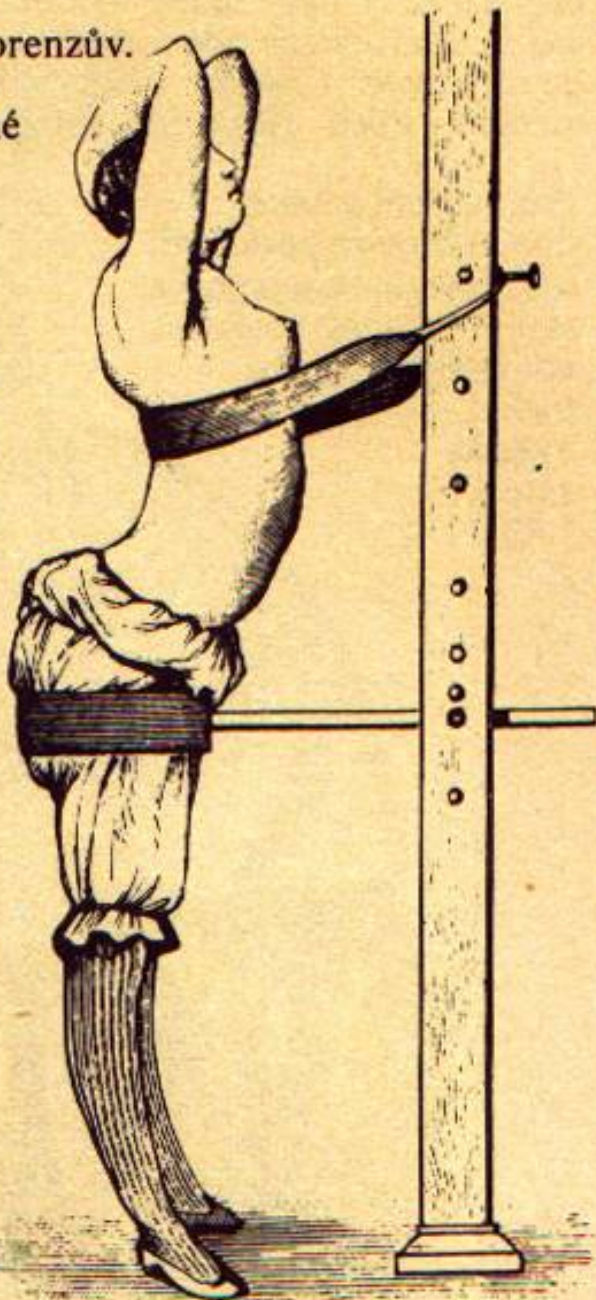


# Scoliosis – ethiopathogenetic classification

- Congenital
- Idiopathic.....4/5    80%
  - ◆ infantile
  - ◆ iuvenile
  - ◆ adolescent
- Neuromuscular
  - ◆ neuropatic
  - ◆ myopatic
- Neurofibromatosis
- Secondary
  - ◆ Postural
  - ◆ Tumours
  - ◆ Other syndromas (Marfan, Ehlers-Danlos.....)
- Hysteric
- Degenerative

Apparát Lorenzův.

Uprostřed  
vyčalouněné  
železo,  
nahore  
volný  
kožený  
řemen,  
přes který  
se pacient  
prohýbá.  
Ruce  
za hlavou  
zvyšují  
účinek  
cvičení,  
kterými se  
rovná  
pateř.



# IDIOPATHIC SCOLIOSIS

- **Unknown etiology, multifactorial**
- **Genetic predispositions**
- **8 times more frequent in girls**

# Idiopathic scoliosis

- **Infantile**

- ◆ < 3 years, neonatorum, mostly spontaneous regression, but some times with serious progression

- **Juvenile**

- ◆ Age of 3 y. – puberty start (10 y.)

- **Adolescent**

- ◆ From puberty start (10 -12 y.) – up to puberty end

# **Classification according to the curve gravity**

**Up to 10 °** -observation

**10-20 °** -physiotherapy,  
observation

**20-40st.** -physiotherapy, bracing

**More than 40 °** -surgical treatment



# **Conservative therapy**

Physiotherapy

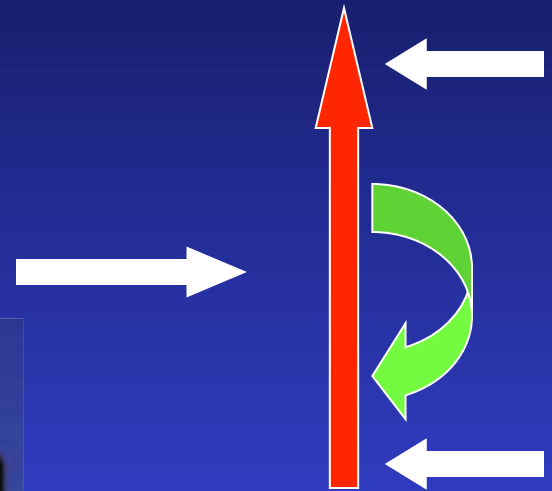
Brace

## **Brace characteristics:**

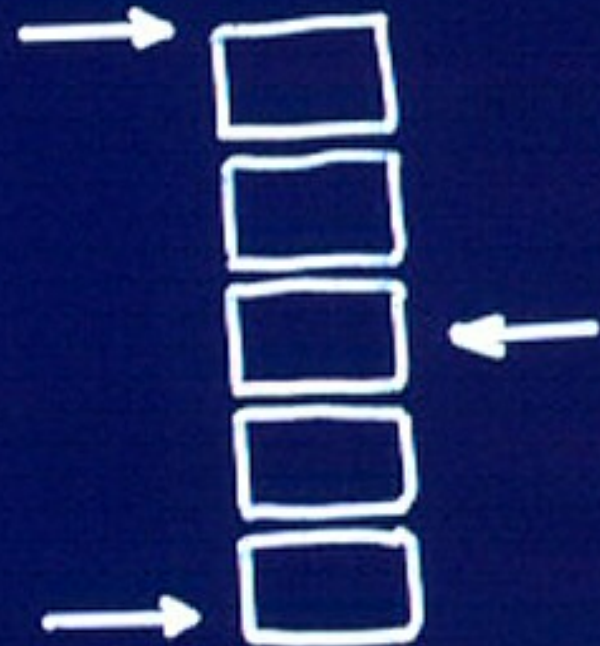
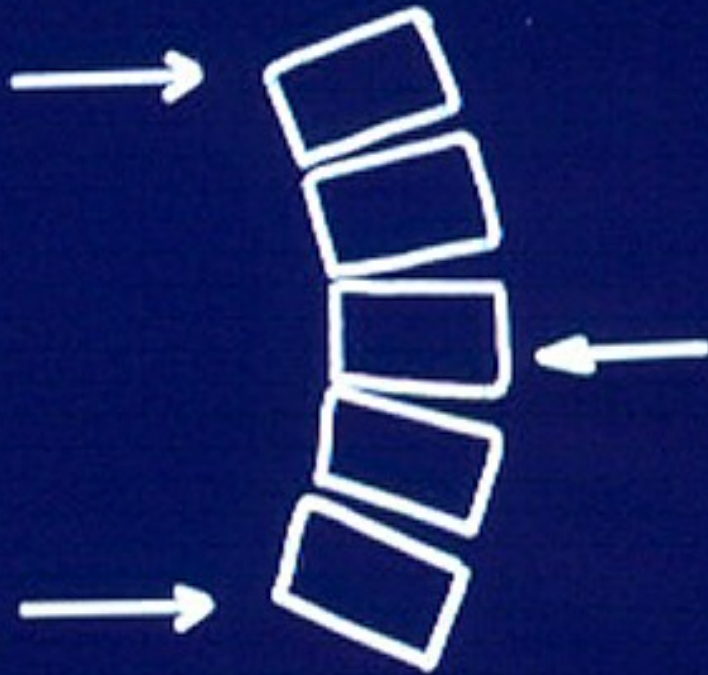
- maximally effective
- active and pasive curve correction
- lite
- easily slip-over
- without chest compression

## Effective forces: \_

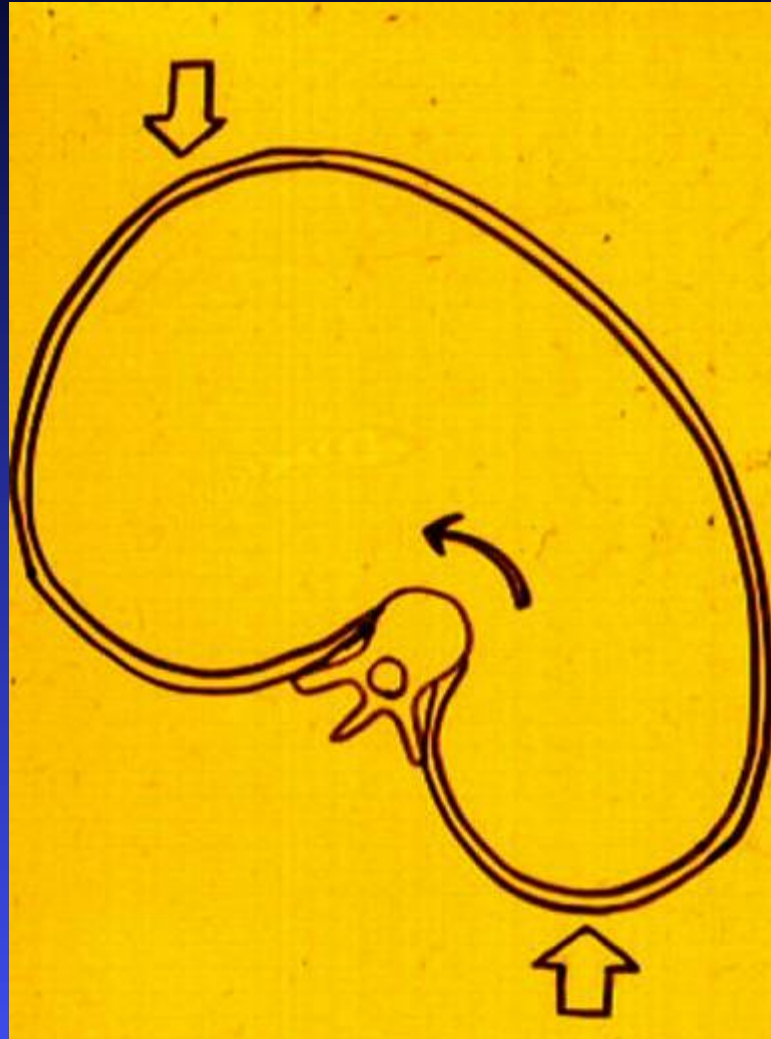
- distraction
- derotation
- three-point system



# Three-point principle



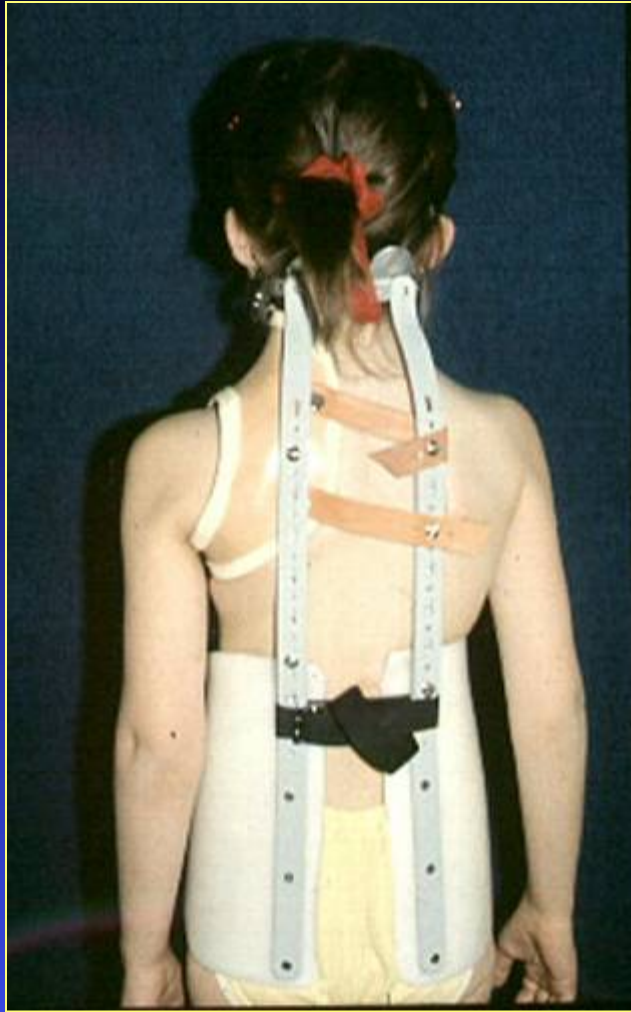
# Derotation



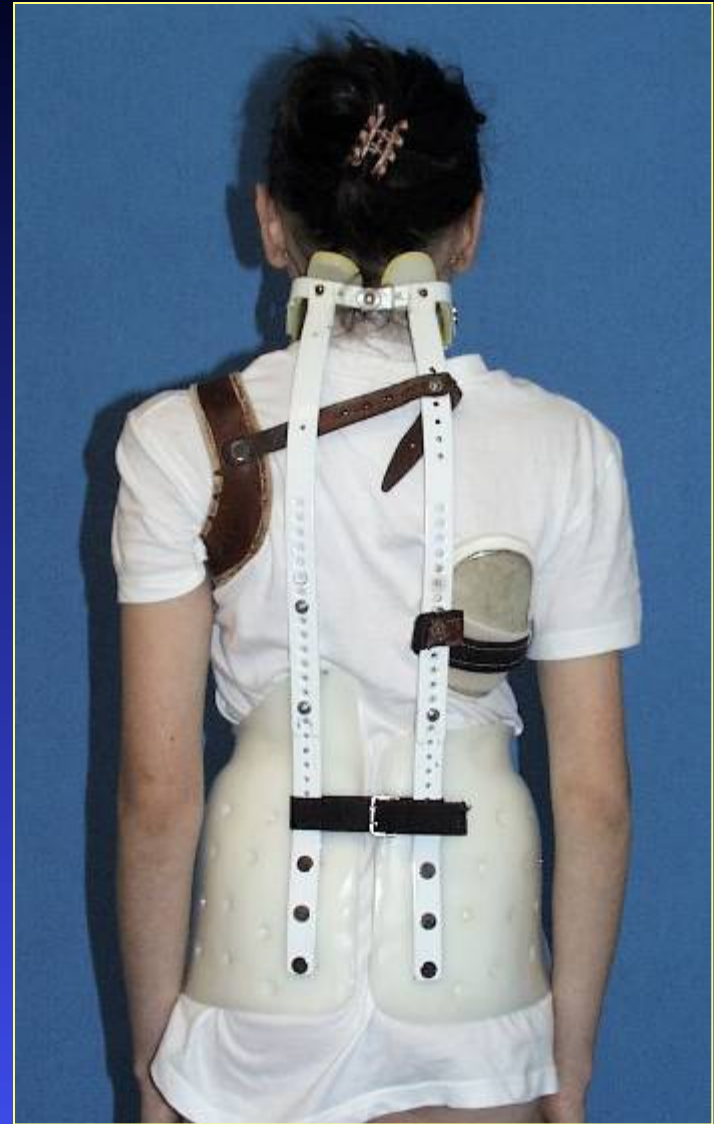
















# Physiotherapy in brace

- body posture
- strenghtening



# Body posture

wrong



good





## strengthening







- without brace

- swimming

- hippotherapy

- exercises according to Vojta

- (limited effect) and Schrott





- Breathing – *deep breathing*
  - *special bottles*
  - *derotation breathing*



# **Surgical therapy**

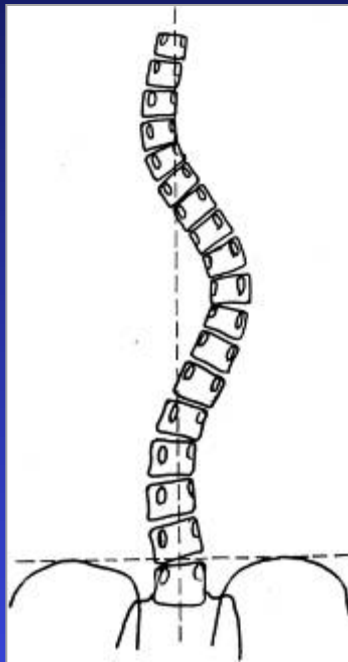
# King classification



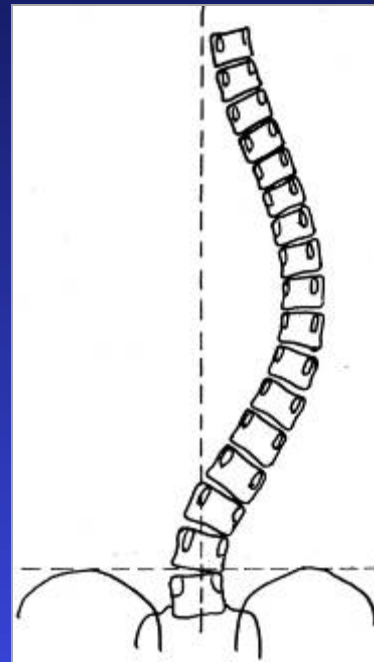
I



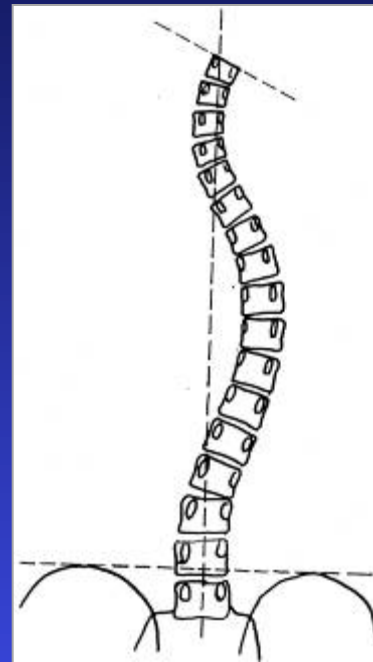
II



III



IV



V

# Lenke classification

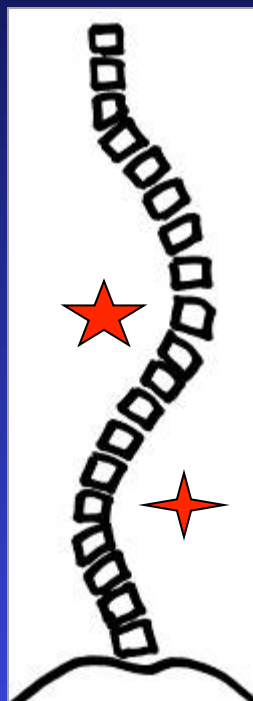
## basic types



1



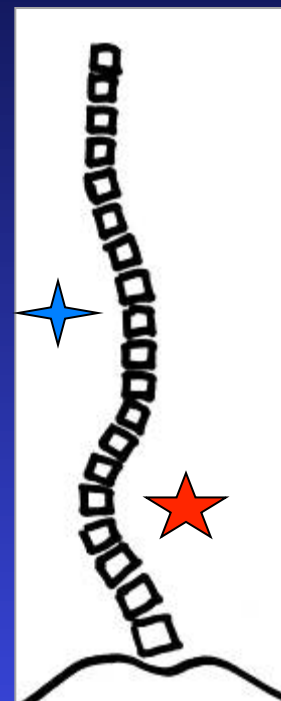
2



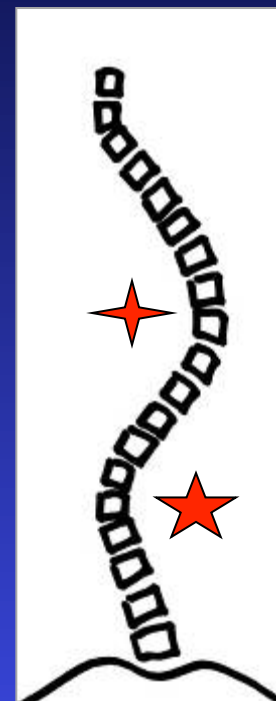
3



4



5



6



Main





















V struct.



V non-struct.

