# Scoliosis and Orthotic Management

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# Scoliosis

- A general spinal deformity characterized by lateral curvatures and vertebral rotation.
- It may be associated with a fixed structural curve or reducible functional curve.

# Classifying Scoliosis

| Functional | Structural |
|---|---|
| Muscle Spasm<br>Paraspinal strain<br>Herniated disc (unilateral)<br>Postural | Congenital<br>Bar<br>Block<br>Hemivertebra or other body anomaly<br>Idiopathic<br>Adolescent (spinal cord or brainstem disease?)<br>Juvenile<br>Associated with congenital heart disease<br>Acquired<br>Degenerative<br>Posttraumatic (fracture)<br>Overuse (repetitive microtrauma)<br>Senile<br>Secondary (disease related)<br>"Paralytic" neuromuscular disease (spinal muscular atrophy, muscular dystrophy, myelomeningocele, etc.) connective tissue disease (Ehlers-Danlos, chondrodysplasia, Marfan's, etc.) |

# Functional Scoliosis

- Due to malpositioning or unilateral paraspinal muscle pull.
- May be associated with back pain and muscle spasm
- No significant vertebral body rotation, and scoliosis is reversible

# Structural

- Not reversible
- May be idiopathic, congenital, or acquired

# Evaluation-Adams test(forward bending test)

- The child bends forward with legs straight at the knees and hands together as if trying to touch the toes
- Because scoliosis is a three-dimensional deformity, there is a rotation of the involved vertebrae as well as a lateral curvature
- This vertebral rotation leads to a prominence on the posterior trunk that corresponds to the convex side of the curve

# Plain Radiography

- initial examination of the spine should include: posteroanterior(PA) and lateral radiographs on 36 × 14-inch filmcassettes
- **PA Paprojection:**
- nearly all the important radiographic features can be assessed on a single film:
- the curve pattern/type of scoliosis (congenital oridiopathic)/overall balance of the spine and trunk/skeletal maturity as determined by the Risser sign/ presence
- of a lower limb length discrepancy (pelvic tilt).
- **The lateral projection:**
- to evaluate the global sagittal contour of the thoracic and lumbar spine/ determine the presence and severity of thoracic hypokyphosis/screen for spondylolysis and spondylolisthesis.

