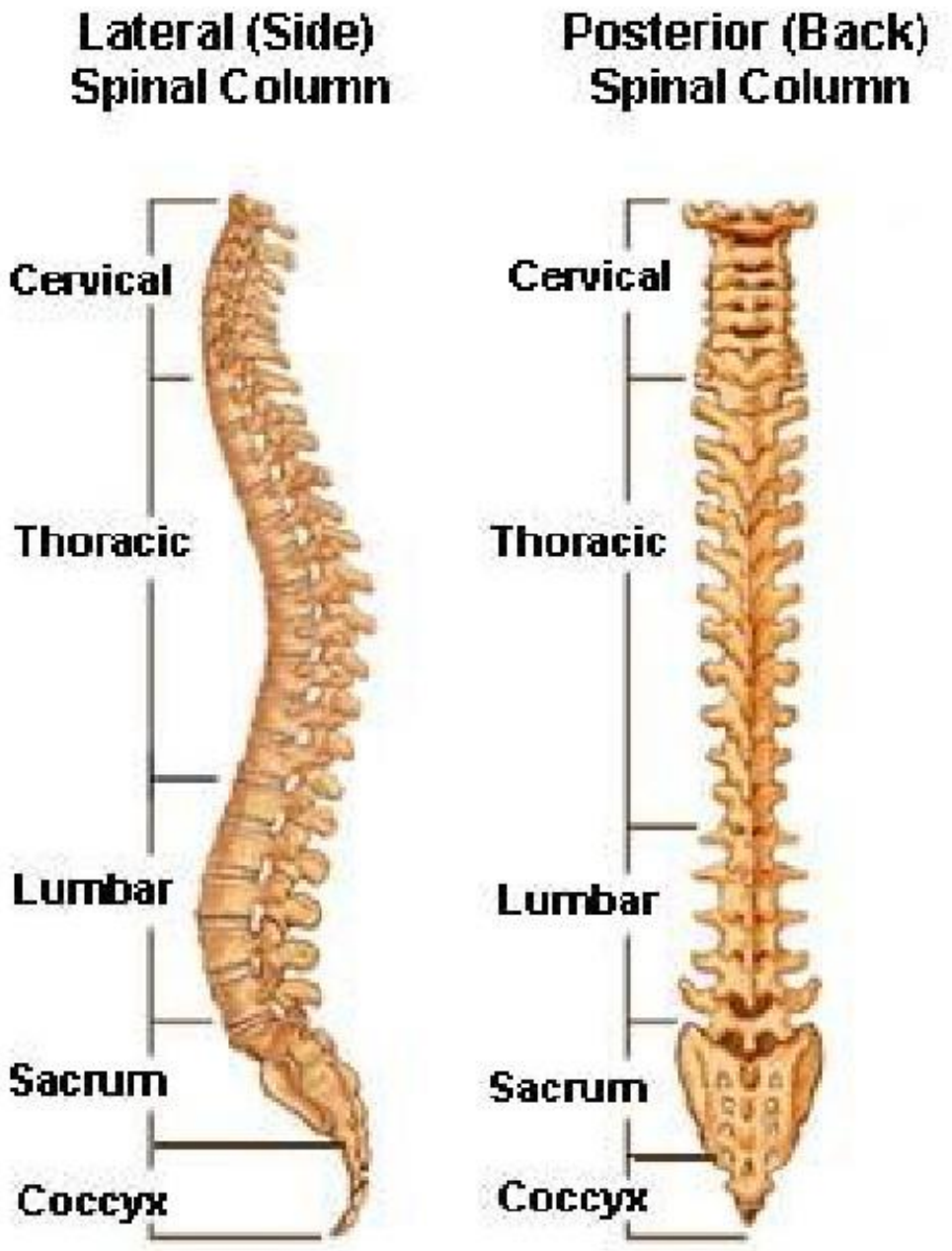
Paper I: Upper Limb prosthetics and orthotics and Spinal orthotics

Variations of design in spinal orthotics

Level of spine



Abbreviation

- Cervical orthoses (CO)
- Lumbar-sacral orthoses (LSO)
- Thoraco-lumbar-sacral orthoses (TLSO)
- Cervical-Thoraco-lumbar-sacral orthoses (CTLSO)
- Sacro-iliac orthoses (SIO)

Why do we need to prescribe SO for Pt.?

