

## SCOLIOSIS

Lateral curvature of the spine with a rotatory component of the vertebrae (Vertebral body rotated towards the convexity). Adolescent scoliosis is common and it usually present at or about the onset of puberty.

### International scoliosis classification

- |                          |   |
|--------------------------|---|
| 1 <b>Idiopathic:</b>     | Infantile, Juvenile, Adolescent, Adult  |
| 2. <b>Neuropathic</b>    | Cerebral palsy, myelomeningocele,, Polio, Spinocerebellar degeneration, cord tumor, cord trauma, spinal atrophy                   |
| 3. <b>Myopathic</b>      | Muscular dystrophies (Duchenne, Limb-Girdle, FSH), Arthrogryphosis, Congenital hypotonia, myotonia dystrophica                    |
| 4. <b>Congenital</b>     | Failure of Formation – Hemivertebra, Failure of Segmentation bar, Mixed [failure to form or segment]                              |
| 5. <b>Bone Dysplasia</b> | Achondroplasia, spondyloepiphyseal dysplasia, diastrophic dwarfism, Morquio's syndrome Metabolic Rickets, Osteogenesis imperfecta |
| 6. <b>Miscellaneous</b>  | Neurofibromatosis, Marfans syndrome, Homocystenuria, Ehlers-Danlos syndrome   |

### Etiology for Idiopathic scoliosis

#### 1. Endocrine system

Patients with idiopathic scoliosis often taller. Studies on somatomedin (Insulin like GH) levels conflicting but significant differences found.

#### 2. Postural equilibrium

Abnormalities in the vestibular system in the brain stem in scoliosis have been demonstrated.

**3. Neurotransmitter** - Scoliosis experimentally produced by removing pineal gland in chickens. No specific neurotransmitter defect identified. ?Melatonin

**4.Genetics** - Increased incidence in affected relatives found. Mother and father - 80%, Mother and sister - 20%, Mother - 10%, Sister - 3%. Indicative of multifactorial mode of inheritance.

### **Pathogenesis**

Lordosis may be the biomechanical initiator of deformity.

Thoracic lordosis lies in front of normal axis of rotation. This causes rotation of lordotic section in flexion.

Changes of vertebral shape are effects secondary to rotation of lordosis [Dickson]

### **Natural history of untreated scoliosis**

Back pain	56%
Progression	15%
Cosmetic	12%
Unmarried	63%
Pulmonary function	
FVC	Nil with curve < 60° 30% with curve 60-100 ° 50% with curve > 100 °
Psychosocial	Cause psychosocial problems
Mortality	Comparable to normal population

### **History**

**Deformity:** Onset and progress

**Pain:** Dull ache, Relation to Posture or activity

**Neurology:** usually normal [exceptions: neurofibromatosis]

**Growth spurt:** Onset of menarche means approximately 2/3 rd of the adolescent growth spurt has been completed

### **Previous treatment**

### **Family history**

## Epidemiology [Cobb Angle Prevalence]

>10°	3%
>20°	0.3%
>30°	0.1%
>40°	<0.1%

<b>Sex</b>	>10° of deformity	F:M =3.6:1
	> 30° of deformity	F:M = 10:1

(With increasing curve severity there is an increasing female predominance.)

### 1. Is the curvature Structural or nonstructural

	Structural	Nonstructural
Curve is	Fixed curve	Flexible
Bony changes	Yes	No
Curve Disappears on forward flexion	No	Yes
Progresses	Yes	No

### 2. Standing, sitting Height

### 3. Inspection Front, lateral, Back

Look for asymmetry

Comment on shoulder level

Distance from arm to the trunk

Pelvic tilt

Skin lesion (Café au lait spots, Lipoma, tuft of hair, soft tissue swellings), scars,

Muscle wasting

### 4. Adam's test

The right scapula is more prominent "Rib Hump"

Method: The patient bend forward with feet together and the knees straight. The patient's arms are dependent and the hands are held with the palms opposed.



## **Scoliometer**

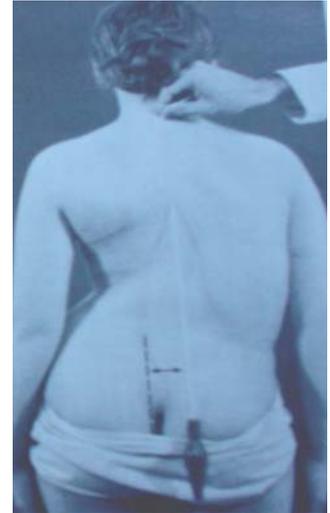
Measures spinal rotation in scoliosis.

Good for screening.

More than 7° of rotation (corresponds to 20° of coronal curvature) should be referred.

