PLEASE CLICK ON THE FOLLOWING LINK TO WATCH THE LECTURE ONLINE:-

https://www.youtube.com/watch?v=sGYPJT3NYco&list=PLuBRb5B7fa_embZp8jWG_hG8_01JXLEeo&index=3

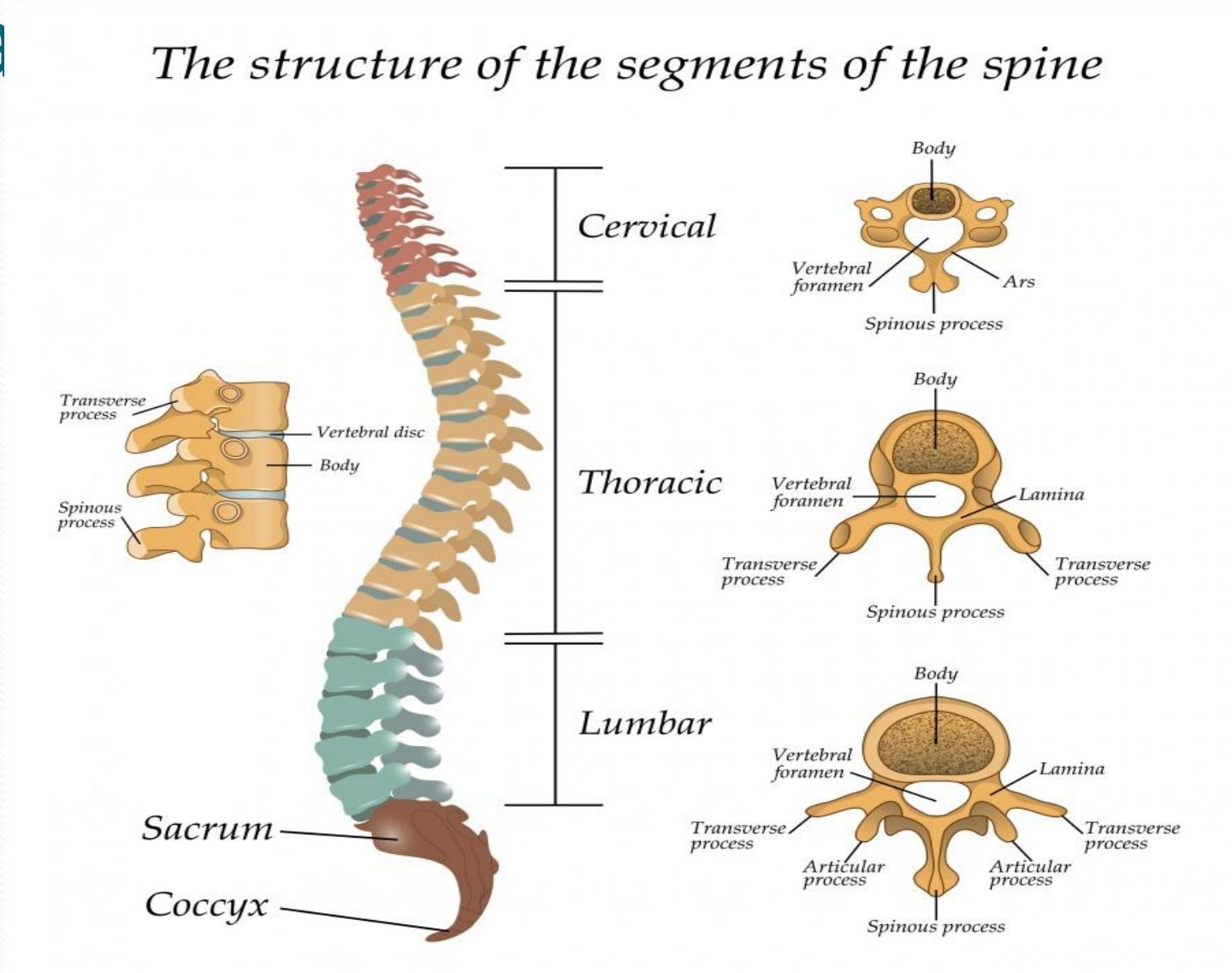
scoliosis

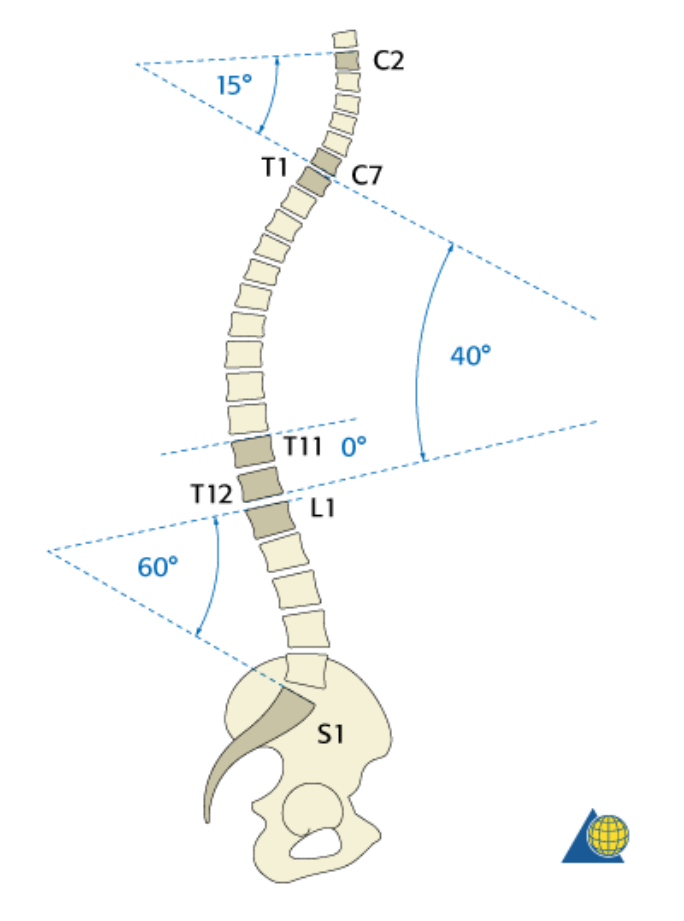
Dr . Sami Alrwashdeh

outline

- anatomy
- definition
- Classification
- Prevalence & natural history
- Clinical evaluation
- Radiographic evaluation
- Treatment

a


The structure of the segments of the spine
Cervical
Thoracic
Lumbar
Sacrum
Coccyx
Transverse process
Vertebral disc
Body
Spinous process
Body
Vertebral foramen
Ars
Spinous process
Body
Vertebral foramen
Lamina
Transverse process
Transverse process
Spinous process
Body
Vertebral foramen
Lamina
Transverse process
Transverse process
Articular process
Articular process
Spinous process

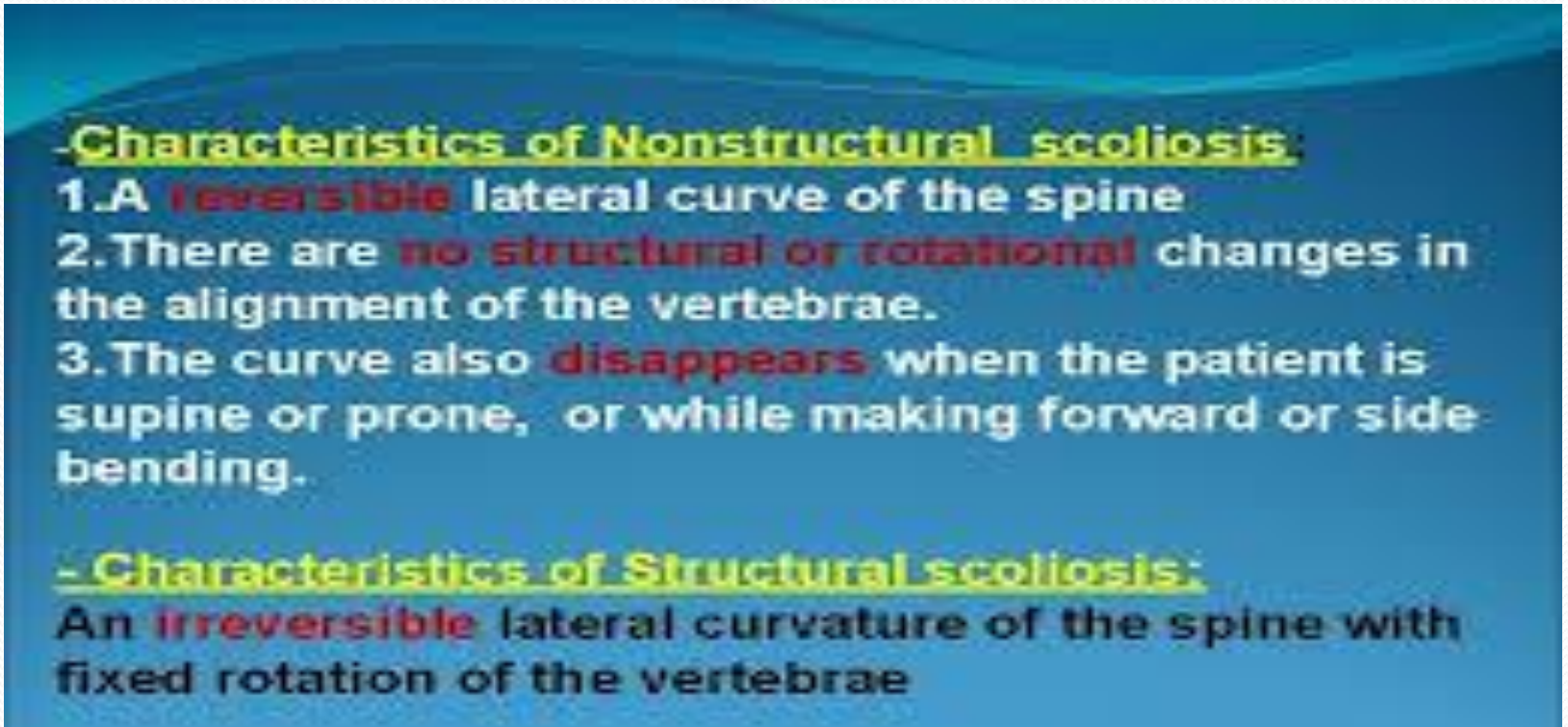

C2
15°
T1
C7
40°
T11
0°
T12
L1
60°
S1

Type of scoliosis

- Structural scoliosis .
- Nonstructural scoliosis .

Structural versus nonstructural

- Nonstructural scoliosis, also known as functional scoliosis, results **from a temporary cause** and only involves a side-to-side curvature of the spine (no spinal rotation). The spine's structure is still normal.



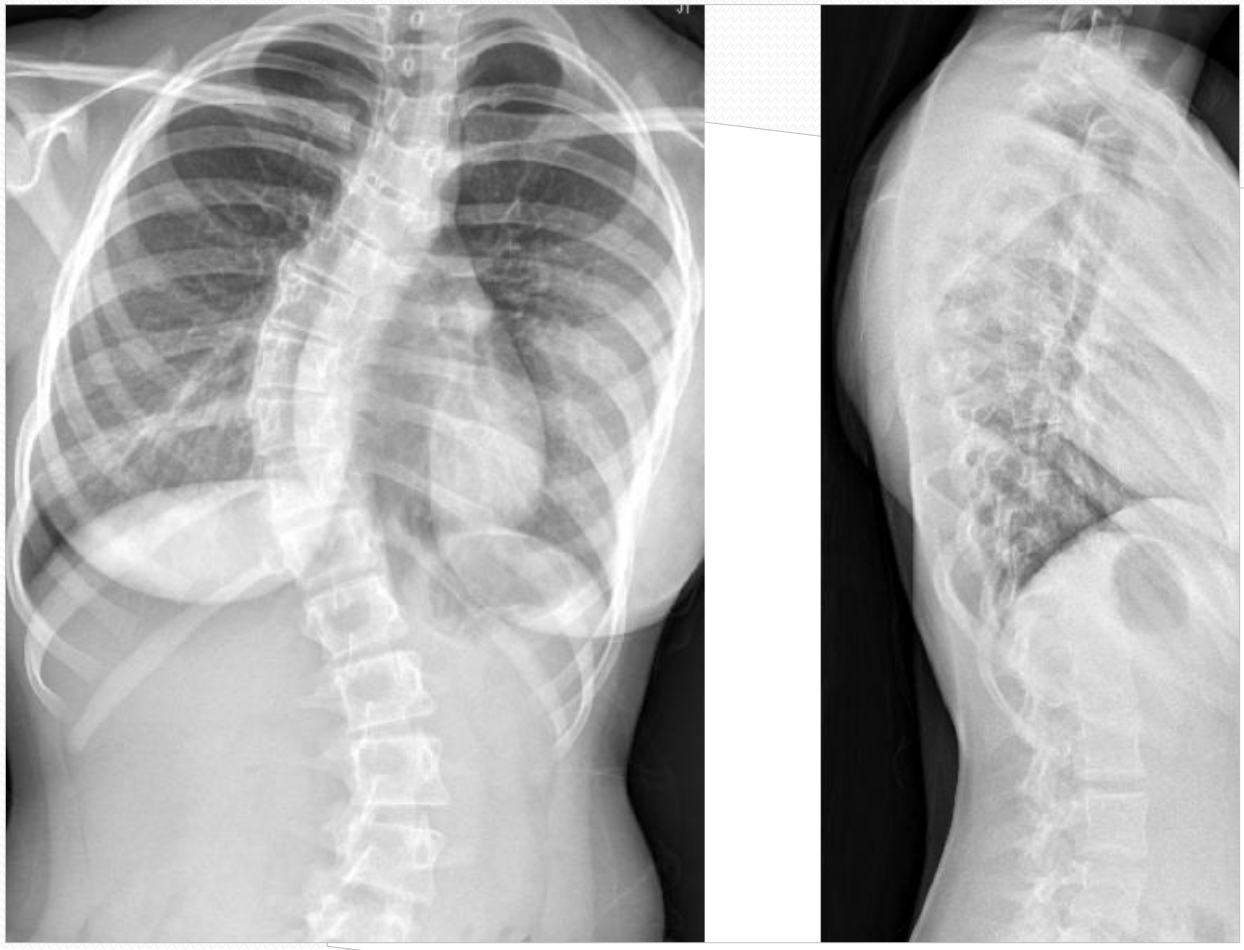
Etiology of nonstructural scoliosis

- LLD
- HABITUAL ASYMMETRIC POSTURE
- MUSCLE GUARDING OR SPASM FROM A PAINFUL STIMULI IN THE BACK OR NECK

STRUCTURAL SCOLIOSIS

definition

- It is a lateral deviation of the normal vertical line of the spine which when measured on radiograph , is greater than 10 degrees associated with rotation of vertebra within the curve.
- A 3D deformity



lat deviation in coronal plane.
Extension in the sagittal plane leading to lordosis of scoliotic segment .