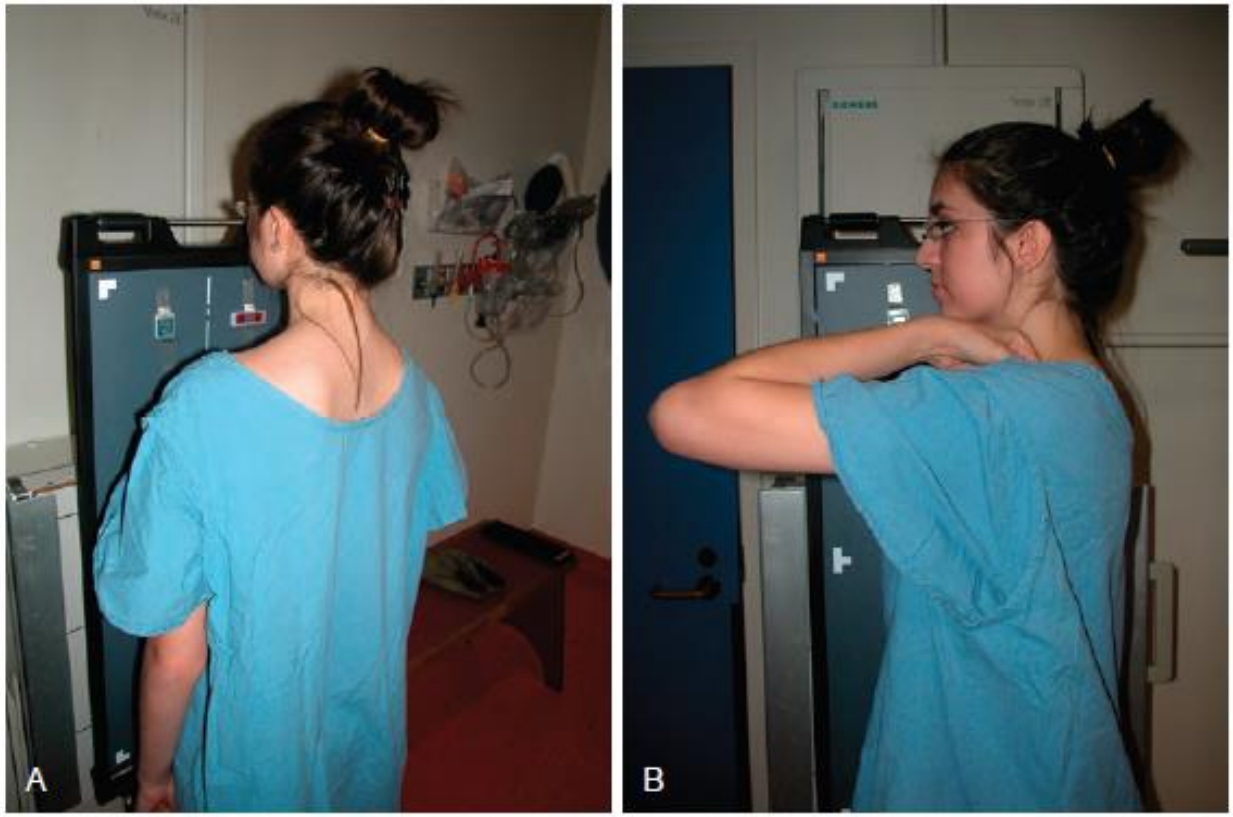



FIGURE 12-16 During radiographic evaluation the patient stands erect with the knees straight and the feet together. The posteroanterior projection (**A**) reduces exposure to breast tissue. During the lateral view (**B**), the arms are held forward to allow clear visualization of the spine.

# Evaluation-Cobb Method

- A radiographic measurement on a PA view of the spine is used to quantify the angle of curvature
- One line is drawn along the superior endplate of the vertebra tilted the most at the top of the curve and a similar line is drawn along the inferior endplate of the vertebra tilted the most at the bottom of the curve.
- Large scoliosis will allow these two lines to intersect forming the angle a, otherwise, if the curve is not large enough, strike perpendiculars to form the angle A

- **some variation** among different measurements
- averages 7.2 degrees if the end vertebrae are not preselected
- improves to 6.3 degrees when they are preselected.

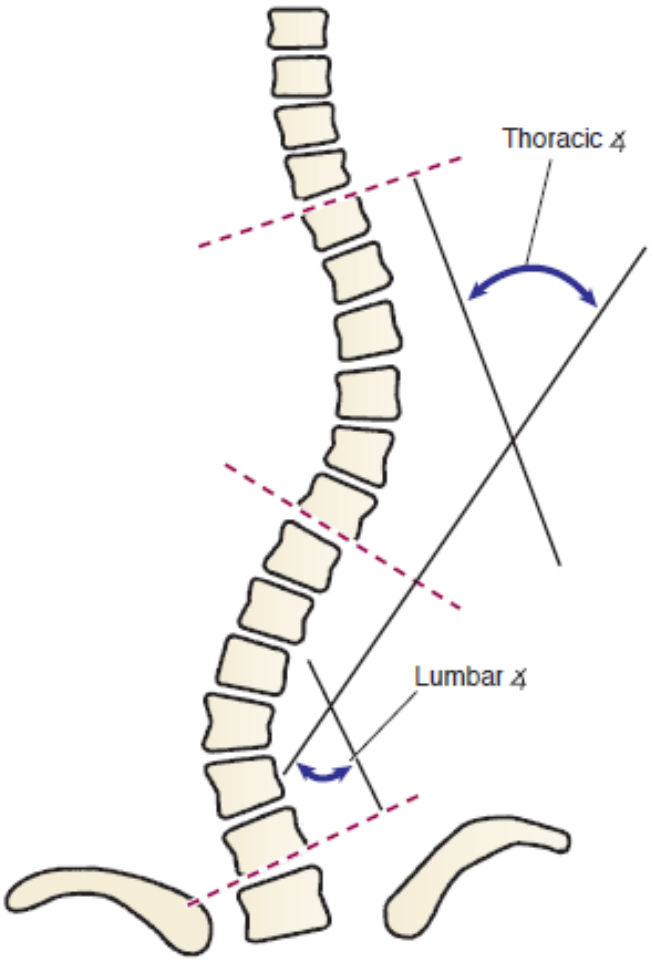



FIGURE 12-17 Cobb angle measurement. The vertebrae with the greatest amount of tilt are selected as the end vertebrae. Lines are drawn perpendicular to the end-plates of the vertebrae. The angle formed at the intersection of these lines is the Cobb angle. If a second curve is present below the primary curve, the original curve's lower vertebra becomes the top vertebra when measuring the second curve, and the same line along its surface is used.

# Risser sign

- A radiographic measurement based on ossification of the iliac apophysis
- It is divided into four quadrants, beginning on the lateral aspect of the iliac apophysis and progressing medially
- grade 0/ no ossification
- grade 4 /all four quadrants of the apophysis show ossification (“capping”).
- grade 5 /When the ossified apophysis has fused completely to the ilium ,the patient is fully skeletally mature
- Patients with Risser grade 0 or 1 (and to a lesser extent, grade 2) are at greatest risk for curve progression because a significant amount of spinal growth remains.