# Lenke classification

<u>Lumbar Spine Modifier</u>	<u>Curve Type (1 - 6)</u>					
	Type 1 (Main Thoracic)	Type 2 (Double Thoracic)	Type 3 (Double Major)	Type 4 (Triple Major)	Type 5 (TL/L)	Type 6 (TL/L - MT)
<b>A</b> (No to Minimal Curve)	 1A*	 2A*	 3A*	 4A*		
<b>B</b> (Moderate Curve)	 1B*	 2B*	 3B*	 4B*		
<b>C</b> (Large Curve)	 1C*	 2C*	 3C*	 4C*	 5C*	 6C*
Possible Sagittal structural criteria (To determine specific curve type)	 Normal	 PT Kyphosis	 TL Kyphosis	 PT + TL Kyphosis		

- : <10°

\* T5-12 sagittal alignment modifier: -, N, or + N : 10-40°

+ : >40°



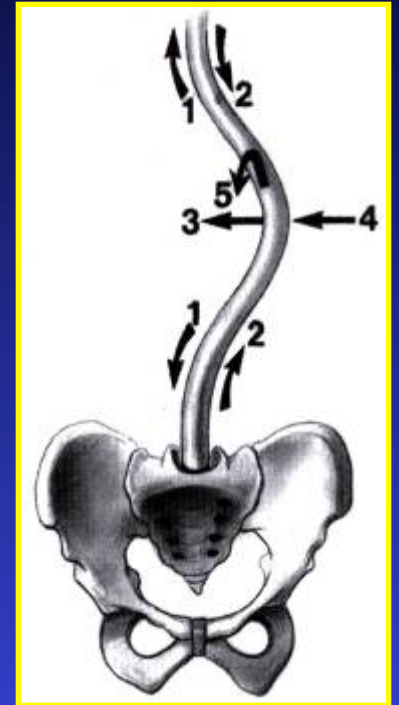
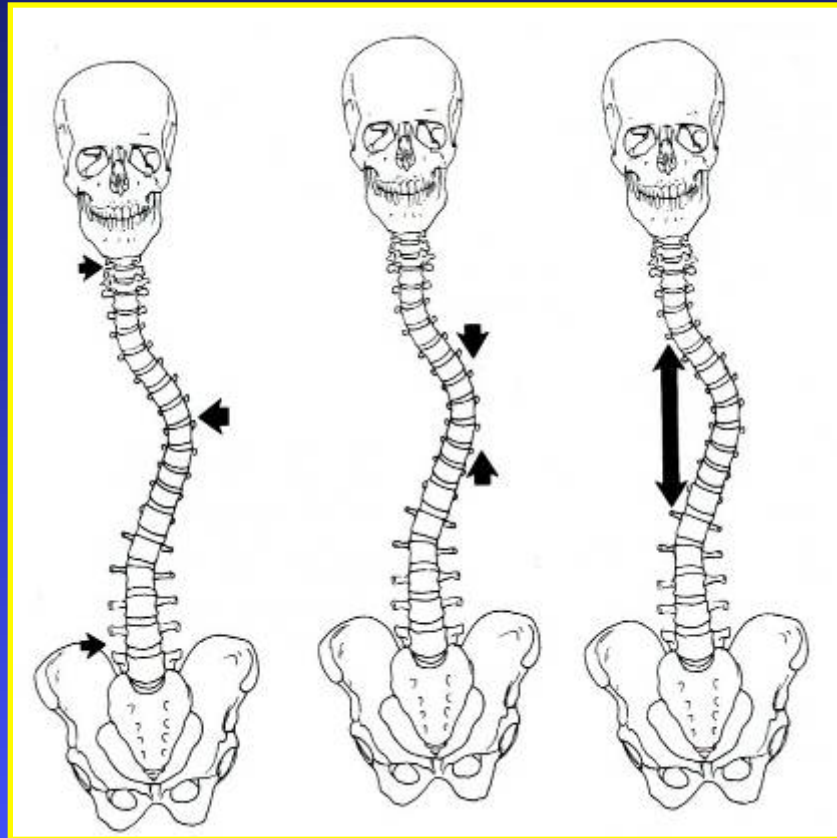
# Therapeutic planning

**1.Observation** **up to 20°**

**2.Conservative treatment** **20-40 °**

**3.Surgical treatment** **over 40 °**

# Methods of correction

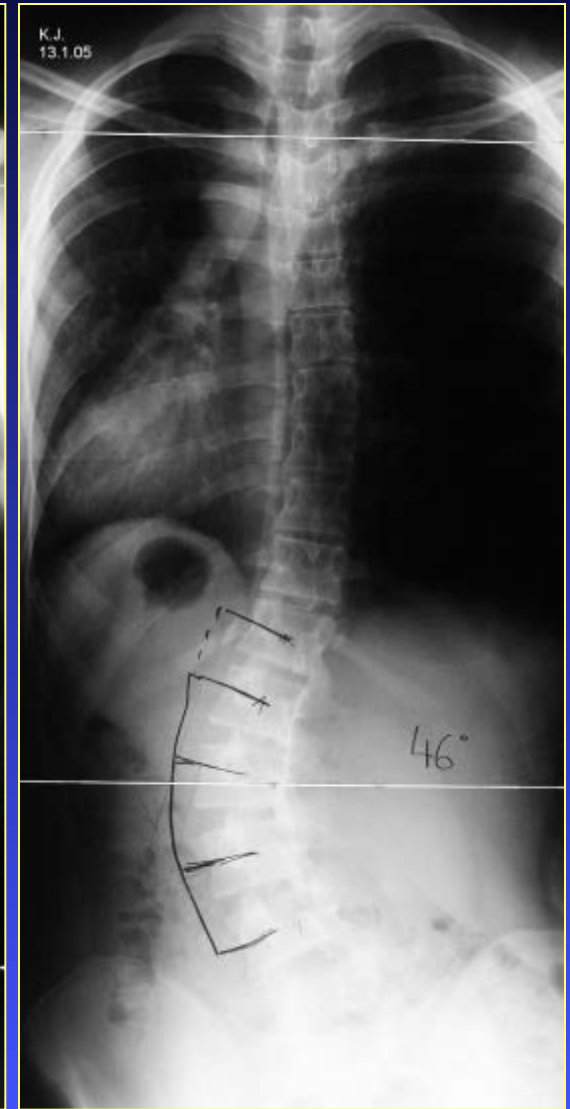
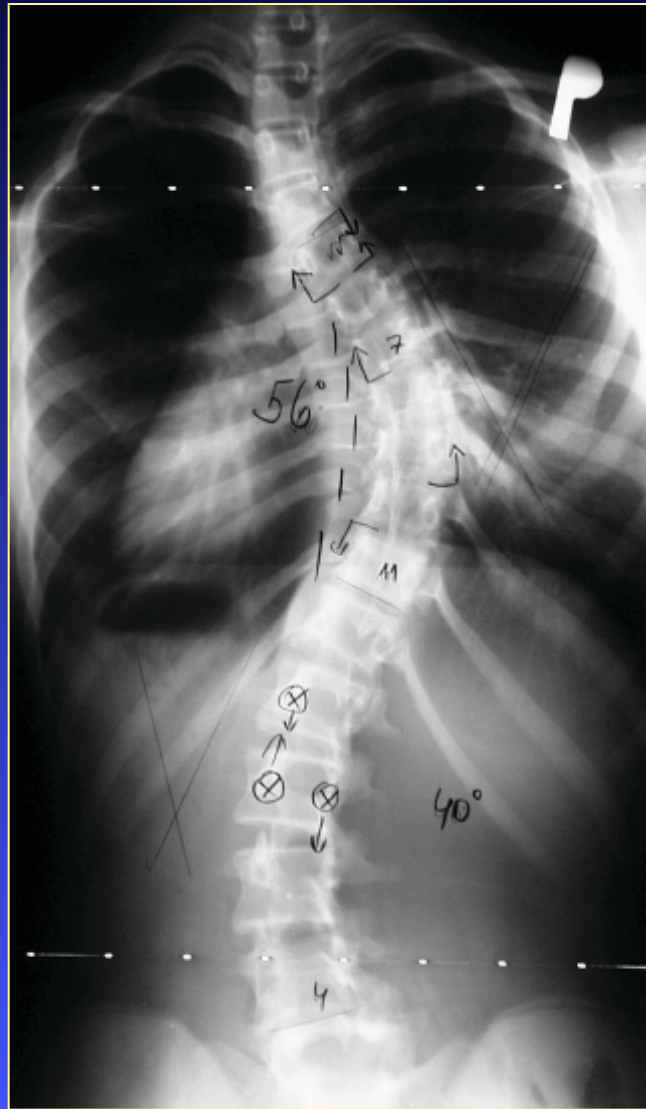
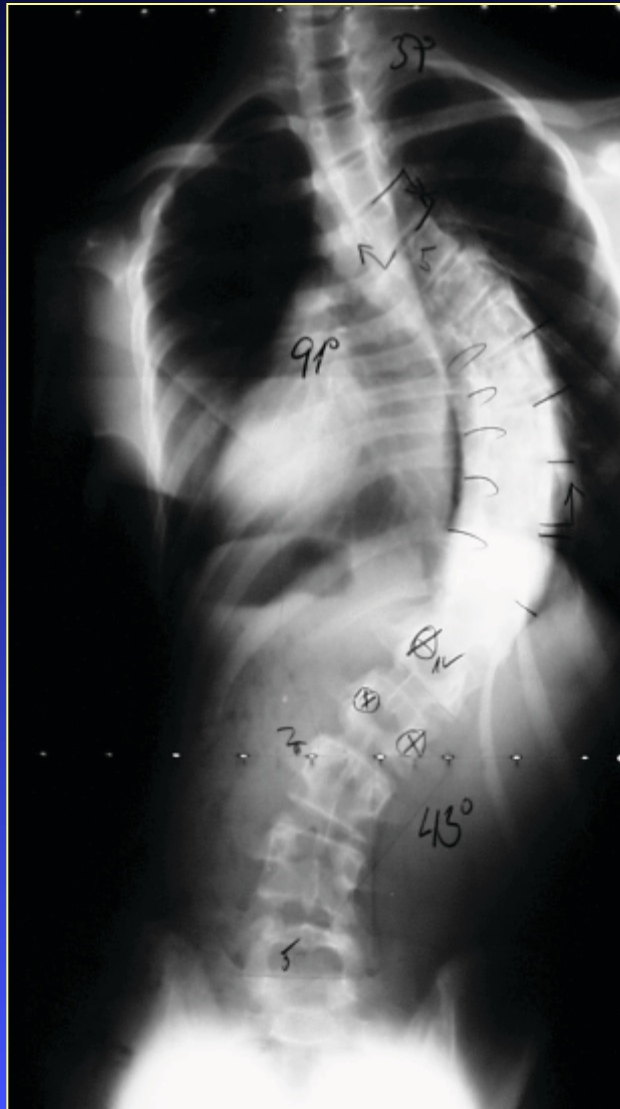


# **Adolescent scoliosis**

## **Definitive treatment**

- Segmental deliberation (posterior, anterior)
- Deformity correction
- Curve instrumentation
- Stabilisation
- Fusion

# Preoperative planning



# Preoperative planning

- Posterior approach
- Anterior approach
- Combined approach
  - ◆ One-session
  - ◆ Two-sessions



# Posterior approach

- One or two curves stabilisation
- Hyperkyphosis
- Neuromuscular curves

# Anterior approach

- Stabilisation of one curve only

# **Extent of instrumentation**

- **Posterior approach**

- ◆ **Neutral – neutral vertebra**

- **Anterior approach – saving 1-3 segments**

- ◆ **Ending - ending vertebra**

# Types of surgery

- **Posterior approach**

- spine only

- spine and pelvis instrumentation

- **Anterior approach**

- transthoracic

- transthoracoretroperitoneal

- retroperitoneal

- thoracoscopic

- **Combine approach**

- anterior release + posterior instrumentation

- anterior + posterior instrumentation

# Indication for posterior approach

According to Lenke Classification

## ➤ Posterior approach

- Rigid curves
- Double curves
- Long curves
- Severe curves
- Curves with hyperkyphosis

## ➤ Anterior approach

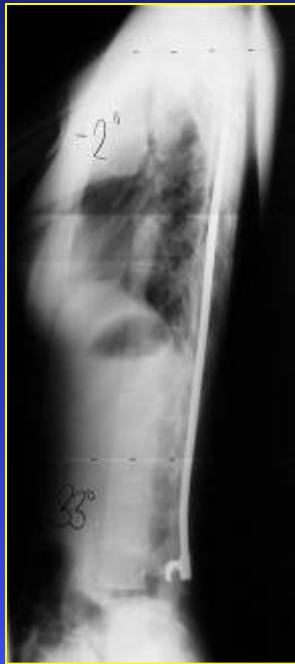
- Simple thoracic curves
- Thoracolumbar curves
- Flexible curves
- Curves with hypokyphosis

# **POSTERIOR APPROACH**



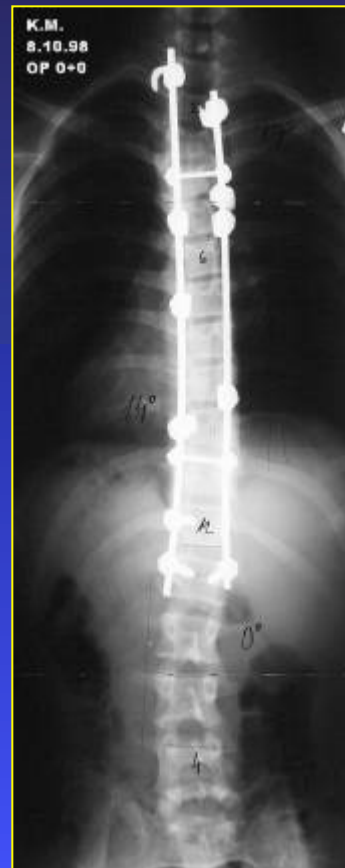
# Types of instrumentation

- **distractive**  
-Harrington



- **segmental**

- SSE Evolution
- USS
- Miami-Moss
- ISOLA

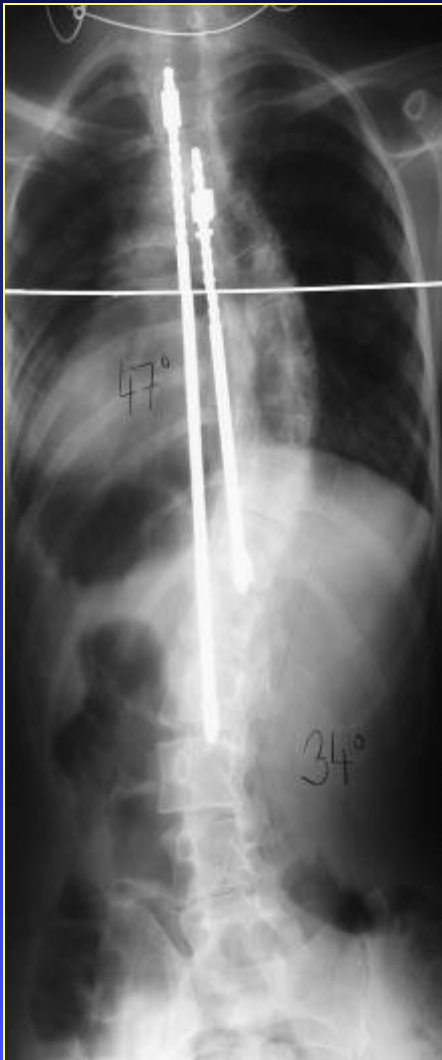


# HRI

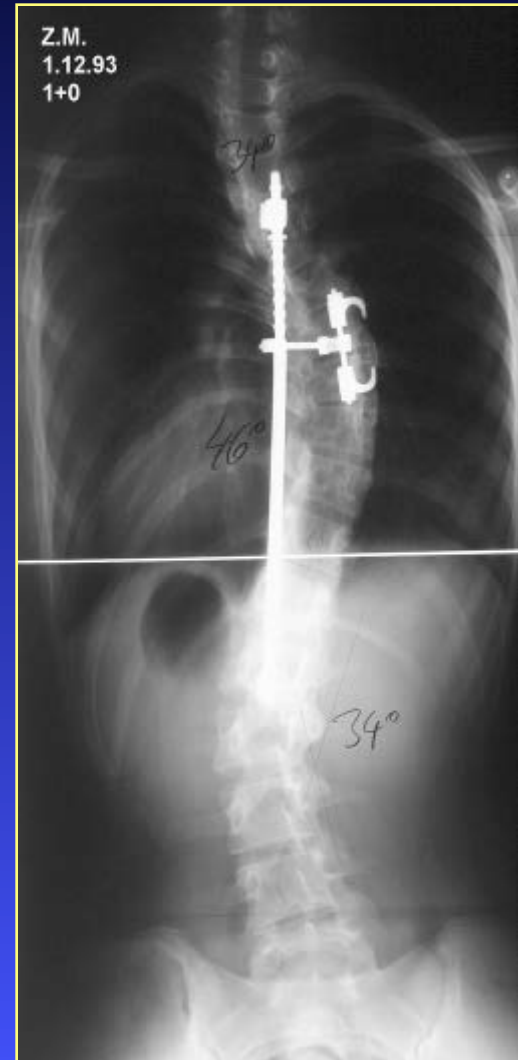
- distraction correction method
- ideal posterior fusion
- postoperative plaster necessity