## **5. Compensated or decompensated curve**

A plumb line is dropped from C7 spinous process passes through the gluteal cleft



## **6. Maturity Assessment**

### **A. Breast Grading (Tanner system)**

I Elevation of papilla only

II Breast bud stage (small mound)

III Further enlargement of II

IV Projection of areola to form a secondary mound above the level of breast

V Projection of papilla only due to recession of the areola to the breast

### **B. Pubic hair stage**

I Preadolescent; no pubic hair

II Slight growth of long, slightly pigmented hair along the labia

III Darker, coarser hair over the pubis

IV Hair is adult type with no spread to medial spread of the thighs

V Spread to the medial side of the thigh

## 7. Curve Flexibility

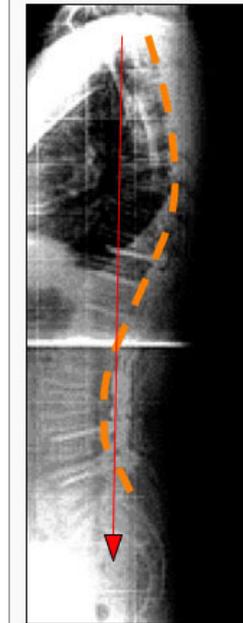
1. Lateral bending, scoliosis disappears
2. In children: suspend the patient with the head



## Radiological Examination

### 1. Normal

Cervical	30° of lordosis
Thoracic	20-40° of Kyphosis
Lumbar	40° of Lordosis
Sacral	Kyphosis



### The normal sagittal profile

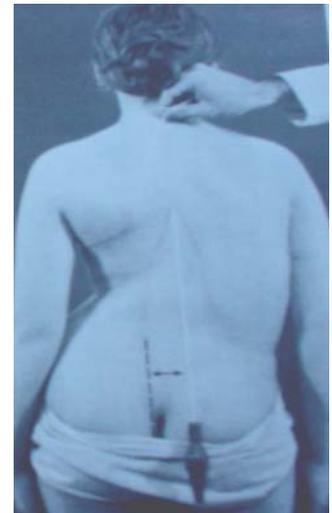
The normal profile shows a harmonic lumbar and thoracic curve. The plumb line of C7 falls on the end plate of S1.

### 2. Sagittal alignment

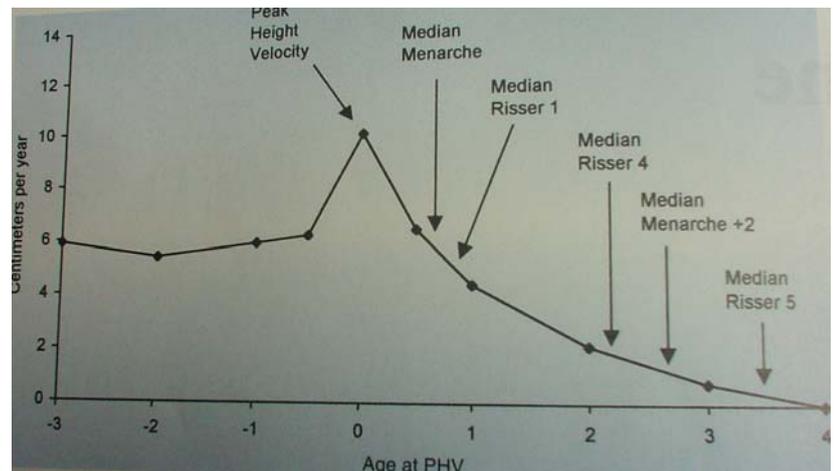
- Clinical : Ear lobe to the highest point of the iliac crest
- X ray: C7 to 2 cm from front of S1 and 5 cm from front of S2

### Coronal alignment

Plumb line from the C7 spinous process to the natal cleft.



### 3. Assess puberty



### 4. Look for spondylolisthesis

Congenital spinal deformity

Any dysmorphic features of Neurofibromatosis

### 5. Define the scoliosis [Discussed under classification]

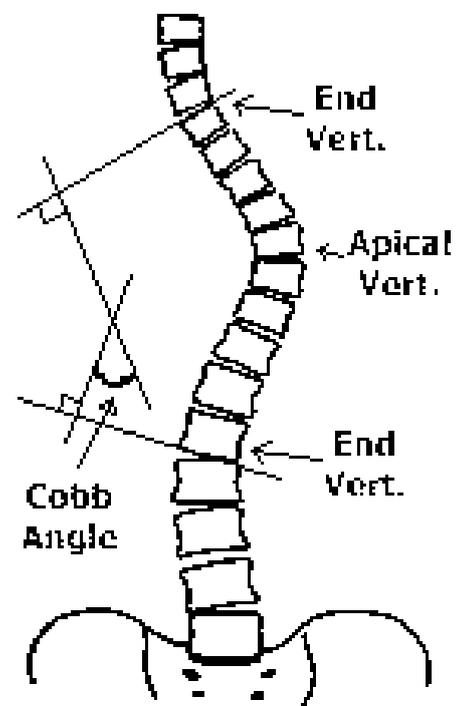
a. Anteroposterior view [long films, PA, Standing]

#### Cobb Method of assessment

End vertebra : Those tilted maximally at the top and bottom

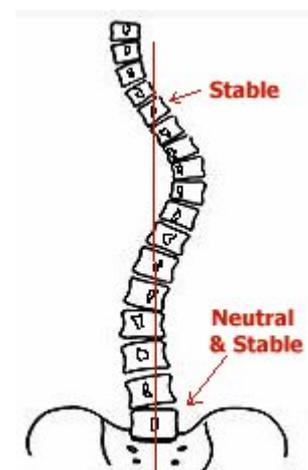
Line from the upper end plate upper vertebra and lower vertebra

The perpendicular lines drawn to these lines and the angle of the intercept is the angle of scoliosis.