- Pain relief
- Mechanical unloading
- Correction of Pathological position (i.e. Scoliosis, kyphosis, spondylolisthesis, etc….)
- Spinal immobilization after surgery
- Spinal immobilization after traumatic injury
- Compression fracture management
- Kinaesthetic reminder to avoid certain movements

Positive Outcomes

- Decreases pain
- Improves function/trunk support/motion control
- Increases proprioception
- Improves posture/ spinal realignment
- Corrects spinal deformity
- Prevent further deformities of the trunk
- Promotes healing of ligaments and bones
- Ease muscle strain

Possible Negative Effects

- Muscle atrophy
- Difficulty in breathing
- High energy expenditure with ambulation
- Difficulty donning and doffing orthosis
- Difficulty with transfers
- Restricted movements
- Psychological and physical dependency
- Unsightly appearance/Poor patient compliance
- Local pain /Skin breakdown/Discomfort

Selection of spinal orthosis

- Soft devices may be prescribed
  - To provide pain relief by providing warmth and pressure to the skin.
  - They may also serve as a reminder to the patient to reduce movement at the treated area of the spine
  - They cannot limit motion in themselves.

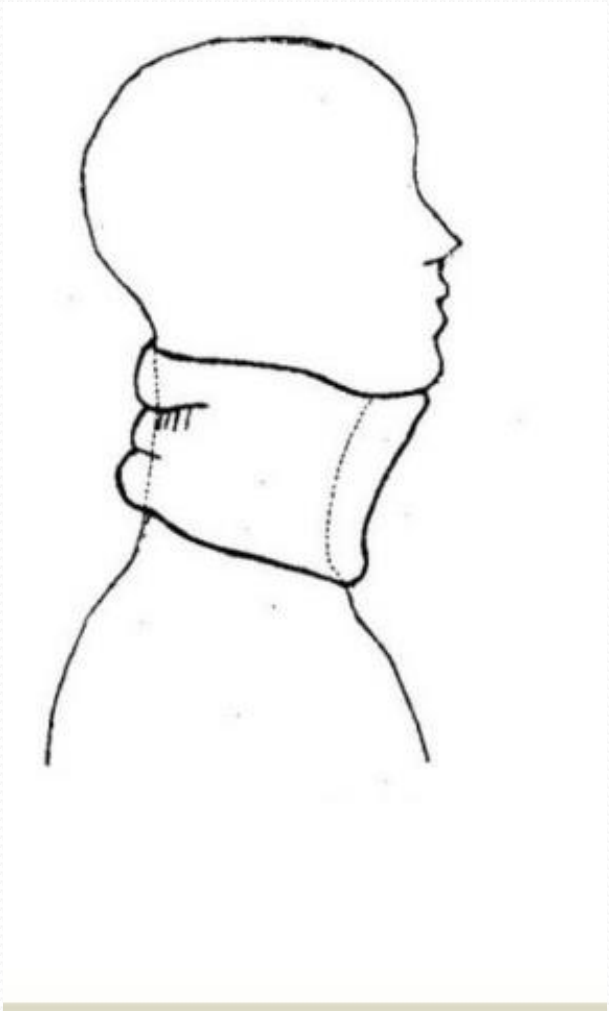
Selection of spinal orthosis

- Semi-rigid and rigid devices can be used
  - To limit certain motions of the spine.
  - The effectiveness of motion limitation will depend on the amount of rigidity of the device and the length of the lever arms of any pressure systems.

