SCOLIOSIS

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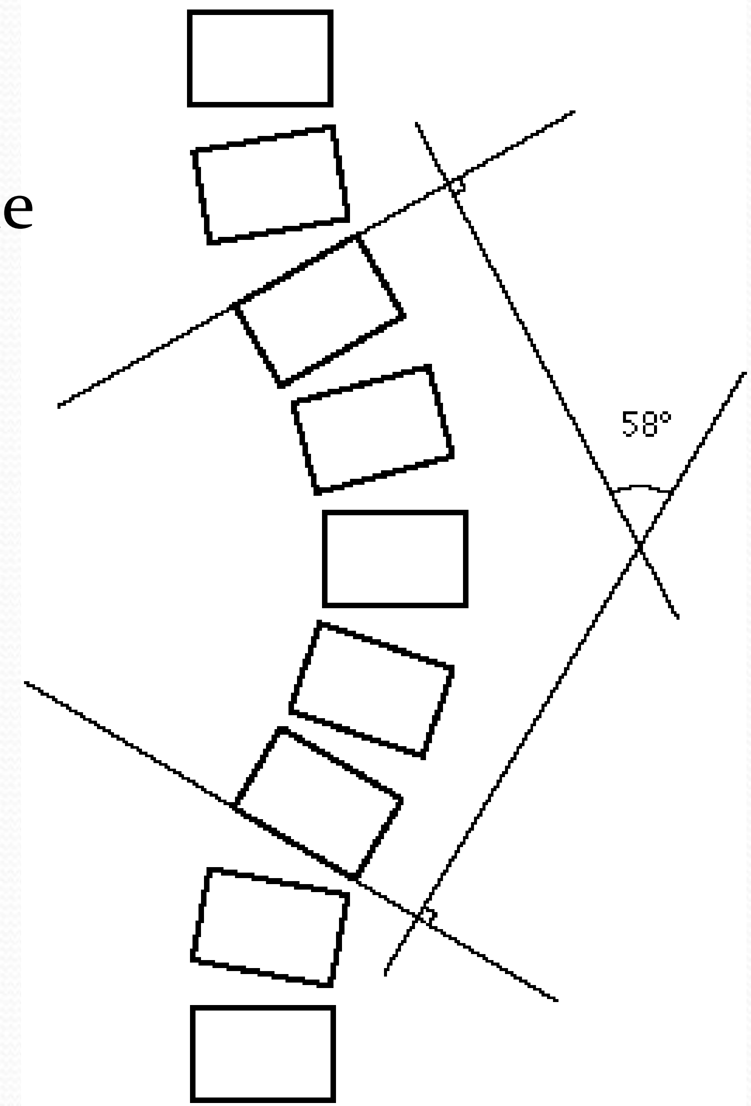
http://www.uclahealth.org/body.cfm?xyzpdqabc=0&id=502&action=detail&ref=750&start=9&issueref=201

What is Scoliosis?

- The lateral curvature of the spine
- Measured by a Cobb Angle
- More prevalent in females
- Adam's Bending test



Adam's Forward Bending Test

Infantile Idiopathic

- <3 years of age
- Usually no bracing or surgery is required
- Spontaneous correction can occur as child grows

Juvenile Idiopathic Scoliosis

- Most common type of Scoliosis
- Can be hard to detect if it has a small Cobb angle
- Observation of progression determines treatment
- Use of brace or surgery depends on severity of the curvature

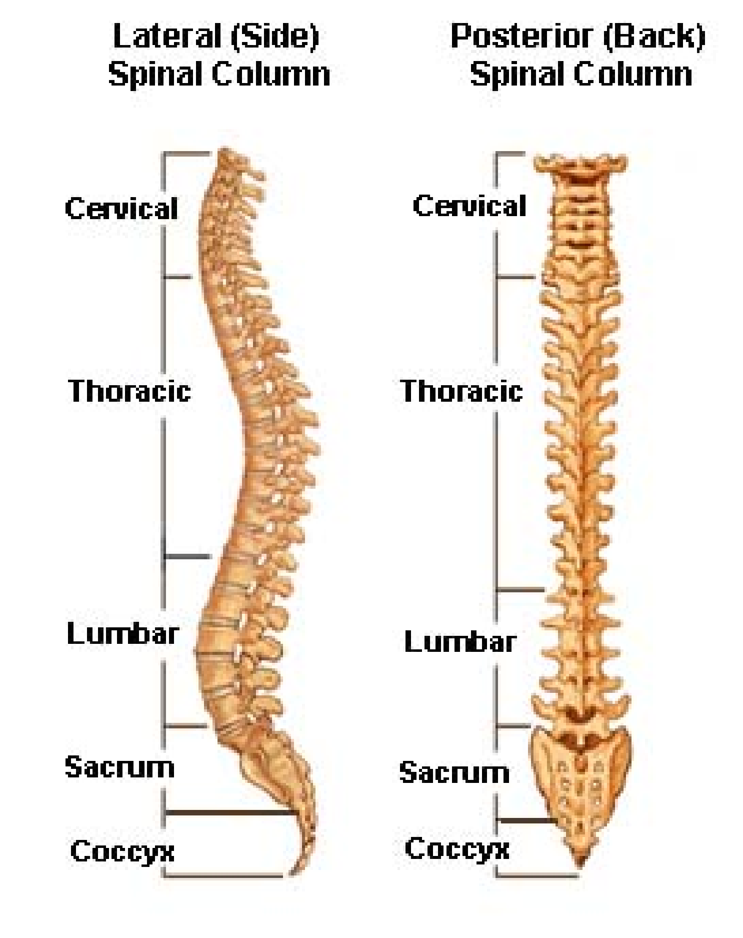
Neuromuscular Scoliosis

- Secondary to another diagnosis
- E.g. Cerebral Palsy, Muscle Dystrophy, Trauma
- Weak muscles or muscles with unusually large tone causes muscular imbalance
- Fast progression

Adult Scoliosis

- Not very common
- Caused by late detection and slow progression until adulthood
- Spine is already mature, so bracing is ineffective

Spine Anatomy



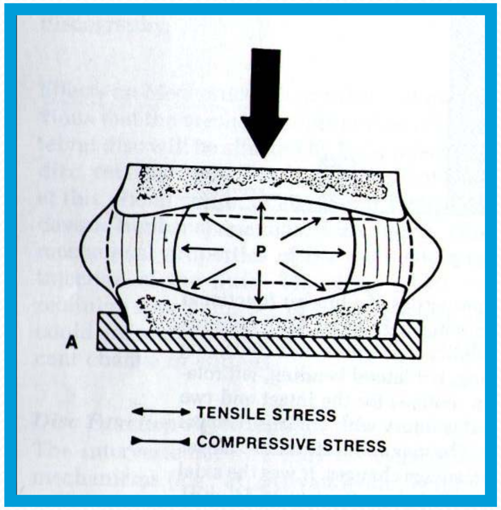
- Consists of vertebrae, facet joints, ligaments, and intervertebral discs
- Spine has a 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal vertebrae
- Spine has 4 natural curves in the sagittal plane and appears straight in the frontal plane.