#### Neutral vertebra or stable

The vertebrae which are bisected by a midsacral line is bisected by mid-sacral line and a neutral Vertebra is one where both pedicles equally visible.



### Apical vertebra

The vertebra at the centre of the curve is the apical vertebra.

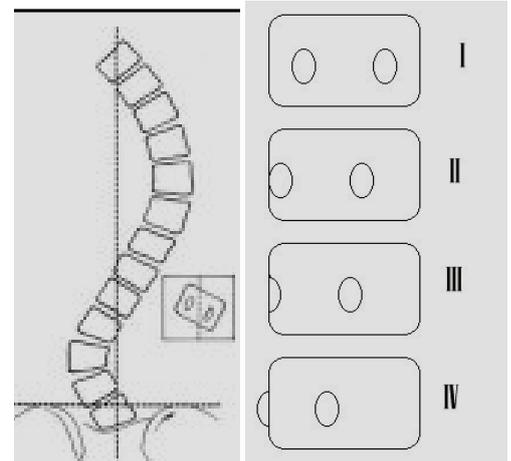
It is the most deviated and rotated vertebra in the curve.

In future, measurement should always be from same vertebrae.

### Assessment of rotation of the vertebra [Mohr's]

Look at the pedicle

See whether it is symmetrical: indication for rotation



### Risser's Sign

Extent of the apophysis of the iliac crest

The lower the Risser grade [I,II] at curve detection, the greater the risk of progression.

IV and V: not much spinal growth left and surgery can be done



### b. Lateral view

In scoliosis commonly hypokyphosis in the sagittal plane (exception is neurofibromatosis in which kyphoscoliosis is seen)

There is high incidence of Spondylolisthesis or lysis in patient with scoliosis.

### c. Side bending view

Supine right and left side-bending films demonstrate curve flexibility and give a good indication of the amount of correction that can be anticipated from surgery.

In severe deformities, bending films help in deciding whether to perform anterior procedures. For patients with severe rigid curves, it may be desirable to consider anterior releases or wedge resection before the posterior procedure.

## **MRI**

- Indicated:
1. Juvenile scoliosis
  2. Abnormal curve [left sided idiopathic thoracic spine]
  3. Sudden increase in growth
  4. Presence of any neurology
  5. Excessive Kyphosis