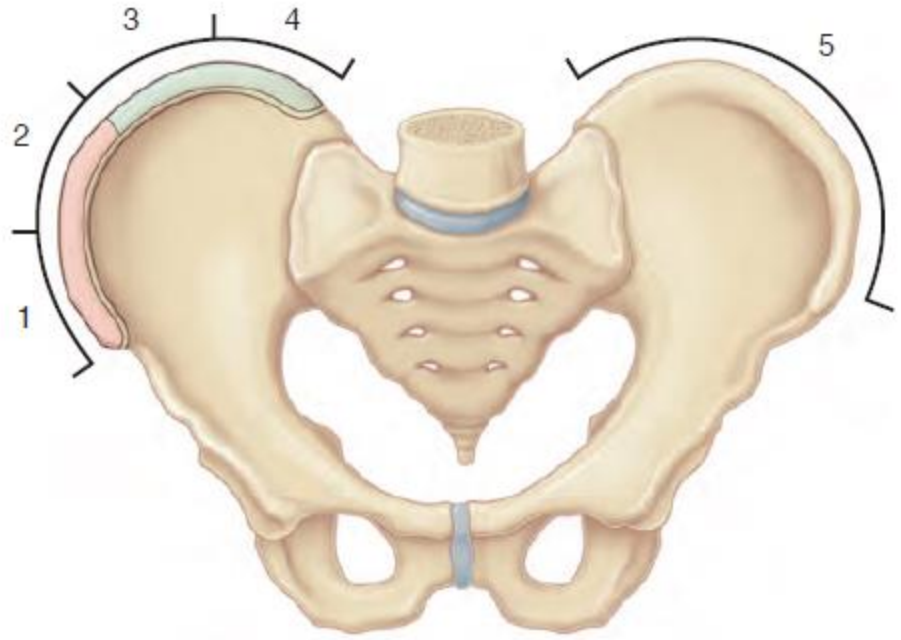



FIGURE 12-2 The Risser sign proceeds from grade 0 (no ossification) to grade 4 (all four quadrants show ossification of the iliac apophysis). When the ossified apophysis has fused completely to the ilium (Risser grade 5), the patient is skeletally mature.

# Spinal Balance

- to assess the amount of decompensation that exists preoperatively or that can occur postoperatively.
- **Coronal balance represents:**
- the horizontal distance between the midpoint of C7 and the center of the pelvis considered poor, or decompensated, if this distance exceeds 2 cm
- **Lateral trunk shift :**
- is measured by drawing a horizontal line to the edges of the ribs of the trunk and a perpendicular line that bisects this horizontal line; the distance between this perpendicular line and the center of the pelvis represents lateral trunk shift

# Coronal Balance

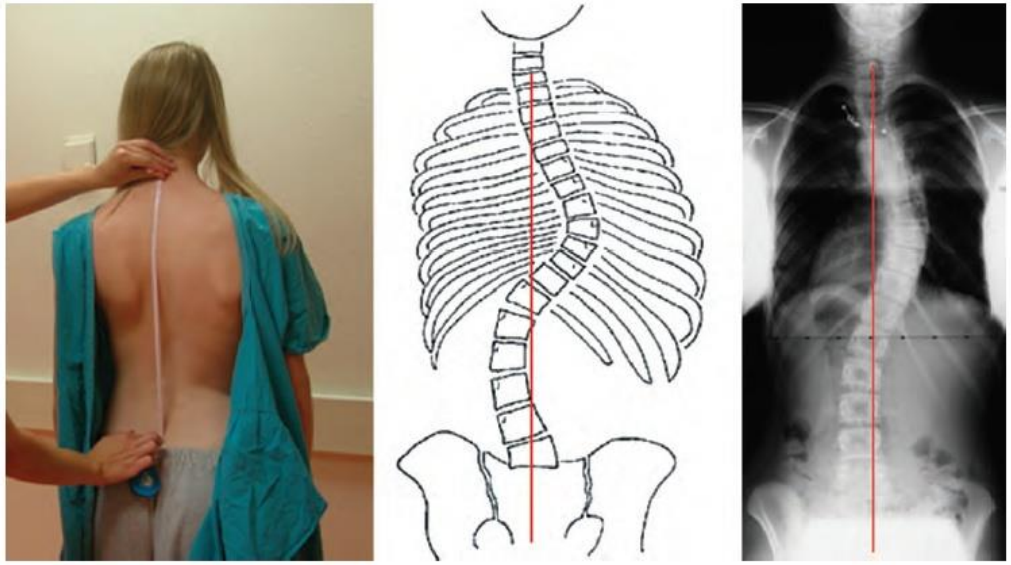


FIGURE 12-12 Coronal balance. A plumb line held at the spinous process of C7 should not deviate from the center of the gluteal fold (center sacral line) by more than 1 to 2 cm.

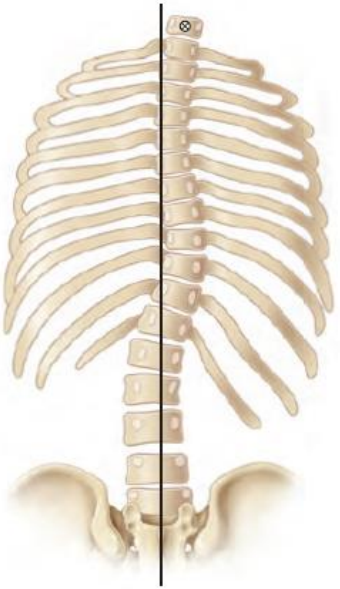


FIGURE 12-19 Coronal balance. A plumb line held at the spinous process of C7 (*x*) should not deviate from the center of the gluteal fold (center sacral line) by more than 1 to 2 cm.