Intervetebral Disc

- “Shock absorber” of the spine; handles most compressive loads, as well as tensile and torsional loads.
- Made up of 3 components: nucleus pulposus, annulus fibosus, and cartiliginous end plates.

Compressive Characteristics of Intervertebral Discs

- Elastic properties depend on the location, mass, and size of the disc.
- Load-deformation curve shows that the discs are flexible at low loads and stiffer at high loads.
- The ability of the disc to handle these loads is due mainly to the nucleus:



Tensile Characteristics of the Intervertebral Discs

- Flexion (tension in posterior annulus); Extensions (tension in anterior annulus)
- Anterior and posterior regions of disc are stronger under tension than central region. (0.7 to 1.4 Mpa)
- The strength and stiffness of annulus fibers under tension vary depending on direction of force
- Disc is designed to manage loading efficiently

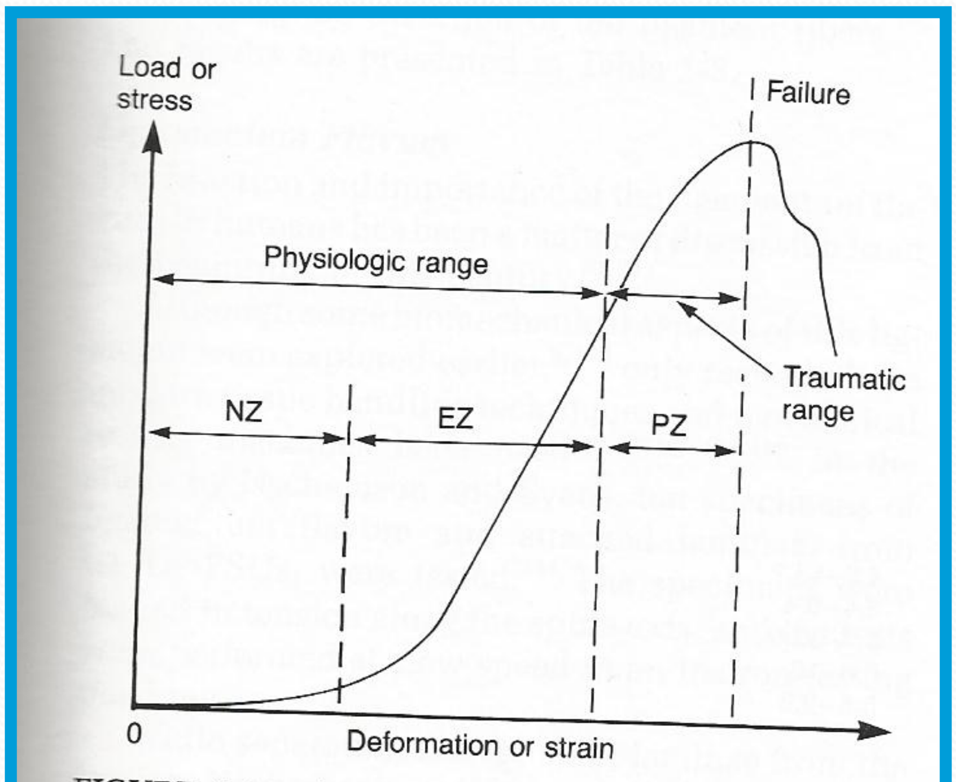
Shear and Torsional Characteristics of Intervertebral Discs

- Angular deformation vs. applied torque curve showed that the disc is less resistant at low torque and more resistant at high torque

- Shear force tests show that a large force is needed to displace a disc in the horizontal plane

Spinal Ligaments

- Main function is to maintain stability of the spine
- General displacement curve:



Spinal Ligaments Cont'd

- Bone and ligaments are both important in the structural aspects of the spine

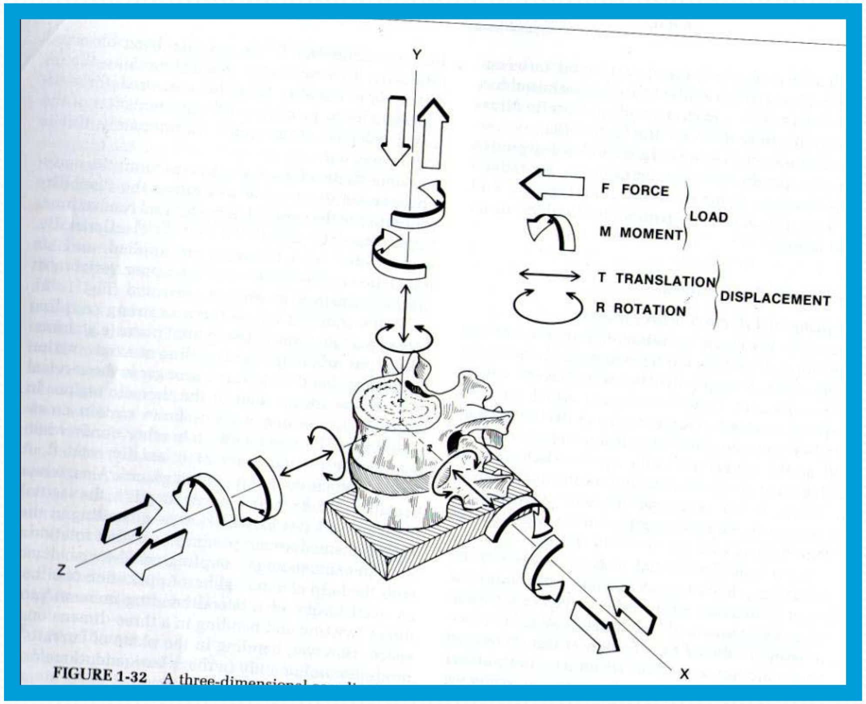
- Bone is stronger than ligaments in fast impact scenarios