Some surgeons routinely get MRI prior to surgery

**CT-Myelography** Abnormal neurology but normal MRI

CT Myelogram to rule out spinal dysraphism

## **School screening [Scoliometer]**

Incidence of scoliosis of  $10^\circ$  is 2%

For curve

$>10^\circ$ : F:M 1.4:1

$>20^\circ$  F:M 4:1

$>30^\circ$  F:M 10:1

5% needed brace

0.1% needed surgery

## **Types of Scoliosis**

### **I Thoracic Scoliosis**

90% right convexity

Average 6 vertebrae

Apex T8, T9

Upper end vertebrae T5, T6

Lower end vertebrae T11, T12



### **II Lumbar Scoliosis**

70% left convexity

Average 5 vertebrae

Apex L1, L2

Upper vertebra T11, T12

Lower vertebra L3, L4



### **III Thoracolumbar**

80% right convexity

Average 6-8 vertebrae

Apex T11, T12

Upper vertebrae T6, T7

Lower vertebrae L1, L2



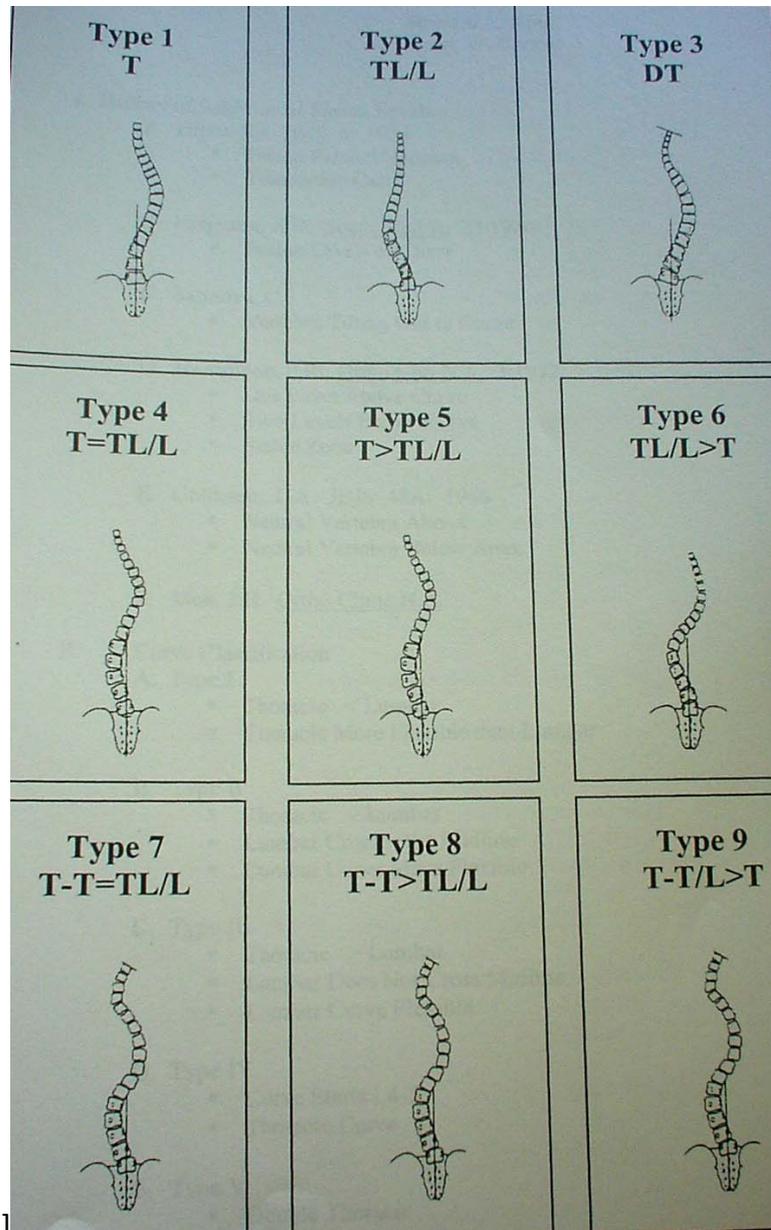
### **IV Double**

90% R thoracic and left lumbar

Thoracic: Apex T7

Lumbar: Apex L2

## Types of adolescent idiopathic scoliosis Linke



### Curve Progression

- |                     |  |
|---------------------|--|
| I. Curve Pattern    | Thoracic curve worse than lumbar spine                     |
| II Double or single | Double curve more than single curve.                       |
| III Riser's sign    | At presentation, Risser's 1 or 2, high risk of progression |
| IV Age              | <10 yrs progression is more than those over 10 years       |
| V Menarche          | Curve detected before menarche progression is higher       |

IV Curve Magnitude	The larger the initial curvature, [ $>50^\circ$ ] more the chance of progression
IV Sex	The risk for curve progression is 10 fold higher in females compared to males.
VI Braced or not	When curve is $>30^\circ$ , only 20% in braced progressed compared to 67% who were unbraced.

### **Magnitude of Curve progression**

Curves $30^\circ$ to $50^\circ$	7-10 years	$3^\circ$ /year
	10-14 years	$12^\circ$ /year
Curves over $50^\circ$	$2^\circ$ /year[after maturity]	

Spine stops growing: 14 yrs for females and 16 yrs for males

### **Treatment**

#### **1. Bracing**

Indicated when the curve is between  $30^\circ$  to  $40^\circ$  or when curve is  $20^\circ$  with rapid progression [ $10^\circ$ /year]

2 types: Milwaukee brace for the curve above T7

Boston brace for the curve below T7 (Apical)

Bracing may help to halt or slow curve progression.

May achieve 50% correction

Disadvantages:

Should be worn 23 hours day.