Basic mechanism of SO

1. Kinetic reminder

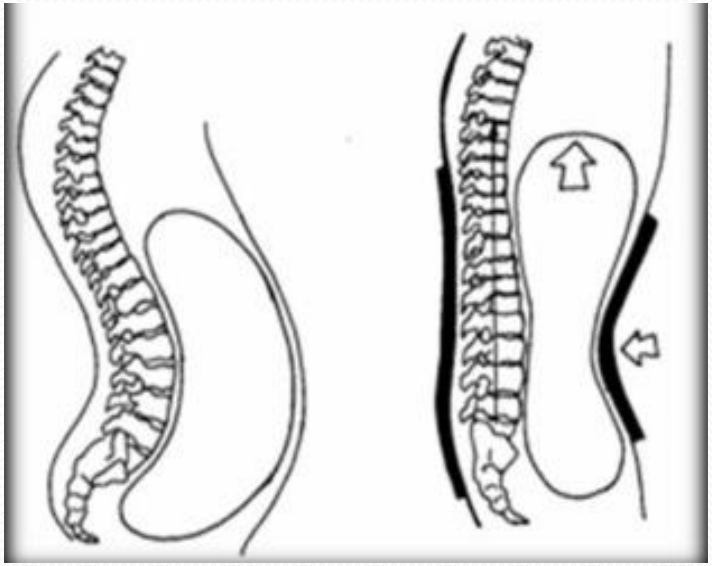
- To provide feedback through sensory system
- To adopt a more corrective or more appropriate position of the spine



Basic mechanism of SO

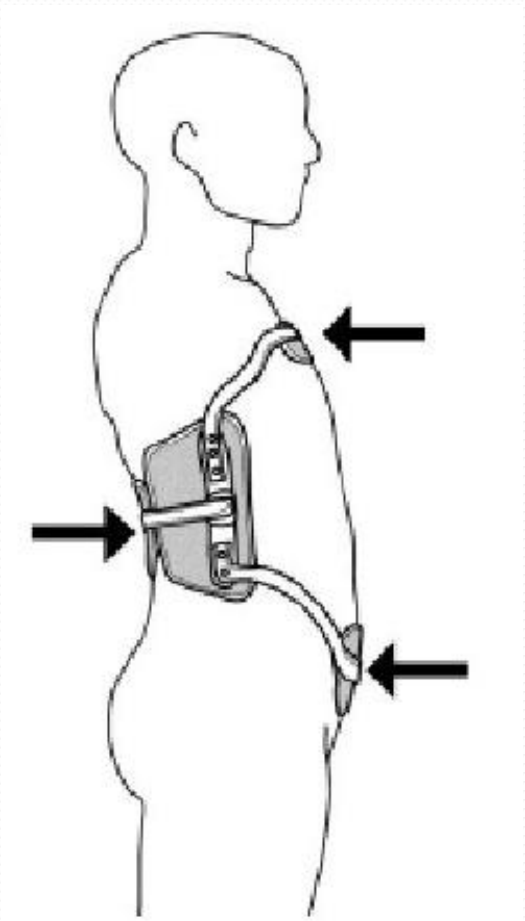
2. Increased intra-abdominal pressure

- To increase pressure inside the body's interior cavities (intra-abdominal pressure)
- To transfer load form intervertebral discs to the surrounding soft tissues
- Reduce the load on the involved spinal segments



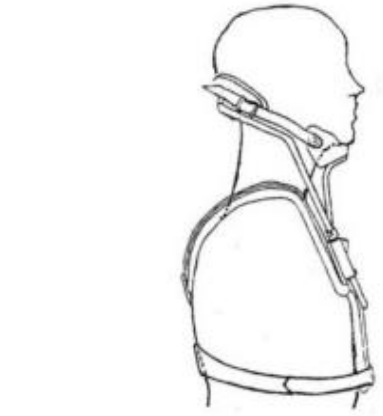
Basic mechanism of SO

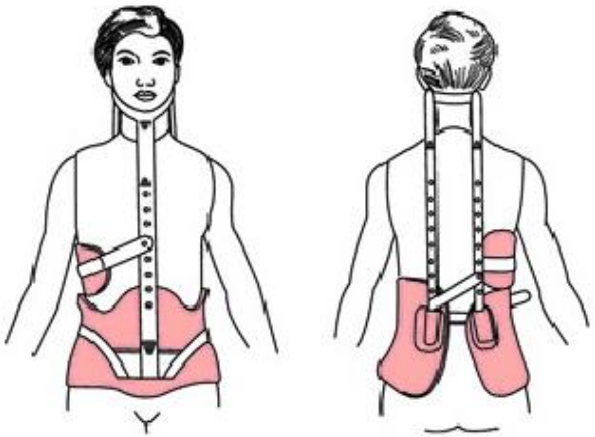
3. Three-point pressure system
   - Provide a force in one direction
   - Equilibrium with two forces in the opposite direction



Basic mechanism of SO

4. End-point control
   - To apply the device in such a way that collapse of the spinal column between opposite end point is resisted
   - Orthotic generation of longitudinal forces along the spine to distract underlying segments





Cervical Orthoses

Soft collar

- Made of soft material e.g polyurethane or foam rubber, cotton stockinet covering and posterior velcro closure.
- Provides no control of motions in the cervical spine, but does provide kinesthetic reminder to limit motion.