# Trunk Balance

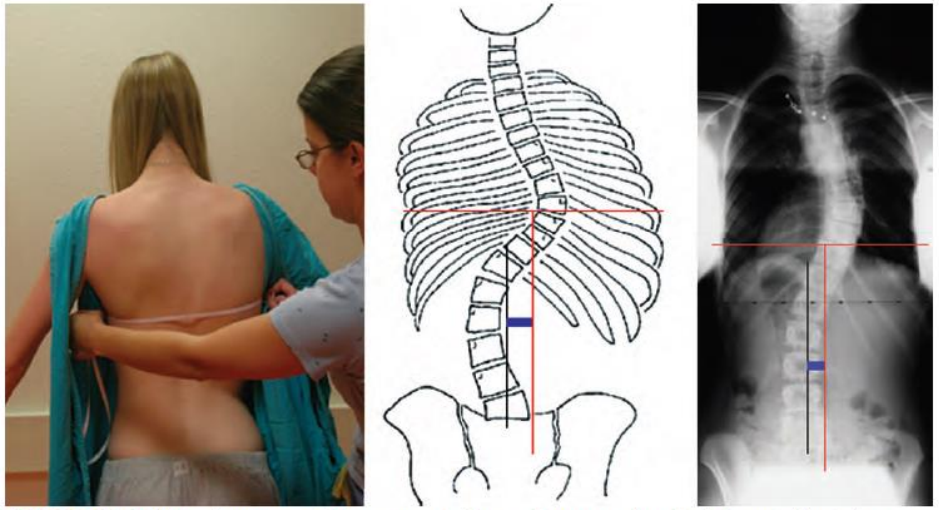


FIGURE 12-13 Trunk balance. To measure trunk balance, two vertical lines are drawn on a radiograph: the first vertical line is the center sacral line, and the second vertical line bisects a horizontal line drawn from the peripheral edges of the ribs of the apical vertebra. The distance between the two vertical lines quantifies the amount of trunk imbalance.

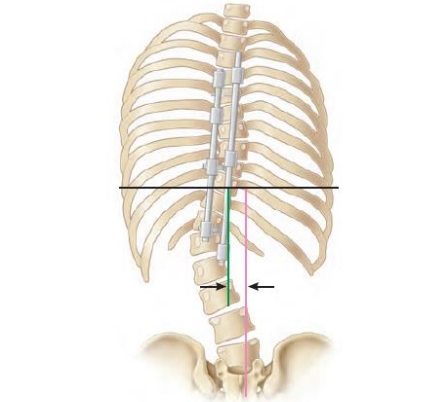


FIGURE 12-20 To measure trunk balance, two vertical lines are drawn on a radiograph (*arrows*). The first vertical line (*pink*) is the center sacral line. The second vertical line (*green*) bisects a horizontal line drawn from the peripheral edges of the ribs of the apical vertebra. The distance between the two vertical lines quantifies the amount of trunk imbalance.

# Follow up interval and radiography

- to limit the number of follow-up films,
- During routine follow-up examinations, only the PA projection is needed
- The period between evaluations depends on the maturity of the patient and the size of the spinal curvature.
- a premenarchal, Risser grade 0, 11-year-old girl with a 25-degree thoracic curve should return for radiographic reevaluation after a 4-month interval,
- a 2-year postmenarchal, Risser grade 4, 14-year old girl with a 30-degree curve need not return for reevaluation before 1 year.
- In most cases the interval between radiographic evaluations ranges from 4 to 6 months.

# Idiopathic Scoliosis

- Approximately 80% of patients with structural scoliosis
- Etiology is unclear
- A multifactorial condition with a genetic predisposition. An autosomal dominant component with incomplete penetrance

- Subdivided according to the age of onset
- 1. Infantile: 0–3 years old
- 2. Juvenile: 4 years old–puberty onset
- 3. Adolescent: puberty to just prior to closure of epiphyseal plates

# Clinical Features of idiopathic scoliosis

| | Infantile | Juvenile | Adolescent |
|---|---|---|---|
| Incidence | Least common | | Most common |
| Onset/Diagnosis | Less than 3 years | 4–10 years | Greater than 11 years |
| Ratio | Males greater than females | Males equal to females | Males equal to females, however, females worsen 8–10 times more frequently |
| Curve Pattern | Left thoracolumbar | Right thoracic or double curve | Right thoracic 1; Right thoracic/Left lumbar 2 |

# Screening

- **Scoliometer** is placed gently on the person's back at the apex of the deformity, perpendicular to the long axis of the body///the angle of inclination is read directly from the scale
- Originally, the recommendation for orthopaedic referral was a **5-degree** angle of trunk rotation at any leve of the spine,95 which meant that the chance of missing a curve exceeding 20 degrees was small
- recommendation has been modified to a **7-degree** angle of trunk rotation.97 With this criterion the chance of missing a curve greater than 30 degrees (the curve magnitude at which bracing is usually initiated) is low.
- **Girls** should be screened twice, at ages 10 and 12 (grades 5 and 7)
- **Boys** once, at age 13 or 14 (grades 8 or 9).