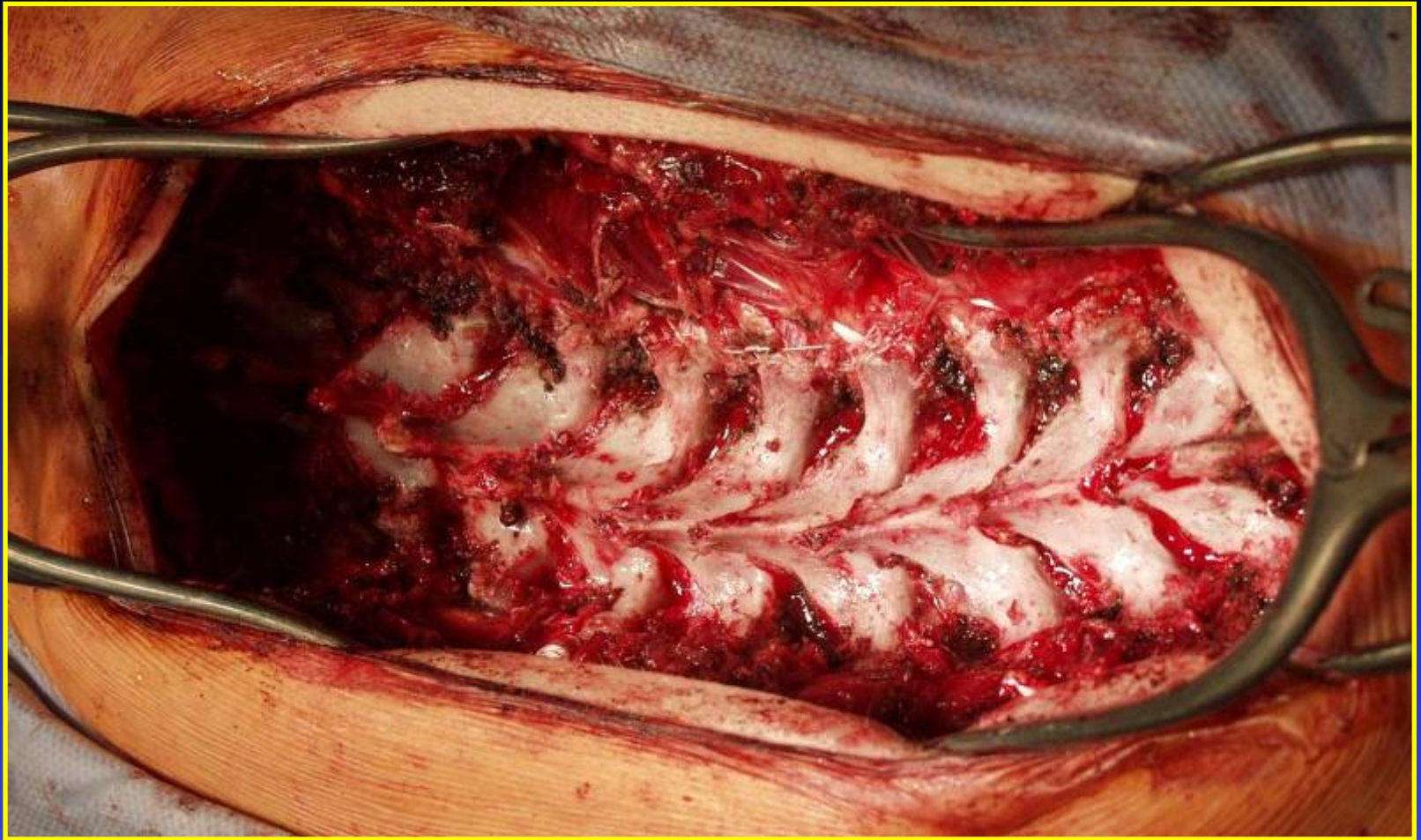
## HRI – 2 paralel rods



## HRI + DTT

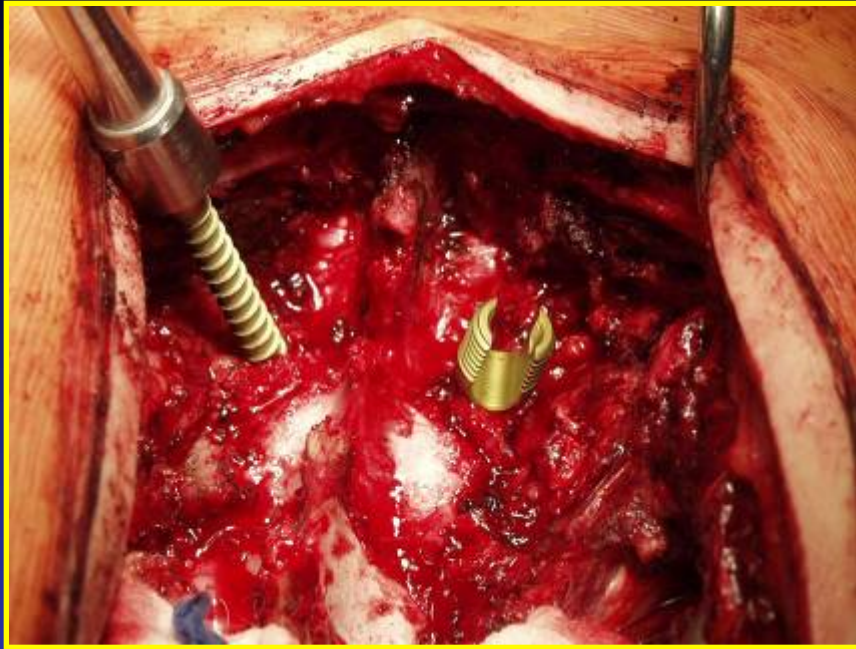


# **Segmental instrumentation**

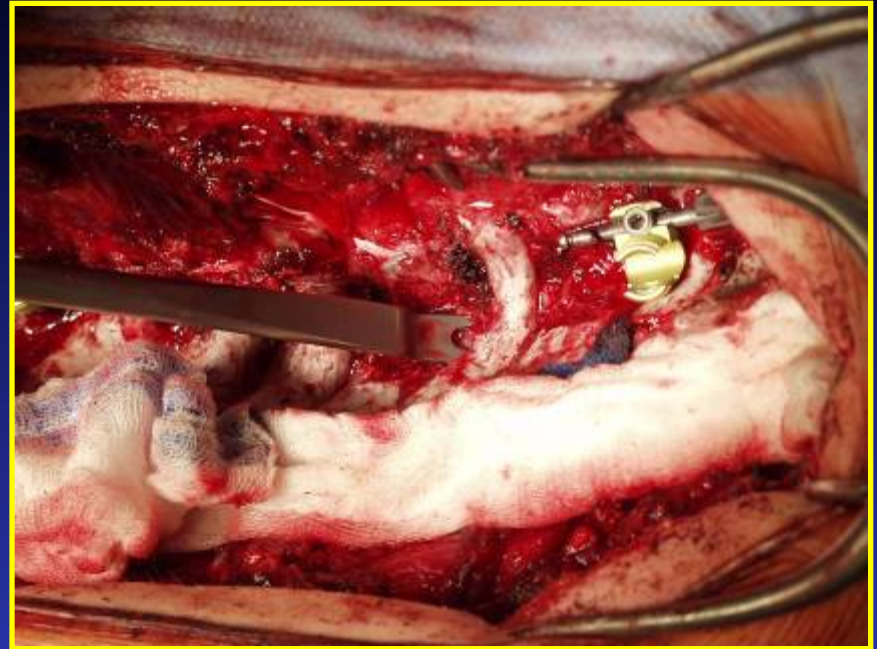


**skeletisation**

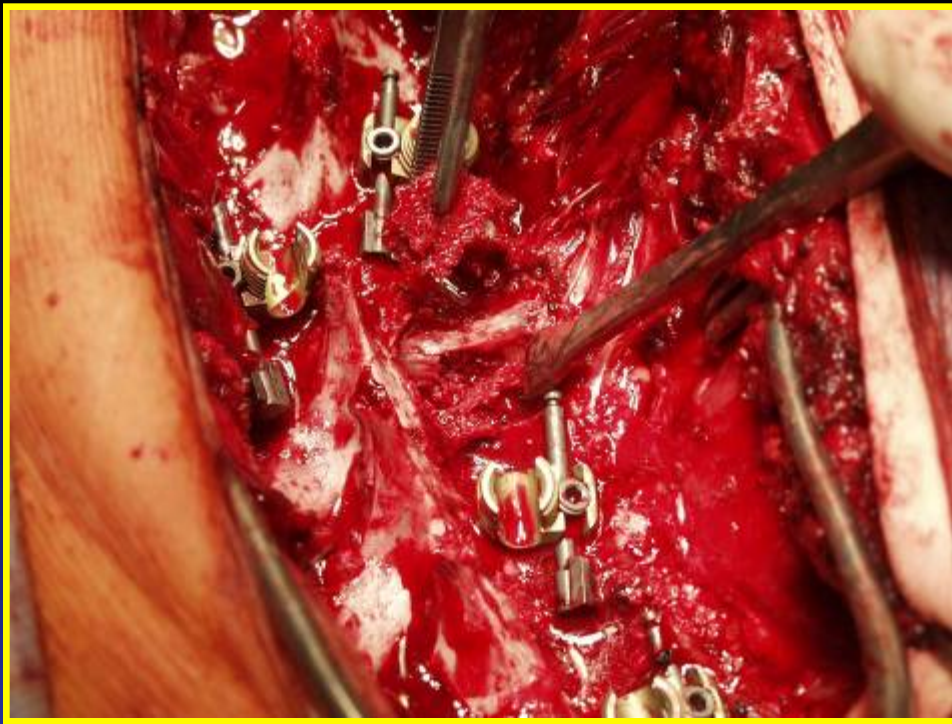




**transpedicular  
screws**



**pedicular  
hooks**



**Joint resection**

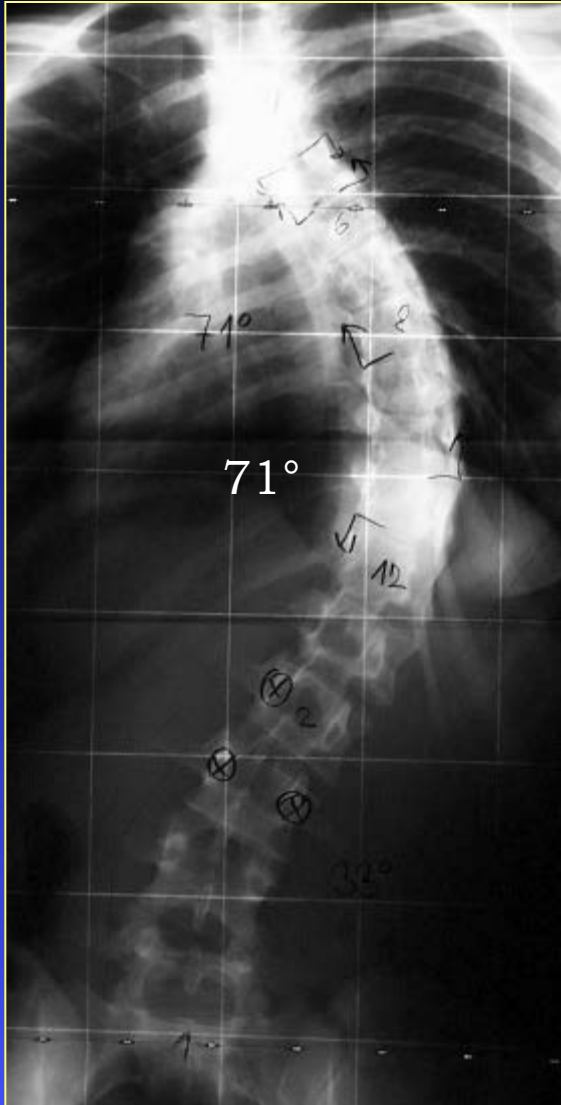
**Posterior elements  
decortication**

**Posterolateral fusion**

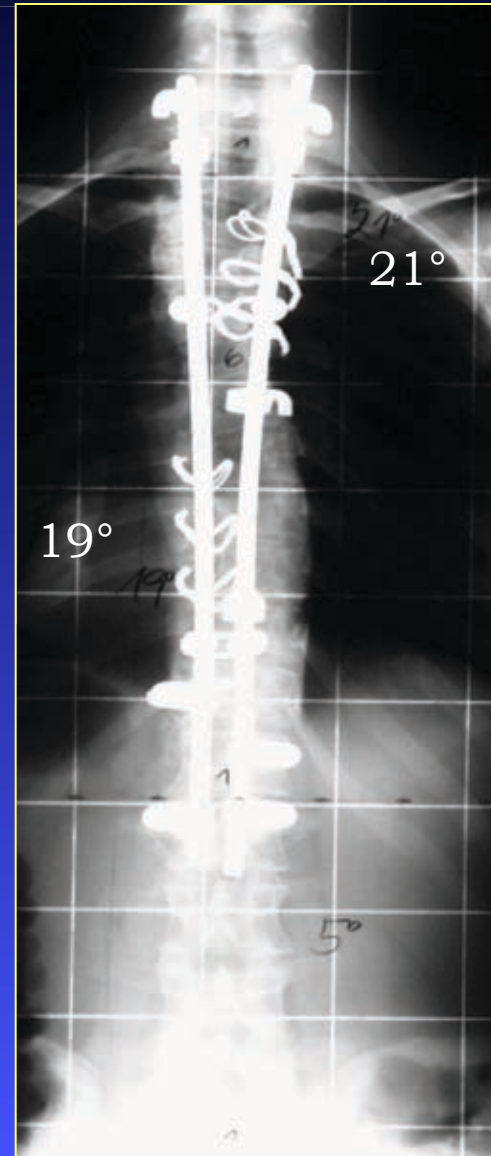
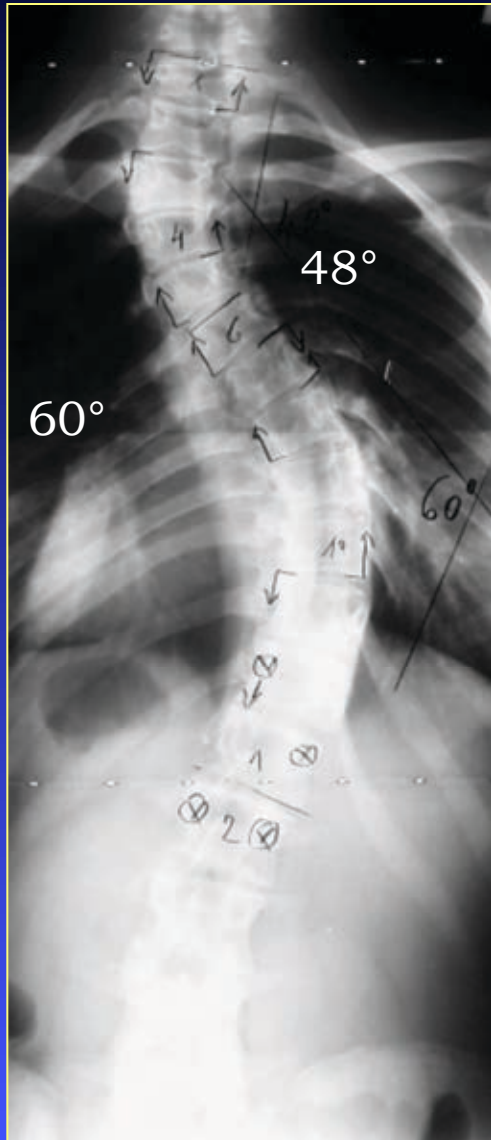




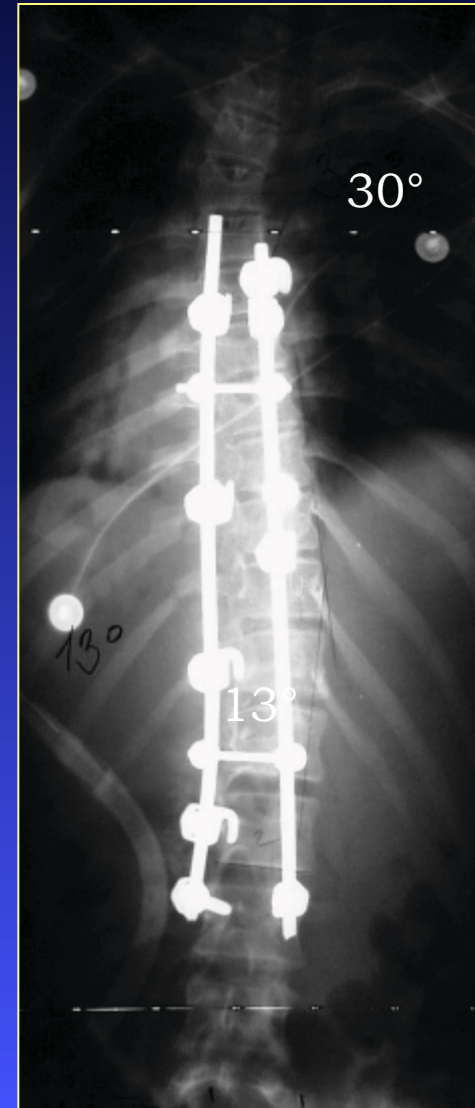
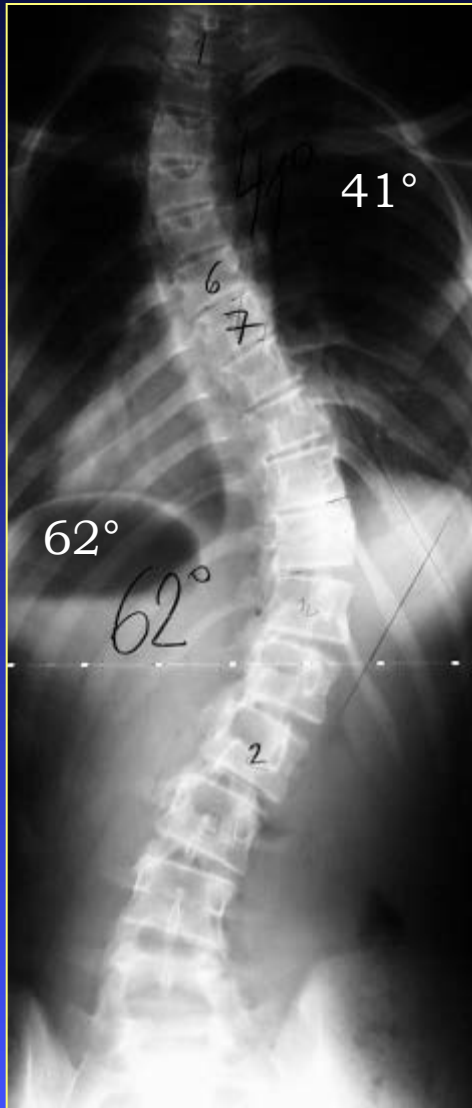
# Lenke 1 – lower thoracic



## Lenke 2 – double thoracic

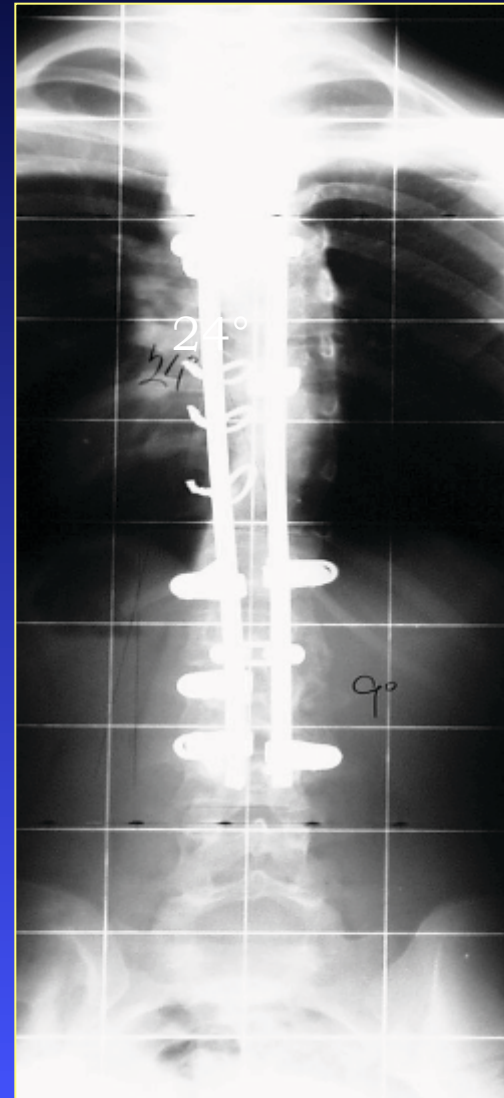
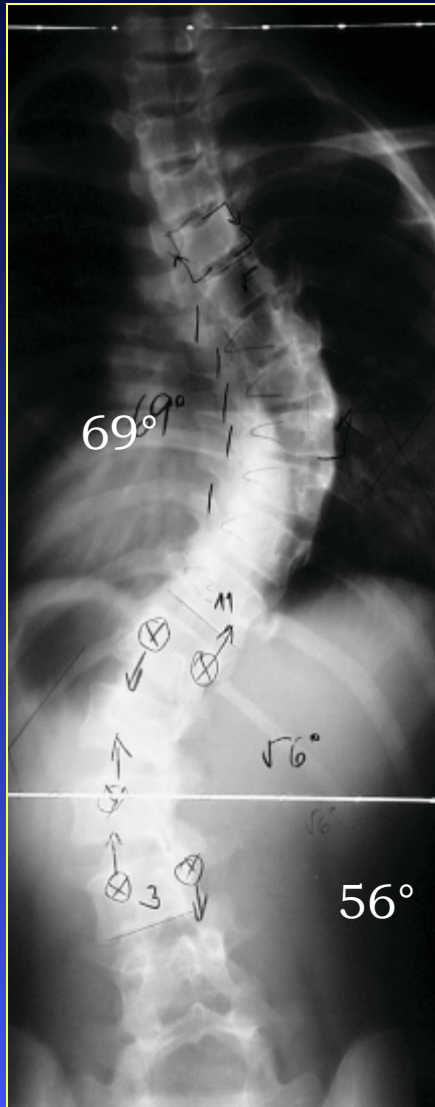


## Lenke 2 – double thoracic



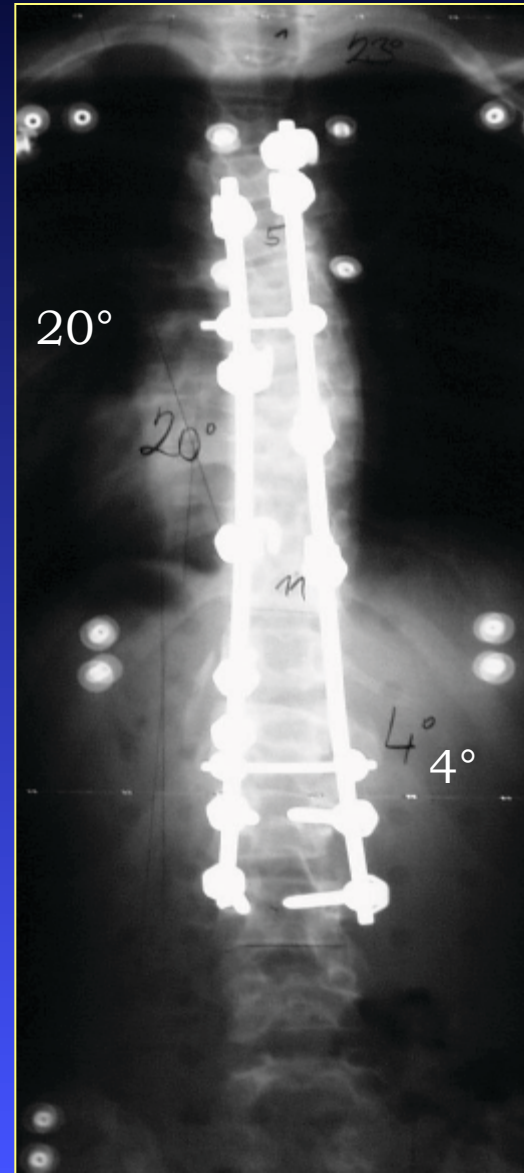
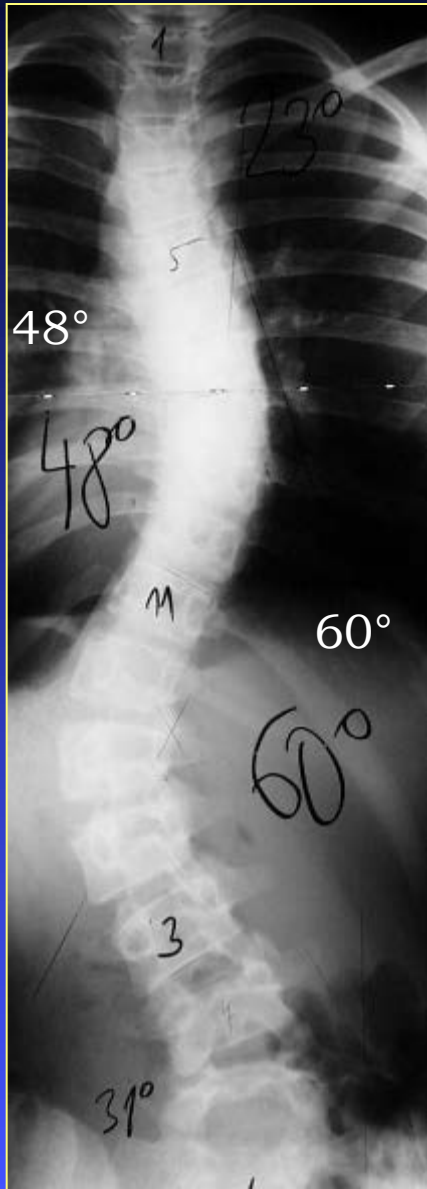


# Lenke 3 – double main



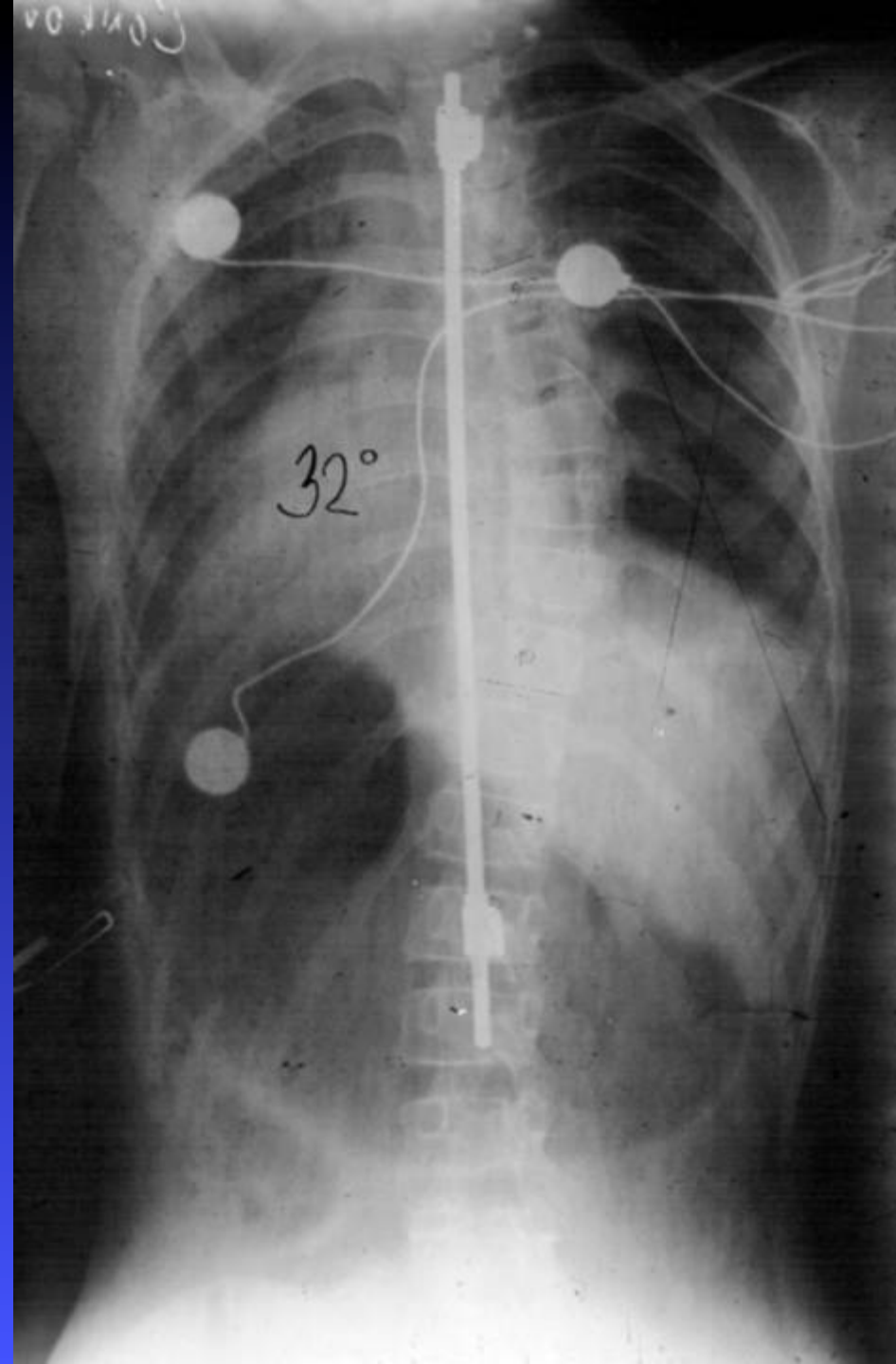
$9^\circ$

## Lenke 6 – TL/L-lower thoracic



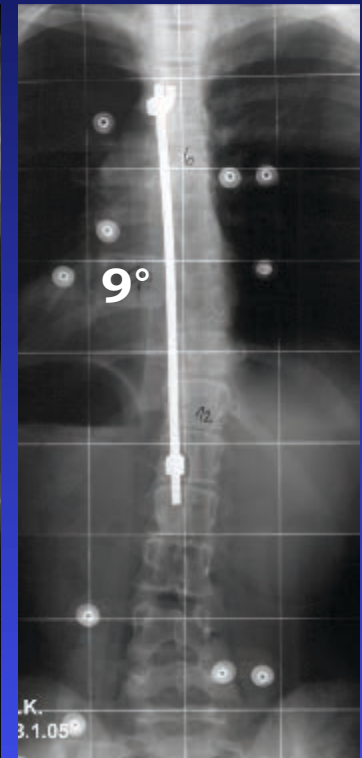
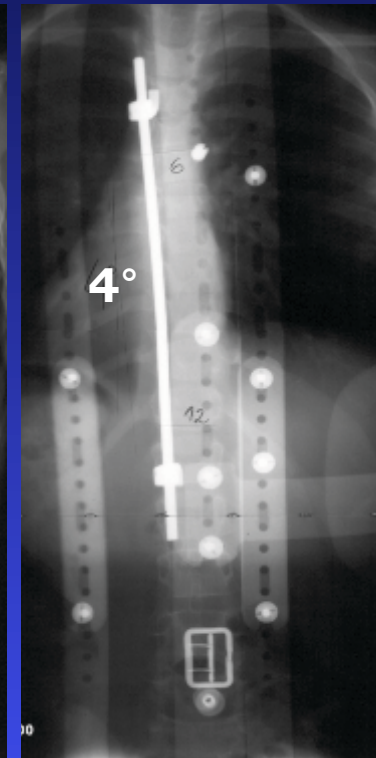
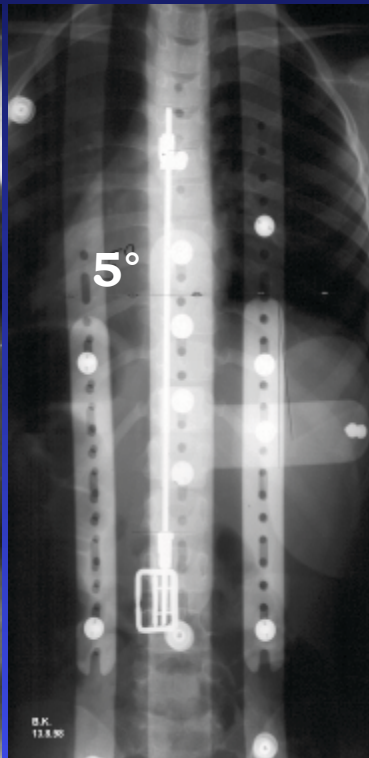
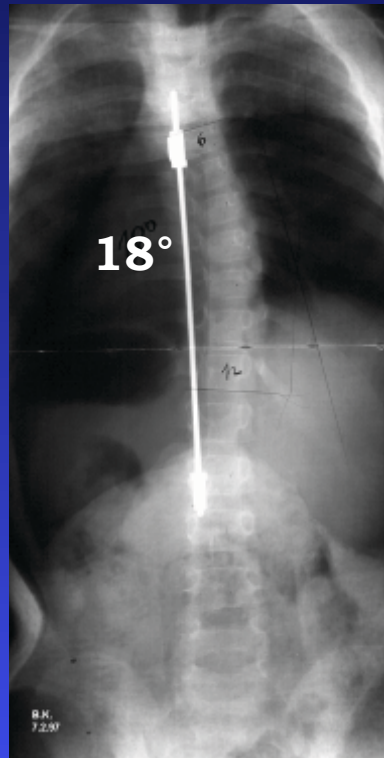
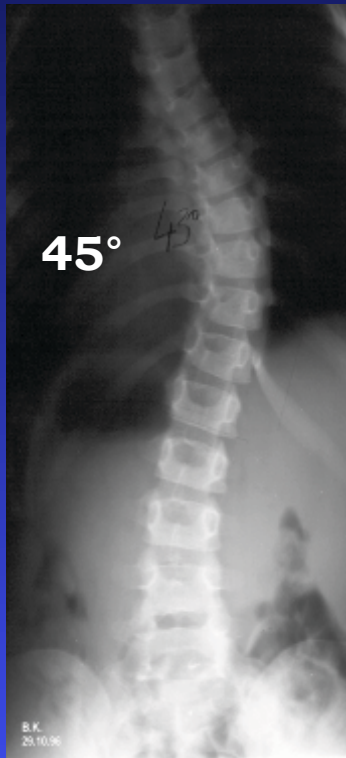
# Juvenile scoliosis