Rotation in the axial plane

Classification based on the etiology

- Idiopathic
- Congenital
- Neuromuscular
- Syndromic

Classification according to the age of presentation

- Early onset scoliosis
- Late onset scoliosis

Adolescent idiopathic scoliosis

Prevalence :

1.5 % to 3 % for all curves.

0.3 % to 0.5 % for curves exceeding 20 degrees .

0.2% to 0.3% for curves exceeding 30 degrees .

- More common in female particularly as magnitude of the curve increase :
- The ratio of affected females to males has been reported to be 1.4 : 1 for curves between 11 and 20 degree , 5.4 : 1 for curves exceeding 20 degree and 7.2 :1 for curves requiring orthopedic intervention .
- So there are increasing female prevalence for large and progressive curves . The clinical significance of these observation is that curve progression is more common in female .

Natural history

Consensus is lacking in the literature regarding the definition of curve progression.

Most studies use an increase of more than 5 to 6 degree as indicative of curve progression.

- Factor associated with curve progression

1. Sex
2. Remaining growth
3. Curve magnitude
4. Curve pattern

Remaining growth

Assessed by maturity indices:

1. Menarchal status

2. Peak height velocity : is a measurement of maximal skeletal growth that occurs during the adolescent growth spurt , calculated from changes in a patient height measurements over time , which is reported to be about 8cm for girls and 9.5 cm for boys

- require serial height measurements of six-month intervals
- It is the earliest and best index available to demonstrate that growth is slowing and the risk for curve progression is diminishing.

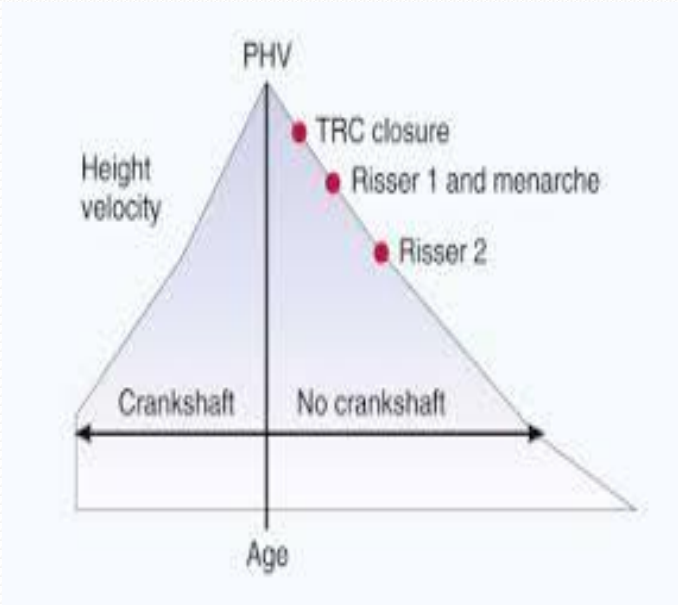
3. Risser sign : a radiographic measurement based on ossification of the iliac apophysis , which is divided into four quadrants ,beginning on the lat aspect of the iliac apophysis and progressing medially .

3. Curve magnitude : the size of the curve when scoliosis is recognized is helpful in predicting curve progression .

A combination of curve magnitude and remaining growth is used to predict the natural hx in young patients with scoliosis.

4. Curve pattern :

Double curve and thoracic curves are most likely to progress , followed by thoracolumber curves . Lumber scoliosis is reportedly the least likely to worsen .



Incidence of progression of untreated adolescent idiopathic scoliosis with the cross-correlation of curve magnitude and Risser sign		
Risser Sign	**Curve Magnitude Using the Cobb angle**	
	<19 degrees	**20-29 degrees**
0-1	22%	68%
2-4	1.6%	23%

Pathophysiology

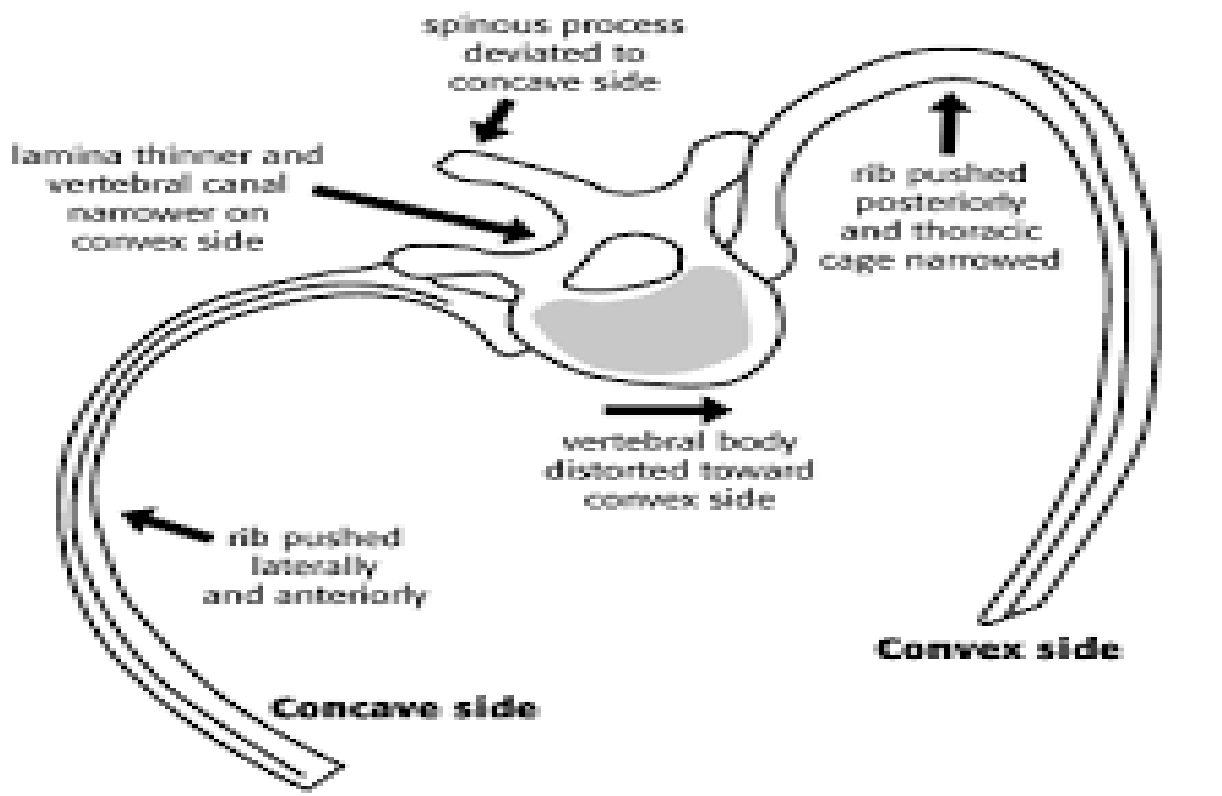
the extent of structural changes varies with the degree of scoliosis these changes are greatest at the apex of the curve and diminish towered the each end

Concave side

- The spinous processes
- Body is lower & condensed
- Facetes have a significantly thicker cortex
- Lamina are narrow and close together
- Pedicles are shorter with narrower transverse endosteal width
- Ribs rotated forward which may produce anterior chest wall prominence
- Capacity of the thoracic cavity increase

Convex side

- Vertebral bodies
- Body is higher & expanded
- Facetes have a significanly thinner cortex
- Lamina are broad and widely separated
- Longer with higher ESW
- Ribs are directed posteriorly which produce posterior rib prominence
- Capacity of the thoracic cavity diminish


spinous process
deviated to
concave side
lamina thinner and
vertebral canal
narrower on
convex side
rib pushed
posteriorly
and thoracic
cage narrowed
vertebral body
distorted toward
convex side
rib pushed
laterally
and anteriorly
Concave side
Convex side

Clinical evaluation

- AIS is usually painless
- Only about 23% of adolescent report a back discomfort at initial evaluation the source of discomfort can be identified only in 10 % of time (spondylolysis , spondylolisthesis and scheuermann kyphosis)

Clinical evaluation

Pt usually seek medical attention due to the physical aspect of the deformity

- Uneven shoulder
- One sided prominence of a scapula or breast
- Elevated or protuberant iliac crest
- Trunk asymmetry
- Waist line asymmetry

Physical examination

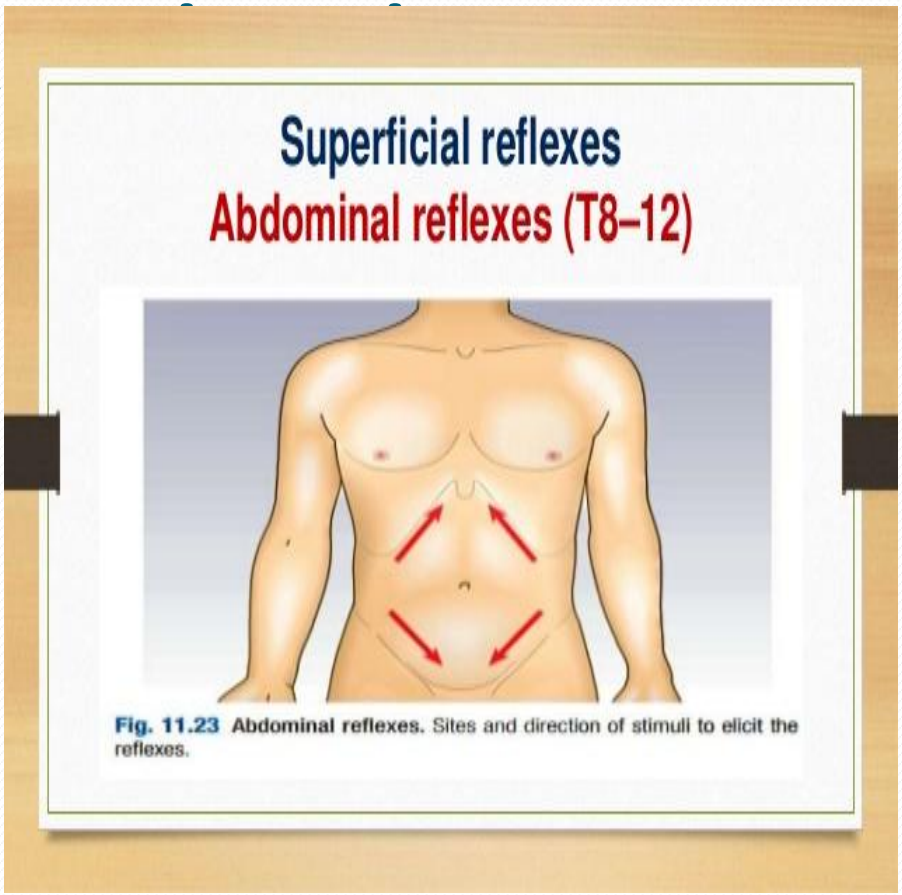
- Look for signs of underlying neurological anomalies (hemangioma , hair tuft , dimpling)
- Palpate the spinous process from the cervical region to sacrum (spina bifida occulta)
- Shoulder level
- Iliac crest level
- LLD

Adams forward bending test

FIGURE 1. Adams forward-bending test

Neurological ex

- Reflexes
- Motor and sensory examinational
- Abnormal posture of hands and feet



Radiographic evaluation

- PA &LAT WHOLE SPINE
- LEFT AND RT BENDING VIEWS (preop planning)
- FROM EXTERNAL AUDITORY MEASTUS TO PELVICE (36 & 14 INCHES FILM CASSETES)
- PT SHOULD STAND AS ERECT AS POSSIBLE ,KNEE STRIAGHT , FEET TOGATHER
- FOR LAT VIEW THE SHOULDERS ARE FLEXED FORWARD , ELBOW FULLY FLEXED ,FISTS REST ON CLAVICLES

PROPER LAT POSITION

ASSESS X RAY FOR

- Skeletal maturity
- LLD (pelvic tilt)
- Spinal balance
- Curve patterns & magnitude
- Vertebral rotation
- Curve flexibility (for preoperative planning)