# Screening


FIGURE 12-5 The scoliometer is a specially designed inclinometer that is used clinically to measure the angle of vertebral rotation. **A,** In the lumbar spine the scoliometer is used to assess paravertebral muscle asymmetry. **B,** In the thoracic spine the scoliometer is used to assess rib asymmetry.

# Management of idiopathic adolescent scoliosis

- Most adolescents with idiopathic scoliosis do not require treatment because of the low probability that their curves will progress
- Considering : adolescent's remaining growth potential/ the severity of the curve / the pattern and location
- The treatment choices :observation/ nonsurgical intervention/surgical intervention

**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

- no treatment is needed for curves less than 25 degrees, regardless of the patient's maturity.
- Follow-up interval : maturity and the size of the curve
- a premenarchal Risser grade 0 adolescent with an initial curve measuring 24 degrees should undergo follow-up examinations every 3 to 4 months, and a brace may be needed if the curve progresses.
- For (Risser grade 3 or higher), longer intervals between visits (e.g., 6 months)
- 5- to 6-degree measured change is considered indicative of curve progression.

# Orthotic Treatment /indications

- restricted to immature children in an attempt to prevent curve progression during further skeletal growth.
- is indicated in growing adolescents (Risser grade 0, 1, or 2) who on initial evaluation have curves in the range of 30 to 45 degrees or who have documented progression exceeding 5 degrees in curves that initially measured 20 to 30 degrees.
- Those who are Risser grade 0 should be considered candidates for bracing when their curves reach 25 degrees.

- Low-profile braces (TLSOs) are the most commonly used orthoses today, but their use is restricted to patients whose curve apex is at T7 or below.

# Orthotic Treatment /Contraindicatios

- large curves (>45 degrees) in a growing adolescent
- emotionally intolerable,

- skeletally mature adolescents (Risser grade 4 or 5 and, if female, 2 years postmenarchal)

# Orthotic management

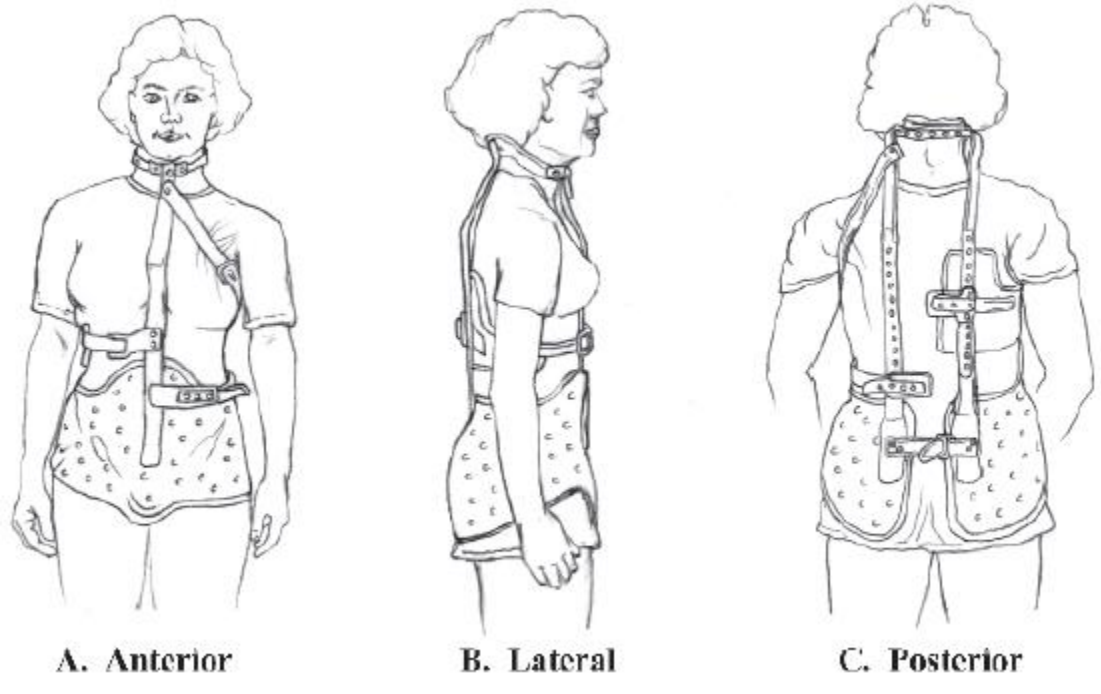
- 1)CTLSO- Milwaukee
- 2)TLSO  Low- profile
- Boston-Wilmington-Charleston
- Low-profile braces are the most commonly used orthoses today/their use is restricted to patients whose curve apex is at T7 or below.

| | |
|---|---|
| Milwaukee brace | High thoracic curves (apex at T8) |
| Low profile TLSO | Lower thoracic, thoracolumbar, and lumbar curves (apex below T8) |