- Ligament is stronger than bone in slow impact scenarios

Coupling of Vertebral Motions

- Coupling describes the natural occurrence of physiological motions together

- Each vertebra has 6 degrees of motion

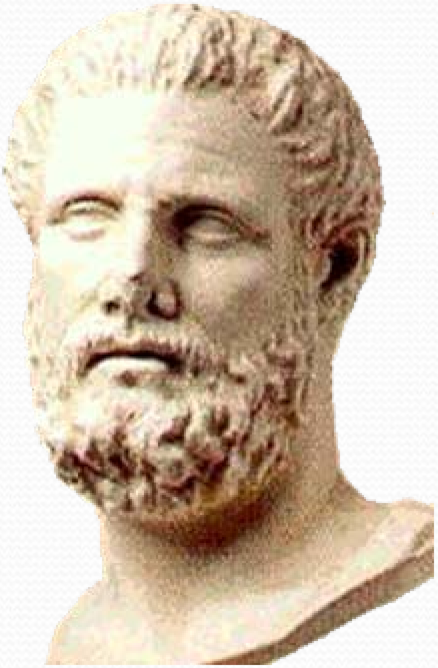


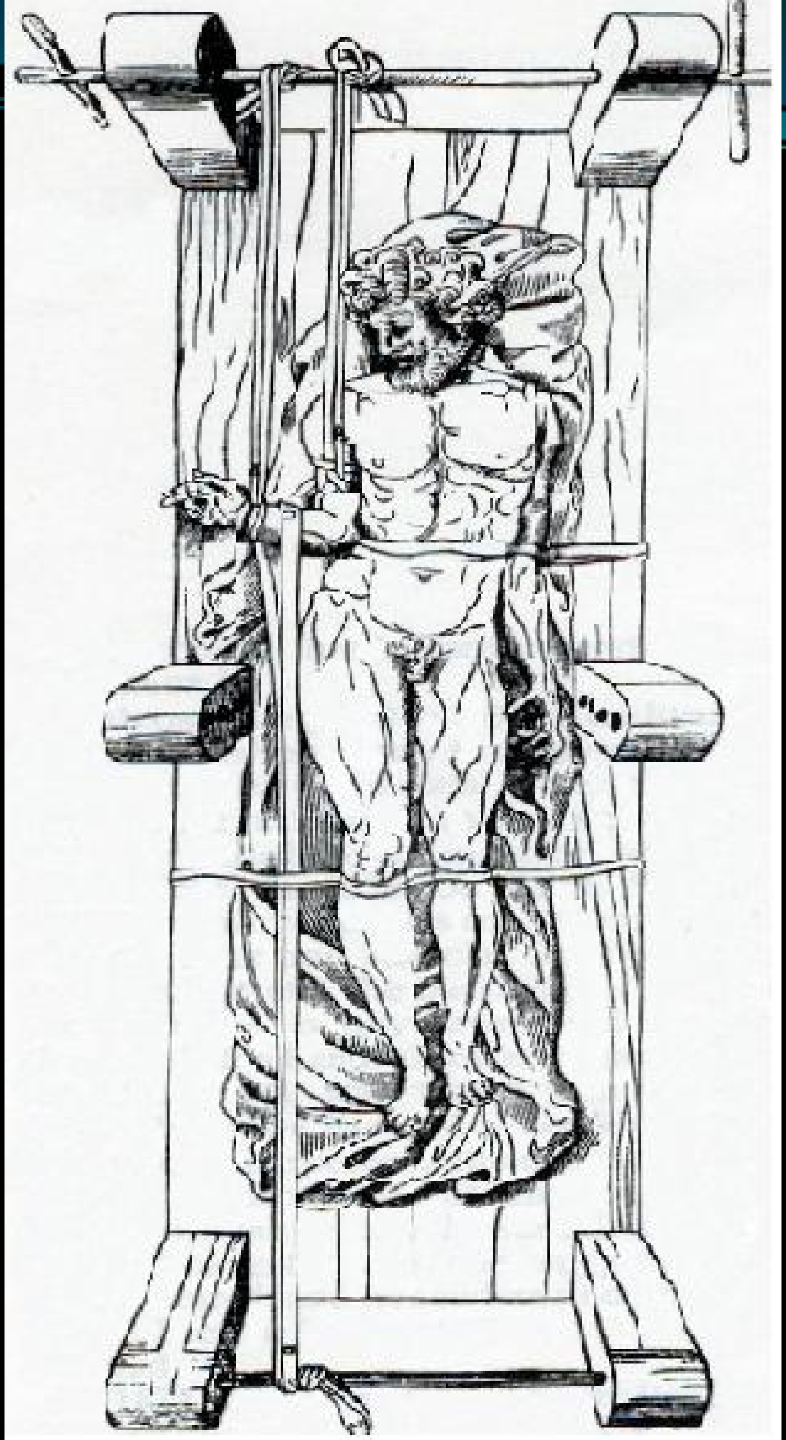
Biomechanical Definition of Scoliosis

- Significant lateral curvature in the frontal plane:
  - Deformations within or between vertebrae
  - Increased axial rotation in the wrong direction
  - Too much curvature in the frontal plane
  - Too little curvature in the sagittal plane

Brief History

- “Scoliosis” coined by Hippocrates (~400 BCE)
- Was thought to be caused by a vertebral dislocation
- Developed the traction table