- Distraction method
- HRI by one rod
- Posterior approach
- Repetitive re-distractions up to growth end





# Repetitive distractions



1996

1997

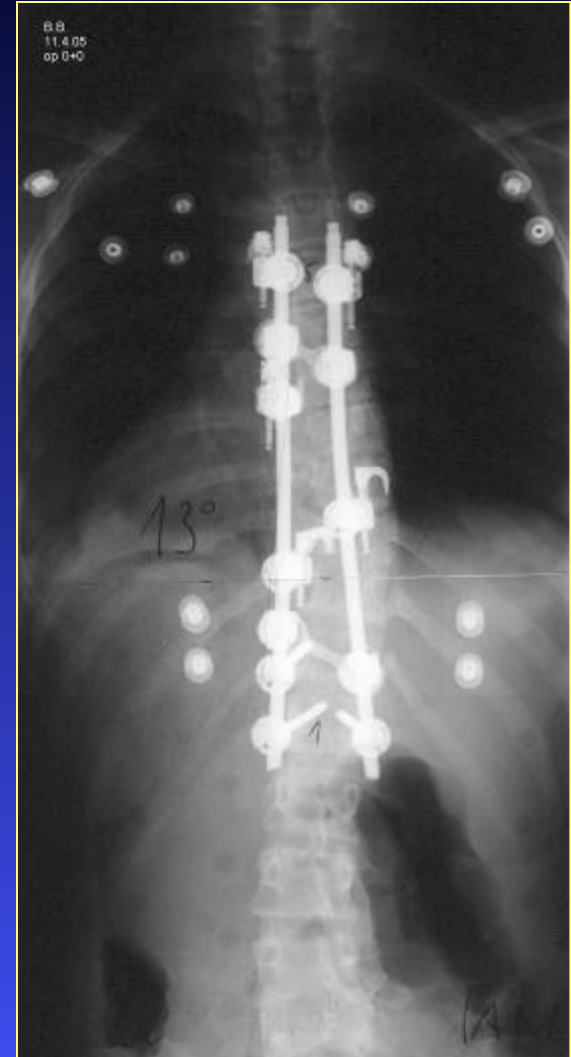
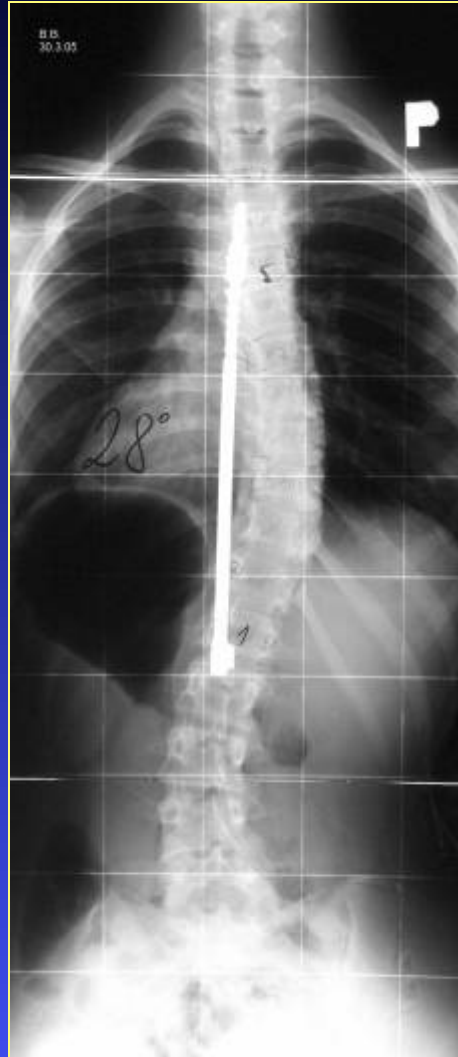
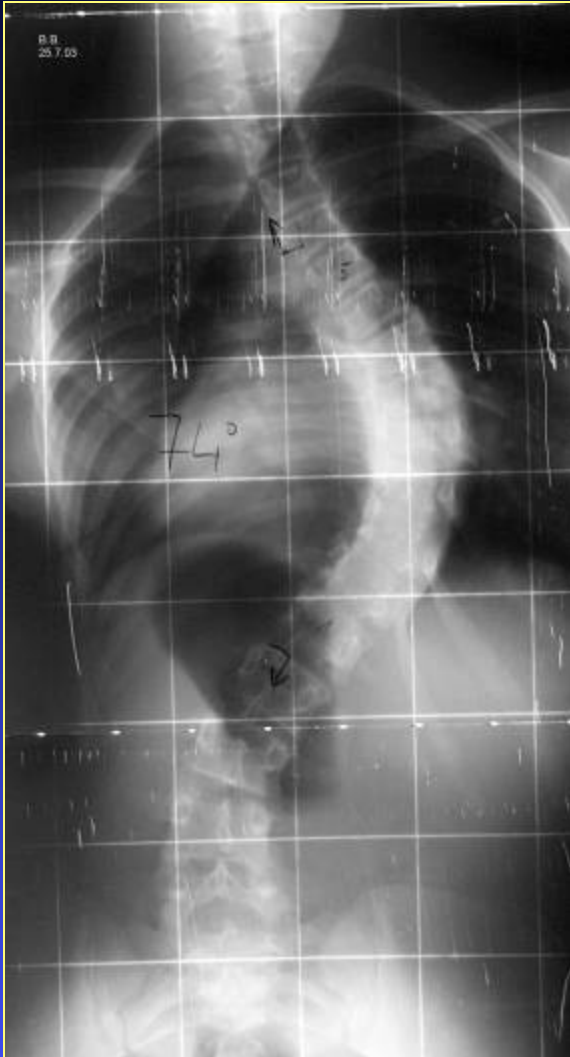
1998

2000

2005



# HRI – distraction + definitive surgery

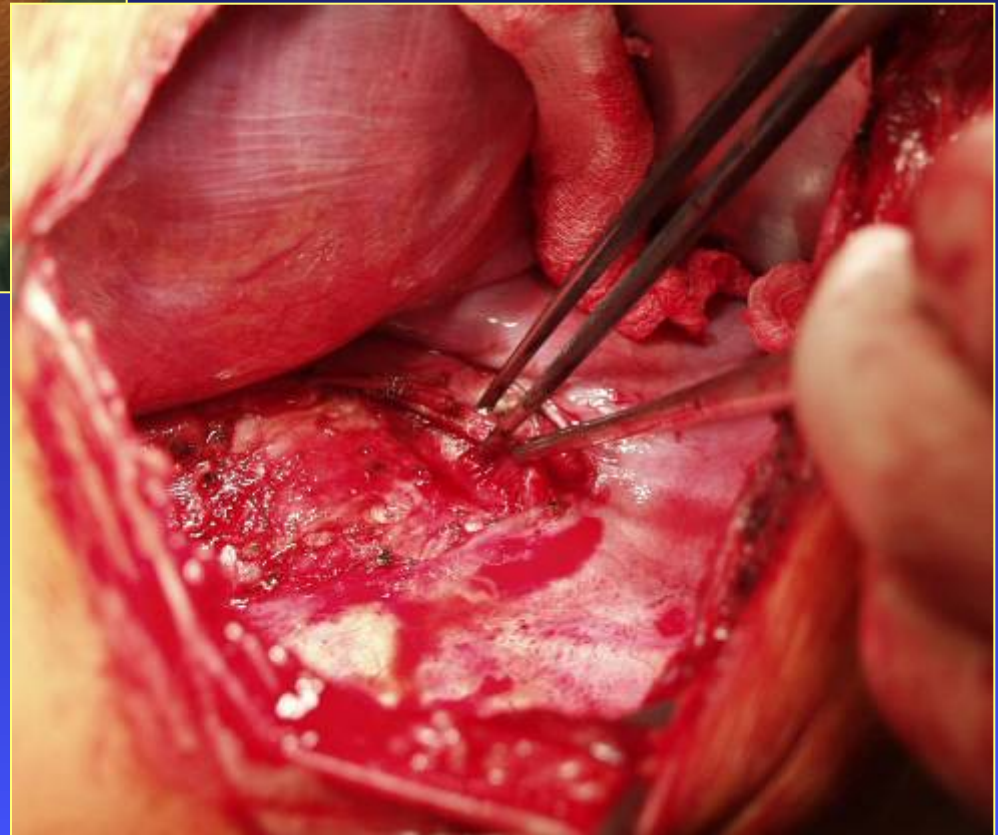


# **ANTERIOR APPROACH**

# **ADVANTAGES OF ANTERIOR INSTRUMENTATION**

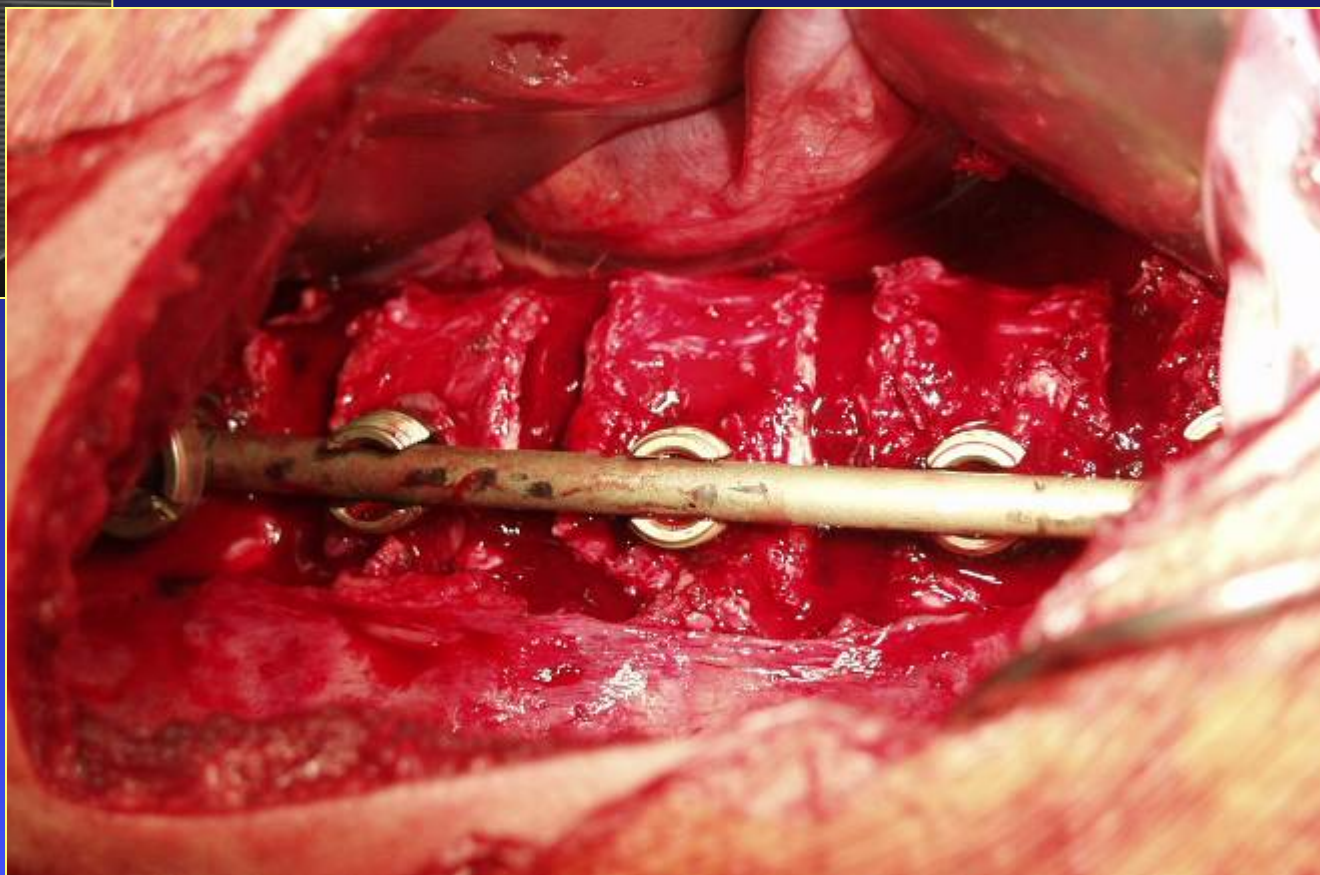
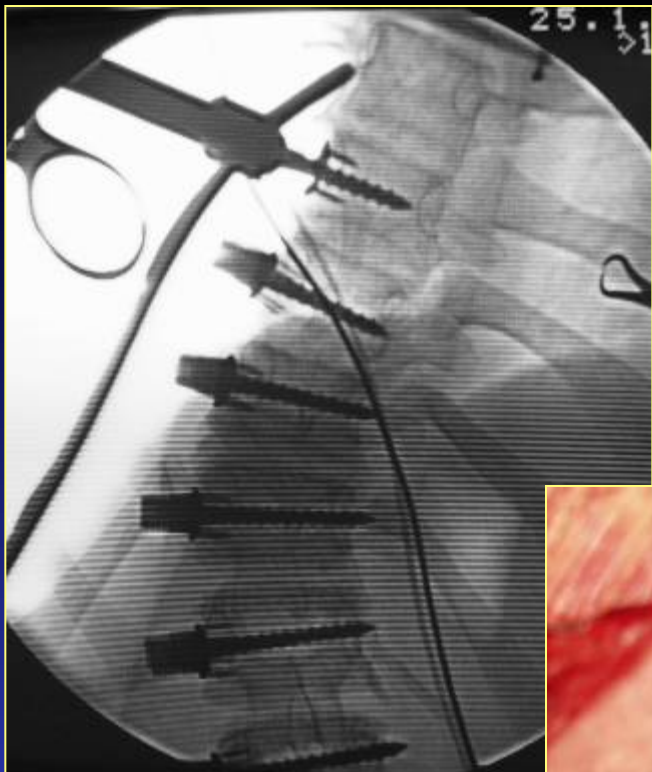
- **Significant derotation**
- **Shorter fusion**
- **Lordotisation**
- **Kyphotisation**
- **Minor blood loss**
- **Minor surgical complications**

# TTRP approach



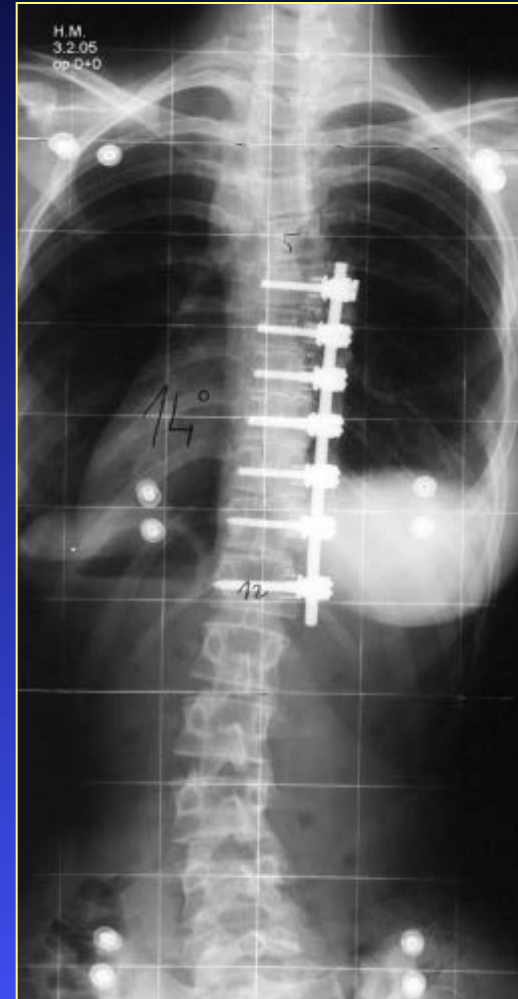


# Implantation of screws and rod



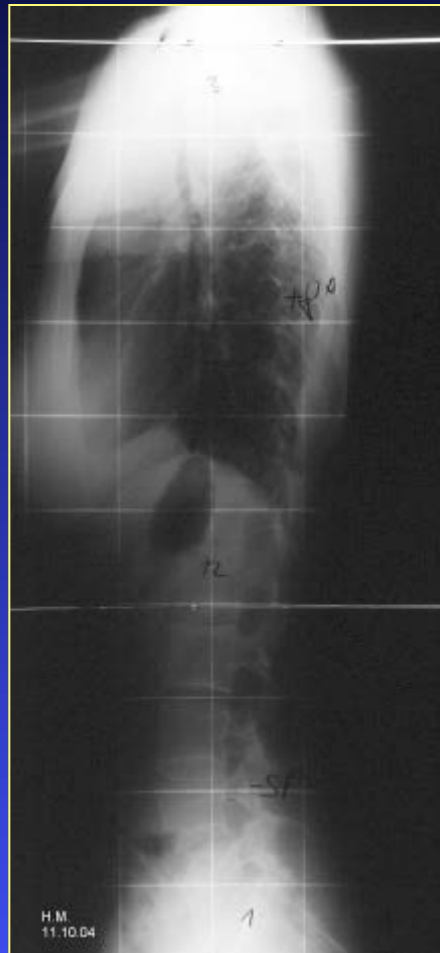


# Lenke 1

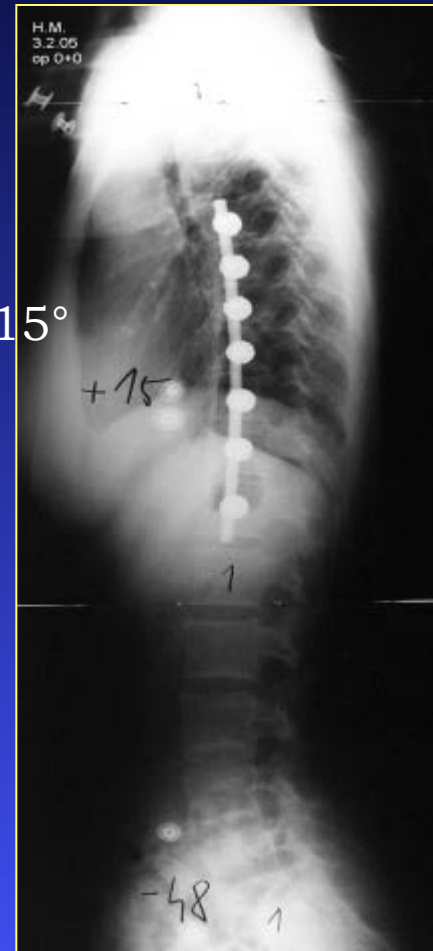


# Lenke 1

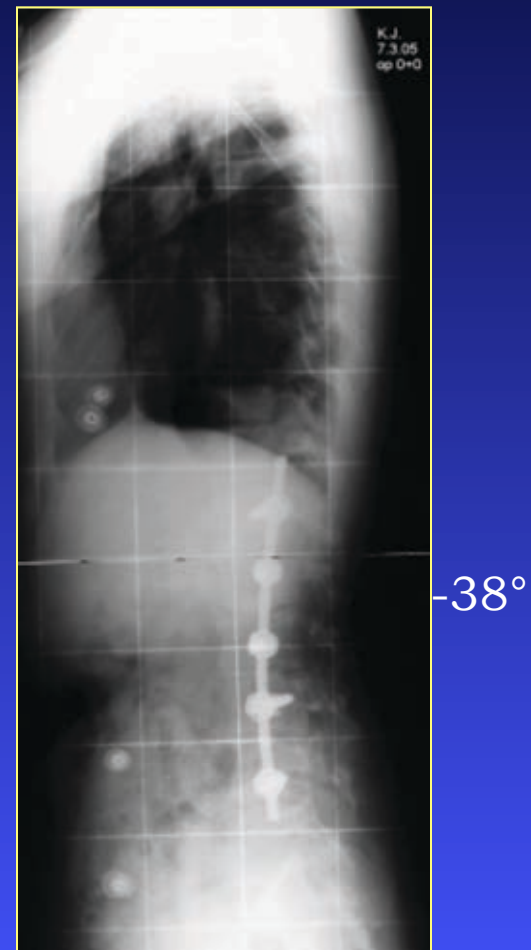
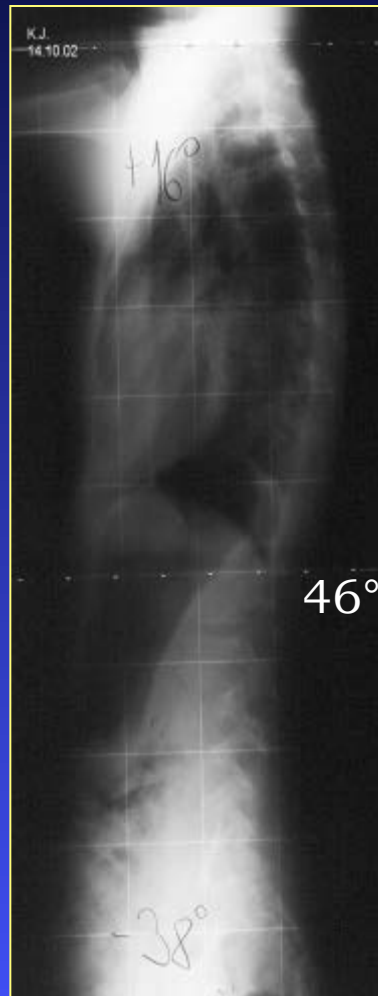
14°