At least 50% of correction is lost when brace is weaned

Compliance is a problem

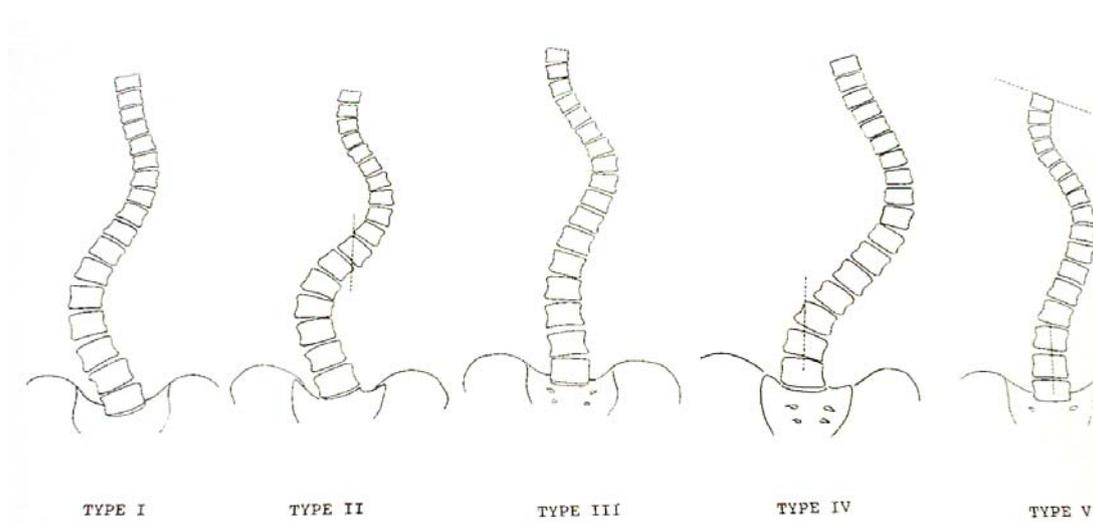
## 2. Surgical treatment

Indication

> 50°	Surgery (Mature or immature) untreated progression 2°/yr
40° - 50°	Gray zone and individualized
30° - 40°	Immature spine Brace treatment and mature spine leave it along
20° - 30°	Immature, Observe [6 monthly] and mature discharge.

### KING( Selection of fusion levels in a thoracic idiopathic scoliosis.

I Lumbar curve more than thoracic	10%
II Thoracic curve more than lumbar	33%
III Thoracic curve only	33%
IV Long thoracic curve	10%
V Double Thoracic curve	10%



### Principle of surgery

1. Pre-operative assessment, consider patients height, nutrition
2. Define the curve and rule out spinal dysraphism [MRI]
3. Major surgery and needs expertise, ICU care
4. Fusion: present trend is fuse less. Avoid fusing distal to second lumbar vertebra
5. Anterior fusion is preferred as fusion area is smaller than posterior approach

6. In severe cases, need anterior and posterior fusion
7. In addition to Posterolateral fusion, instrumentation of the spine is required
8. When significant rib hump is present, requires costectomy
9. Goal is to achieve sagittal and coronal balance and prevent progression of the curve

### **Selection of spinal fusion**

**1. Harrington's Criteria:** From upper neutral vertebra to lower stable vertebra.

### **2. King's criteria for fusion depending on type of curves**

Type I curves are managed by fusion to L-4.

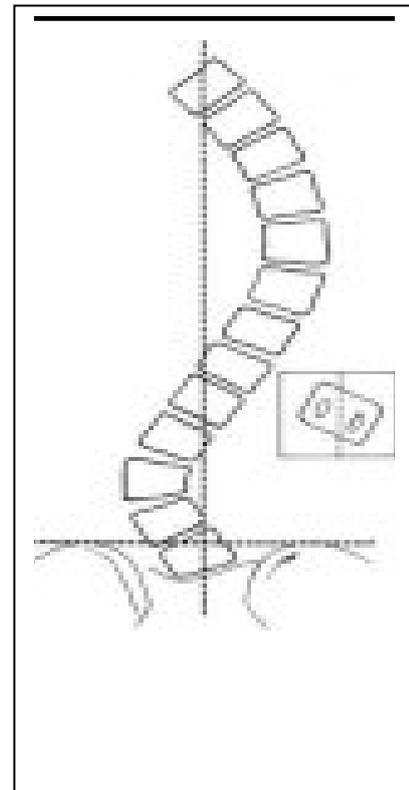
In curve types II through V, a selective thoracic fusion

Present Trend with newer instrumentation

Less fusion to preserve mobility and minimize low backache

A vertical line is then drawn perpendicular to the pelvic line centered on the sacrum. The lowest vertebra most closely bisected by this line is called the stable vertebra).

Ending the fusion at the stable vertebra gives uniformly good results.



When the fusion falls short of the stable vertebra, the curves tend to progress.

Fusing beyond the stable vertebrae, especially in type II curves, tends to aggravate the lumbar curve and also removes additional valuable motion segments.

**Fixation**

I. Historical

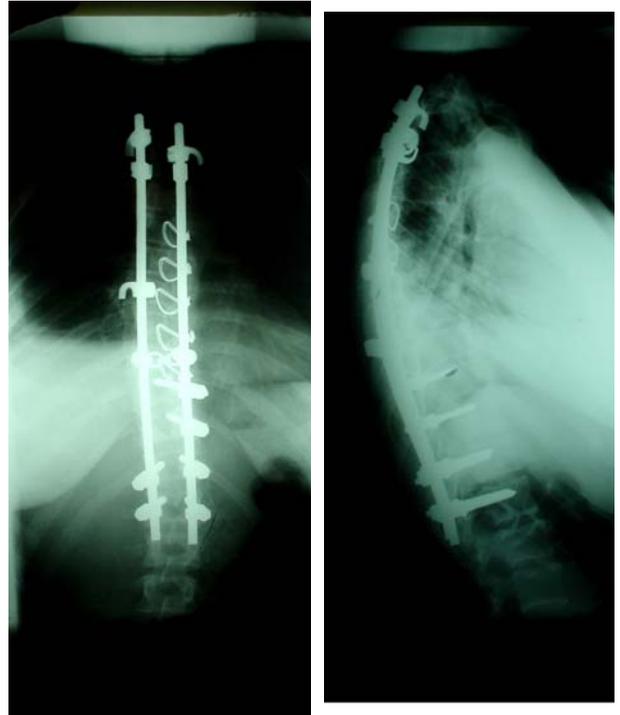
- Harrington Rod system
- Luque sublaminar fixation
- Wisconsin instrumentation