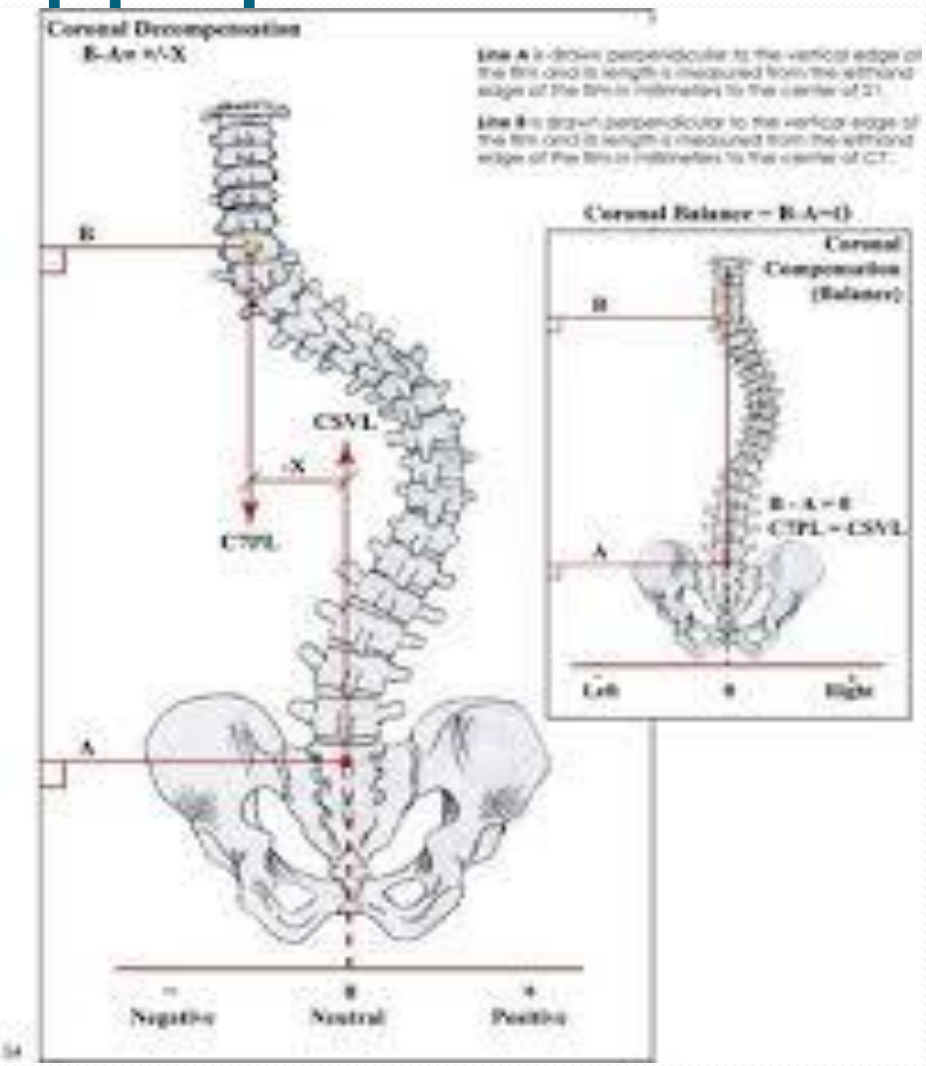
Assess spinal balance

- Coronal balance : to determine the alignment of the head over pelvic (the head is almost always positioned directly above the pelvic in AIS) .

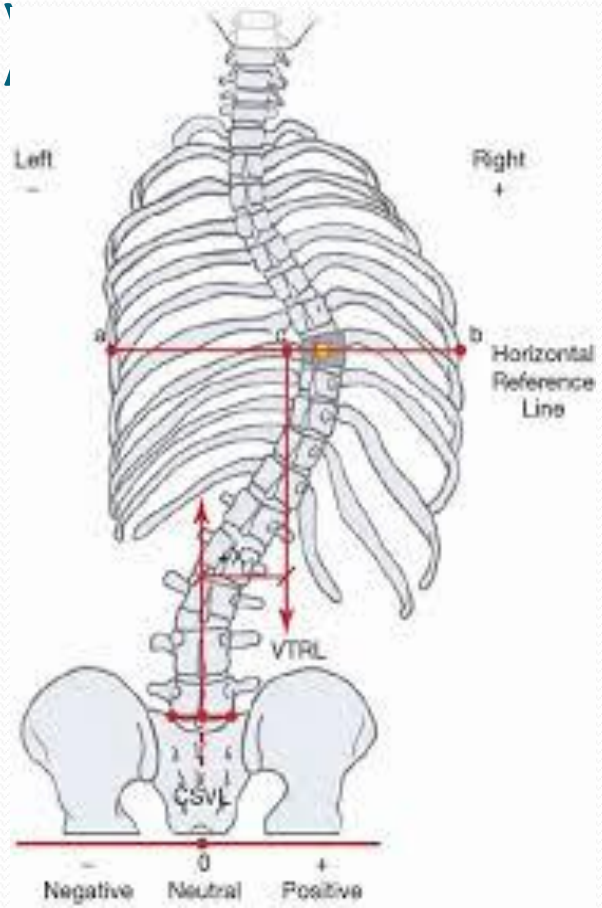
  represents the horizontal distance between the CSVL and C7 PLUMP LINE (C7PL)
- TRUNK BALANCE : AIS pt may have a significant imbalance of the trunk over pelvic .

  distance bet csvl and second vertical line which is bisects a horizontal line drawn from the peripheral edges of the ribs of the apical vertebra .
- Observe the sagittal contours of the scoliotic segment (typically hypokyphosis) .

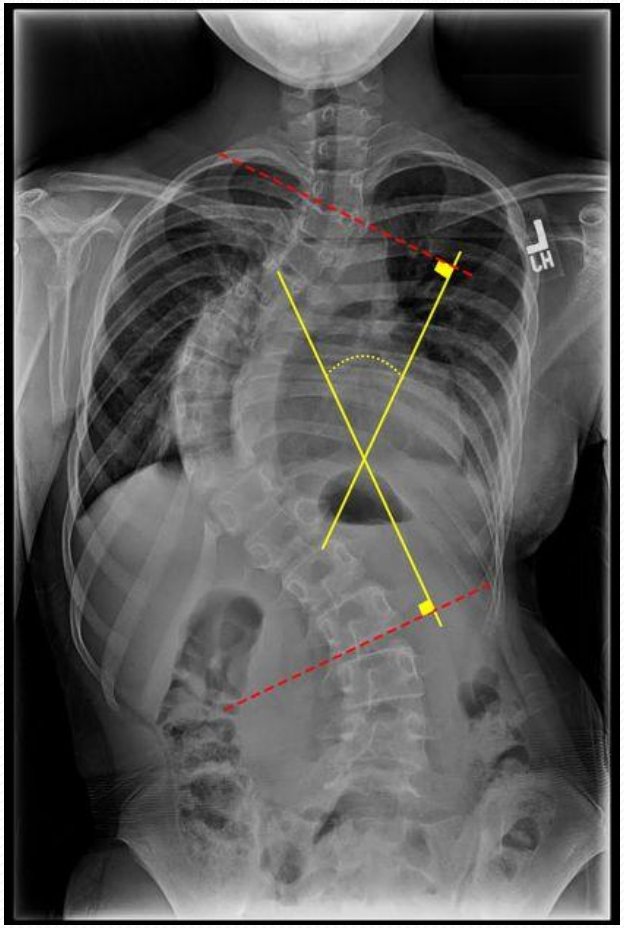
Corona

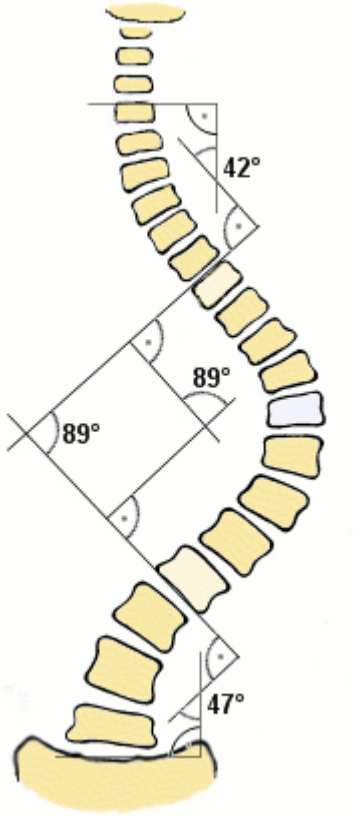

Coronal Decompensation
B-A= +/-X
Line A is drawn perpendicular to the vertical edge of the film and its length is measured from the leftmost edge of the film in millimeters to the center of S1.
Line B is drawn perpendicular to the vertical edge of the film and its length is measured from the leftmost edge of the film in millimeters to the center of C7.
B
CSVL
X
C7PL
A
Negative
Neutral
Positive
Coronal Balance = B-A=0
Coronal Compensation (Balance)
B
B - A = 0
C7PL = CSVL
A
Left
Right

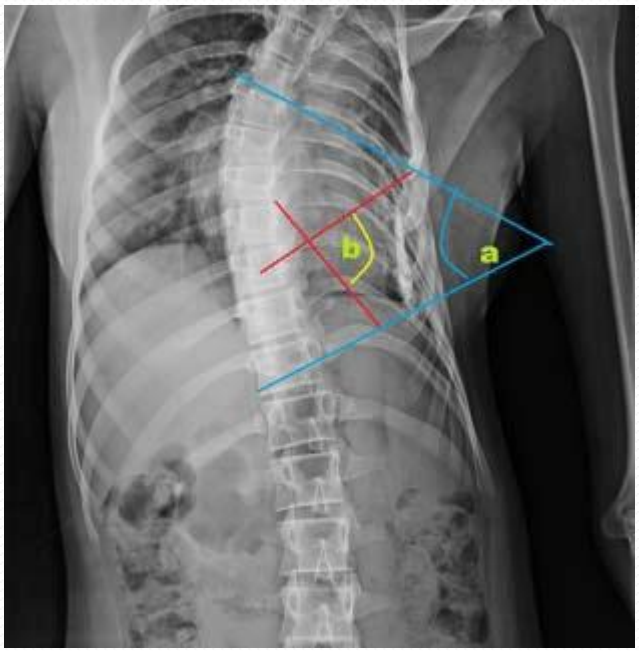
Trunk balance (lat trunk shift)



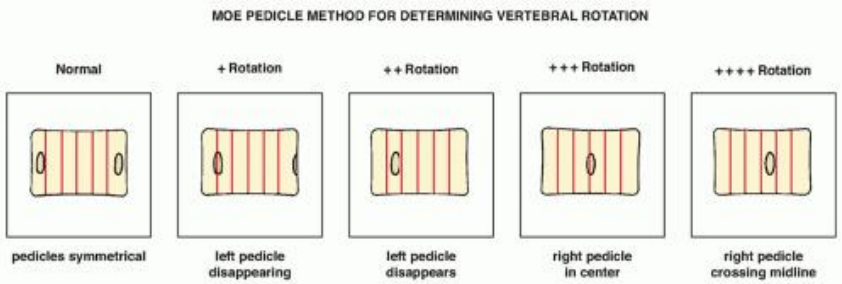
Curve magnitude cobb method

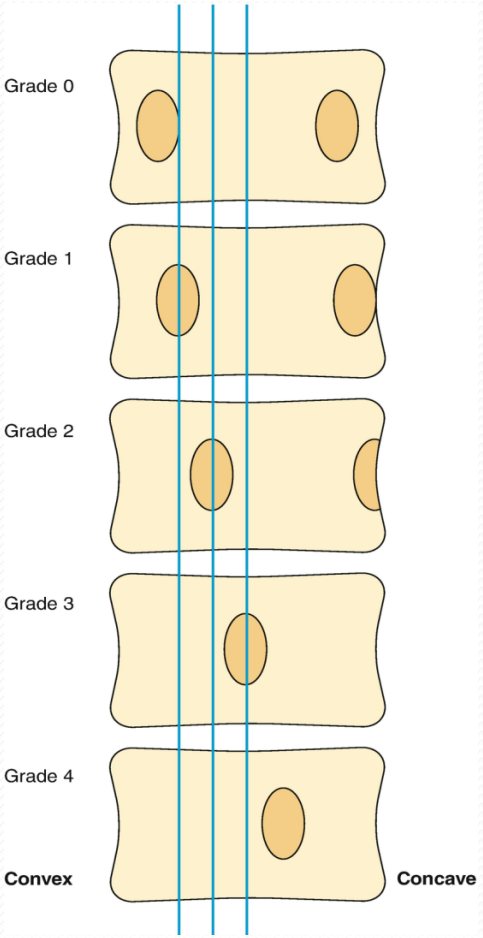



42°
89°
89°
47°


b
a

vertebral rotation Nash-Moe





Curve flexibility

- Reflect the amount of curve correction that can be achieved and determine the flexibility of the spine .

1. Used to provide a lenke classification .
2. Preoperative assessment for the possible needs for intra operative posterior mobilization tech .
3. To determine and confirm the LIV

- Assessed on rt & lt side bending radiograph looking for reduction of cobbs angle , the amount of reduction is correlated with curve flexibility .