# Milwaukee brace-CTLSO

- Cervico-thoracic-lumbo-sacral orthosis (CTLSO)
- consists of a rigid plastic pelvic girdle connected to a neck ring over the upper thorax by one anterior, broad aluminum bar and two posterior paraspinal bars.
- The cervical ring has mandibular and occipital bars, which rest 20–30mm inferior to occiput and mandible
- Pads strapped to the bars apply a transverse load to the ribs and spine to correct scoliotic curvatures
- Idiopathic or flexible congenital scoliosis with curves 25 to 40° have traditionally been treated with this orthosis if the curve apex is located superior to T8, shows signs of progression, and growth remains

# Milwaukee Brace



# Advantages of Milwaukee

- May removed for ADL
- Open design- minimal restriction for respiration
- Good air circulation to minimize skin problems
- Adjustable to growth and curve changes
- Physical activity permitted with wearing except foir gymnastics

# Disadvantages of Milwaukee

- Must be worn over 20 hours
- Non cosmetic-occipital and chin pads extended above the clothing
- More difficult fabrication

# Boston Brace

- Prefabricated in 6 size
- Symmetric thoracolumboar-pelvic polypropylene module opens posteriorly
- Customized based on shape and the radiographic parameters
- Applying corrective forces at the convexity of the curve with providing relief opposite these areas of pressure through windows cut in the plastic
- Designed and fit based on a bluprint created from full length radiograph

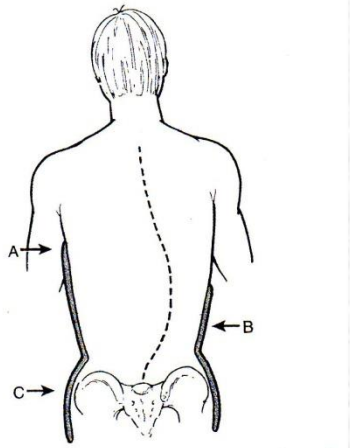



Figure 17-7. Three-point pressure of a TLSO for scoliosis. Forces applied to the lower thoracic curve (B) are balanced by high thoracic (A) and pelvic forces (*C*).

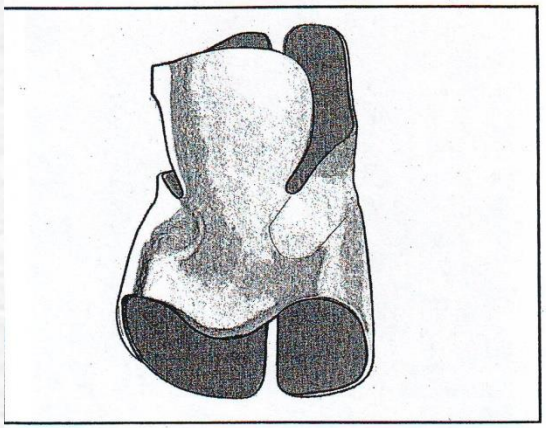


**Figure 7-13.** Boston orthosis (reproduced with permission of Boston Brace International, Inc.).

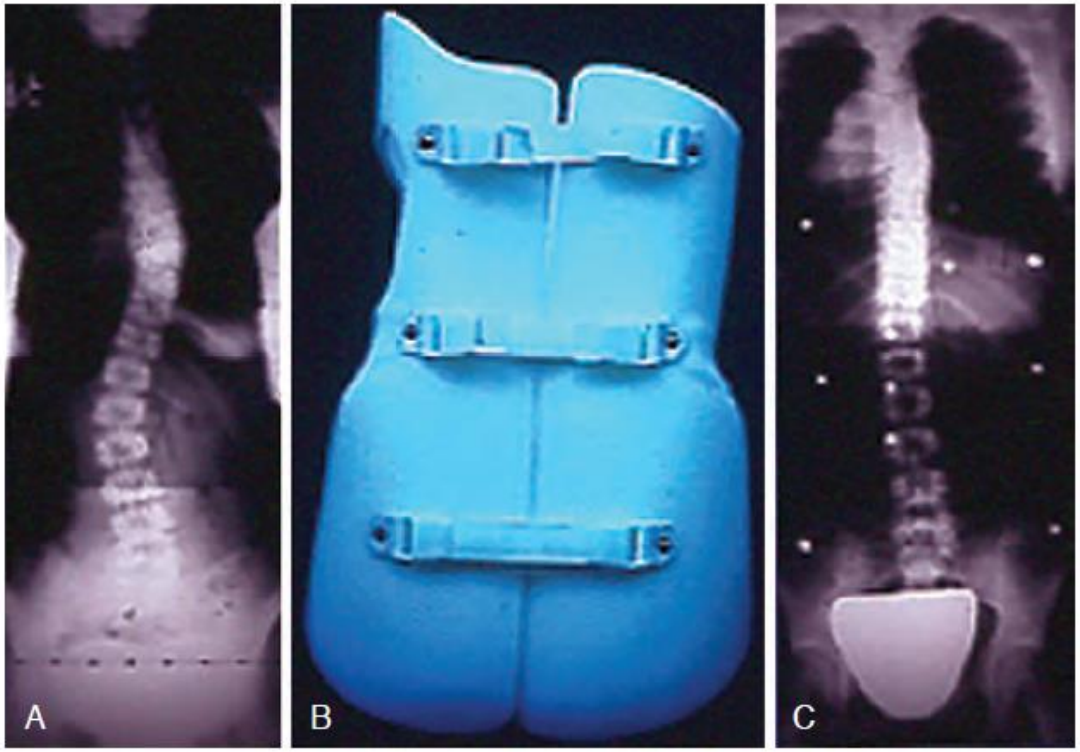



FIGURE 12-22 **A,** Scoliosis deformity before brace application. **B,** Posterior view of the Boston brace. **C,** Correction of scoliosis with the patient in the brace.