Soft collar

- Indication
  - Mild soft tissue injury
  - Whiplash injury
  - Muscle strain
- Contraindication
  - Ligament or bony injury of the neck
  - Need strong immobilization

Semi-rigid collar

- Made of Polyethylene sheet Sometimes vertical stays are added for the reinforcement
- Provides mild motion controls in the cervical spine compare with soft collar



Simple Hard collar

Semi-rigid collar

- Indication
  - Mild soft tissue injury
  - Whiplash injury
  - Muscle strain
- Contraindication
  - Ligament or bony injury of the neck
  - Need strong immobilization

Semi-rigid collar

- Philadelphia
  - It was developed in 1971 by Anthony Calabrese, an orthotist in Philadelphia.
  - Manufactured of polyethylene foam with anterior and posterior plastic reinforcement
  - It is more restrictive than the ordinary collar.
  - It can be used to control hypertrophy scarring in patients with burn wound on the neck.



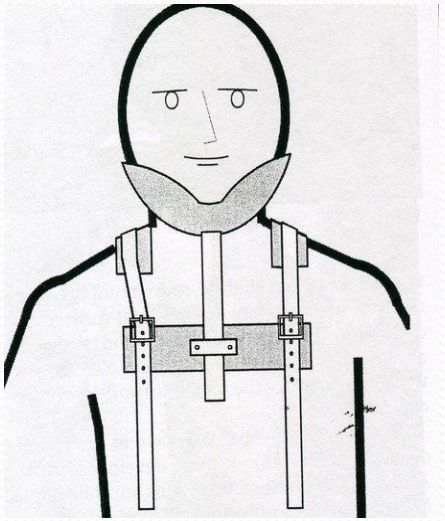
Philadelphia collar

- The collar extends from the chin to the manubrium in front
- And from the occipital tuberosity to the region above the scapular spines at the back.

Post orthoses

- Two-Post
- Three-Post
- Four-Post

Two-Post orthosis



- Made of anterior and posterior midline posts with chest and upper back fixation.
- Provides restriction of extension and flexion, but less limitation in rotation or lateral flexion.
- Indication
  - Need moderate immobilization for the neck
  - Mid or low stable cervical fractures and arthritis
- Contraindication
  - Unstable cervical fractures
  - Chin, occipital, sternum or upper thorax can not tolerate pressures

Three-Post

- Sternal-Occipital-Mandubilar Immobilizer (**SOMI**)
- Made of anterior midline post terminating in the mandibular plate and 2 curved posts extending from the chest plate to each side of the occipital plate.
- Provides strong restriction in flexion but poor in extension and less limitation in rotation or lateral flexion.





Three-Post

Indication

- Need moderate immobilization for the neck
- Arthritis
- Stable cervical fracture from C4-T3
- Post surgical fusion after removal of halo

Contraindication

- Unstable injury especially in extension
- Not for control of lateral flexion and extension
- Chin, occipital, sternum or upper thorax can not tolerate pressures

Four-Post

- Made of anterior and posterior set on either side of the mandibular and occipital plates.
- Provides restriction of flexion extension, plus rotation and lateral flexion
- **Indication**
  - Need of firm immobilization for the neck
  - Arthritis and mid or low stable cervical fracture
- **Contraindication**
  - Chin, occiput, sternum or upper thorax can NOT tolerate pressures



Four Post CTO (Online Catalogue, 2014)