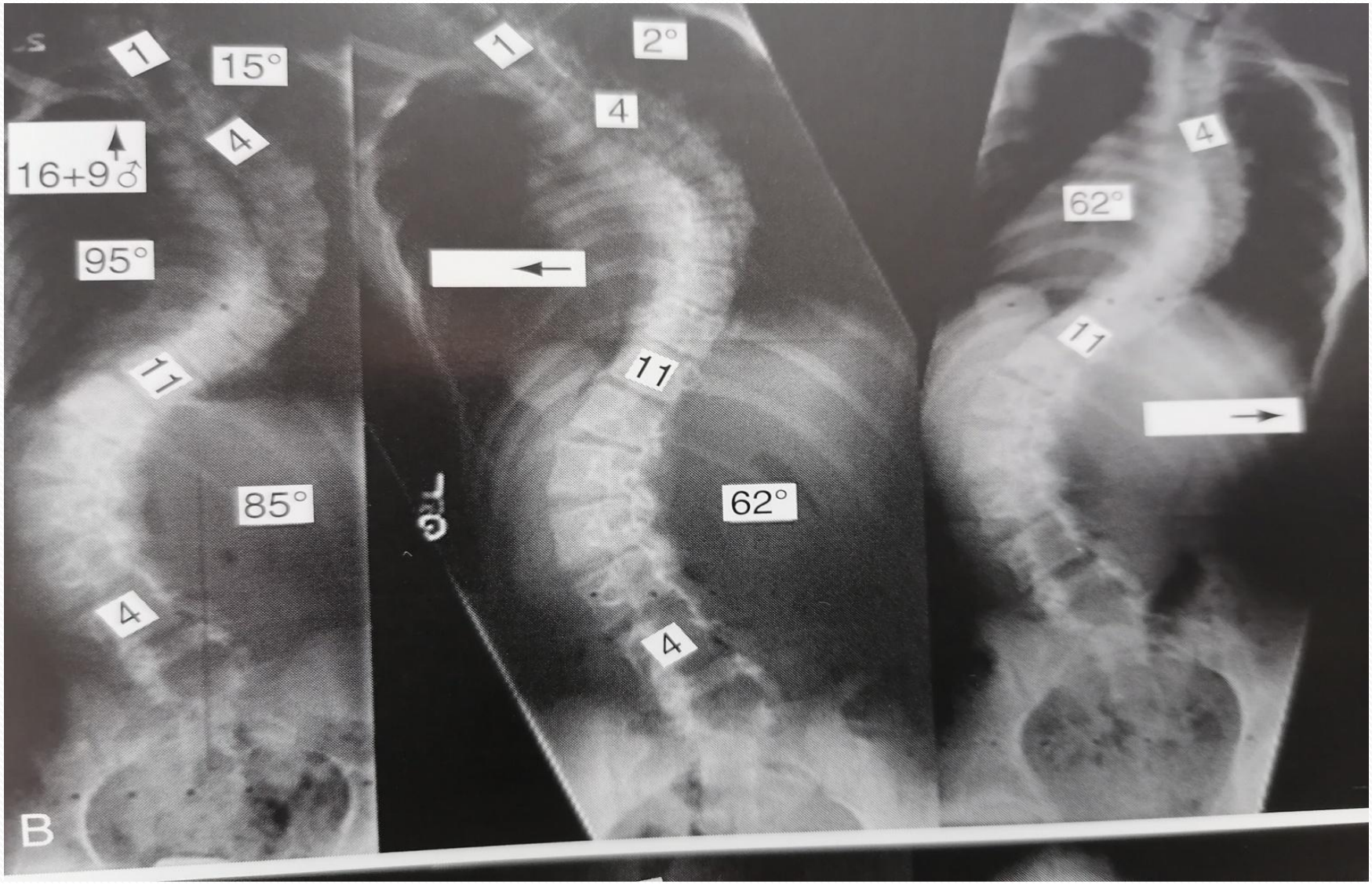
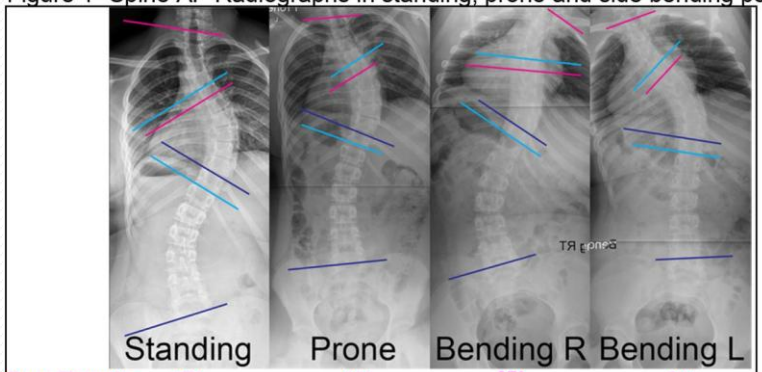

1
15°
4
16+9♂
95°
11
85°
4
B
1
2°
4
11
62°
4
62°
4
11

Figure 1- Spine AP Radiographs in standing, prone and side bending position



Prox. Thoracic	37°	16°	27°	24°
Main Thoracic	63°	46°	25°	52°
Thoracolumbar/ Lumbar	47°	24°	36°	13°

MRI

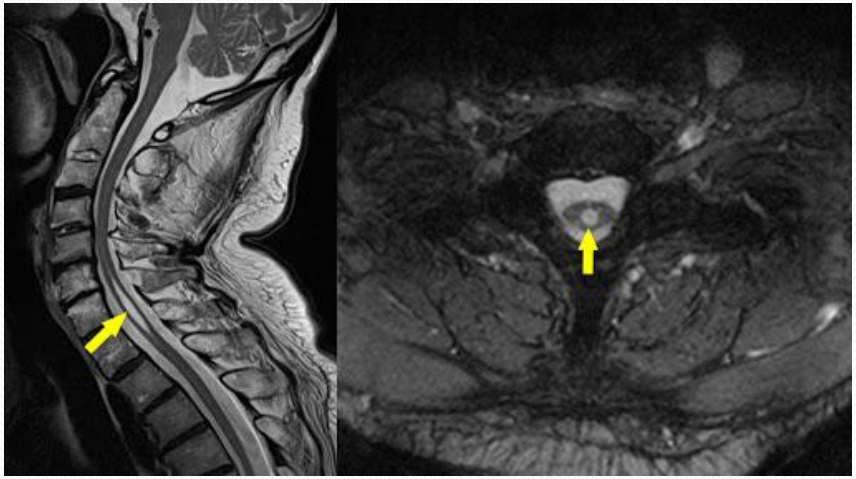
Indicated for pt with atypical manifestation of idiopathic scoliosis :

1. Painful scoliosis
2. Abnormal neurologic finding (weakness , abnormal reflexes , ataxia , progressive foot deformity…)
3. Excessive thoracic kyphosis
4. Left thoracic curve

MRI LOOKING FOR

- SYRINGIOMYELIA
- CORD TETHERING
- DIASTEMATOMYELIA
- SPINAL CORD TUMOR
- ARNOLD-CHIARI MALFORMATION

ALL HAVE BEEN IDENTIFIED IN INDIVIDUALES PREVIOUSLY THOUGHT TO HAVE IDIOPATHIC SCOLIOSIS



TREATMENT OF AIS

- OBSERVATION
- ORTHOSIS
- OPERATIVE

TREATMENT

Table 12-2 Guidelines for Treating Patients With Idiopathic Scoliosis

Curve Magnitude (Degrees)	Risser Sign		
	Grade 0/Premenarchal	Grade 1 or 2	Grade 3, 4, or 5
<25	Observation	Observation	Observation
30-40	Brace therapy (begin when the curve is >25 degrees)	Brace therapy	Observation
>45	Surgery	Surgery	Surgery (when the curve is >50 degrees)

OBSERVATION

- Curves less than 25 regardless of skeletal maturity
- Curves of 30 to 40 in pt with risser 3 or more
- 3-4 month follow up interval for premenarchal , risser less than 3
- 6 month interval for risser 3 or more
- In general the higher magnitude the shorter the follow up interval

orthosis

Principles

- apply corrective forces on the spine to release load on the concave (inner) part of the curve and increase load on the convex (outer) part of the curve
- Aims to reduce or slow curve progression until the child reaches skeletal maturity

ORTHOSIS

- Indicated for immature children (risser 2 or less)
- Curves of 30 to 45 degree on initial evaluation
- Documented progression of more than 5 degree on pt whose initial curve measured 20 to 30

ORTHOSIS

CONTRAINDICATION

- LARGE CURVES (MORE THAN 45`)
- EXTREM THORACIC HYPOKYPHOSIS
- SKELETAL MATURITY (RISSER 3 OR MORE , 2 YEAR POSTMENARCHAL)
- Pts WHO FOUND BRACE WEARING TO BE EMOTIONALLLY UNSTABLE

BRACE TREATMENT PROTOCOL

- Full time (23hr/day) is more effective than part time (8 to 16 hr /day)
- Initial brace evaluation after 2 to 4 week of brace wear
- Assess in brace curve correction(initial in brace x ray)
- 4 month follow up visit for skeletally immature children
- PA out of brace radiograph is obtained at follow up to assess curve progression
- Female with successful brace treatment , discontinue brace at (no further increase in height , 18 to 24 month postmenarchal or risser 4)
- For male discontinue successful treatment at risser 5

operative

GOALS

- WELL-BALLANCED SPINE (head , shoulder and trunk are centered over the sacrum)
- Reduce the magnitude of curves
- FUSION FOR PREVENTION OF FUTURE PROGRESSION

INDICATION

- Curve magnitude remain the primary factor in surgical decision making .
- Thoracic and double major curves exceeding 50 degree
- Thoracolumber and lumber curves exceed 40 to 45 degree
- Pt appearance as perceived by the family , pt and the surgeon play a role in surgical decision making

Preoperative planning

- Spinal balance
- Curve flexibility
- Curve pattern
- Surgery related needs (transfusion requirement , bone graft , spinal cord monitoring , postoperative pain management)

CURVE PATTERN
LENKE CLASSIFICATION SYSTEM

- AIMS TO DETERMINE WHICH OF A PATIENTS SCOLIOTIC CURVE SHOULD BE INCLUDED IN INSTRUMENTATION AND FUSION
- BASED ON 3 VARIABLE :

1. LENKE CURVE TYPE
2. LUMBER SPINE MODIFIERS
3. THORACIC SAGITTAL MODIFIERS

LENKE CLASSIFICATION

- 3 CURVES LOCATION

1. Proximal thoracic PT : apex of the curve between T3 and T5
2. Main thoracic MT : apex bet T6 and T11-12 INTERVERTEBRAL DISC

3. ThoracoLumber/Lumber : apex bet T12 and L4

Lenke curve type

- Determine patient curve location (PT ,MT , TL/L) according to the apex location .
- Determine which of patient curves are structural .
- Determine the major curve (the one with largest cobbs)

structural criteria are :

1. Curve > 25 degree on side bending radiographs
2. Kyphosis : +20 between T2 AND T5 for PT curve , +20 between T10 AND L2 for MT and TL/L curve.

This result in 6 curve type :

Curve type

Type	Proximal thoracic	Main thoracic	Thoracolumbar/lumbar	Description
1	Nonstructural	Structural (major)	Nonstructural	Main thoracic (MT)
2	Structural	Structural (major)	Nonstructural	Double thoracic (MT)
3	Nonstructural	Structural (major)	Structural	Double major (DM)
4	Structural	Structural (major)	Structural (major)	Triple major (TM)§
5	Nonstructural	Nonstructural	Structural (major)	Thoracolumbar/lumbar (TL/L)
6	Nonstructural	Structural	Structural (major)	Thoracolumbar/lumbar-main thoracic (TL/L-MT)

Structural criteria
(Minor curves)

Proximal thoracic
- Side bending cobb ≥25°
- T2-T5 kyphosis ≥+20°

Main thoracic
- Side bending cobb ≥25°
- T10-L2 kyphosis ≥+20°

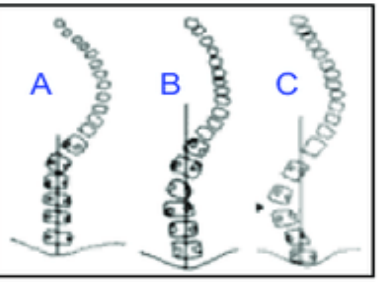
Thoracolumbar/lumbar
- Side bending cobb ≥25°
- T10-L2 kyphosis ≥+20°

Location of apex
(SRS definition)

Curve	Apex
Thoracic	T2-T11/12 disk
Thoracolumbar	T12-L1
Thoracolumbar/lumbar	L1/2 disk-L4