# Wilmington

- Custom made from a positive mold of the patients torso in which the scoliosis is maximally corrected in a Risser or Cotrel type cast (in maximum passive correction)
- Indications are same as Boston

- Not the popularity of the Boston brace

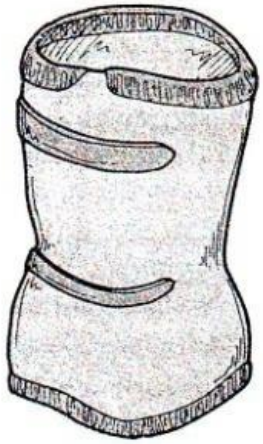


Figure 17-8. Wilmington orthosis. (Figure adapted from Bassett, G. S., & Bunnell, W. P. (1987). Influence of the Wilmington orthosis on spinal decompensation in adolescent idiopathic scoliosis. *Clinical Orthopaedics and Related Research, 223,* 164–169.)

# Charleston Brace

- Night –time (part-time) bending orthosis/worn only at night for 8 to 10 hours.
- Orthosis is molded in maximal reverse bending (over correction)/holds the patient in maximal side bending correction
- Designed to take advantage of the recumbent position to shift the convexity of the curve as much as possible toward the midline and unbending the curve above the apex in the opposite direction for maximum side bending correction
- The side-bending force exerted by the brace does not allow its use in the upright position,
- Efficacy lesser than Boston
- should be reserved for single lumbar or thoracolumbar curves less than 35 degrees.

# Charleston Brace

# Providence Brace

- Night use only like the Charleston
- Using CAD/CAM technology
- Similar to the Charleston in design with regard to shifting the convexity of the curve to midline
- Molded with a low inferior trimline on the contralateral side and a high superior trimline on the ipsilateral side of the apex
- Differs from the charlston primarily by being designed not to unbend the curve in the opposite direction superior to the apex
- Use in place of the Charleston brace for the treatment of thoracolumbarbor lumbar curves.

# Providence Brace



FIGURE 12-23 **A** and **B**, Patient with thoracolumbar scoliosis treated with a Providence brace.

# Spine-Cor Brace.

- a dynamic flexible brace. *Several*
- studies have reported its effectiveness
- a failure rate significantly higher than that of a rigid spinal orthosis

# Advantages of TLSO-Low profile

- Low profile –can be worn under clothing
- Quicker fabrication

# Disadvantages of TLSO-Low profile

- Solid design-limits adjustments for vertical growth
- Closed design-heat retention and possible skin problems
- Restrict respiration because of thoracic compression of the TLSO
- Thoracic curves with an apex above T8 cannot be treated

# Orthosis Control

- Pelvic girdle terminates above the pubic symphysis and the grater trochanter
- Pelvic girdle does not exert excessive pressure over the iliac crests
- Pelvic girdle compress the abdomen
- Occipital pads lie just below the occipital tuberosities
- Lumbar, thoracic pads apply firm pressure to the apices of the curvatures
- Uprights allow for chest expansion during respiration

# Brace Treatment Protocols

- bracing (with TLSOs or the Milwaukee brace) /full-time bracing (23 hr/day) is more effective than part-time bracing (8 to 16 hr/day)
- After 2 to 4 weeks the patient should return to the orthopaedist's office for an initial brace evaluation
- An in-brace radiograph should be obtained to verify the amount of curve correction being achieved.

- With the Boston brace: a minimum of 40% to 50% curve correction should be obtained in the brace
- With the Charleston and Providence: in-brace correction should
- approach 90% for flexible curves and 70% for rigid curves

- If proper correction cannot be obtained with brace use, orthotic treatment should be discontinued.