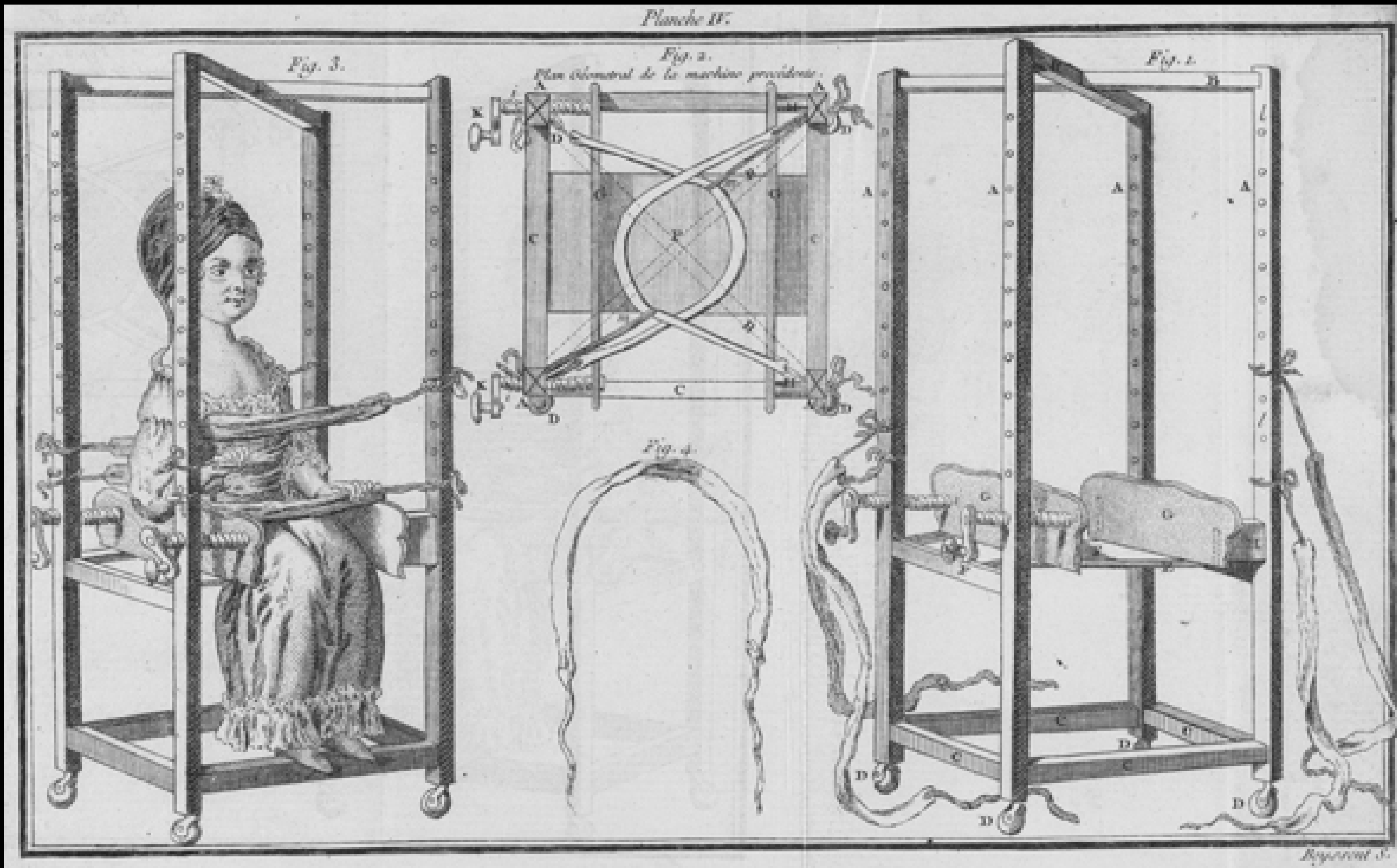
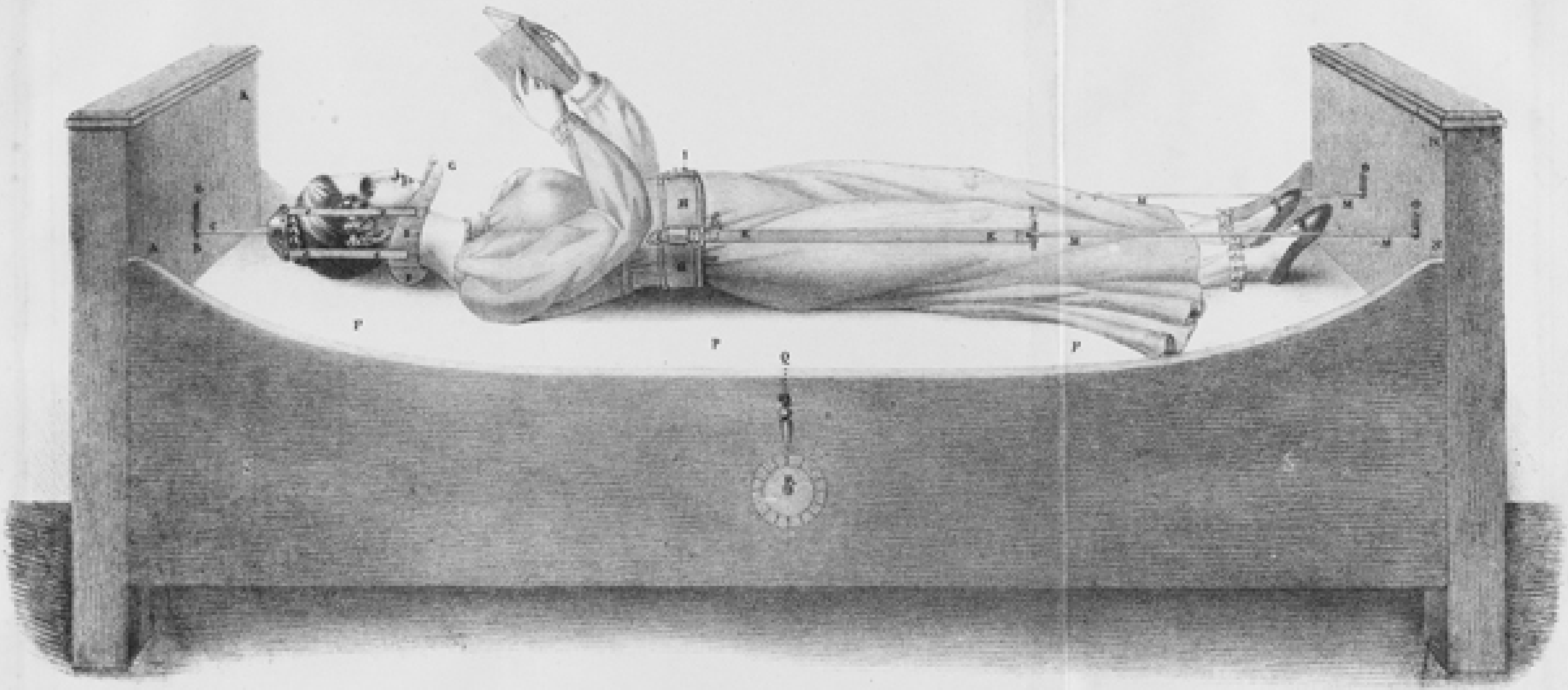


Planche IV.
Fig. 3.
Fig. 2.
Plan Géometral de la machine précédente.
Fig. 1.
Fig. 4.

Pl. 2.



Lit à extension de la colonne vertébrale de l'invention du D.eur Maisonabe.