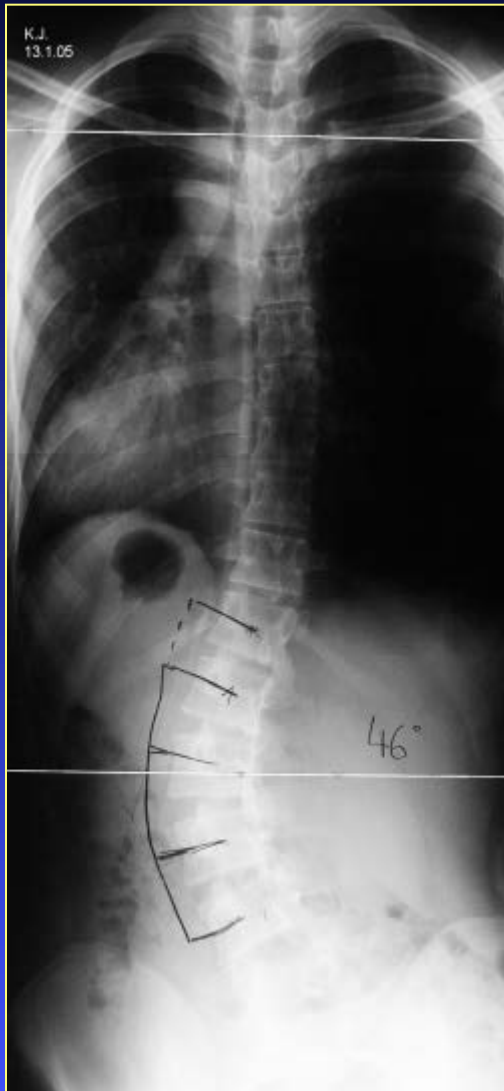
15°



# Lenke 5



# Lenke 5



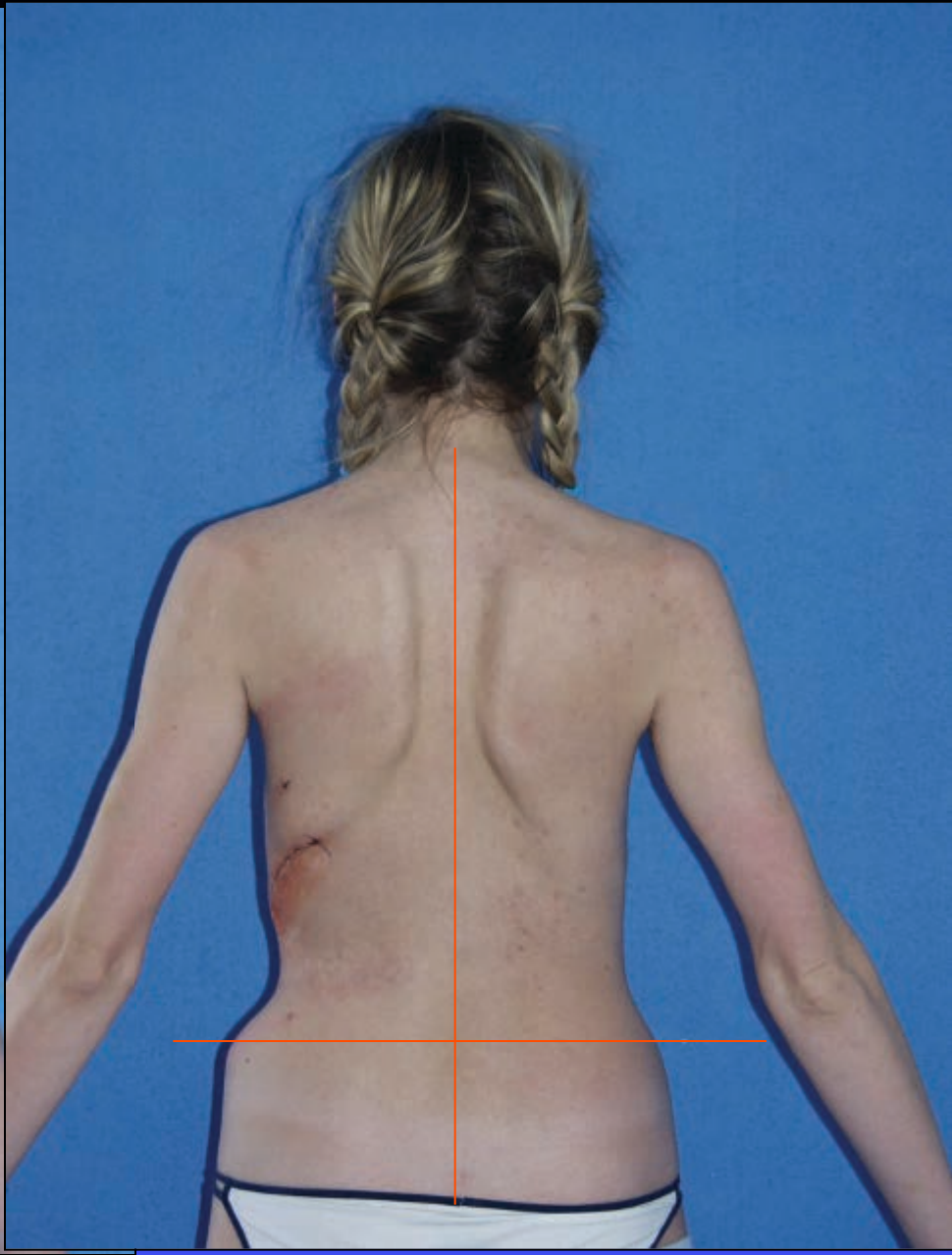
# Lenke 5





# Lenke 5

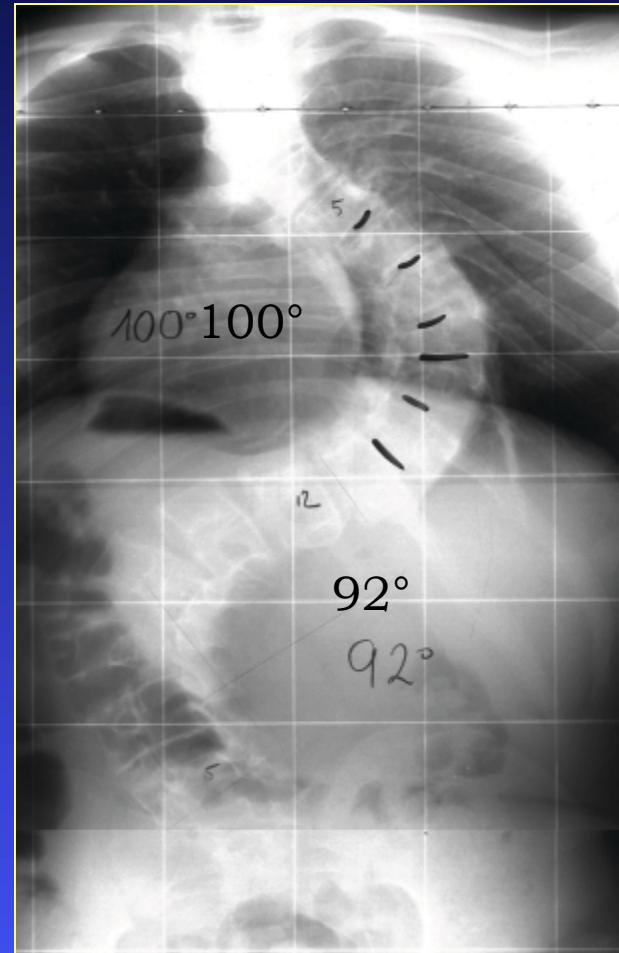




# **Combined approach in rigid curves**

1. Anterior release from minithoracotomy
2. Facultative traction
3. Posterior stabilisation and fusion

# Rigid curve Lenke 3



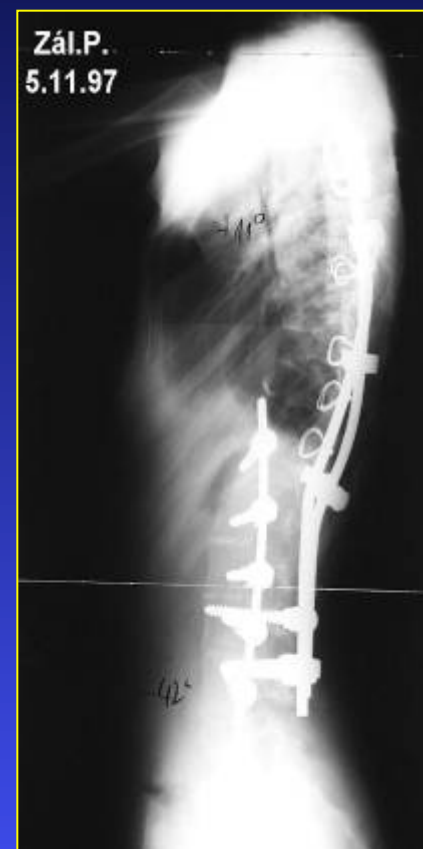
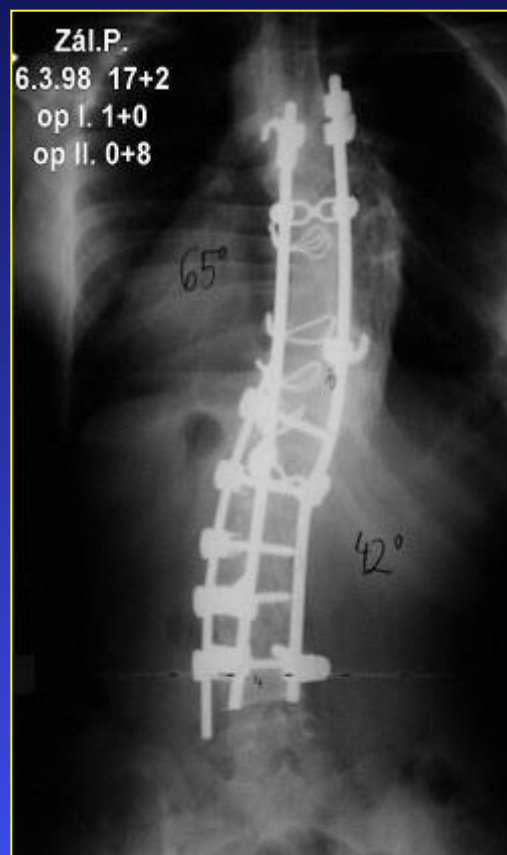
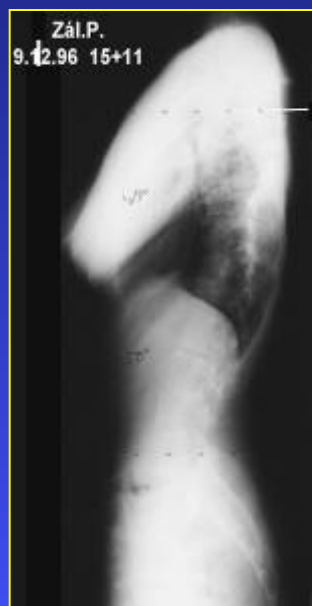


# Halo traction

*Physiotherapy and  
wheelchair*







# 6 months postoperatively



# **Congenital scoliosis**

# Etiologic classification of congenital scoliosis

---

## 1. defects of formation

- wedge vertebra

- hemivertebra

## 2. defects of segmentation

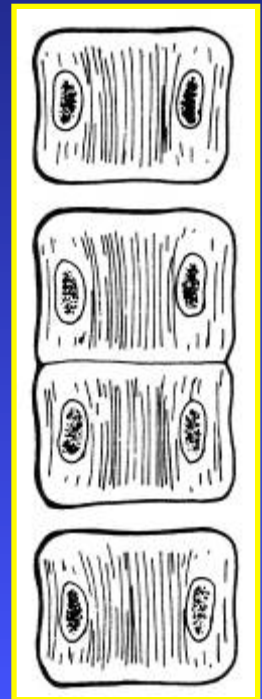
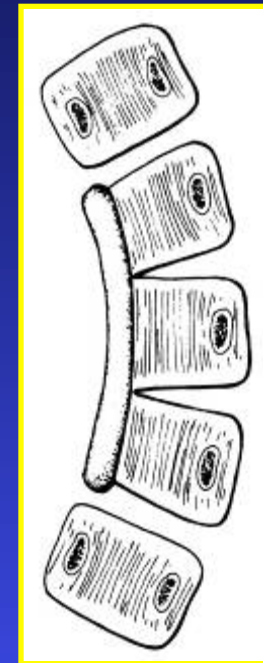
- unilateral failure (unsegmented bar)

- bilateral failure

## 3. combined defects

# Defects of segmentation

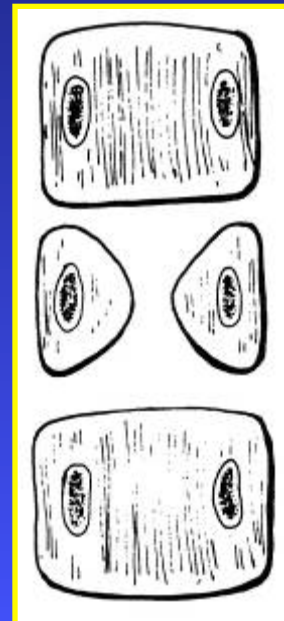
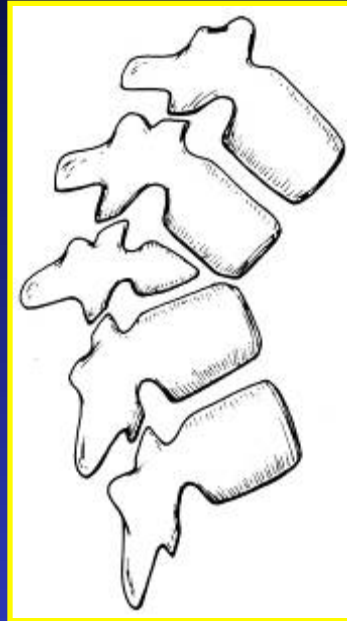
- anterior → kyphosis
- posterior → lordosis
- lateral → scoliosis
- posterolateral → lordoscoliosis
- anterolateral → kyphoscoliosis
- complete



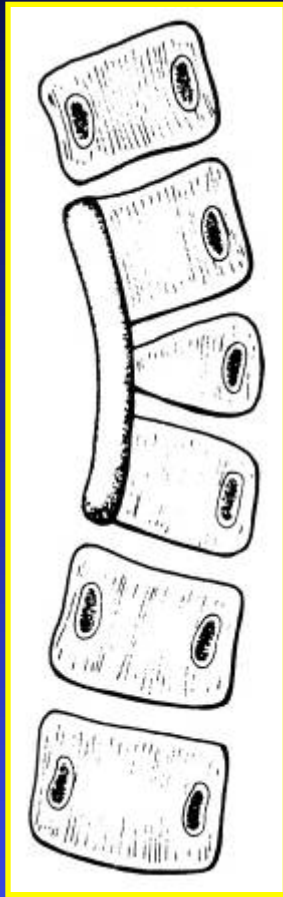


# Defects of formation

- anterior → kyphosis
- posterior → lordosis
- lateral → scoliosis
- anterolateral → kyphoscoliosis
- anterior central defect



# Combined failure



Hemivertebra +  
unilateral bar

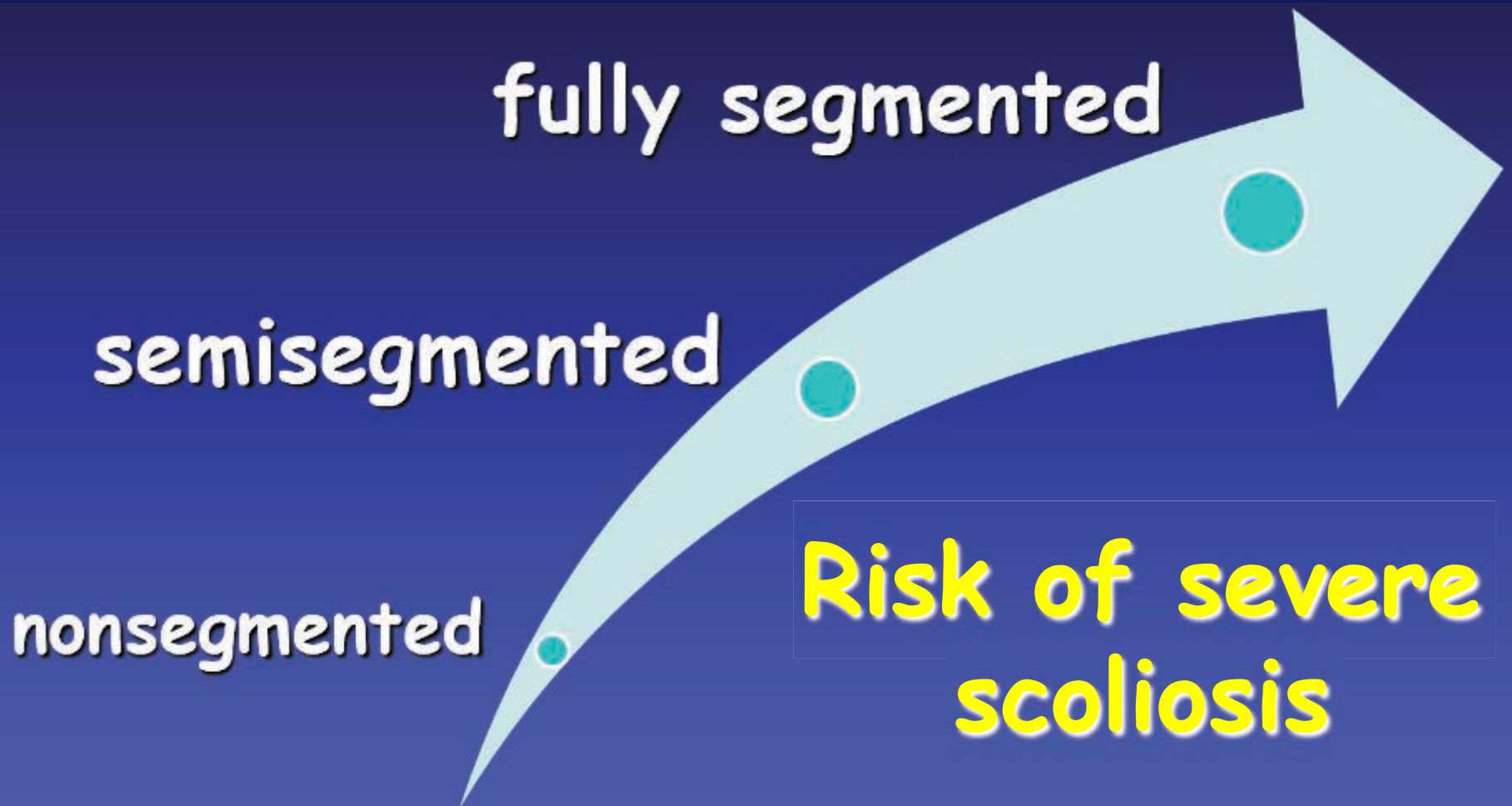


Nonsegmented  
hemivertebra

# Hemivertebra

=the most common failure

---



# Evaluation of congenital scoliosis

- anamnesis (personal and family)
- physical evaluation
- neurological evaluation
- spinal imaging methods (X-ray, CT, MRI)
- echocardiogram
- renal ultrasound

## X-ray

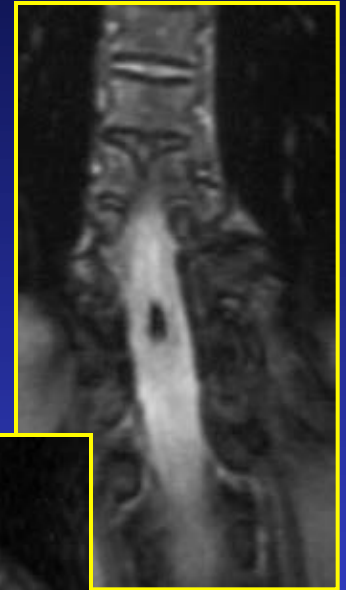


## CT with 3D reconstr.





# Magnetic resonance imaging (MRI)



# Treatment possibilities

- **conservative treatment**

- observation
- casting and bracing

- **surgical treatment**

- simple bony fusion
  - hemiepiphyseodesis
  - complete posterior
  - combined a/p
- posterior instrumentation
- hemivertebrectomy
  - combined a/p surgery
  - posterior only surgery

# Observation

## Indication:

- small curves  $<20^\circ$
- curves at low risk of progression
  - nonsegmented hemivertebra
  - bilateral defects of segmentation
- curves  $<40^\circ$  at the end of an adolescent age

- ## Follow up:
- clinical examination every half year
  - follow-up X-ray once per year up to growth completion
  - FU X-ray every five years in adults

Progression over  $25^\circ$   bracing or surgery

# Bracing

---

## Indication:

- curves 20°-40°
- curves at low risk of progression
  - semisegmented hemivertebra
- controlling of secondary curves in growth period

Progression over 40°  surgery

# 2 main surgical techniques used today



## Simple bony fusion

Arrest of curve progression  
(without direct correction)

- in small curves
- in early detection

## Hemivertebrectomy with instrumentation

Correction of scoliotic curve

- in greater curves
- in supposed curve progression



# Simple bony fusion

---

## Indication:

- hemivertebra without kyphosis
- short curvature < 5 vertebrae
- curvature < 50°

## Technique:

- bilateral bone desis
- unilateral bone desis - hemiepiphyseodesis (convex side)
- posterior, anterior or combined