Modifiers

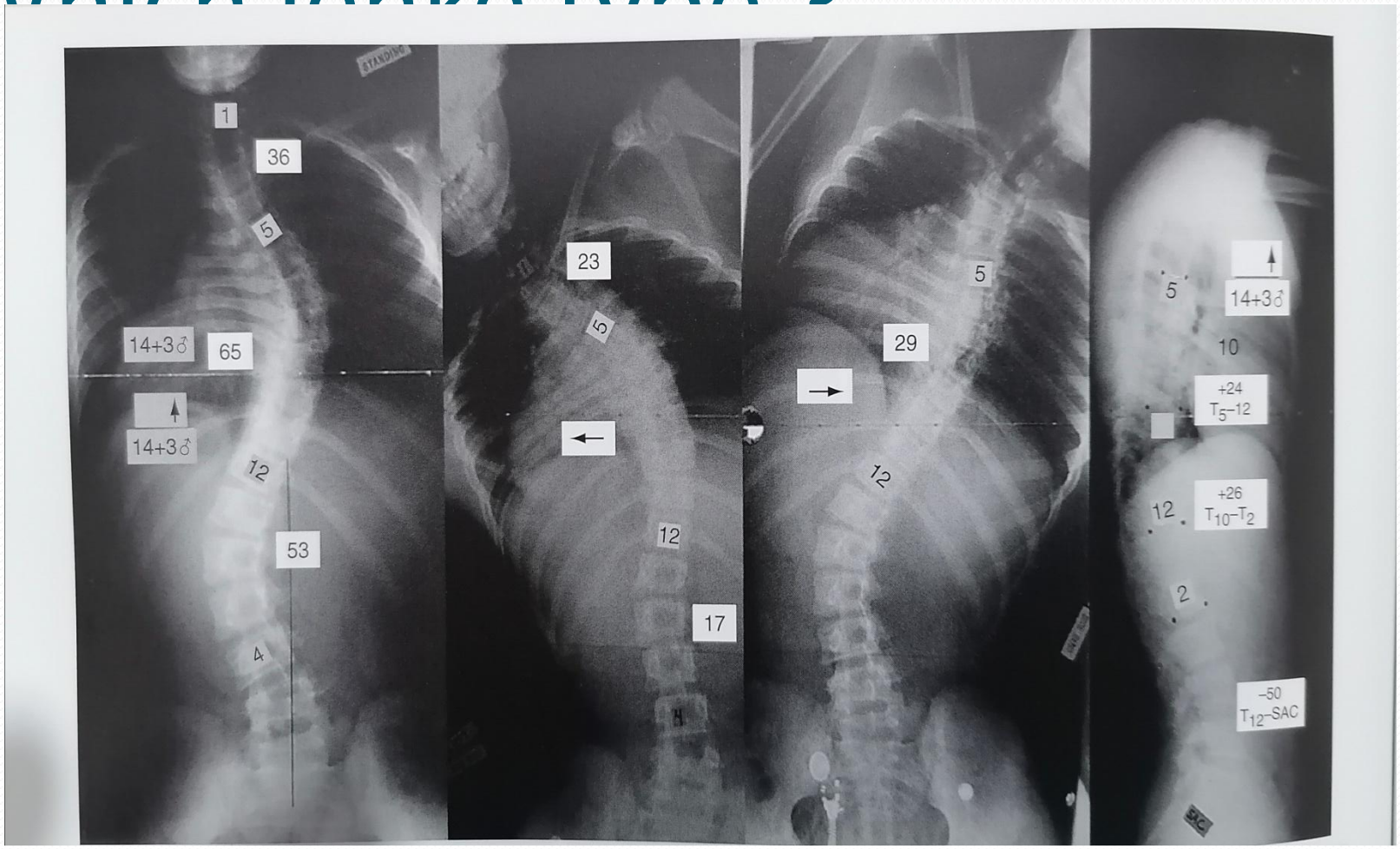
Lumbar spine modifier	CSVL to lumbar apex
A	CSVL between pedicles
B	CSVL touches apical body(ies)
C	CSVL completely medial



Thoracic sagittal profile T5-T12	
– (hypo)	<10°
N (normal)	10°–40°
+ (hyper)	>10°

Curve type (1–6) + lumbar spine modifier (A, B, C) + thoracic sagittal modifier (–, N, +)
Classification (eg, 1B+): _____

Which Lenke type ?

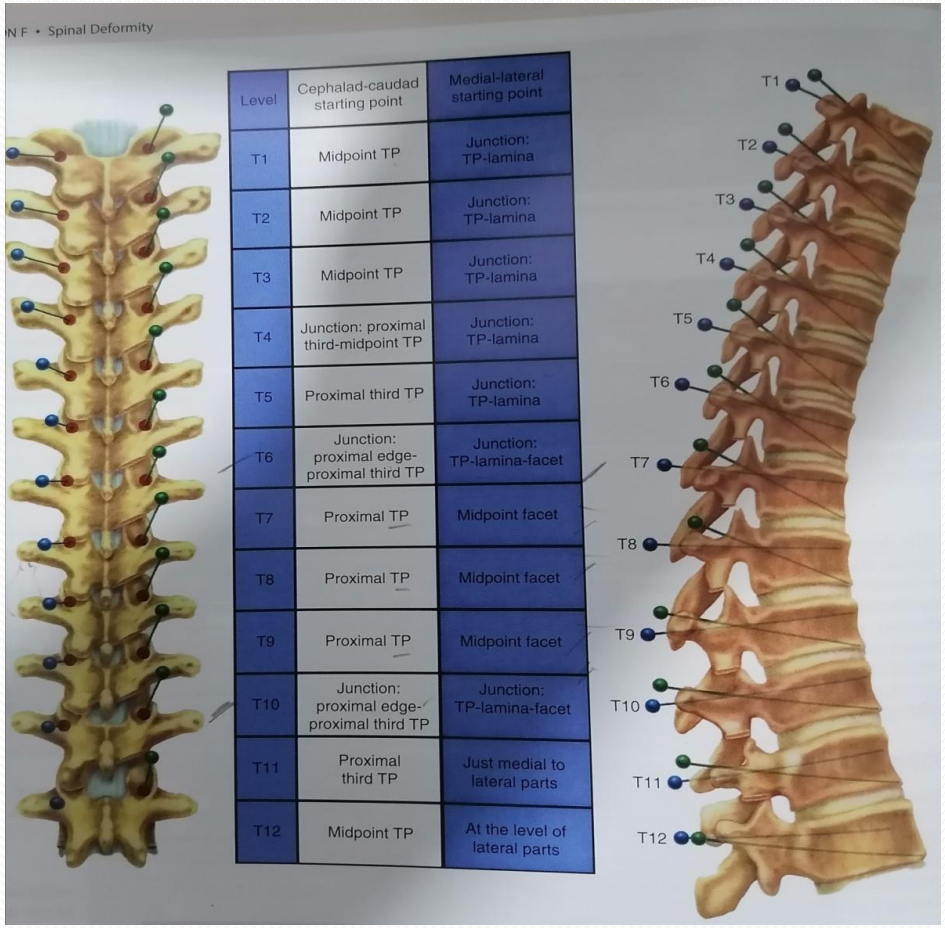


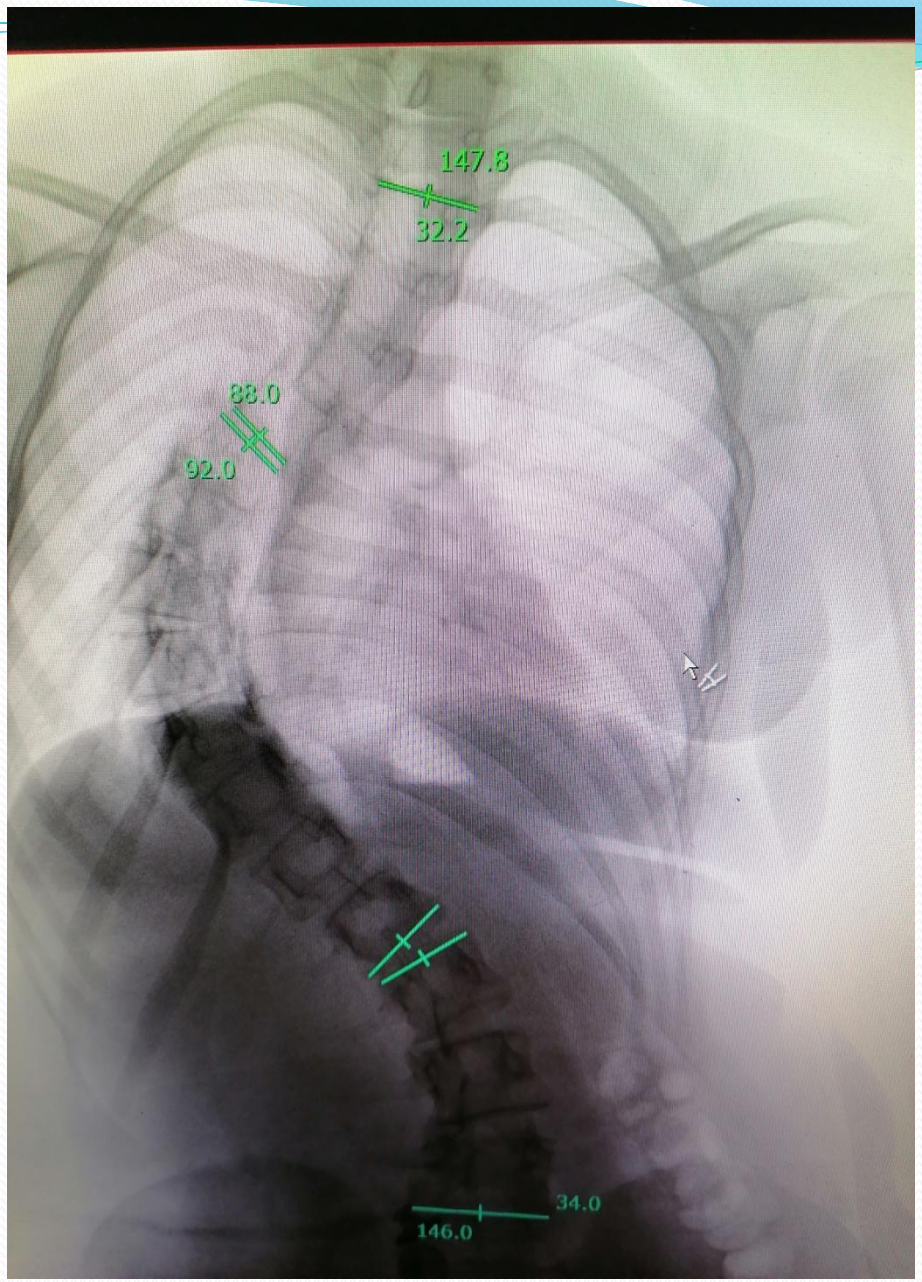
- AS A GENERAL ROLE LENKE SUGGEST INCLUDING THE MAJOR AND THE STRUCTURAL CURVE ONLY IN THE INSTRUMENTATION AND FUSION

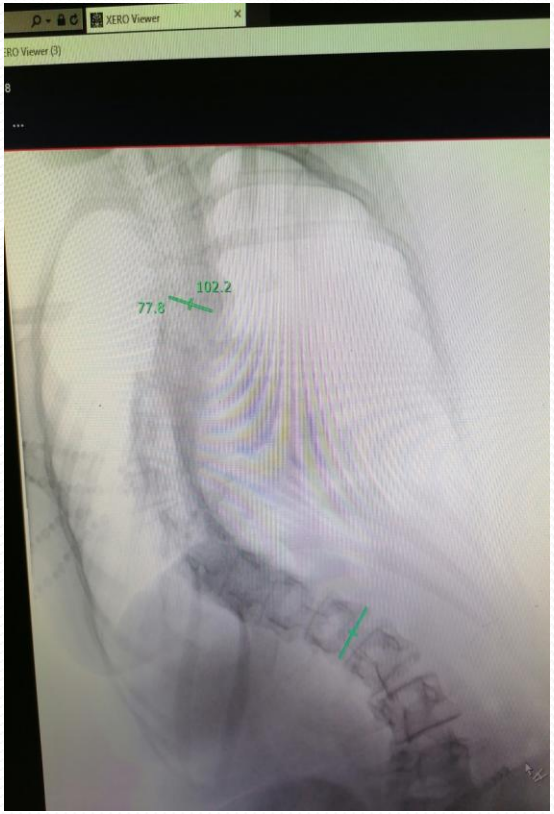
Surgical tech PSSF

- Approach : posterior midline
- Instrument : pedicle screw rod system .
- Posterior mobilization tech (FACETECTOMY,SPO , PONTE O , RIB RESECTION , PSO , VCR).
- Reduction tech : (rod derotation tech , apical translation , compression ,distraction , DVR)
- Fusion principles : (facetectomies , meticulous soft tissue cleaning , decortecation , bone graft)