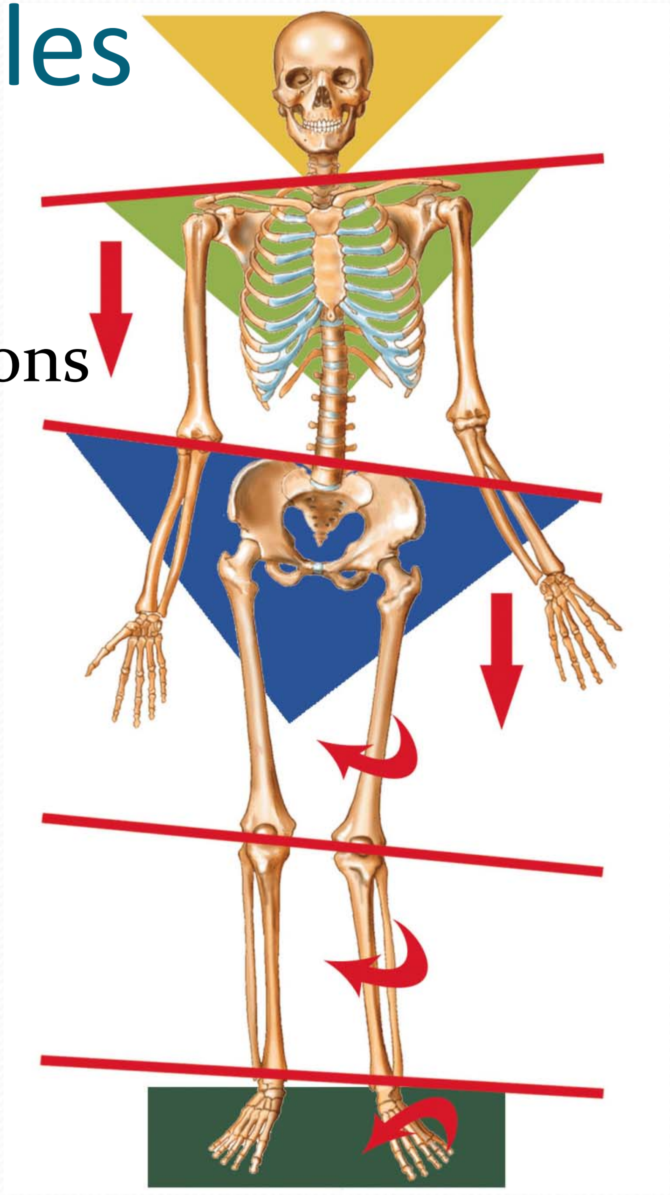
History contd…

- First spinal fusion by Russel Hibbs in 1914

- First use of instrumentation to straighten the spine by Paul Harrington the 1960's

Biomechanical Principles for Treatment

- Some of the biomedical foundations for scoliosis correction
  - Force coupling
  - Creep and relaxation
  - Axial loading
  - Transverse loading



Force Coupling

- Use natural motion coupling to correct different scoliotic deformities at once
- For example: target bending the curve out and potentially fix incorrect axial rotation
- This is seen in Dwyre Instrumentation

Creep and Relaxation

- Viscoelastic properties: they change with time
- Creep: load is constant while deformation changes with time
  - Seen in traction
- Relaxation: deformation is constant while load changes with time
  - Seen in Harrington instrumentation

Axial Loads

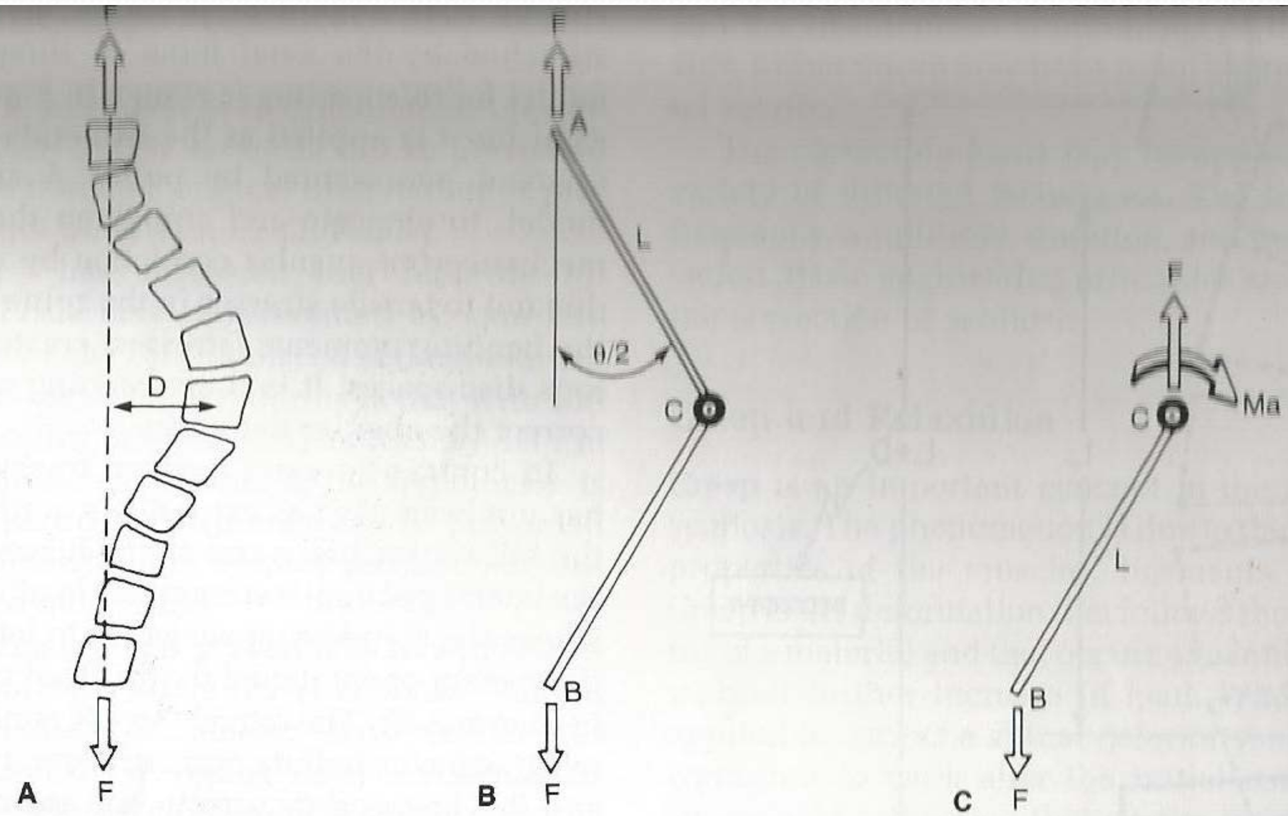


FIGURE 3-7 Axial load. **(A)** The scoliotic spine under axial load. **(B)** A simplified model of the spine being subjected to axial distraction force F. **(C)** Free body diagram of the model link BC and the joint C.