II. Newer Fixation

- Texas Scottish Rite hospital
- Cotrel Dubousset Horizon
- Moss Miami
- ISOLA

Idiopathic scoliosis is a 3 dimensional deformity

- Coronal angulation of the vertebra
- Torsion
- Apex vertebral lateral translation



3 deformities can be corrected by 2 newer fixation

- CD system: “Rod rotation maneuver”
- ISOLA: “Translation technique”

Cotrel Debousset	ISOLA
“Rod rotation maneuver”	“Translation technique”
Multiple hooks: Pedicle, Laminar (Supra/Infra), Transverse	Hooks, Sublaminar wires, Pedicular system
Principle load: borne by multiple vertebra: end vertebrae, apical, intermediate	Principle load by mainly apical vertebrae rather than end vertebrae

### **Ideal radiological correction**

1. Well centered fusion mass with the appropriate fusion levels
2. Lowest fusion vertebra should be the stable vertebra. [not in a case of selective fusion as suggested by King's criteria]
3. Upper most vertebra in fusion should have neutral to rotation.
4. Sagittal alignment is Lordosis at lumbar region, Kyphosis at the Thoracic and slightly lordotic Thoracolumbar region

### **Rib osteotomy (Thoracoplasty)**

Posterior angle 8-10 ribs (rib hump)

Exposed lateral to the erector muscle, subperiosteal and osteotomised.

Thoracoplasty may compromise pulmonary function and need an intercostals drain

### **Anterior surgery**

Indicated: In congenital scoliosis

Used by some surgeons routinely for adolescent scoliosis

> 75° in Female

Dwyer system was first system used.

Zielke system

Miami system

#### Advantages

Better correction with a shorter fusion level

Reduce the incidence of proximal junctional Kyphosis

Reduce implant prominence

Reduce denervation of posterior spinal muscle

#### Disadvantages

Negative effect on Pulmonary function with trauma to diaphragm

Longer paralytic ileus

Incidence of Pseudarthrosis is not well reported

## Combined approach

1. Surgery in Adults for scoliosis and is rarely in Idiopathic scoliosis [ $>70^\circ$  and rigid]
2. Congenital scoliosis
3. Scoliosis surgery: in immature patients (to prevent crankshaft effect)

## Complications

### 1. Neurologic deficit. To avoid use:

1. Intra-operative monitoring (SSEP);
2. Stagnara's wake up test
3. Clonus test

When neurology is recognized, undo the correction

### 2. Wound infection (1-2%)

### 3. Pneumothorax

### 4. Dural tear

### 5. Inappropriate ADH secretion

### 6. Implant failure

### 7. Flat back syndrome: Early fatigability and pain due to loss of lumbar lordosis (Minimized by rod contouring)

### 8..Pseudarthrosis - Solid fusion should occur by 6 months. Occurs 1-2%

### 9. Back pain - Appears to be due to Fusion below L4 , Loss of lumbar lordosis:

### 10.Crankshaft phenomenon: Immature patient with scoliosis after posterior fusion. (due to increase anterior growth)

## CONGENITAL SCOLIOSIS

Can progress rapidly

Incarcerated

Non-incarcerated

### Classification [Winter]

I Failure to develop:

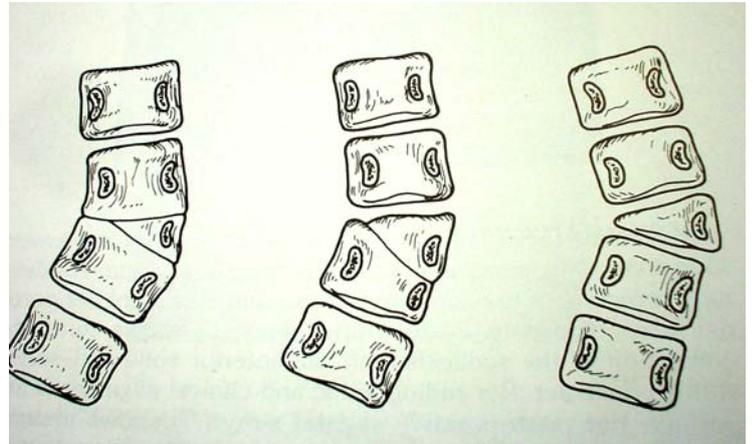
Hemivertebra

Fully segmented [nonincarcerated]