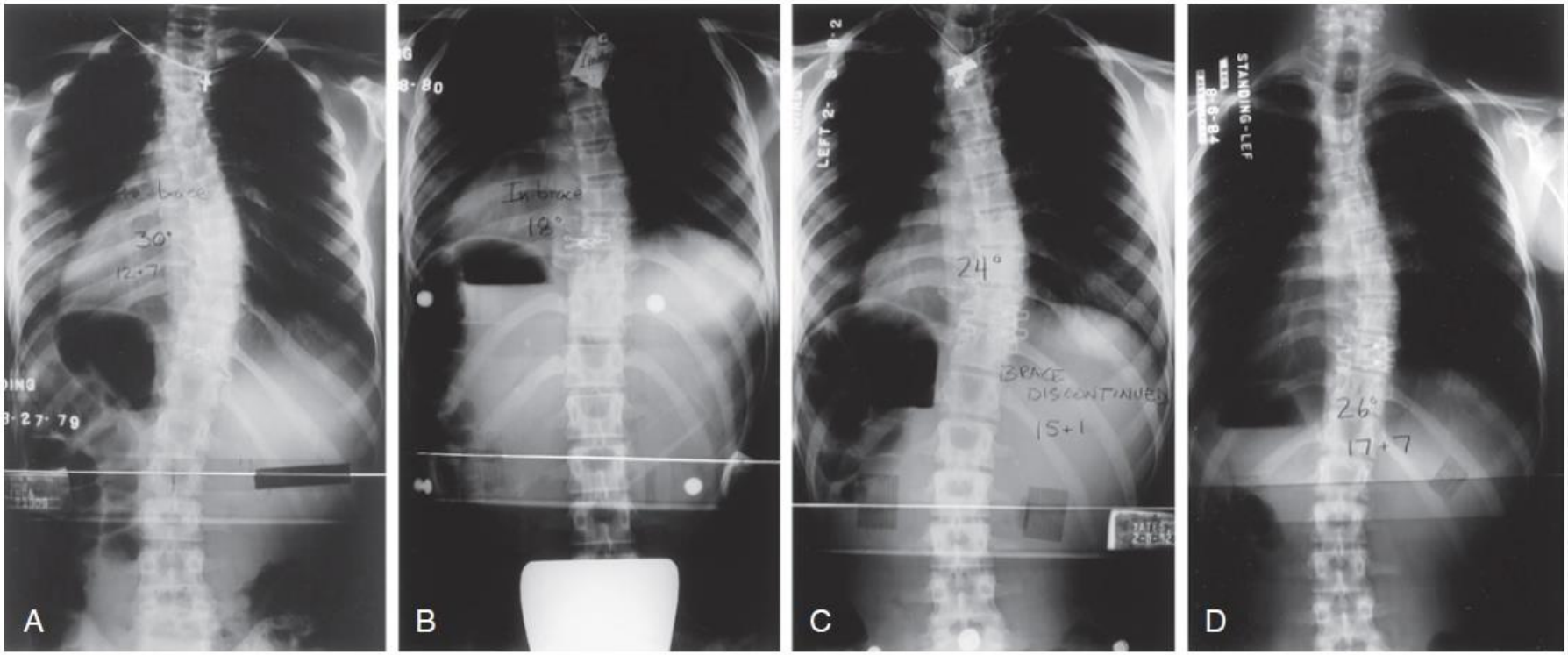



FIGURE 12-24 Radiographic findings with brace wear. **A,** Initially, this premenarchal girl aged 12 years 7 months had a 30-degree thoracic curve and was Risser grade 0. **B,** Treatment in a Boston brace was begun, with in-brace correction to 18 degrees. **C,** Brace wear was continued until the patient was 2 years postmenarchal and Risser grade 4. **D,** Thirty months later, the curve remained stable at 26 degrees.

# Brace Treatment /Interval Visits

- **Interval visits** During brace management:
- At 4-month intervals for rapidly growing adolescents with large curves.
- At 6 months for patients nearing maturity whose curves have shown no recent changes.
- During these visits: a single standing PA thoracolumbar radiograph out of the brace

# Brace discontinue

- In girls:
- With successful controlling curve progression, when the girl is approximately 18 to 24 months postmenarchal and Risser grade 4 and when no further increase in her height has occurred

- in boys:
- bracing may need to be continued until Risser grade 5 is achieved.
- Rather than tapering use of the brace, discontinue it completely at that time.

# Congenital

- Results from abnormal spinal formation during embryonic development
- The most common presentation is a hemivertebra
- Associated with a number of congenital anomalies
- About 30% of infants with congenital scoliosis have a congenitourinary abnormality; most commonly unilateral renal agenesis
- About one-third of children with congenital scoliosis also have a spinal cord abnormality
- All children with any congenital vertebral anomaly should have a renal ultrasound to assess possible anomalies of the genitourinary system

# Acquired –Secondary or disease related

- Neuromuscular Scoliosis –paralytic neuromuscular disease
- Most commonly seen in CP, muscular dystrophy, spina bifida, and spinal muscular atrophy.
- Scoliosis is uncommon in children with neuromuscular disease who are able to walk
- In CP, scoliosis is primarily seen in the spastic quadriplegic who is unable to stand or walk
- In Duchenne's muscular dystrophy, scoliosis is unusual until the child becomes wheelchair bound
- Children with spinal bifida who have no neurologic function below the thoracolumbar region have a high incidence of progressive scoliosis

# Acquired –Degenerative

- Post-trumatic
- Overuse
- Senile

# Treatment

- Early diagnosis, keep curvature controlled during the growth spurt.
- During the period of rapid adolescent growth, progressive curves increase at the rate of approximately 1° per month

| Degree of Curvature | Idiopathic | Muscular Dystrophy | Cerebral Palsy |
|---|---|---|---|
| 1°–20° | Observation | Observation | Observation |
| 20°–40° | Brace | Surgery (sooner if rapidly progressive) | |
| >40° | Surgery | | Surgery (may wait until 60° or more in some cases) |