Custom cervical orthosis

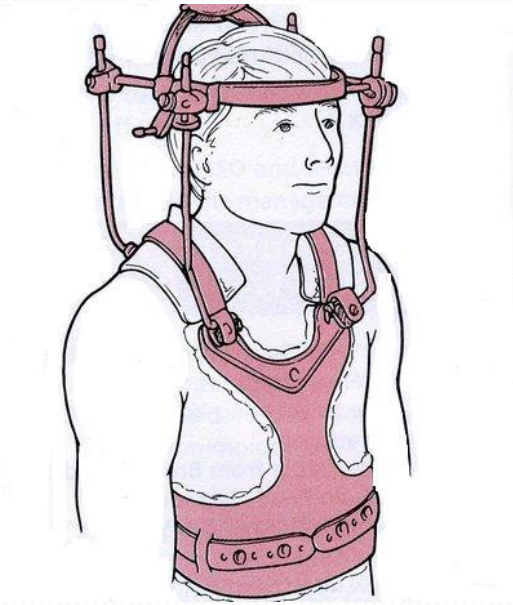
- These orthoses are prescribed for patient with **unstable cervical fracture** with or without spinal cord injury.
- They are classified as noninvasive, worn on the outside of the head or invasive, having pins inserted into the cranial bone.

- Custom-molded orthoses
  - **Halo**
  - **Minerva**
  - **Cuirass**

Halo

- Made of metal ring joined with four post fixed to the skull by pins and connected to the thorax by a prefabricated plastic body jacket.
- Provides strongest restriction of the motion of the cervical or upper spine more than another COs





Custom cervical orthosis: Halo

- **Indication**
  - Post surgical management
  - Non-displaced upper cervical fractures.
- **Contraindication**
  - If the sternum or upper thorax can NOT tolerate pressures.
- Complication associated with Halo orthoses
  - Infection of the pin site
  - Loosening of pin
  - Pin discomfort
  - Pressure sores
  - Nerve injury

Minerva orthosis

- Made of **custom-molded jacket** and mandibular and occipital support connected by frame.
- Provides restriction of flexion extension, plus rotation and lateral flexion.





Minerva orthosis

❖ Indication

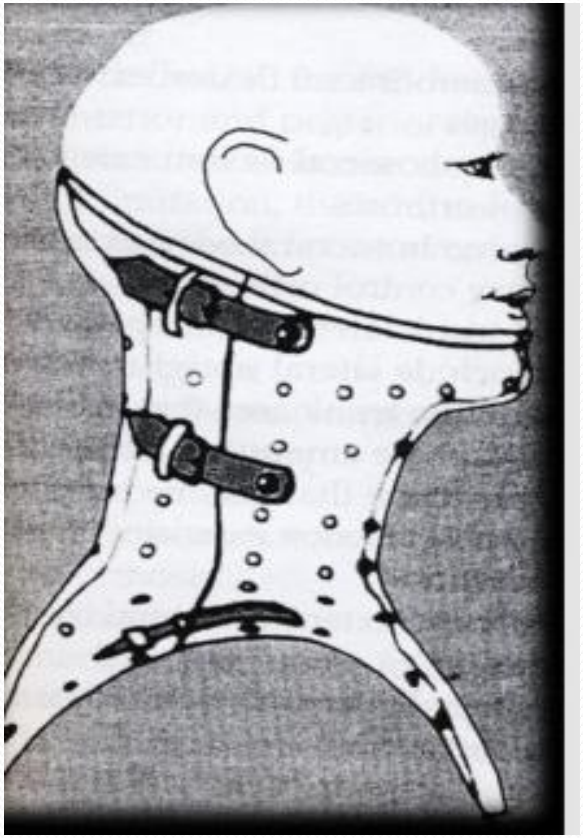
- for the needs of firm immobilization for the neck
- It is indicated for unstable fractures C3-T2 or stable fractures of C2-T3.

❖ Contraindication

- for the case if the chin, occiput, sternum or upper thorax can NOT tolerate pressures.