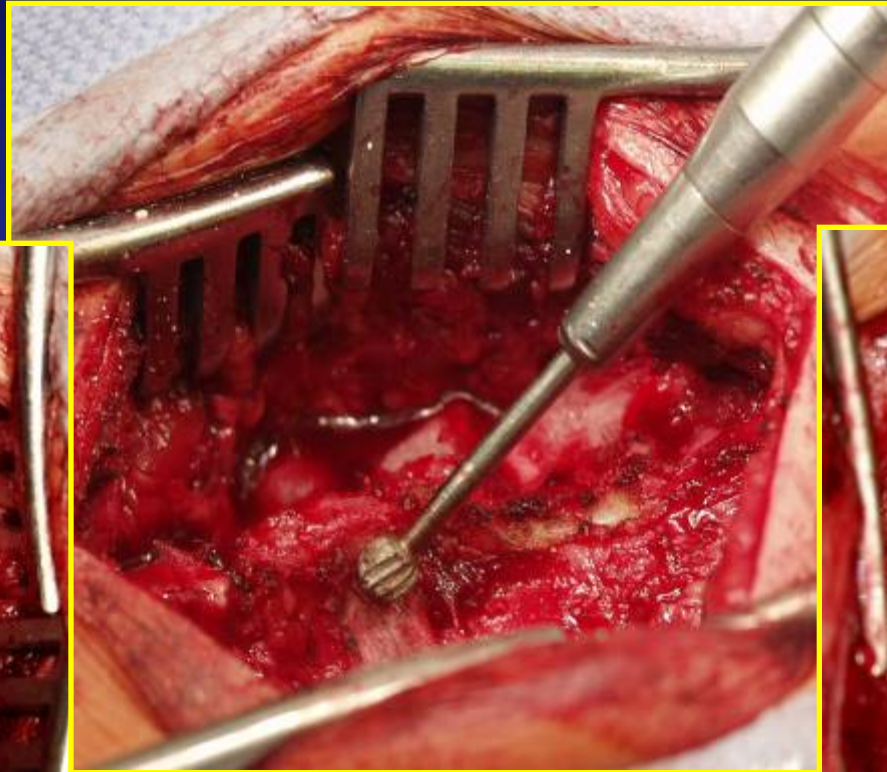
Unilateral fusion



growth arrest on convex side

allow growth on concave side

# Simple bony fusion



funkcn1

# Postoperative care

Plaster cast:  
first 6-12 months

Bracing:  
till the growth ending

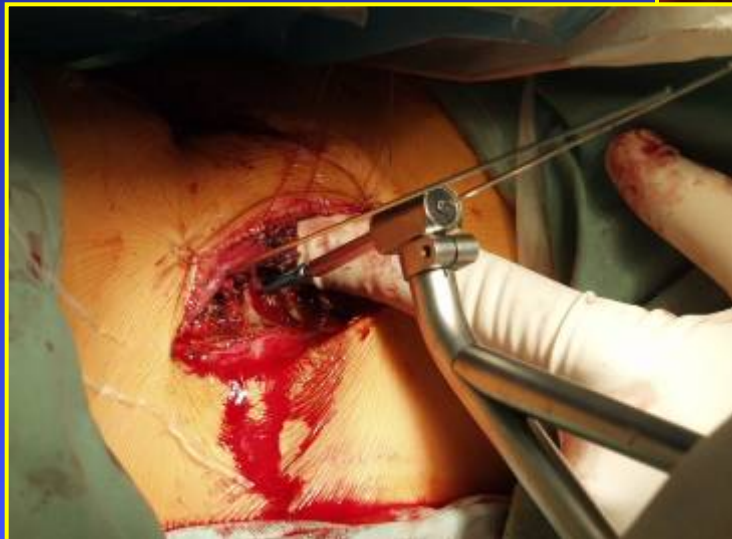
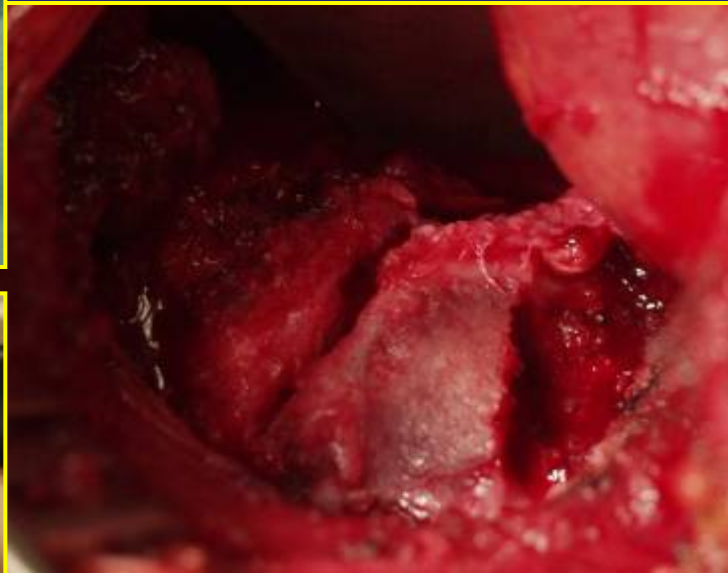


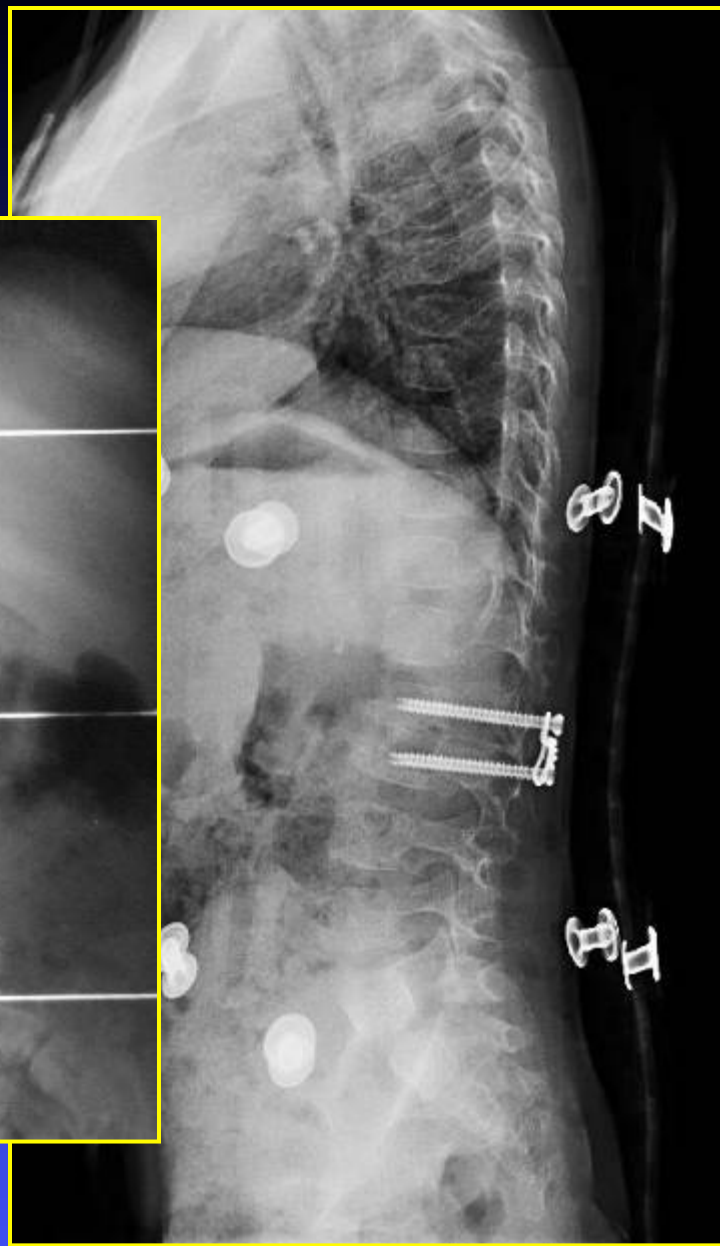
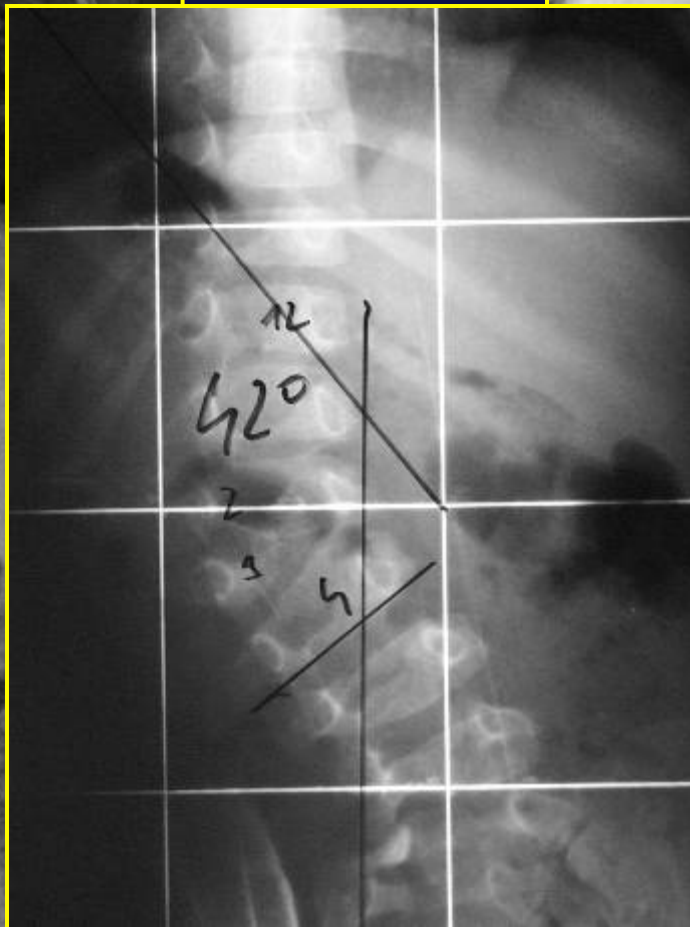
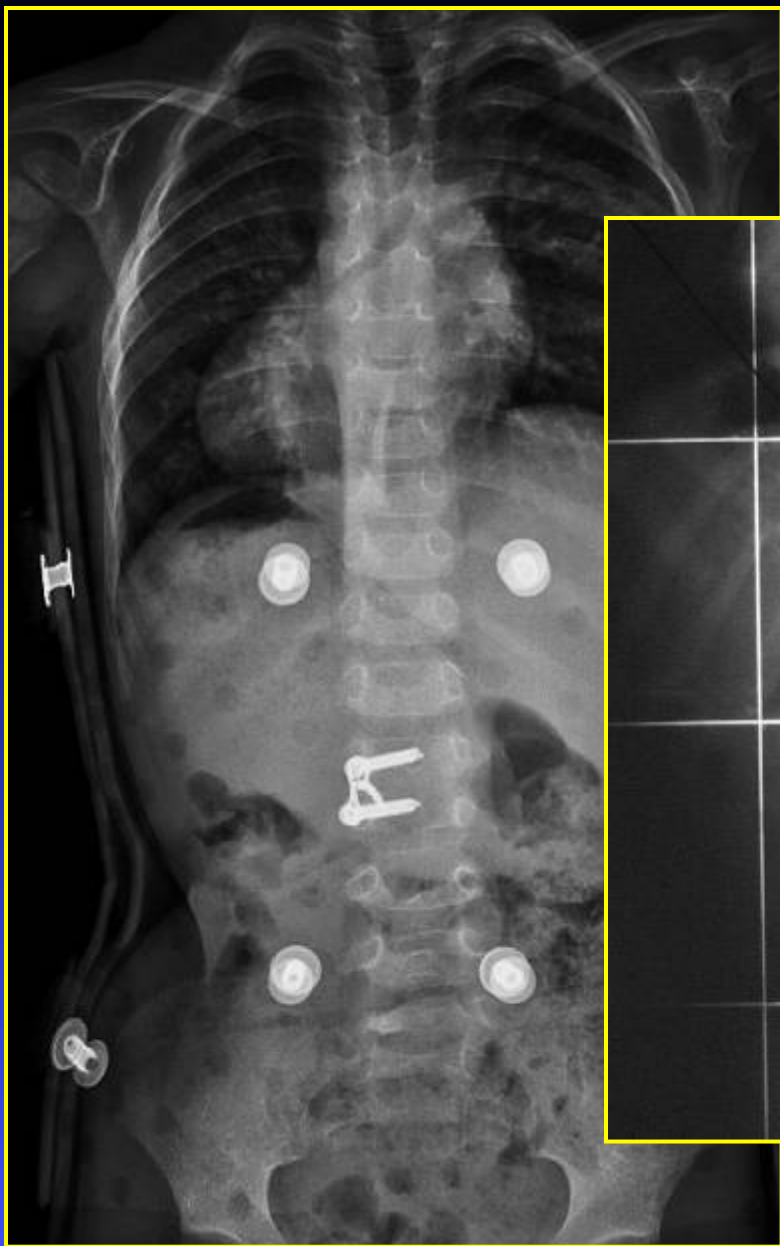
- clinical examination every half year
- follow-up X-ray once per year  
up to growth completion



# Hemivertebrectomy

using combined a/p surgical approach with instrumentation stabilization

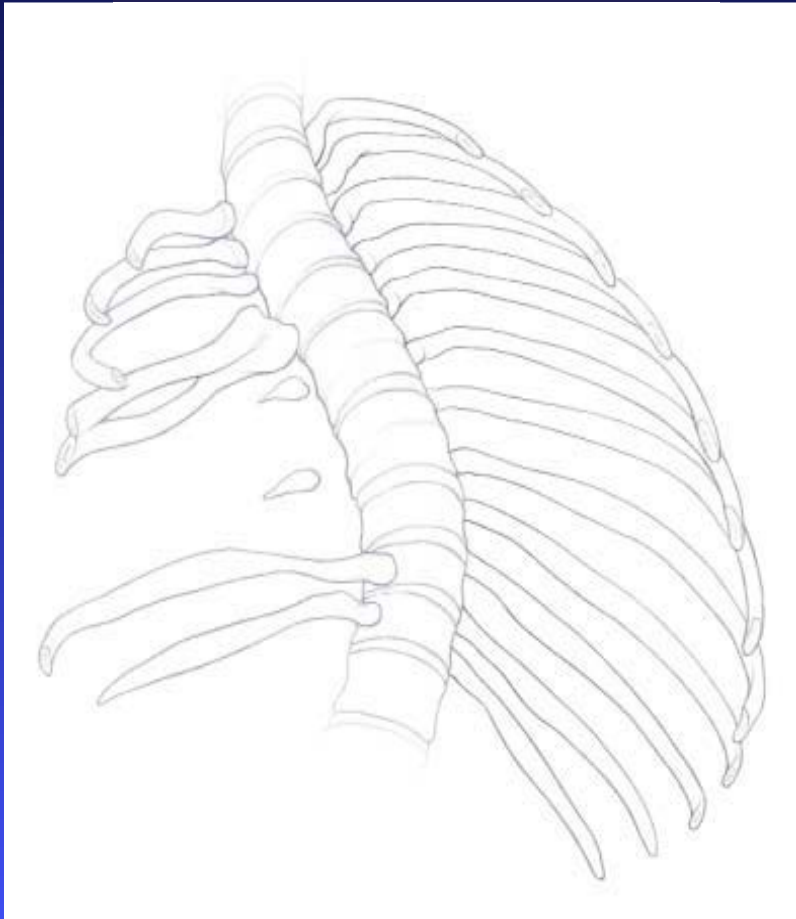




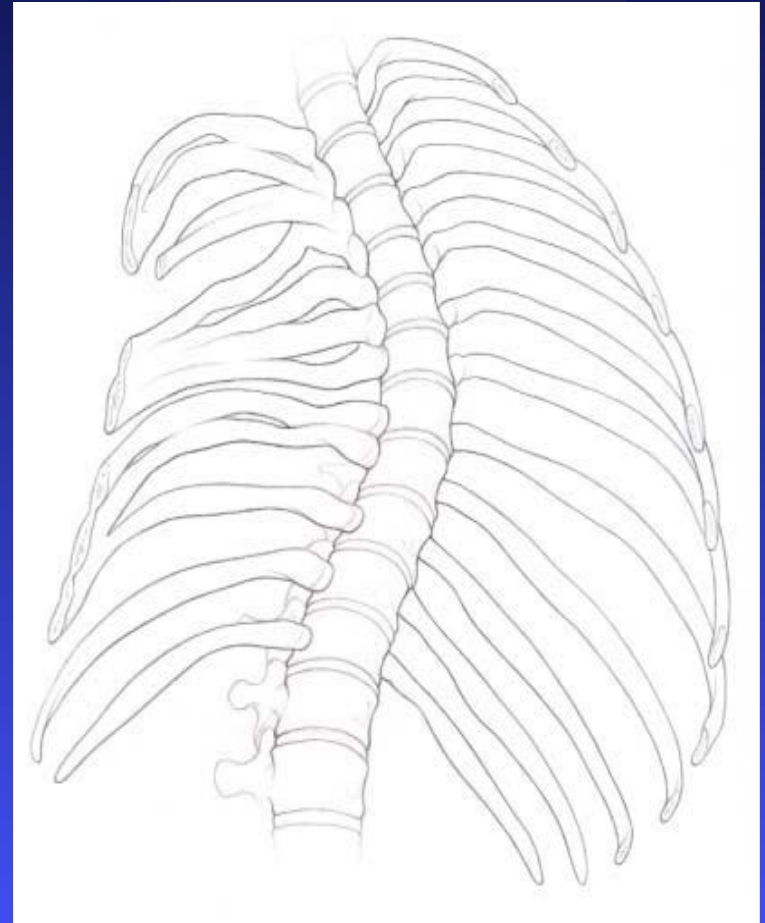


# Associated rib cage deformities

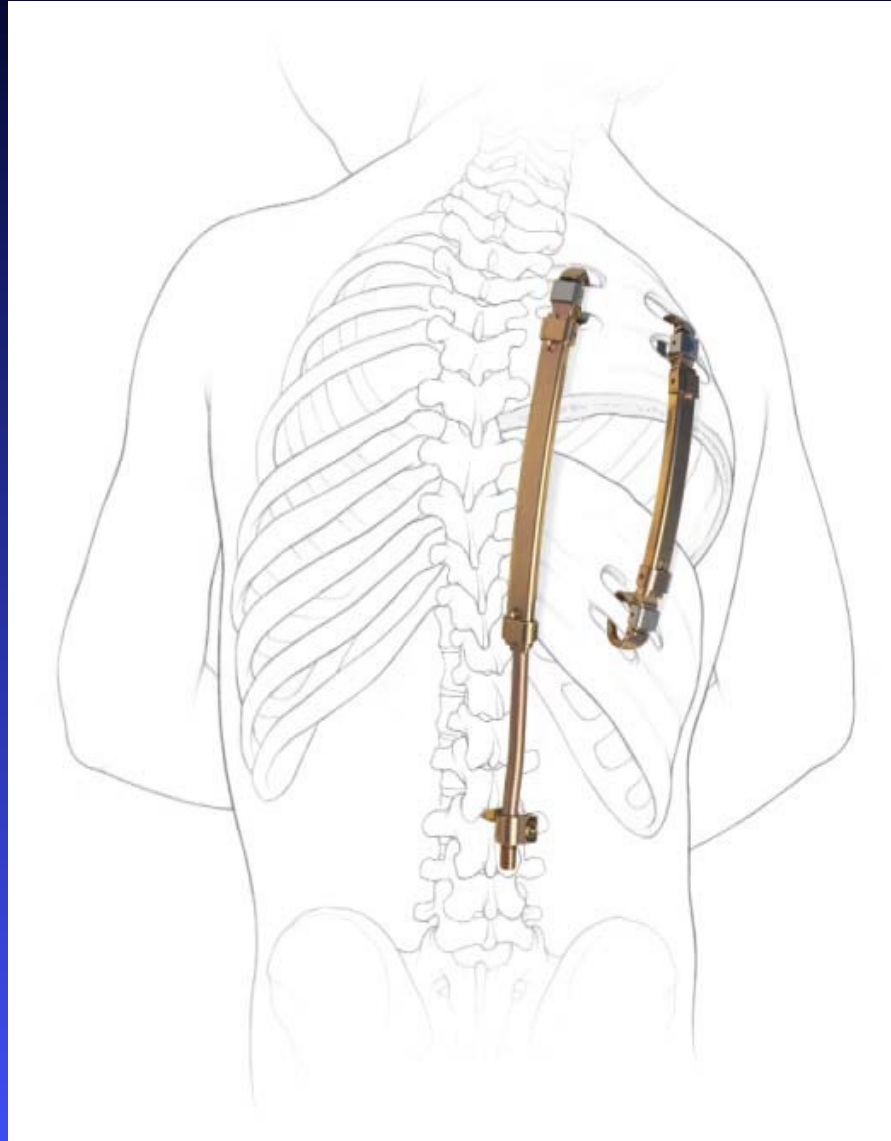
## Absented ribs



## Fused ribs



# Vertical Expandable Prosthetic Titanium Rib (VEPTR)



# The main factors of quality treatment results:

- early detection
- good timing
- choosing of adequate surgical treatment type

# **Neuromuscular scoliosis**



# Neuromuscular scoliosis

## the 3rd main scoliotic deformity

---

- extensive progression (even after mature)
- weighty deformities
- associated with pelvic and hip deformities
- high rate of associated dysfunctions
  - cardiopulmonal
  - urinary
  - pressure sores
  - osteopenia



# Neuromuscular scoliosis

**Sitting instability**



**Standing instability**



# Etiologic classification of the spinal neuromuscular deformities

---

## 1. neuropathic

- affection of the upper motoric neuron

- cerebral palsy

- spinocerebelar degeneration (Friedreich, Charcot-Marie-Tooth, Roussy-Lévy)

- syringomyelia

- spinal tumours

- spinal trauma

- affection of the lower motor neuron

- poliomyelitis

- spinal muscular atrophy (Werdnig-Hoffmann)

- paralytic myelomeningocele

## 2. myopathic

- artrogryphosis

- muscular dystrophy (Duchenne)

# Neuromuscular scoliosis

- long unilateral curve
- kyphoscoliosis
- lumbar hyperlordosis
- pelvic and hip deformities



- |                    |   |                      |
|--------------------|---|----------------------|
| 1. Spastic forms   | → | rigid kyphoscoliosis |
| 2. Hypotonic forms | → | paralytic curves     |

# Pelvic deformities

## 1. structural

- in spinal deformities

## 2. functional

- in muscle imbalances





# Pelvic deformities

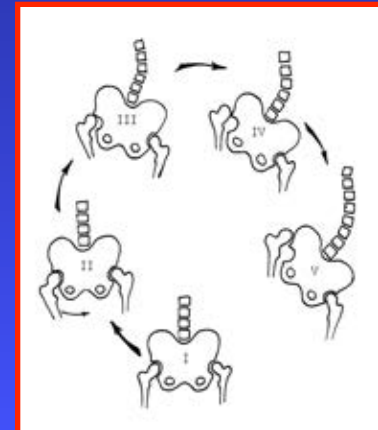
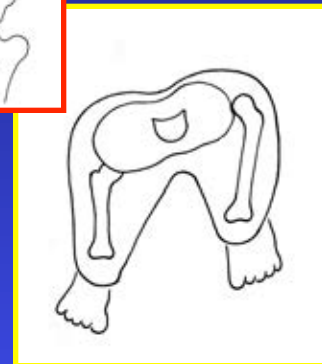
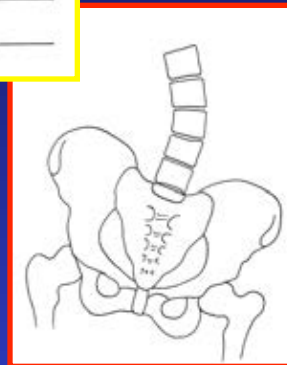
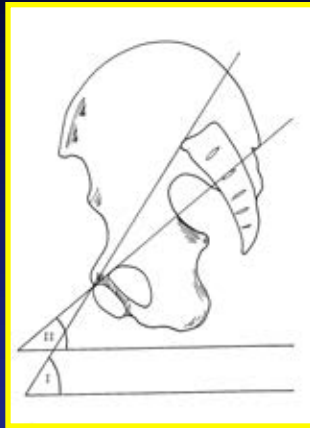
•Posterior tilt