Transverse Loads

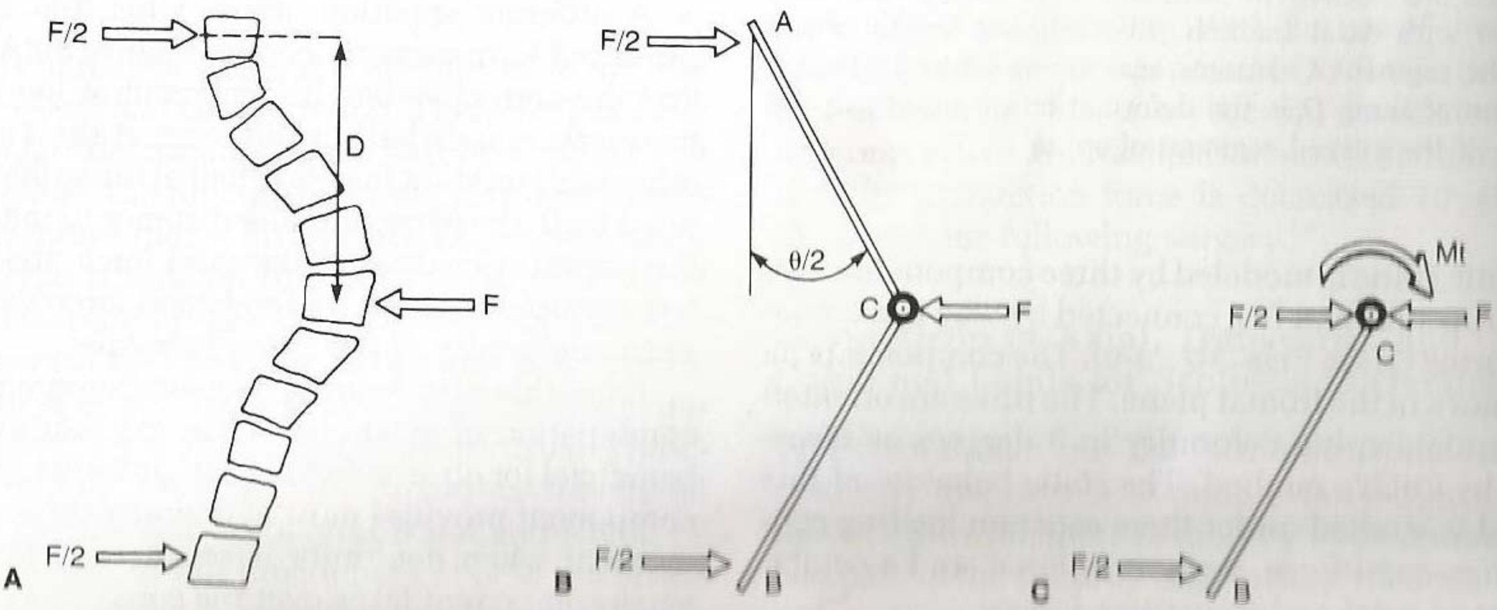
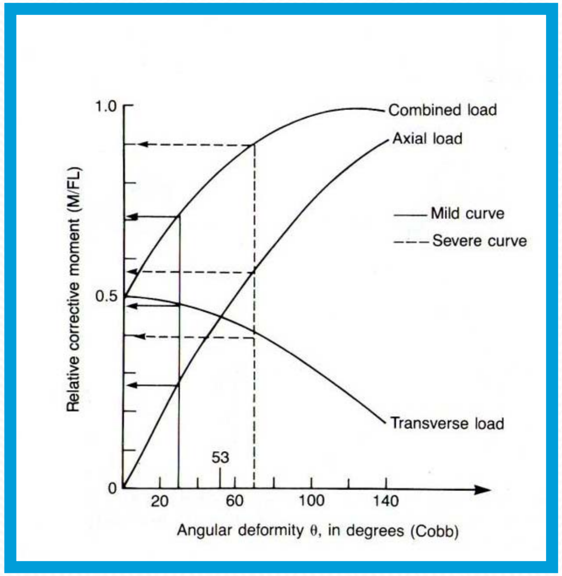


FIGURE 3-8 Transverse loads. (A) The scoliotic spine under transverse loads. (B) A simplified model of spine being subjected to three-point transverse forces. (C) Free body diagram of the model link in BC and the joint C.

Axial vs. Transverse Loads

- Intersection at 53 degrees of angular deformation
- Axial does better for larger deformities
- Transverse does better for smaller deformities
- Combination of axial and transverse is the best



Curves <20º

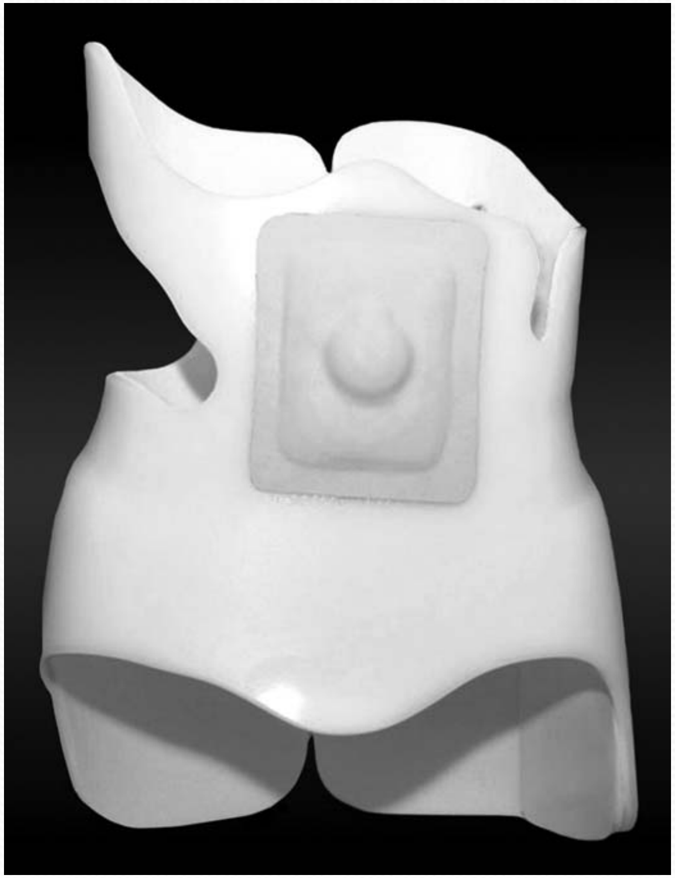
- Invasive treatments are not required
- Regular monitoring of progression