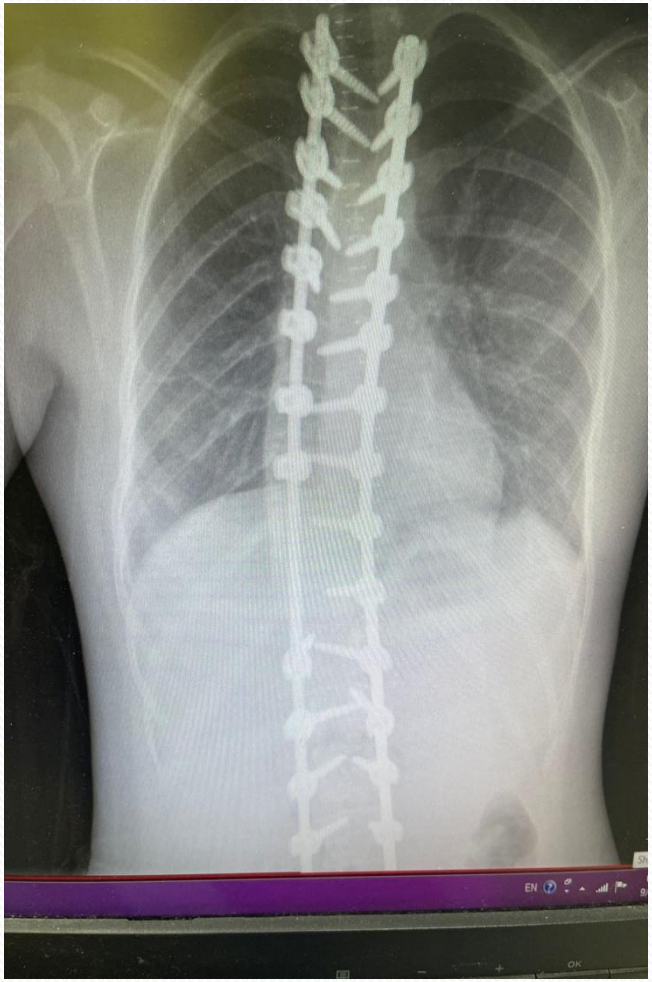
FREE HAND PEDICLE SCREW PLACEMENT



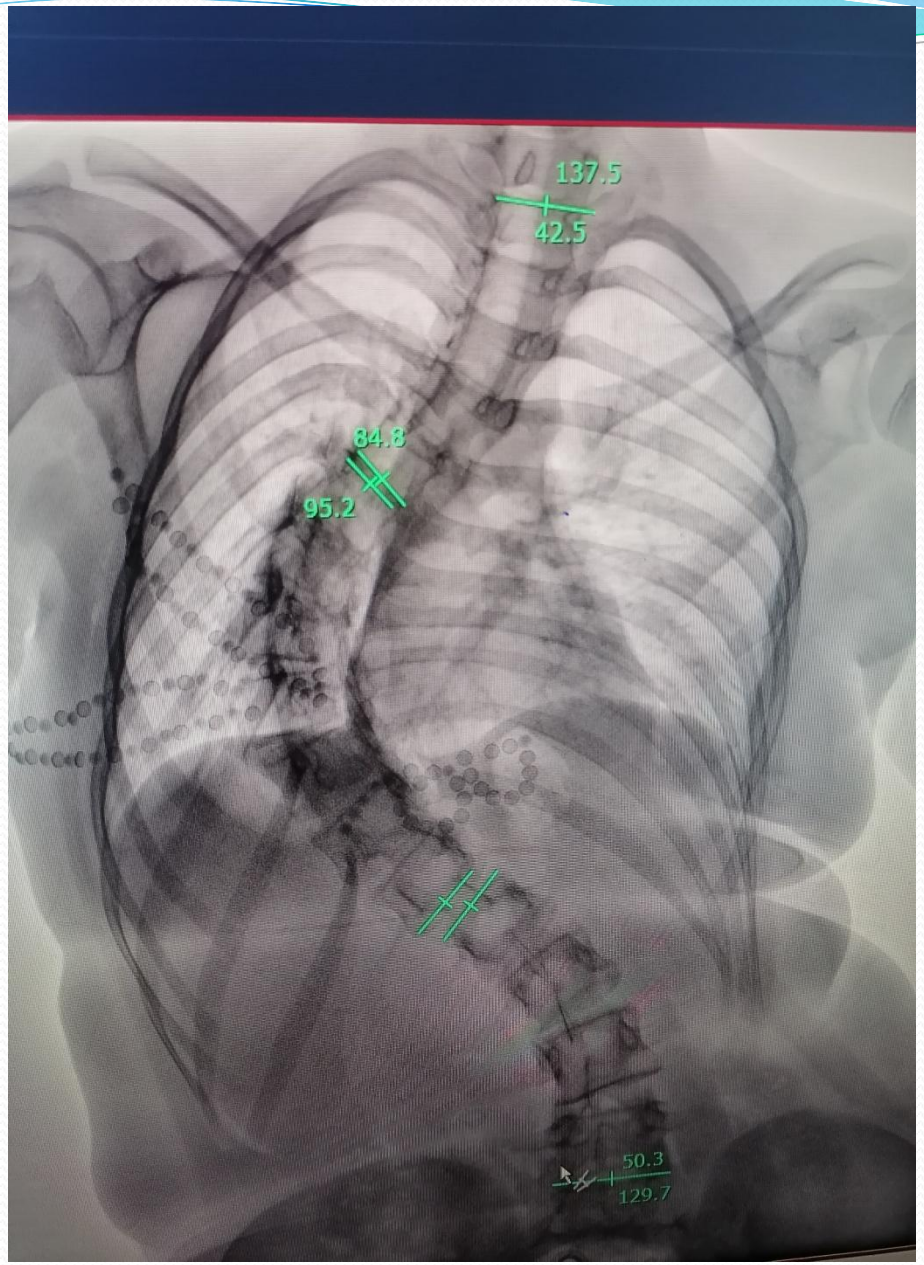

147.8
32.2
88.0
92.0
34.0
146.0

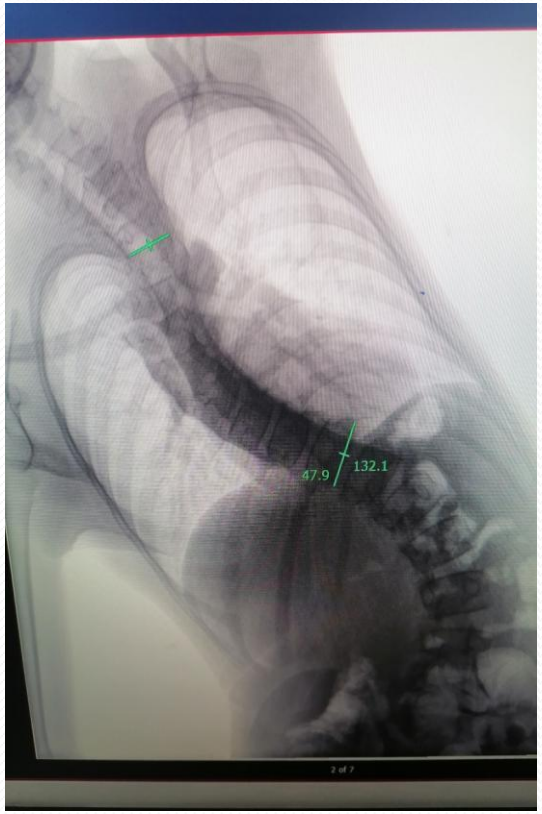

XERO Viewer
77.8
102.2


158.8
21.2
149.1
30.9

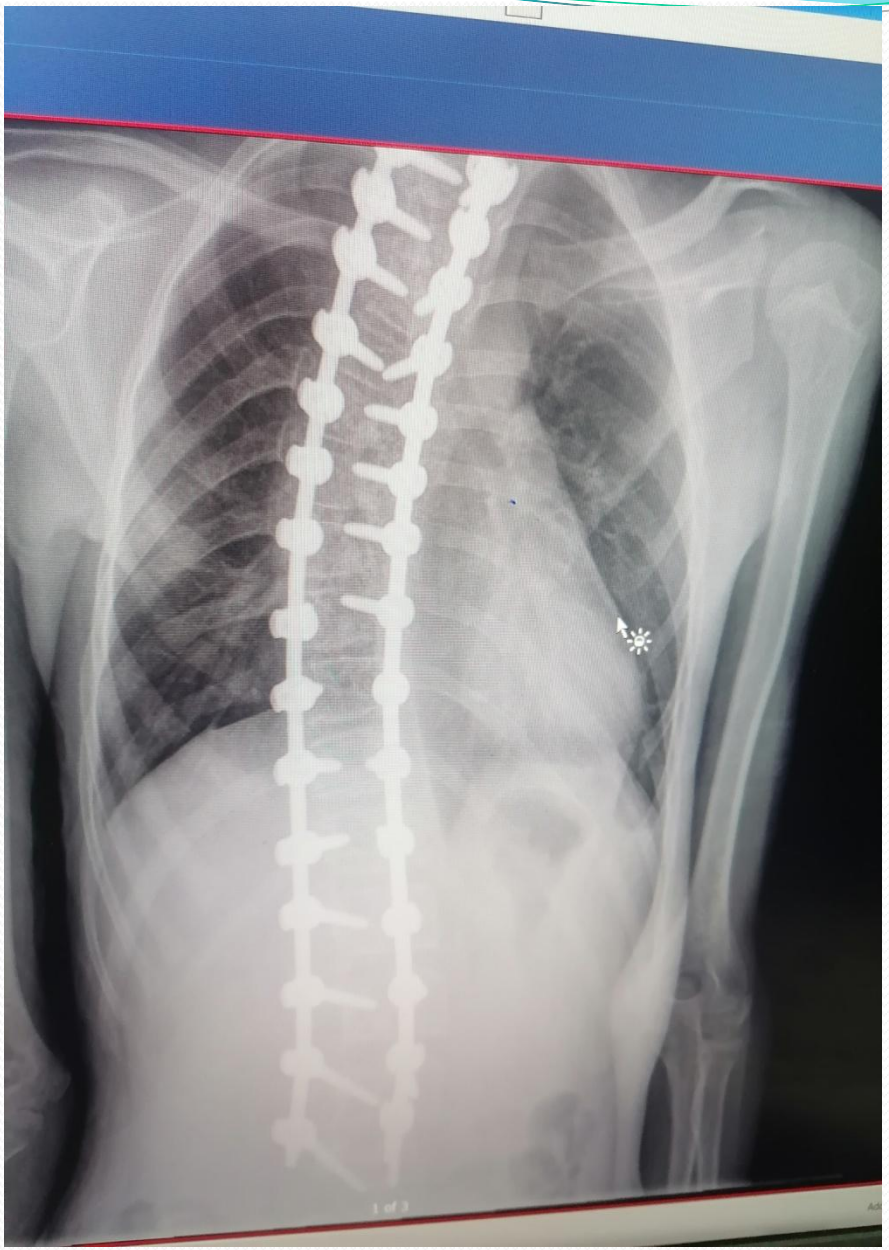



L
lat
3 of 3


137.5
42.5
84.8
95.2
50.3
129.7


47.9
132.1
2 of 7


Viewer
L
Tat
149.4
30.6
153.4
26.6
3 of 7



complication

- Infection
- Neurologic deficit : incidence less than 1%
- Implant related complication : prominence , discomfort , failure .
- pseudoarthosis

Early onset scoliosis (EOS)

- Describe the often sever , complex deformity of the spine and thorax , presenting before 10 years of age , they are unified only in age and in the presence of spinal deformity .
- Accounts for 10% of all pediatric scoliosis cases .

Includes :

1. Infantile & juvenile idiopathic scoliosis .
2. Congenital scoliosis .
3. Neuromuscular scoliosis .
4. scoliosis associated with syndromes (neurofibromatosis , VACTERL , Marfan syndrome ….)

They are grouped together because they share a common management goals which include :

1. Regulating progression of spinal deformity .
2. Maximizing thoracic volume .
3. Optimizing function and health related quality of life .
4. Minimizing complication and negative effects of treatment .

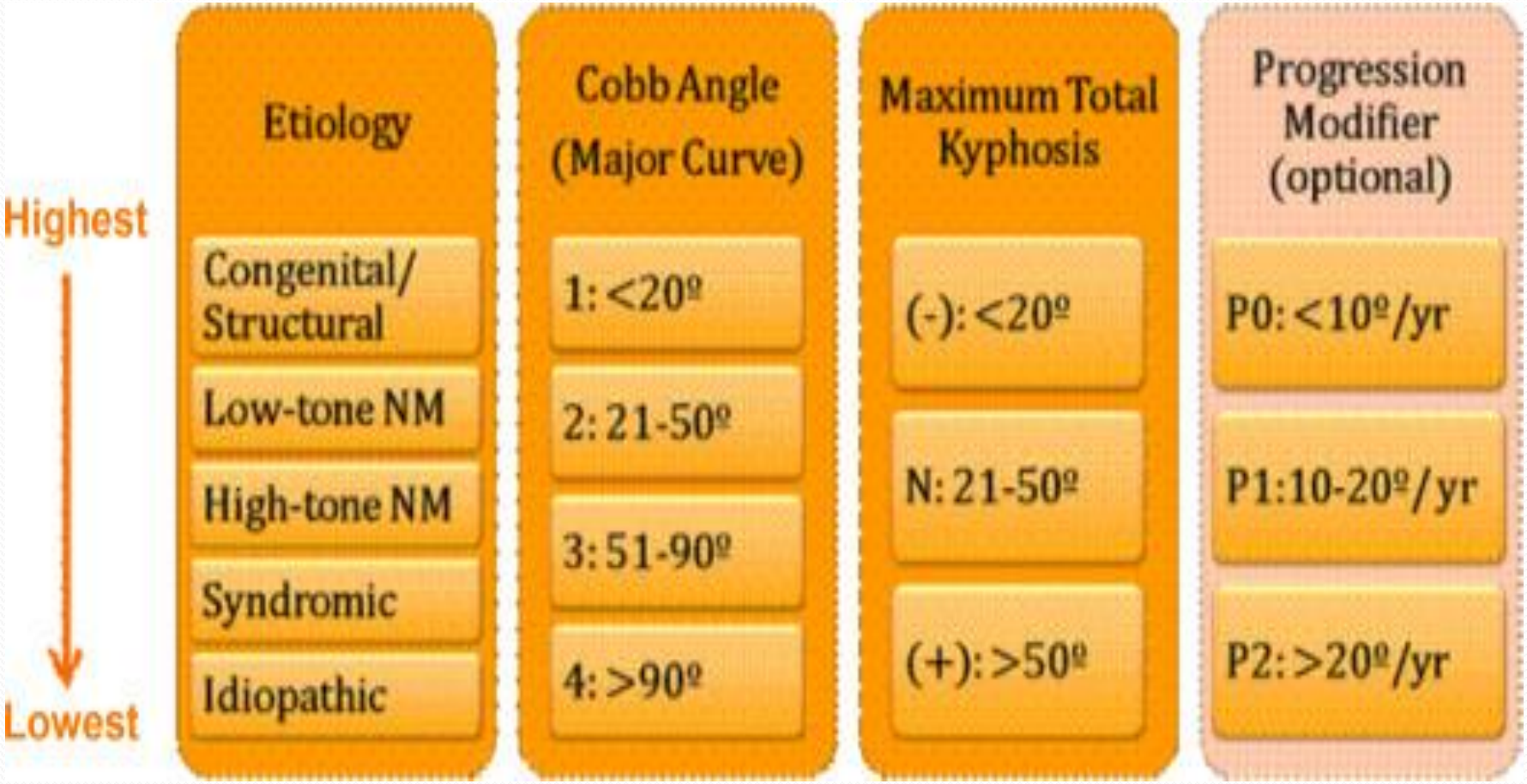
EARLY ONSET SCOLIOSIS

- Because scoliosis develop at early age they are at risk for development of thoracic insufficiency syndrome , defined as inability of the thorax to support normal respiration and lung growth .
- EOS patients are classified as separate group in which emphasis is not on treating the spine only but also maintaining the growth of the thorax to promote increased lung volume throughout the critical first decade of life .
- Furthermore EOS patients have double the mortality rate as in the general population mostly due to respiratory issues .