•Anterior tilt

•Pelvic obliquity

•Pelvic rotation

•Windswept hip phenomenon

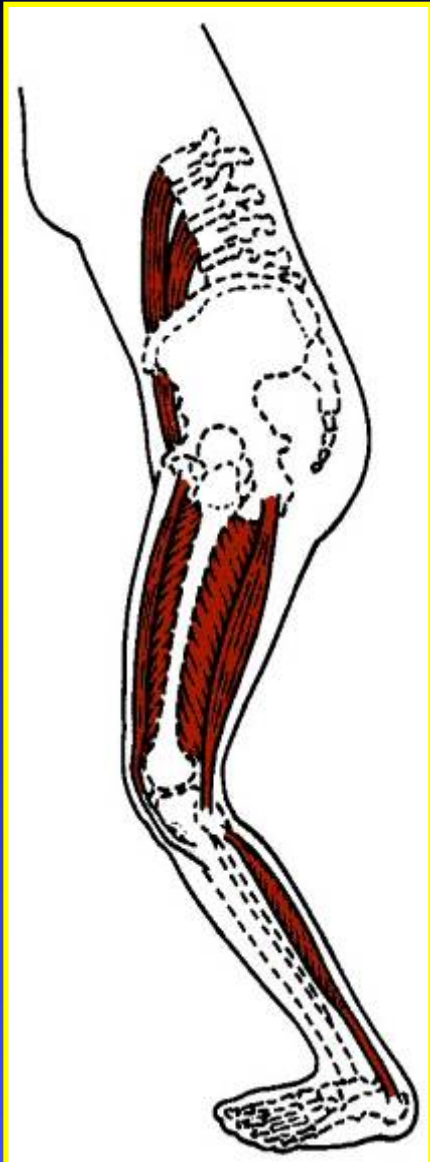




# POSTERIOR TILT



## POSTERIOR TILT



- Hyperactivity of hip extensors
- Hamstrings shortening
- Weakness of lower back extensors



- Decreasing of lumbar lordosis
- Lumbar spine flexion

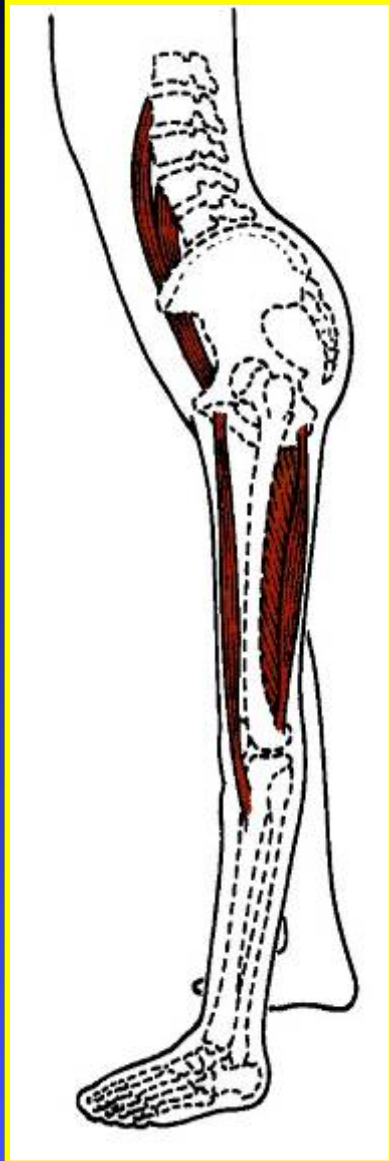


**Extensive pelvic posterior tilt**

# ANTERIOR TILT



## ANTERIOR TILT



- Shortening of lower back extensors
- Weakness of trunk muscles
- Shortening of iliotibial tractus
- Shortening of hip extensors



• Increasing of lumbar lordosis



**Extensive pelvic anterior tilt**

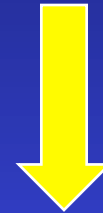
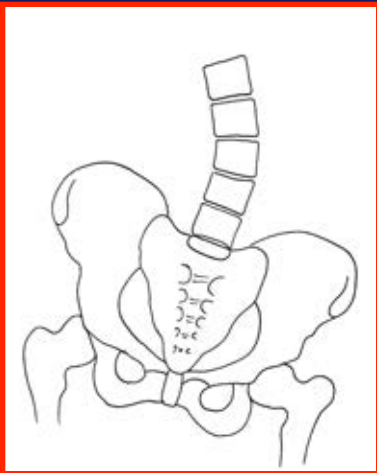
# PELVIC OBLIQUITY





# PELVIC OBLIQUITY

- Unbalanced trunk
- Lumbar scoliosis
- Hip dislocation
- Muscle imbalance:
  - Hip adductors imbalance
  - Hip abductors weakness

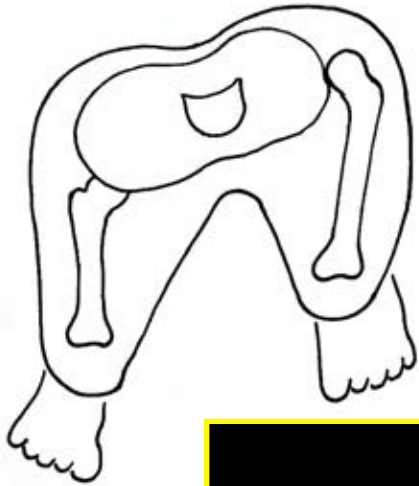


**Pelvic obliquity**

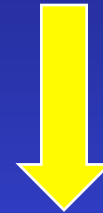
# PELVIC ROTATION



# PELVIC ROTATION



- Often associated with scoliosis
- Dislocated hip located in posterior side of rotation



**Pelvic rotation**

# WINDBLOW HIP DEFORMITY

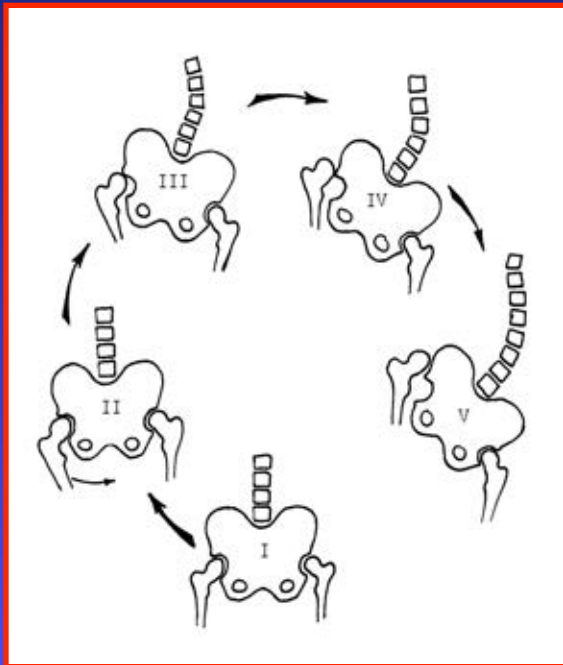
- 1st hip:  
Flexion+abduction+external rotation
- 2nd hip:  
Adduction+internal rotation



- Hip dislocation
- Pelvic obliquity and rotation
- Scoliosis
- Different leg length



**Wind hip deformity**



# Therapy of the neuromuscular spinal deformities

---

## 1. conservative

disadvantages:

- low effect
- poor tolerance of the orthosis
- worsening of the cardiopulmonal functions
- pressure sores

## 2. surgical

- indications:
- collapse and instability of the spine
  - progressivity in cardiopulmonal dysfunctions
  - back pain
  - tendence to pressure sores



# Surgical therapy

- doesn't solve the primary affection
  - improving the secondary dysfunctions
- 

## Main aims of the surgical therapy:

- prevention of the deformity progression
- correction of the deformity
- improving of the sitting and standing stability
- compensation of the pelvic obliquity
- improving of the cardiopulmonal functions

# Combination of the surgical techniques

**LUQUE** = segmental spinal  
sublaminar instrumentation  
with translation forces

**GALVESTON** = pelvic stabilisation



# Luque

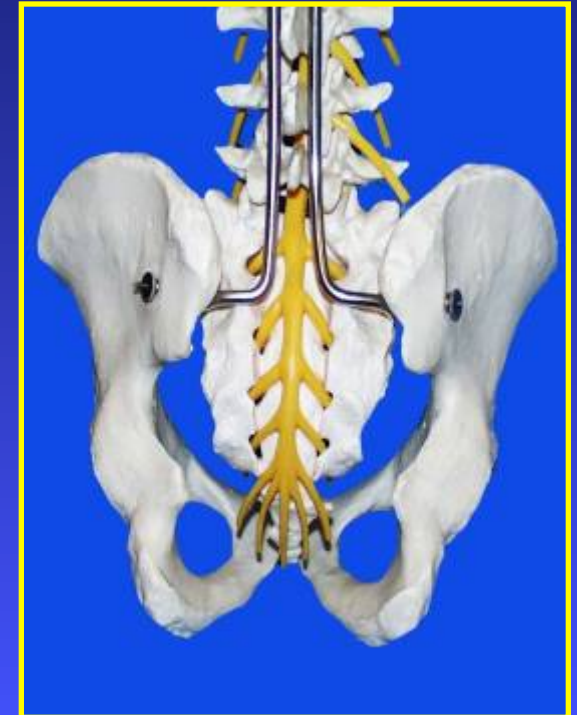
## spinal segmental instrumentation

- good and safe correction
- stable instrumentation
- allows the release of the orthosis
- possibility of the extending  
to the pelvis



# Galveston

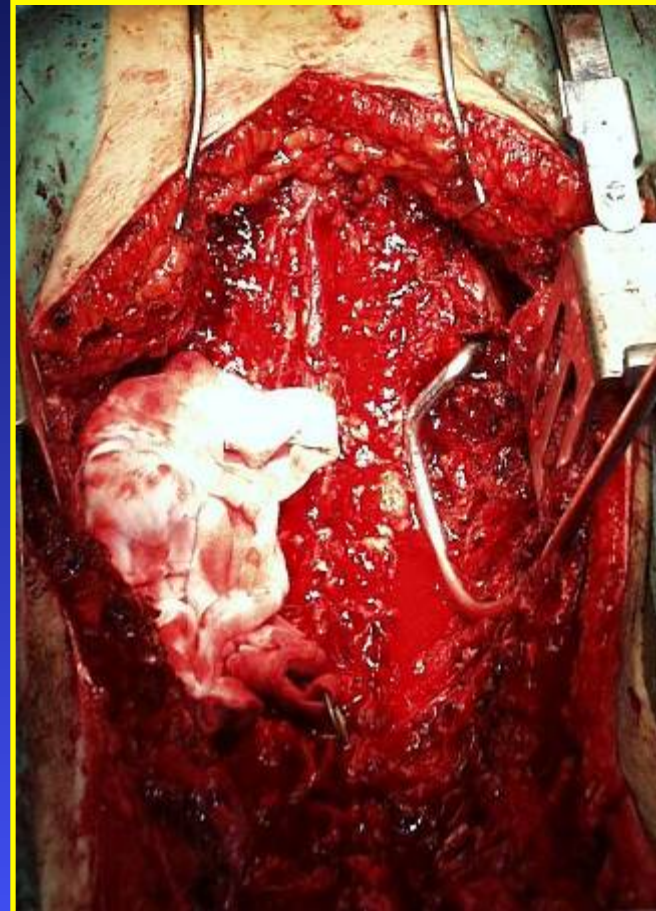
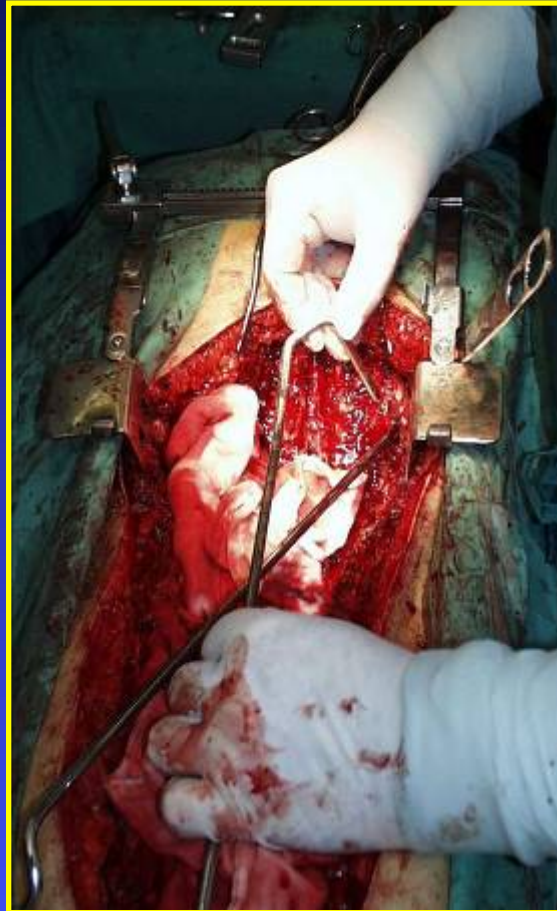
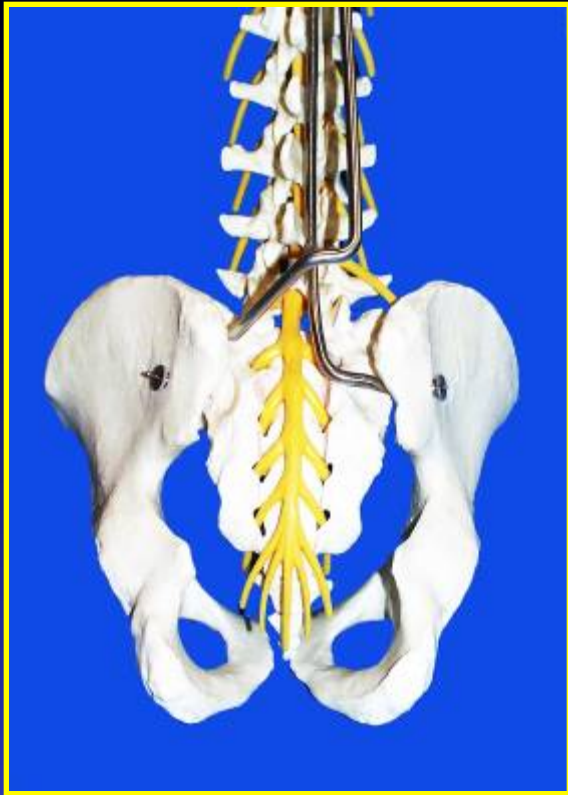
## pelvic stabilization





# GALVESTON

---





# LUQUE + GALVESTON



# Main complications in instrumentation

## Incorrect implantation of the rod to the pelvis



## Dislocation of the upper instrumentation part



# Other scoliosis

# Neurofibromatosis





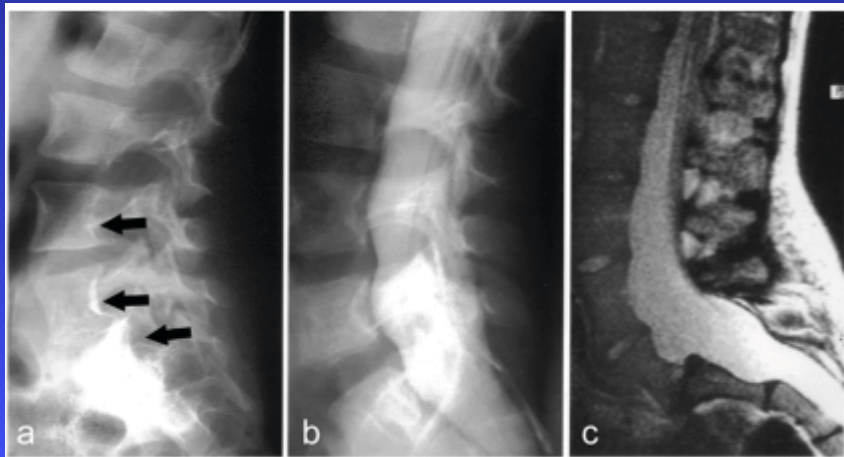
# Neurofibromatosis „café au lait“





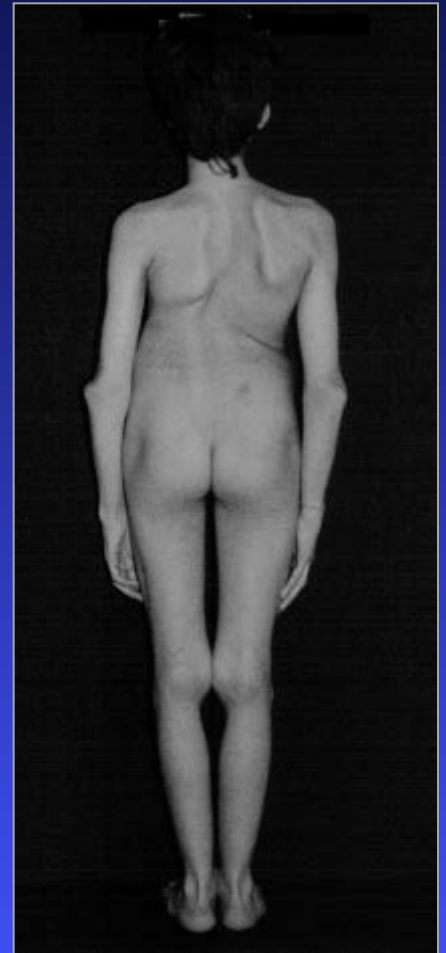
# Neurofibromatosis

- Sharp curves
- High rate of pseudoarthrosis
- Reexploration of fusion



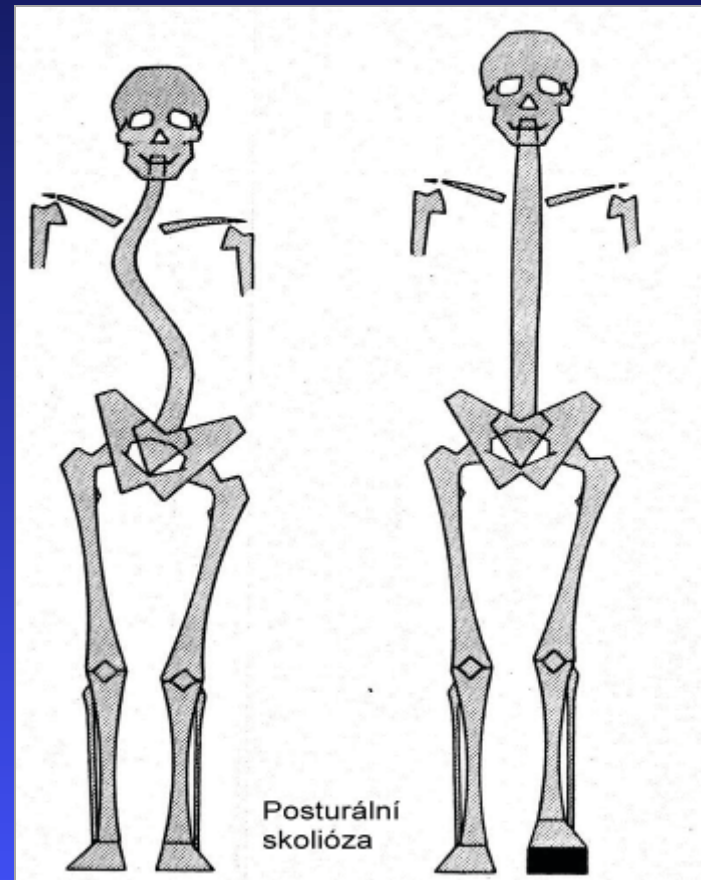
# Scoliosis in other syndromas

- Osteochondrodystrofy
- Ehlers – Danlos
- Marfan
- Morquio
- O. imperfecta

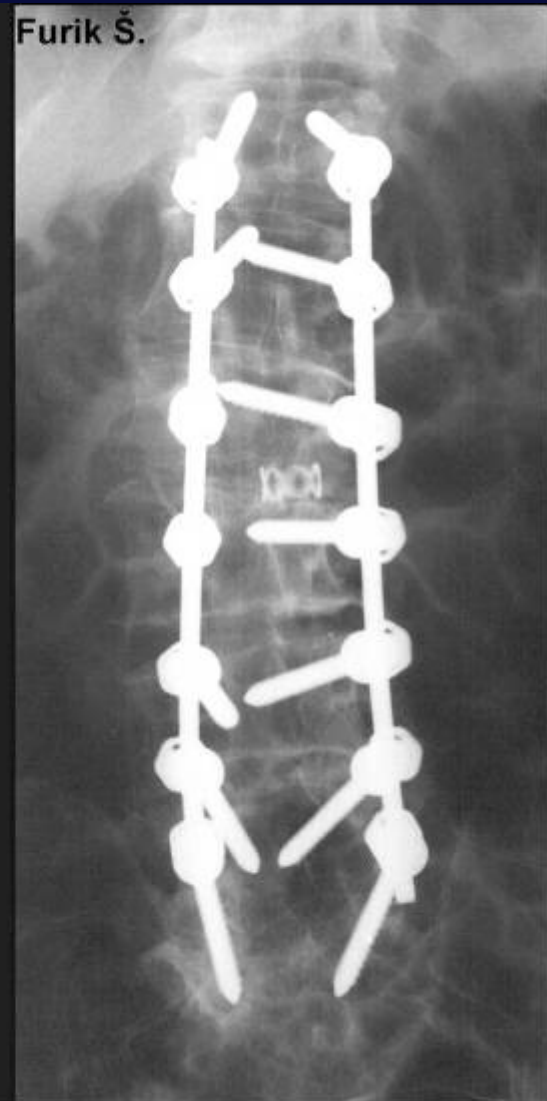
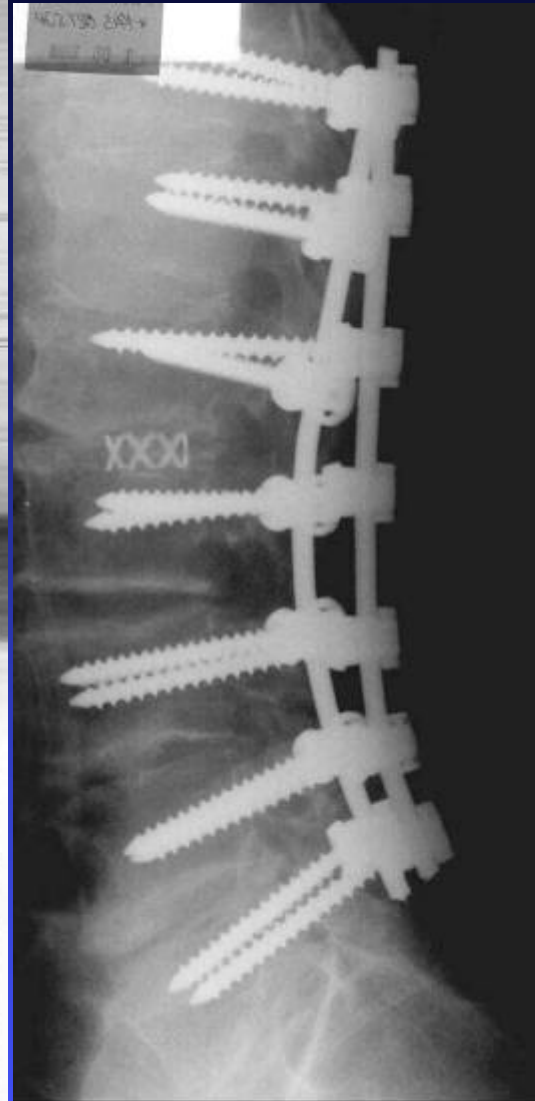