Curves between 20º and 40º

- Bracing is often used for treatment
- "Pressure pads" act against the abnormal curve of the spine
- Braces only halt the progression of Scoliosis and are for adolescents without fully mature bones

TLSO – "The Boston Brace"

- Thoraco-Lumbar-Sacral-Orthosis
- Applies 3-point pressure to the curvature
- It can be concealed under clothes
- It must be worn at least 23 hours a day



CTLSO – "The Milwaukee Brace"

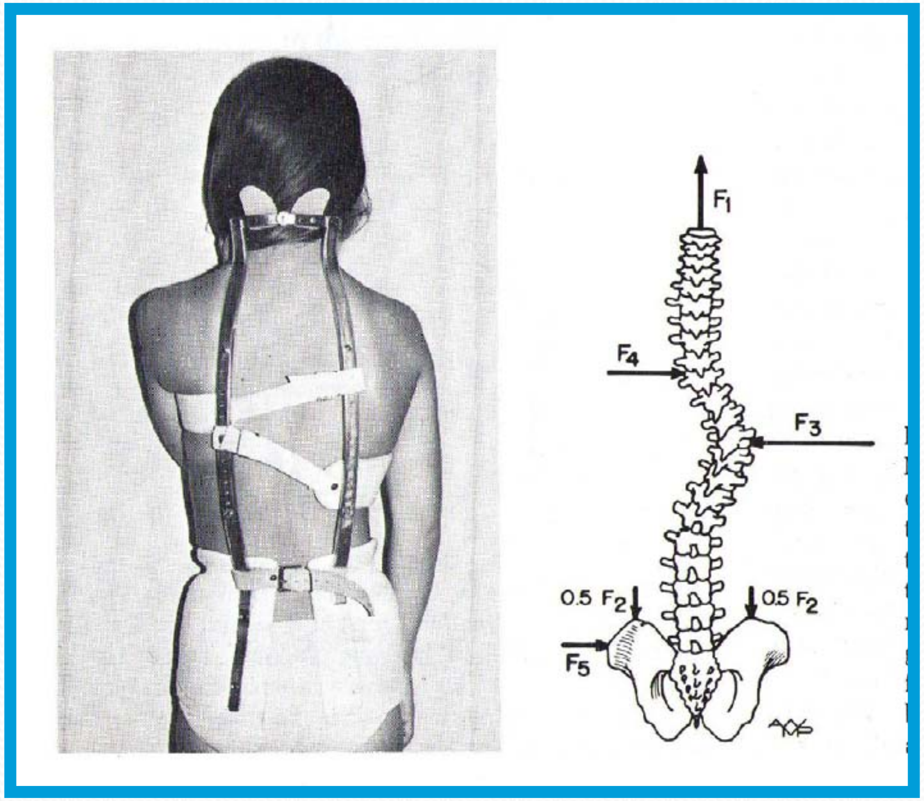
- Cervico-Thoraco-Lumbar-Sacral-Orthosis
- Similar to the Boston Brace with the addition of a neck ring
- Very unappealing cosmetically and for comfort
- Vertical bars form main back support and structure

The Charleston Brace

- “The nightime brace”
- Over-correcting pressure on the concavity of the spine, to correct curvature
- Not suitable for curvatures higher on the spine

Biomechanics of the Braces

- Use combined axial and transverse loading

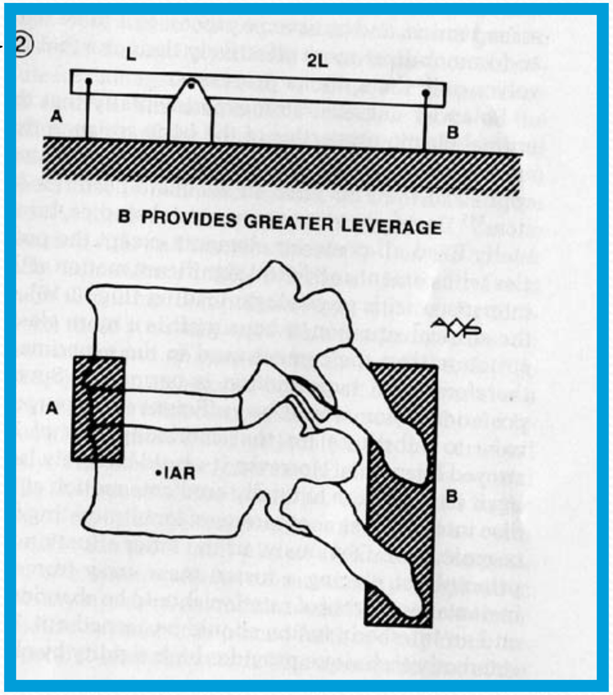


Curves >40^o

- Surgery is a very common option at this point
- **Spinal fusion** is the combination of two or more vertebrae for the linear correction of the spine
- Combined with instruments such as screws, hooks, and rods for more stability
- Bone grafts are used to facilitate the fusion
- Other materials such as a titanium mesh can be used

Biomechanics of Bone Fusion

- Restrict the rotation of a vertebra relative to the one below
- Certain motions should be restricted to reinforce angular correction
- Use principle of rotation and torque: F X r
- Basically grafting the side further away from the instantaneous axis of rotation will resist more movement