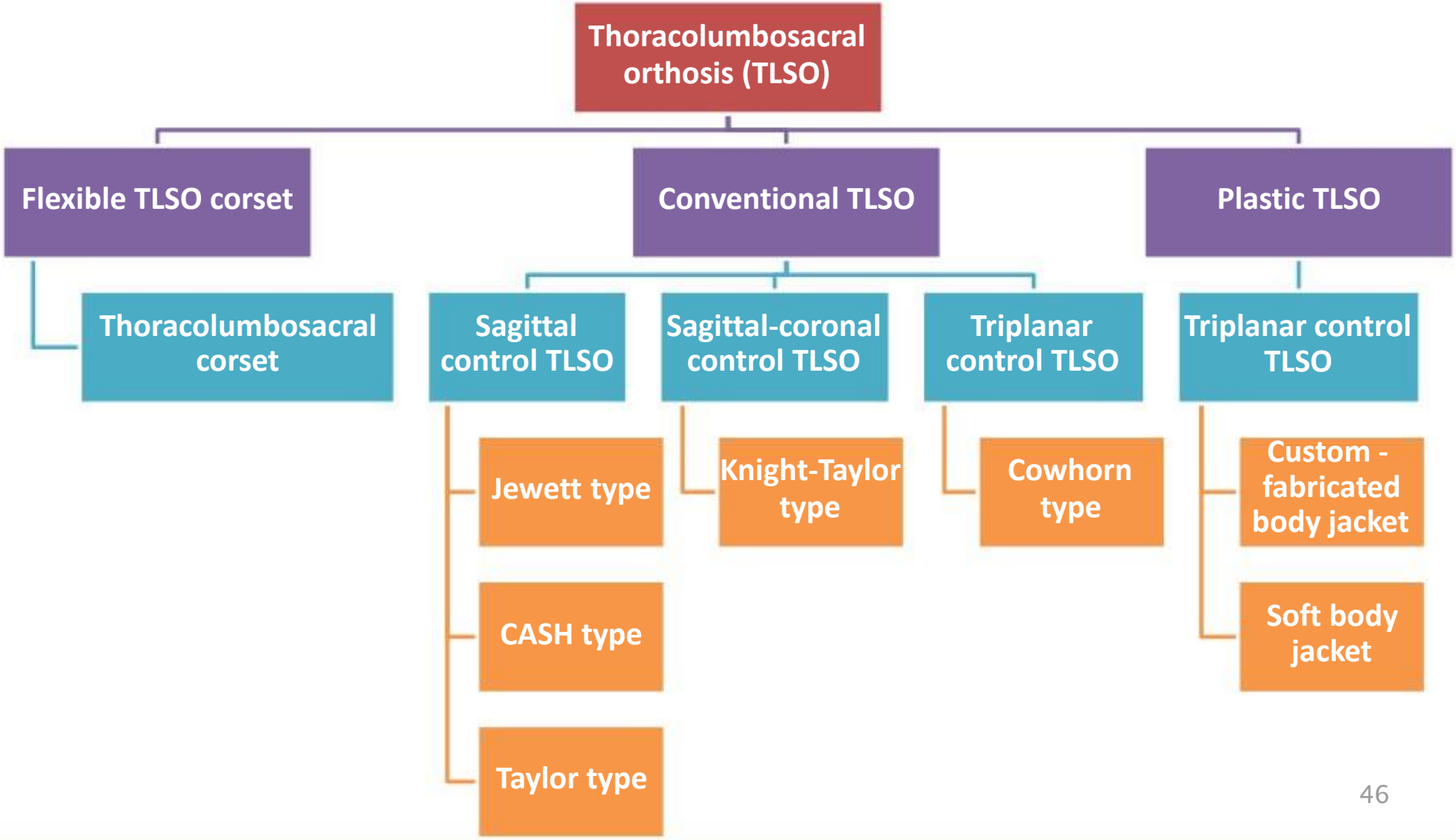
Cuirass orthosis

- The cuirass orthoses is a custom made semi rigid plastic orthoses
- Anterior chest section extend from the mid chest to the chin
- The posterior section terminates superior at the occipitoparietal margin of the skull.
- Used to prevent neck contracture due to burns or torticollis



Thoracolumbosacral Orthoses

Variations of TLSO



Flexible TLSO corset

Flexible TLSO

- Function
  - To be as kinesthetic reminder
  - To support the trunk
  - To provide some degree of trunk immobilization (by the axillary straps and depend on the rigidity of the stays)* but not a motion control
  - To increase intra-abdominal pressure



Flexible TLSO

- Indication
  - Soft tissue injuries to thoracic and lumbar spine
  - Kyphosis secondary to osteoporosis
- Contraindication
  - Severe respiratory problem