# Secondary curves

- Postural
- Inflammations
- Tumours
- Hysteria
- Degenerative



# Degenerative scoliosis



# **Complications of surgical therapy**



# Neurological complications

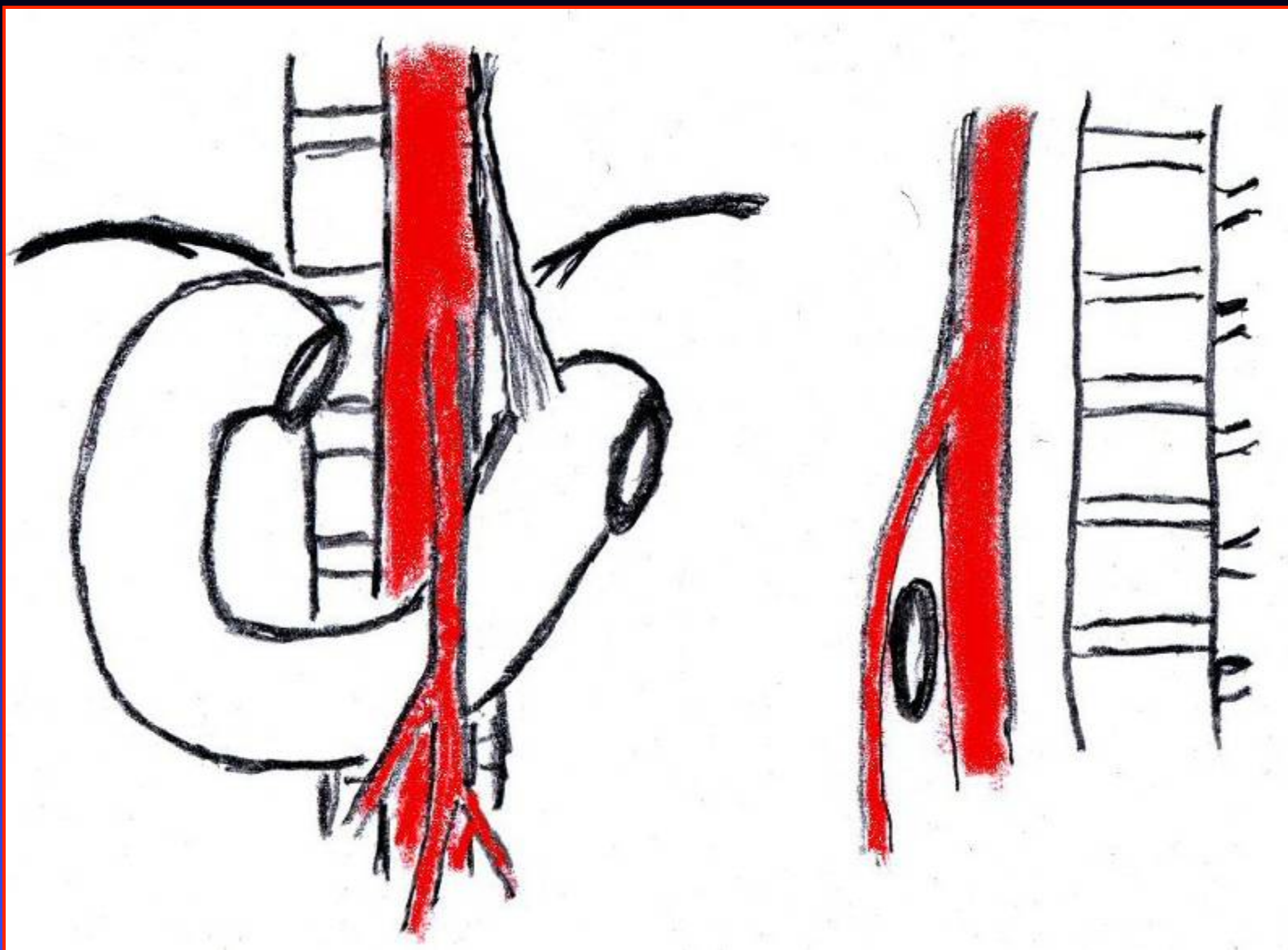
- ✓ perioperative – implantation of instruments
- ✓ overcorrection
  - ✓ – mechanical (spinal cord distraction)
  - ✓ – vascular

# Cast syndrome

– vascular duodenal compression

- ✓ acute (postop., plaster)
- ✓ chronical (Wilke syndrome)

Duodenal compression in third part between  
a. mesent. sup. and aorta with partial  
duodenal obstruction



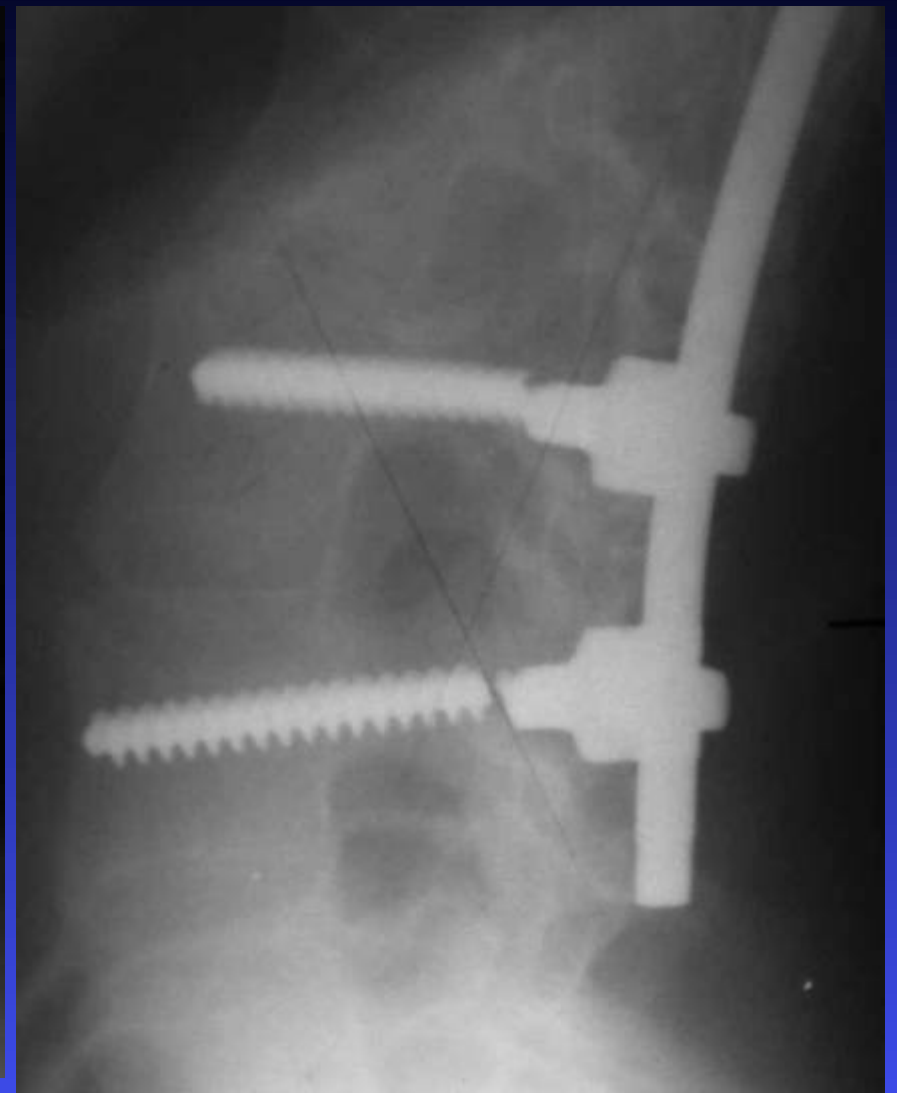
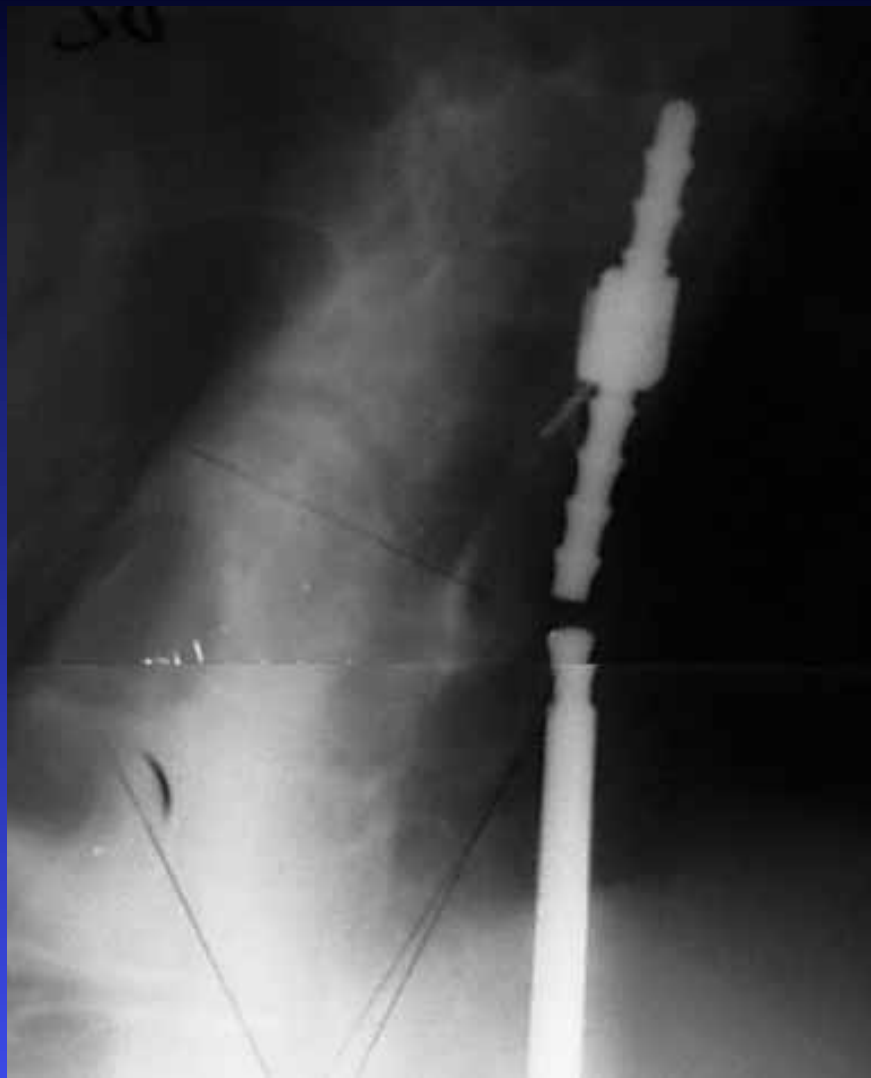
# Therapy of cast syndrome

- ✓ intravenous nutrition
- ✓ nasogastric drain
- ✓ left side body position
- ✓ (side to side duodenojejunoanastomosis)

# Later complications

- ✓ Pseudoarthrosis (loss of correction, pain, loosening of instrumentation)
- ✓ Bending of fusion during growth period
- ✓ Fracture in fusion





# Infection complications

- ✓ superficial

- ✓ deep

- ✓ puncture, antibiotics

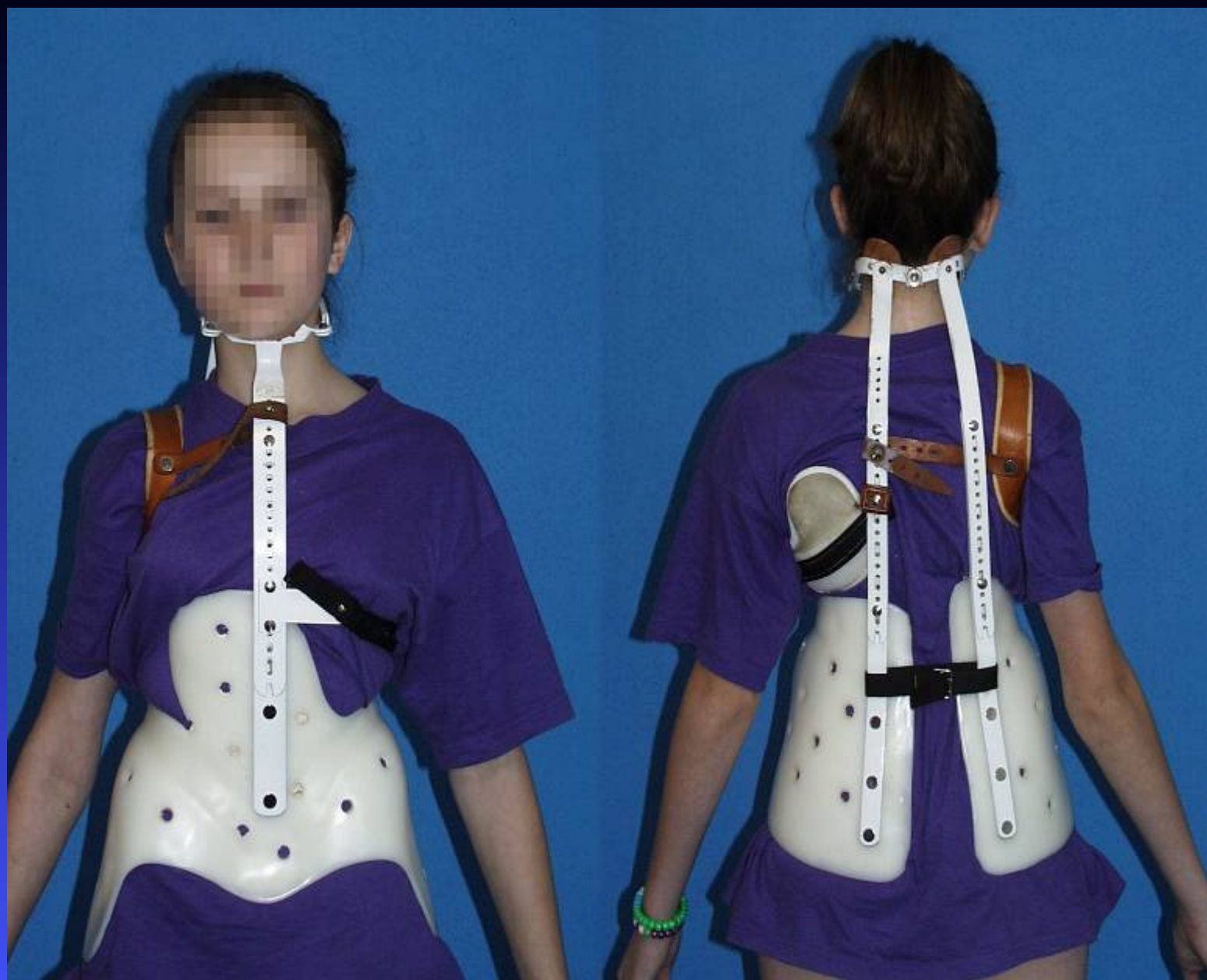
- ✓ surgical revision, drainage

# **Possible postoperative fixations**

1. Milwaukee brace

2. Plaster cast

3. Orthosis













# Halo - cast

*C-Th junction*







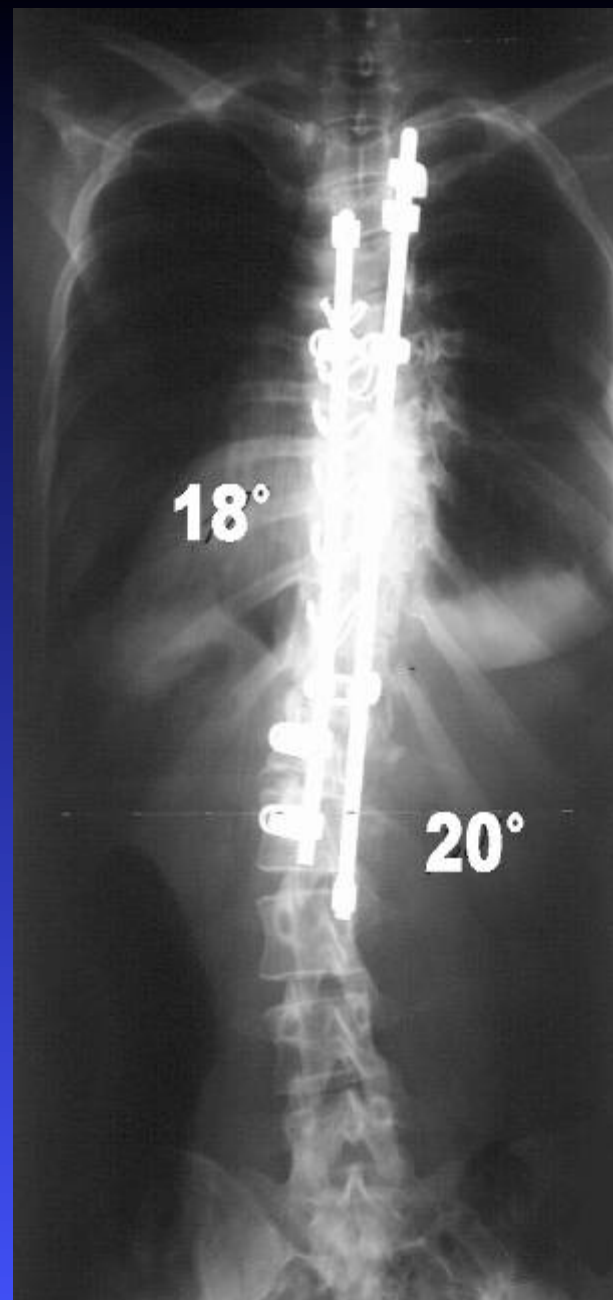




# Pressure sores in plaster cast

- ✓ superficial – conservative treatment
- ✓ deep – surgical treatment – excision, suture
- ✓ Prevention – regular skin care











# Skin observation

- Microscopic defects
- Red colour of skin
- Oedema and secretion



# **DEFORMITIES in SAGITTAL PLANE**

# **Etiological classification**

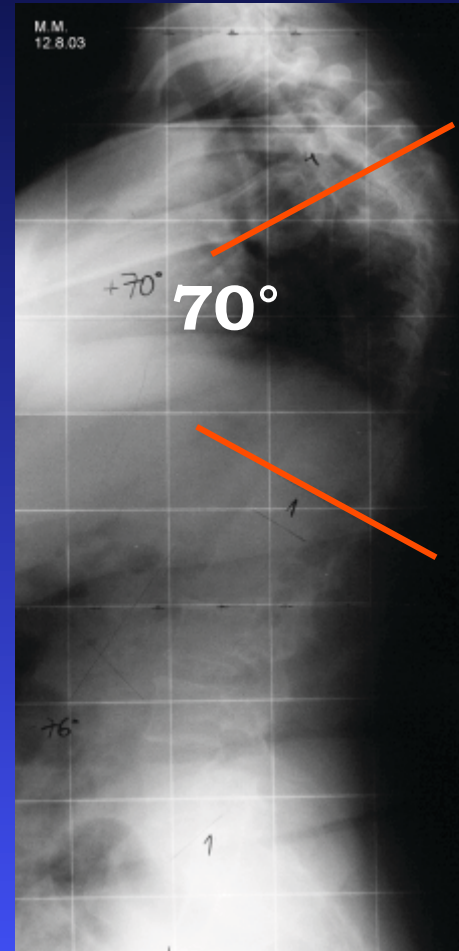
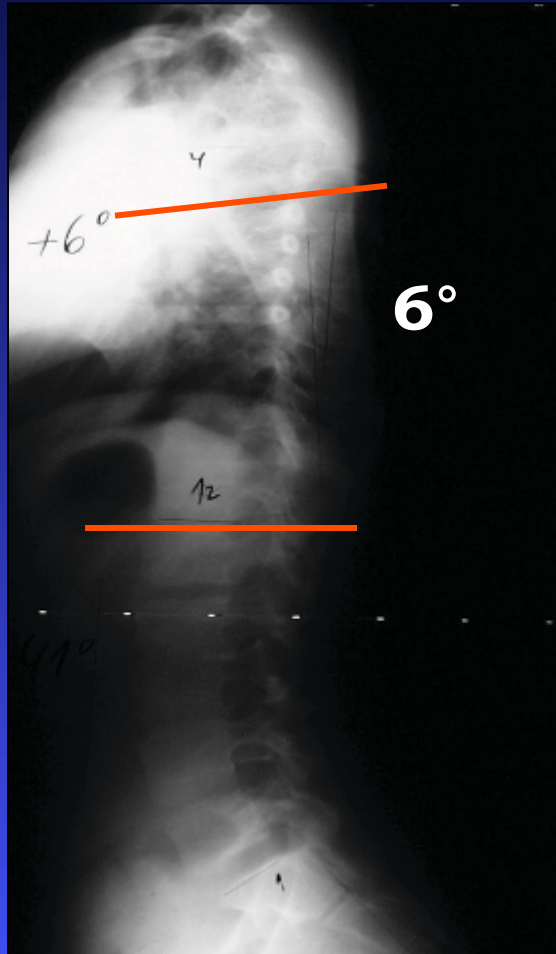
## **HYPERKYPHOSIS**

- Postural
- M. Scheuermann
- Congenital
- Neuromuscular
- in myelomeningocele
- Traumatic
- After surgical treatment



# Hypo - Hyper kyphosis

normal range T5 – T12 = 20° - 40°



**M.Scheuermann**

**kyphosis dorsalis juvenilis, adolescent kyphosis**

- Vertebral plates incongruentio
- Intervetebreal spaces decreasing
- Wedge vertebral deformities over  $5^{\circ}$
- Kyphosis over  $40^{\circ}$

# Therapy

- Physiotherapy
- Milwaukee brace
- Surgical treatment