- The source of the thoracic insufficiency syndrome is :

1. Intrinsic alveolar hypoplasia because the chest deformity prevent hyperplasia of the lung tissue .
2. Extrinsic disturbance of the chest wall function (chest dysfunction) .

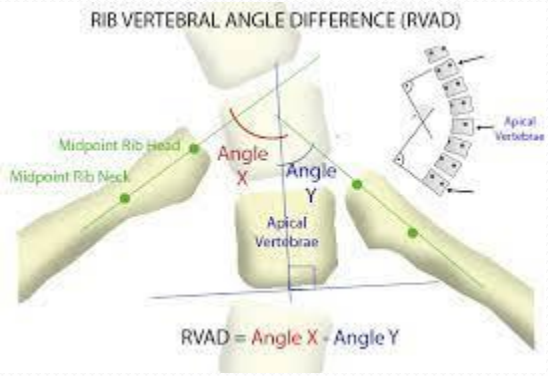
- EFFECT ON RESPIRATORY SYSTEM IS CORRELATED WITH AGE OF ONSET , SEVERITY OF THE DEFORMITY , ASSOCIATED RIB ANOMALIES , PRESENCE OF MUSCLE WEAKNESS .

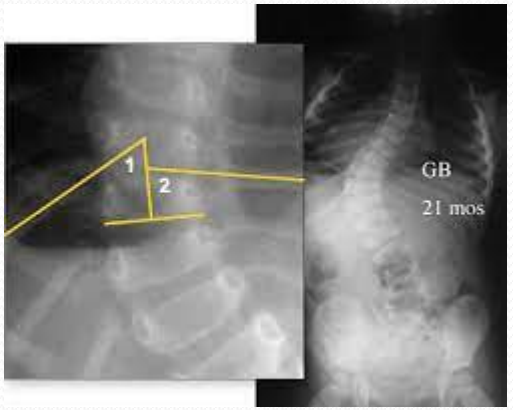

Highest
Lowest
Etiology
Congenital/ Structural
Low-tone NM
High-tone NM
Syndromic
Idiopathic
Cobb Angle (Major Curve)
1: <20º
2: 21-50º
3: 51-90º
4: >90º
Maximum Total Kyphosis
(-): <20º
N: 21-50º
(+): >50º
Progression Modifier (optional)
P0: <10º/yr
P1: 10-20º/yr
P2: >20º/yr

Infantile idiopathic scoliosis

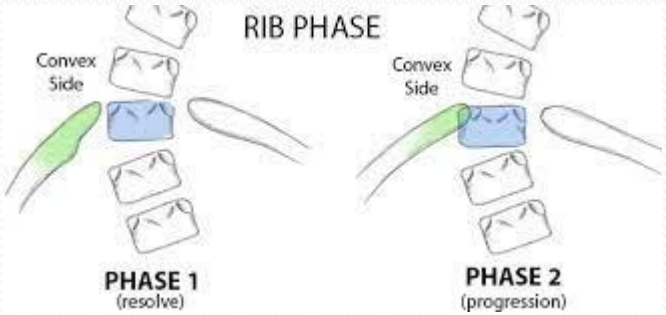
- Less than 1% of idiopathic scoliosis
- More common in boys
- Left thoracic curve more common than RT
- 90% OF CURVE SHOW SPONTANEOUS RESOLUTION
- RVAD and PHASE OF RIB HEAD can predict at risk of progression curve with angls difference more than 20 or phase 2 rib are very likely to progress

RVAD=RVA CONCAVE-RVA CONVEX





IF RIB IS PHASE II NO NEED TO MEASURE RVAD



JUVENIL IDIOPATHIC SCOLIOSIS

- 20 % of idiopathic scoliosis
- More common in female
- Convex right thoracic curve is the commonest pattern
- More likely to progress , less likely to respond to brace treatment and more likely to require surgical treatment than AIS
- NEURAL axis abnormalities is 18% to 26% , most of them are asymptomatic and have no signs of the underlying neural abnormality
- MRI IS RECOMMEDED during the initial evaluation
- RVAD dose not predict curve progression but progressive curves have a steady increase in RVAD ,WHERAS resolving curves have a steady decrease in RVAD .

Congenital scoliosis

- A progressive 3D deformity of the spine caused by congenital anomalies of the vertebra that result in IMBALANCE OF THE LONGITUDINAL GROWTH OF THE SPINE
- 21% TO 37% is the incidence of intraspinal anomalies (tethered cord , diastematomyelia , syringomyelia , intraspinal tumor …….)
- 60% incidence of associated other systems anomalies most commonly genitourinary and cardiac.

classification

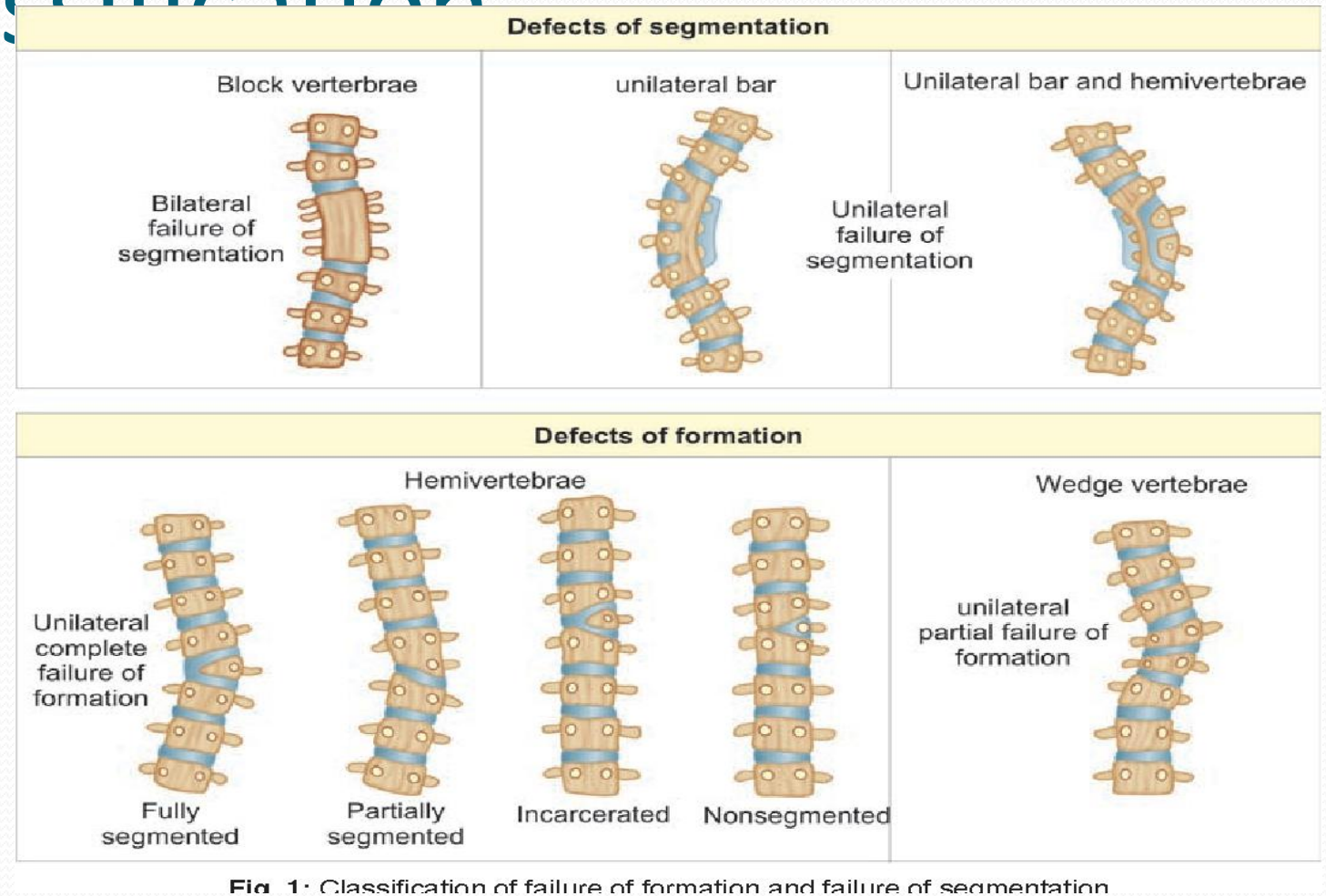
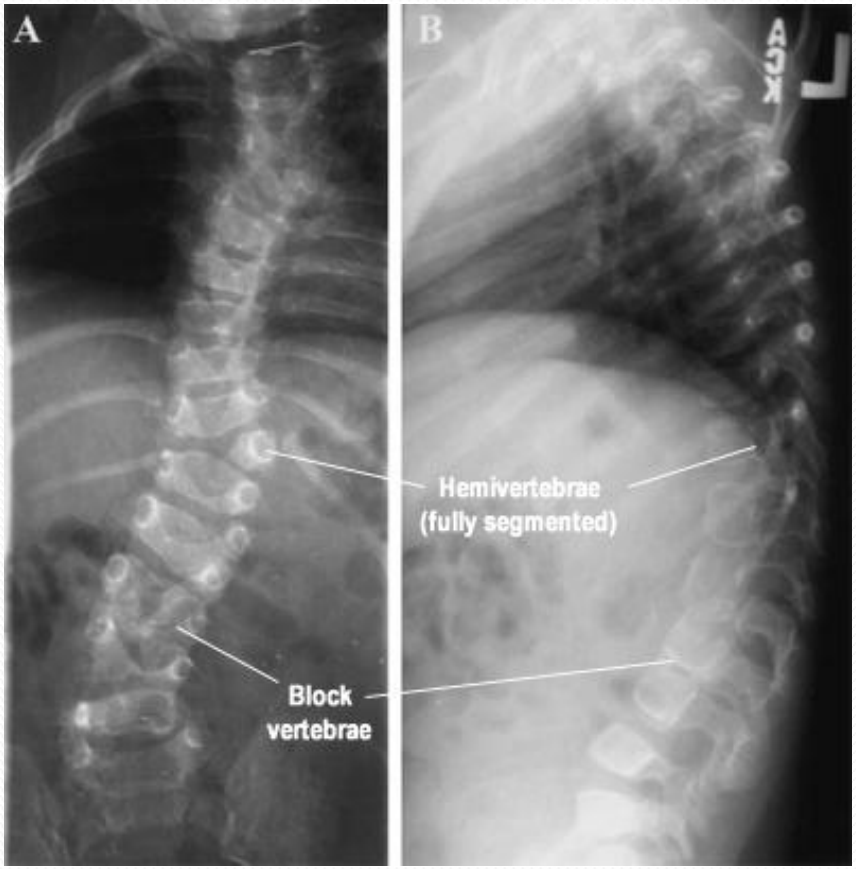
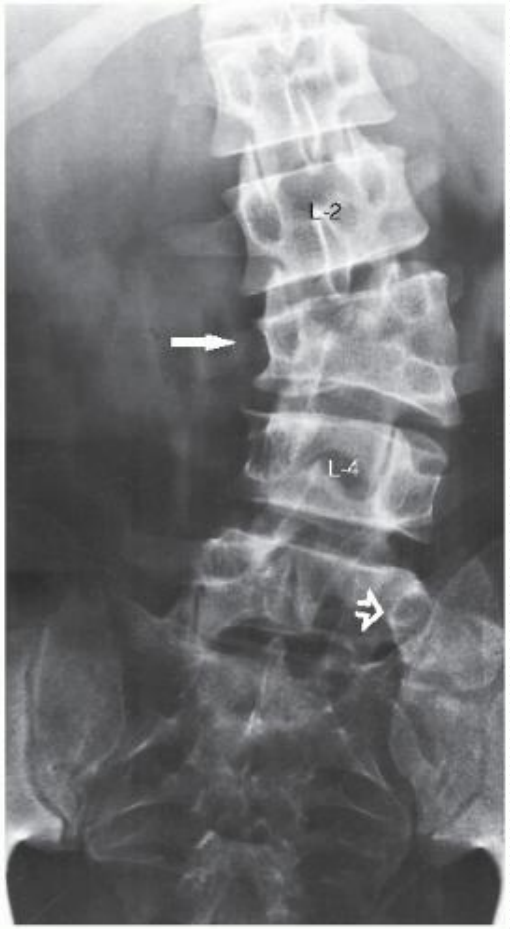
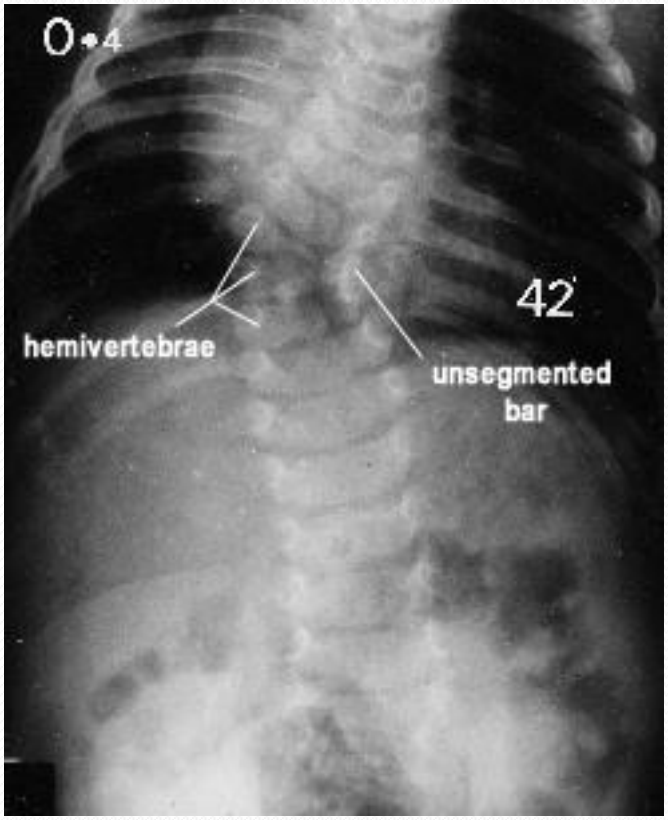
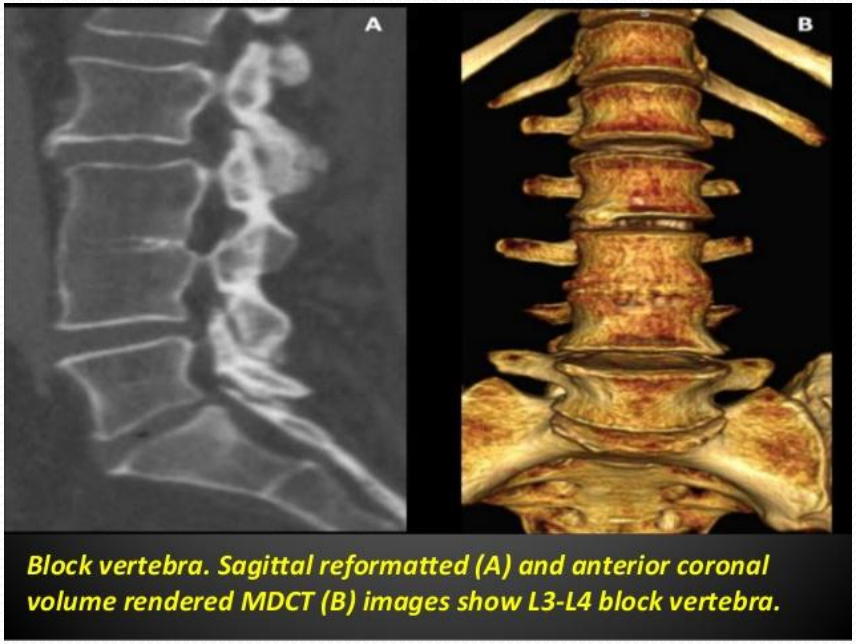