Conventional TLSO

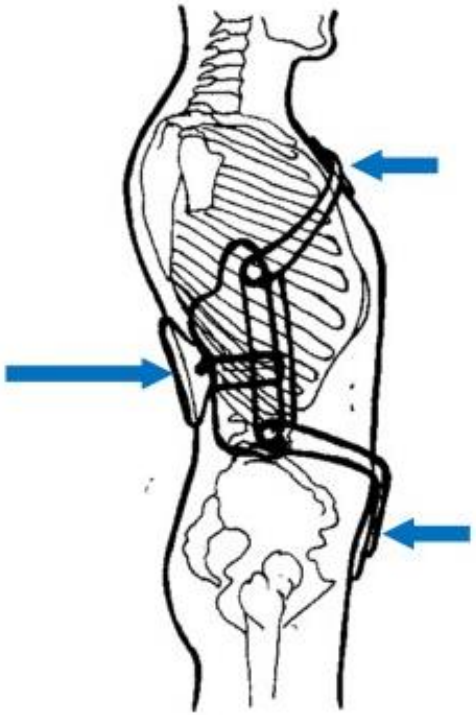
- ✓ Jewett
- ✓ CASH (Cruciform Anterior Spinal Hyperextension)
- ✓ Taylor type
- ✓ Knight-Taylor type
- ✓ Cowhorn type

Jewett type

- Function
  - Sagittal plane control
    - To restrict forward flexion in thoracolumbar area and encourage hyperextension posture
    - The most effective level: T6 and L1

❖ Flexion control of the lumbar spine

- ➢ Two posteriorly directed forces from sternal and suprapubic pads
- ➢ An anteriorly directed force from thoracolumbar pad



Flexion control of the lumbar spine

Jewett type

- **Indication**
  - Compression fracture of thoracolumbar spine
  - Thoracolumbar Scheuermar disease
- **Contraindication**
  - Unstable fracture
  - Spondylolisthesis





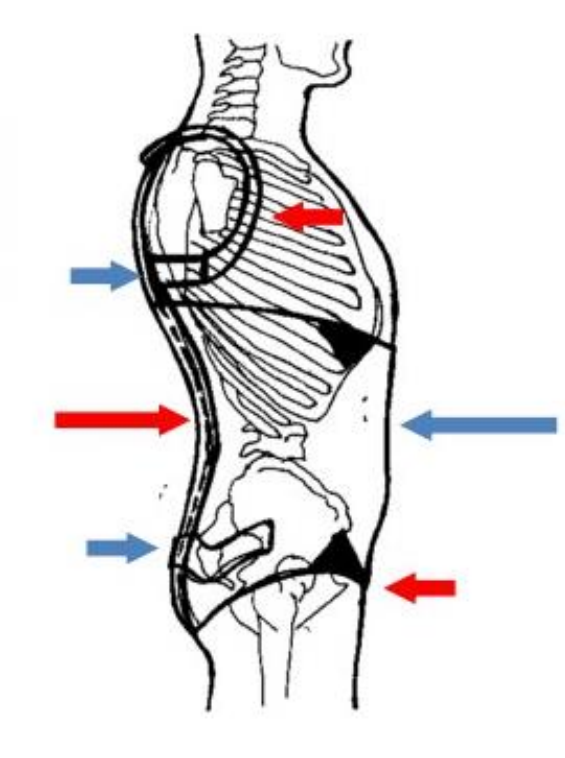
CASH type

- Function
  - Sagittal plane control: Same as Jewette type
- Indication and contraindication
  - Same as Jewett type