Partial segmented

Nonsegmented

II Failure of segmentation: Bar



III Combination: Wedge and Bar

### Worst combination:

Bar on one side and Nonincarcerated wedge on other side



### Assessment

Progress of the curve: 1. Bar with nonincarcerated has worst curve progression

2. Site: Thoracic and thoracolumbar have worse prognosis

3. Age of Presentation: young patient have worse

### Problems

1. Rapid deterioration of the curve requiring early surgery

2. Very rigid curve makes surgery technically difficult

3. Spinal cord anomalies is very often associated

GUT, KFS 25%

Heart disorder 10%

## **MRI**

Always indicated

Any other congenital problems [MRI]

40% intraspinal abnormalities: Spinal dysraphism, Syringomyelia, Low lying conus

## **Treatment**

1. Bracing as little roll
2. Once diagnosed, assess curve progression by follow up: every 4 months
3. Anterior and posterior surgery early

Hemiephyseodesis is ideally done at 5 yrs when curve is over 40°. The graft is placed at the convex side both anterior and posterior.

Excision of a fully segmented Hemivertebra is also an attractive option probable at lumbar region. The approach is both anterior and posterior. This should be combined with one level instrumentation

## **Association**

Klippel Flail syndrome, Block vertebrae, Diastematomyelia, Other spinal dysraphism, Ductal actasia

## **Congenital Kyphosis**

1. Failure of formation is more common
2. Is likely to progress
3. Is the commonest cause for paraplegia [Neurofibromatosis is the II commonest]
4. < 4 yrs: Posterior fusion is adequate
  - > 4 yrs: Posterior and anterior surgery

## **DIASTOMETAMYELIA**

Female : Male = 8:1

2 segments of the spinal cord: with a septum by fibrous, cartilage or bone

60% occurs in the lumbar region

90% x-ray shows a wide interpedicular distance

40% associated with vertebral deformity like Hemivertebra

10% in all congenital anomaly of the spine

### **Clinical**

Hairy patch: 75%

Calf muscle asymmetry in 50%

Cavus deformity ; unilateral in 50%

Scoliosis in 75%

### **Treatment**

Referred to neurosurgery

## **NEUROMUSCULAR SCOLIOSIS**

### **Classification**

#### 1. Neuropathic

a) UML: I. Cerebral Palsy

II. Spinocerebellar: Friedreich's

CMT

III. Syringomyelia

IV. Spinal cord tumor/Trauma

b) LML: I. Polio

II. Spinal muscular atrophy

III. Kugelberg-Welander disease, Wernig-Hoffmann

#### 2. Myopathic: Arthrogryposis

DMD

Myotonical Dystrophica

Cerebral palsy and DMD are important and common

### **Assessment**

#### 1. Family conference

Education and informed consent.

High incidence of complication to be discussed.

#### 2. Non-op: TLSO or Modify wheelchair with support

Physiotherapy

#### 3. Surgery

Nutritional assessment: Albumen >3.5 g/l; Lymphocyte [>1.5]

#### 7. Imaging spine: X rays

MRI

## **Surgical principles**

1. Always long fusion: otherwise transitional deformities
2. Posterior: Sublaminar wiring or pedicle screw
3. Young or Severe deformity: Anterior release and posterior surgery
4. Pelvic included in fusion or not: Avoid in ambulant patient.
5. Pedicle fixation: go as high as possible; sublaminar and hook above
6. Need allograft

## **Scoliosis in Cerebral Palsy**

Rapid deterioration of the curve.

Sometimes: Ilium forms part of the curve and there will be pelvic obliquity.

In this situation rule out hip dislocation.

Usually requires long fusion and fusion to the pelvis using Galverston technique

Incidence of scoliosis is 7% in ambulant cerebral palsy; 40% in the wheel chair patients and 82% spastic quadriplegia.

Usually have pelvic obliquity at presentation

Avoid surgery: when there is no sitting balance or head control.

Usually there is extensive Curve with pelvic obliquity and curve gets rapidly fixed.

## **Duchene Muscular Dystrophy**

95% develop scoliosis

>20° always progresses and needs early surgery as waiting causes deterioration of pulmonary function.

It is probably better to fuse spine to the pelvis as there is late deformity can occur between spine and pelvis. [Galverston technique]

In DMD, the Vital capacity reduced by 4% per year + 4%/10° deterioration of the curve.

When scoliosis surgery at 20° scoliosis and nocturnal ventilator support can prolong average survival to 25 years.

## INFANTILE SCOLIOSIS

Less than 3 yrs;

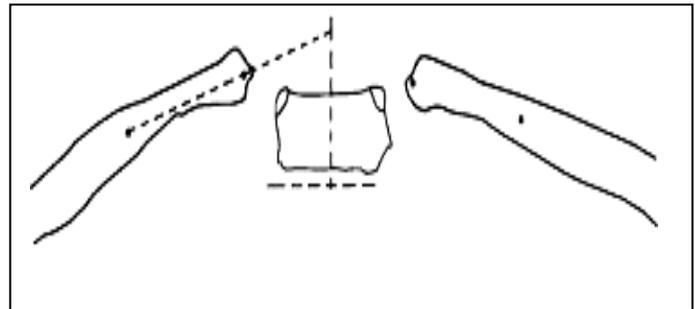
Common in Boys

There has been decrease in prevalence of infantile scoliosis

Common type is left thoracic 90% [cf. in adolescent it is right thoracic curve]

It is associated with plagiocephaly and considered to be part of molded baby syndrome.