Fig. 1: Classification of failure of formation and failure of segmentation


A
B
Hemivertebrae
(fully segmented)
Block
vertebrae


L-2
L-4





Block vertebra. Sagittal reformatted (A) and anterior coronal volume rendered MDCT (B) images show L3-L4 block vertebra.

Natural history

- The rate of curve progression and the final severity are related to :

1. Type , number , location of vertebral anomalies present .
2. Patients remaining growth at the time of diagnosis (two period of accelerated growth)

- Severe deformities are caused by (in order of decreasing severity) : unilat unsegmented bar with contralateral hemivertebra , isolated unilateral bar , multiple fully segmented hemivertebrae ,single fully segmented hemivertebrae ,

radiograph

- The details of vertebral abnormality are best seen on films obtained before the development of significant deformity _ often during infancy .
- The initial radiograph must serve as the baseline study against which further curve progression is measured .
- CT with 3D is helpful for visualizing of vertebral anomalies and for preoperative planning .
- MRI IS INDICATED during the initial evaluation and for all patients who are undergoing surgical intervention because up to 37% of patients have an intraspinal abnormality .

TREATMENT

1. BRACING is NOT successful in the treatment of congenital scoliotic deformities .
2. Should not be attempted to control curve progression secondary to unsegmented bar and hemivertebra .
3. Operative is the mainstay of treatment .

NEUROMUSCULAR

- Involve neurologic or muscular deficiencies that produce progressive multiplanar spinal deformities .
- these patients have an impaired ability to control the muscle that support the spine .
- They require a multidisciplinary team of doctors and health professionals working together to provide optimal care for them .
- Classification of NMS can be based on the underlying disorder :

1. Neurologic
2. Muscular

- Neuromuscular Condition Incidence of Scoliosis Cerebral palsy (2-limbs involved) 25% Myelodysplasia (lower lumbar) 60% Spinal muscle atrophy 67% Friedreich ataxia 80% Cerebral palsy (4-limbs involved) 80% Duchenne muscular dystrophy 90% Myelodysplasia (thoracic level) 100% Traumatic paralysis (<10 years) 100%

Common feature of NMS include the following :

1. Large curve early in life
2. Stiff curves : because of the early onset of neuromuscular deficiency resulting in limited mobility and secondary contracture .
3. Progressive curves which is greatest during rapid growth and loss of ampulation .
4. Long curves
5. Pelvic obliquity : resulted from lower extremity contracture and imbalanced spinal deformity which may impair comfortable sitting for these patients .
6. Sagittal balance deformity including thoracic and lumber hyperkyphosis or lumber hyperlordosis .

Natural history

- It begins early in life , is rapidly progressive , and cause significant morbidity .
- Some patients are capable of ambulation , although many lose their ability to walk early in life or never achieve ambulatory status at all .
- The use of wheelchair afford these patients educational and social opportunities that enriches their lives .
- Spinal deformity can impair comfortable sitting and dramatically reduce the individual's quality of life .
- Unbalanced curves and significant pelvic obliquity make wheelchair positioning difficult and may cause uneven distribution of weight that may lead to pressure sore .
- There is a correlation between deformity size , functional decline and decubitus .
- Treatment of NMS CAN HELP THE CARETAKERS OF THESE PATIENTS , IMPROVING THE EASE OF TRANSFERE , POSITIONING , FEEDING AND HYGIENE .
- THE ULTIMATE GOAL OF THEIR TREATMENT IS THE MAINTENANCE OF AS MUCH INDEPENDENCE AND FUNCTION AS POSSIBLE .
- The natural history for a given patient is determined by the specific underlying NM condition and the degree of involvement .

Treatment principles

- Observation alone is employed until curves begin to cause functional impairment .
- Bracing is controversial may be used for postural support (to provide sitting support while the patient grows)
- Generally , patients with spastic disorder do not tolerate rigid brace treatment , whereas patients with flaccid paresis are more apt to be compliant with brace treatment .
- Timing of surgical intervention is influenced by curve severity , the underlying pathology , and the curve effect on patient functional status and on pulmonary function .

SURGICAL MANAGEMENT OF EARLY ONSET SCOLIOSIS

Goals

- Control progression of scoliotic curves .
- Maintain spine and chest growth .
- Allowing more normal cardiopulmonary development and function .

Surgical techniques

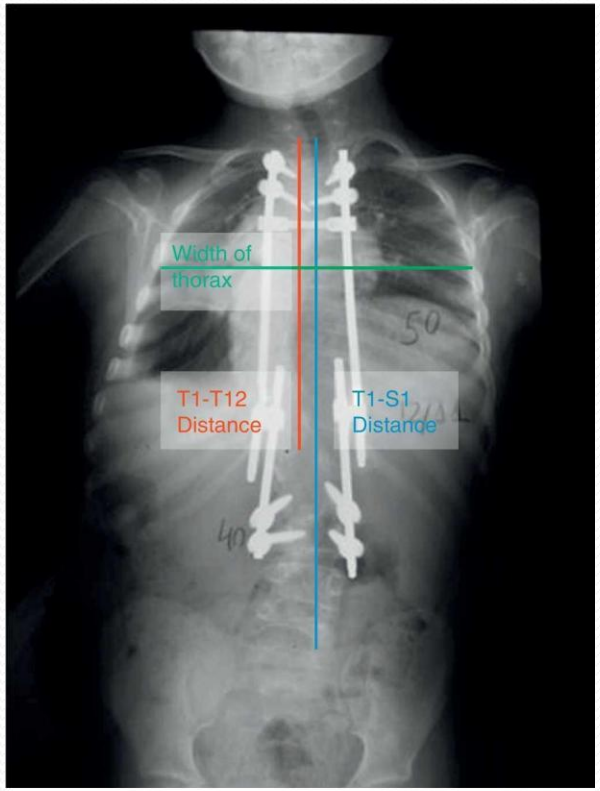
- Distraction technique :

1. Traditional growing rods .
2. Magnetically controlled growing rods {MCGR}
3. VEPTR .

- Growth guided technique .

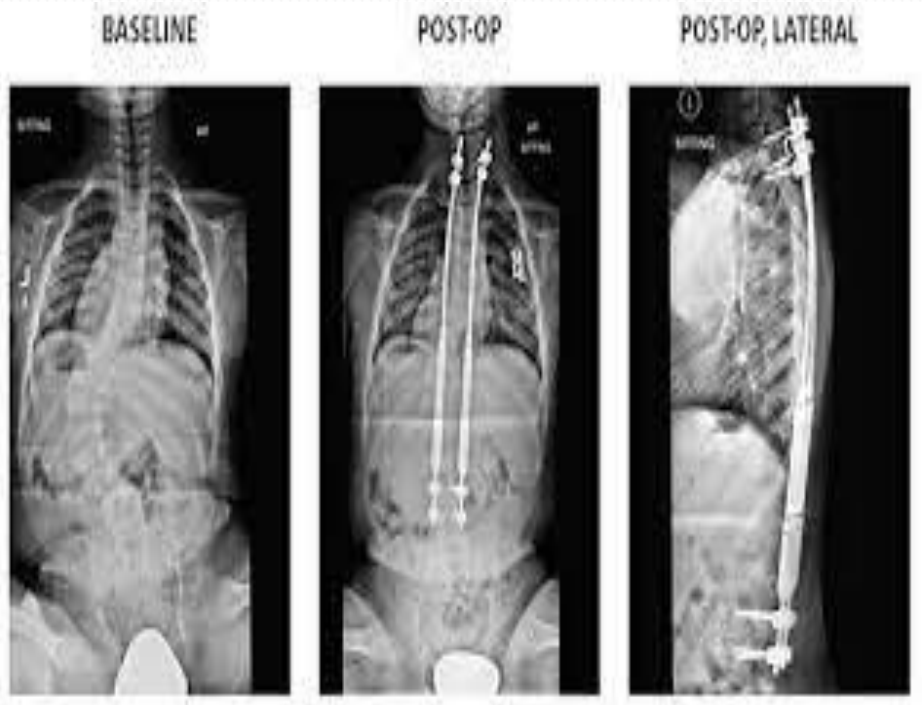
  the shilla procedure

Traditional growing rods

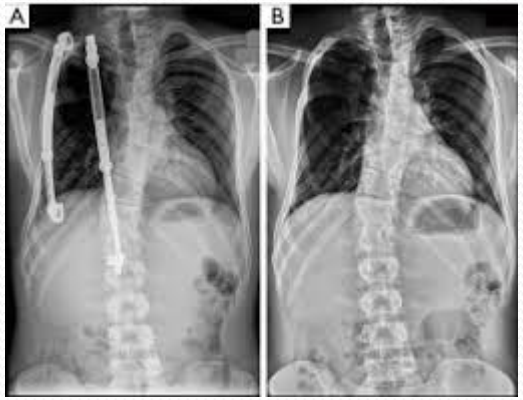


Rev Esp Cir Ortop Traumatol. 2013;57:178–85

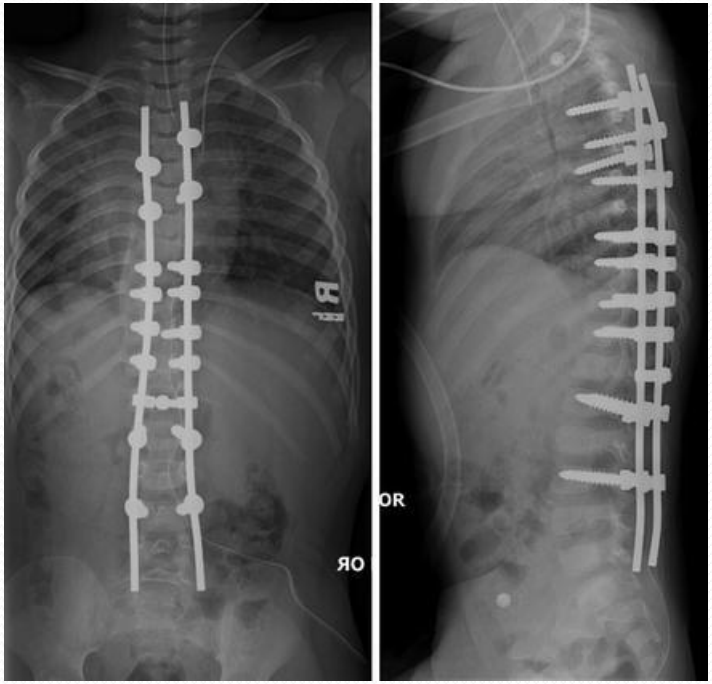
MCGR



VEPTR



Shilla procedure



thank you