Anterior vs. Posterior Surgery

Anterior

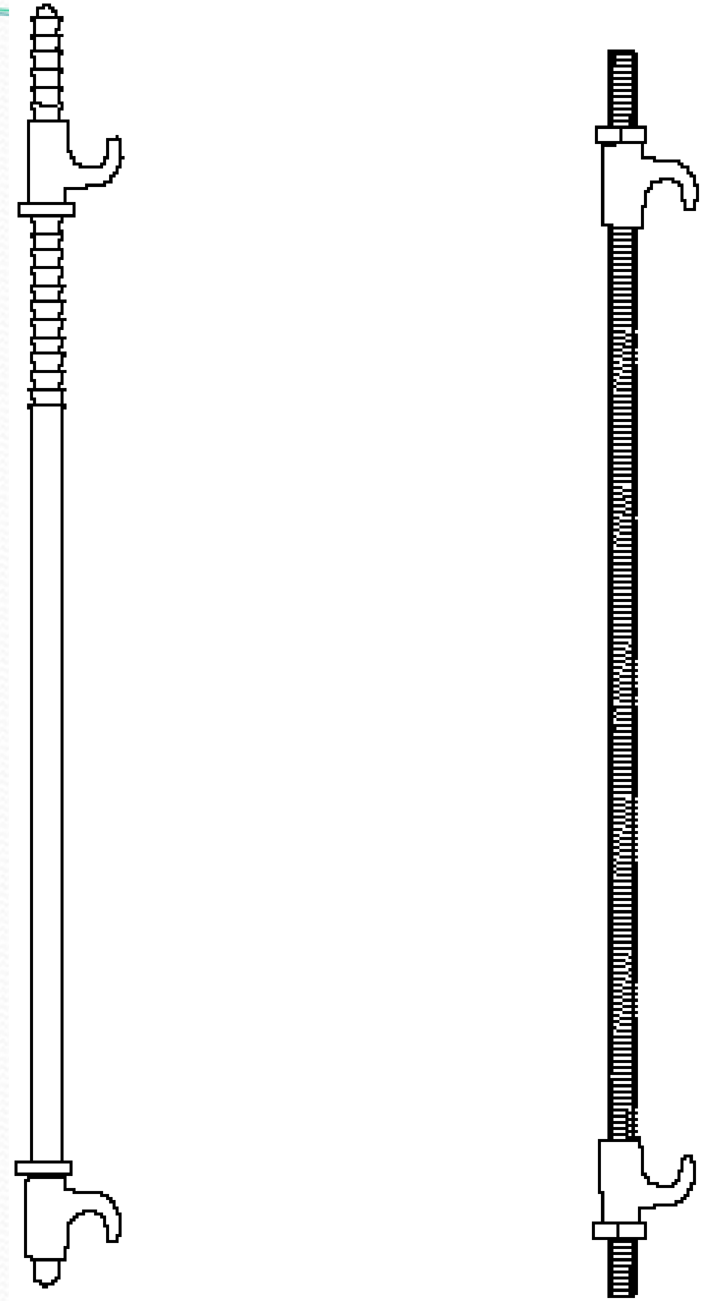
- Less fusion is required
- More mobility
- Force is applied directly to load bearing part of the spine
- Can only be used for lumbar scoliosis curves

Posterior

- Easier surgical access
- Can be used for curvature in all areas of the spine
- “Crankshaft Effect”

Harrington Rods

- Huge advancement in Scoliosis treatment
- Two rods – a compressor and a distracter
- Can cause "flatback" condition
- Long term complications

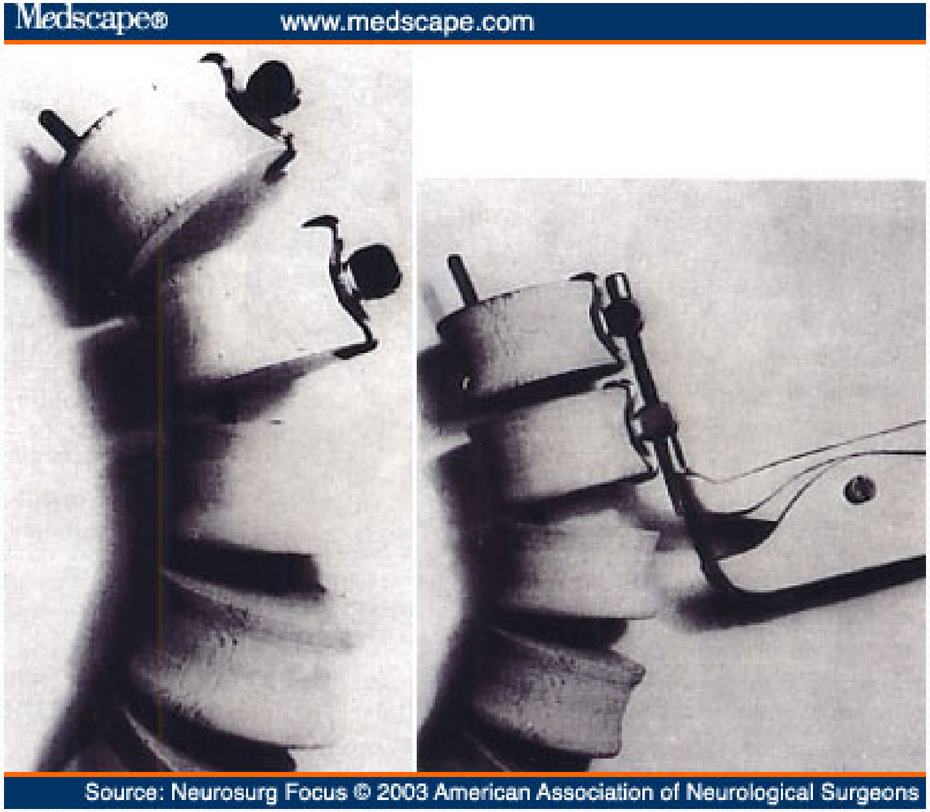


Biomechanics of Harrington Rods

- Distraction rod is about 5 times stiffer than compressive rod
- Uses axial loading and slight transverse loading
- Relaxation deformity occurs
  - Good because it reduces the stress on the curve with time

Dwyer Instrumentation

- Next advancement in the 1970s
- Titanium screws are placed in the vertebrae, and a titanium cable is threaded through the screws
- Resulting tensioning forces straighten the spine
- Allows for the rotation of the vertebrae – "coupling motion"



Mechanical Failures

- Past the yield point of the vertebral body, a screw may cut through the bone
- Screws face pull-out forces
- Plastic deformation of the instruments due to fatigue caused by spine movements
- Leads to further surgery and complications

Halo-Femoral Traction

- Patient has pins inserted into scalp tat holds a weighted ring on the head. A weight is then applied to this ring in an upward direction; axial loading.

Traction Cont'd

- Biomechanics
  - Axial loading
  - Creep deformation occurs

- Used in combination with other treatments

- Negatives include: pain and weakness of neck musculature, pin tract infections, pin loosening, and cranial nerve palsy

Non-Fusion Technology

- Memory Alloy Staples – Changes shape with temperature (Nitinol)
- Growing Rods
- Screw anchors and polypropylene tethers

Future

- Bone-anchor ligament tethers

- CADCAM

Bone-anchor ligament tether

- Still in development
- Increased flexibility = decreased forces during motion
- Decreased forces = protects the bone anchor from loosening
- Safer and biocompatible

CADCAM

- Computer Aided Design-Computer Aided Manufacture
- Avoids manual casting
- Algorithms to calculate and position pressure points specifically for each individual

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