Most resolves on observation .



### Rib Mehta's angle

(Difference at the apical rib)

is of prognostic value

The RVA difference (RVAD) is the difference between the values of the RVAs on the concave and convex sides of the curve [apical vertebra]. If the convex apical rib head does not overlap the apical vertebral body, a curve with an initial RVAD of  $20^\circ$  or more is considered progressive.

One line perpendicular to the apical vertebral endplate and another from the mid neck to the mid head of the corresponding rib.

### Treatment

Progressive: Need casting

Mehta's angle helps in differentiating : Resolving Vs Progressive

## Juvenile scoliosis

4-10yrs

Female: male 2-4:1

20-25% associated with intrathecal pathology. MRI

Look for: Tethered cords, Syringomyelia

Thoracic curves the most common.

70 % progress and require treatment and of these 50% require surgery

Indications for surgery

Similar to adolescent idiopathic scoliosis

Often requires anterior and posterior fusion to avoid crankshaft phenomenon.

## Paralytic scoliosis

When pelvic obliquity is present in neuromuscular scoliosis, understanding the curve pattern will help avoid a common pitfall:

An oblique sacrum and pelvis must be considered as part of the curvature and should be included in the instrumentation and fusion.



## COMPLICATIONS OF SPINAL SURGERIES

1. Infection post op	<1%
2. Discitis	0.1%
3. Epidural abscess	0.06%
4. Infection with Halo pin	20%
5. Recurrent laryngeal nerve	7%
6. Bone extrusion: single level	< 1%
Multiple level	10%
7. Bone graft site	20% complications
8. Nerve damage	7%: LCNT with anterior and superior cluneal nerve
9. Hematoma	20%
10. Herniation	<1%
11. Chronic pain	20%
12. Dural Tear	
Microdisc	1.8%
Macro disc	5.3
Revision	17.5
13. Mortality	<1%

### Dural leak

Sometimes recognized only after surgery

Head ache – Post neck pain

Dural cutaneous fistulas may lead to meningitis, arachnoiditis or epidural abscess, pseudomeningocele, fistulas, sciatica, strabismus (VI cranial nerve)

### Diagnosis

Immunofixation electrophoresis B 2 transferrin (this is produced only in CSF)

Can be diagnosed within 3 hours

MRI will detect pseudomeningocele

## Treatment

### 1.Prevention

### 2.Operative

#### a. Intra-operative tear

Adequate exposure

Demonstrate any leak before closure: Valsalva maneuver

In revision spine: Start from unscarred to scarred area

#### b. When there is tear

Repair 5'0' gortex suture or 6'0' ethilon

Trendlenburg position may decrease fluid from the defect

Start few mm proximal to the laceration

Check the repair with Valsalva maneuver

Tight fascial closure: if necessary lateral release incision

No wound drain

Smooth reversal of anesthesia

Urinary catheter and bed rest for 3 days

Take it easy for 10 days

If dural rupture is lateral: inaccessible, plug the dural rent with a small pieces of muscle and suture or fascial patch graft or Fibrin Glue= Fibrinogen and clotting factor and second bottle Thrombin and Calcium.

### Alternatives

1. Epidural blood patch (20 ml of blood) works in 90%

2. Percutaneous aspiration and injection of fibrin glue

## **Pseudarthrosis following spinal fusion**

Lumbar spine surgery: success is only 70%.

There is a high .chance of pseudarthrosis.

Smoking and pseuarthrosis has a strong relation.

Pseudarthrosis: is diagnosed only after 1 year. Although can be suspected at 6 months

### **Incidence**

10%-20%

### **Clinical**

Pain in the back or in the legs

Pain more on activity

Localized back tenderness

Visible nonunion on X ray

Movement on Flexion-extension view

**CT scan**      Gold standard

### **Risk factors**

1. Length of fusion: multilevel fusion, there is increase chance of non-union
2. Type of graft: Less with autograft [cancellous] than allograft
3. Inter-transverse fusion did worse
4. Infection
5. Systemic: Osteoporosis; Growth and thyroid hormone
6. NSAID usage, Chemotherapy, Radiation, Steroids
7. Smoking: 40% in smokers Vs 8% in non-smokers
8. With the use of rigid fixation: 90% fusion and without 70%

### **Clinical importance**

1. Pseudarthrosis: does not mean clinical failure
2. When symptomatic pseudarthrosis: 70% can be helped regrafting and clinical outcome correlates with bone healing