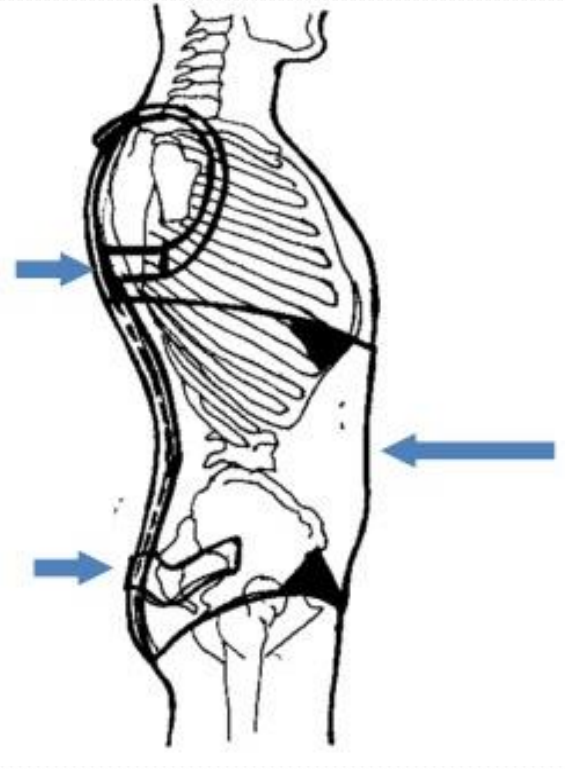
Taylor type

- Function
  - Sagittal plane control
    - Extension control of thoracic and upper Lumbar area
    - Flexion control of thoracic and upper lumbar area
  - To increase intra-abdominal pressure



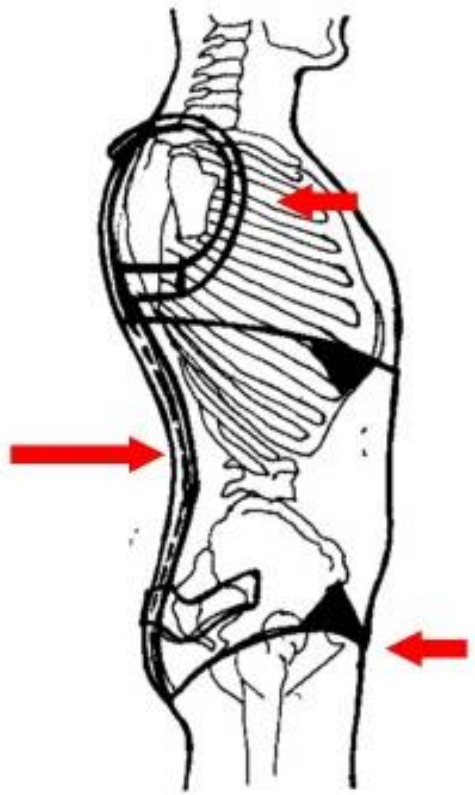
Taylor type

- Extension control of thoracic and upper Lumbar area
  - Two anteriorly directed forces from pelvic and interscapular bands
  - A posteriorly directed force from midsection of abdominal support



Taylor type

- Flexion control of thoracic and upper lumbar area
  - Two posteriorly directed forces from axillary straps and lower border of abdominal front
  - An anteriorly directed force from the center of posterior uprights



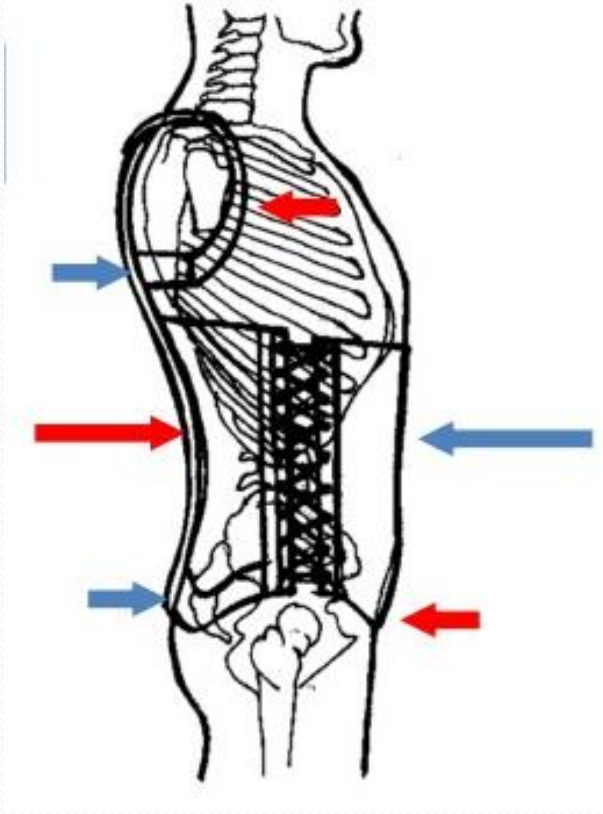
Taylor type

- Indication
  - Pott's disease or tuberculosis of spine
  - Kyphosis secondary to osteoporosis
- Contraindication
  - Adolescent thoracic kyphosis in Sheuermann's disease

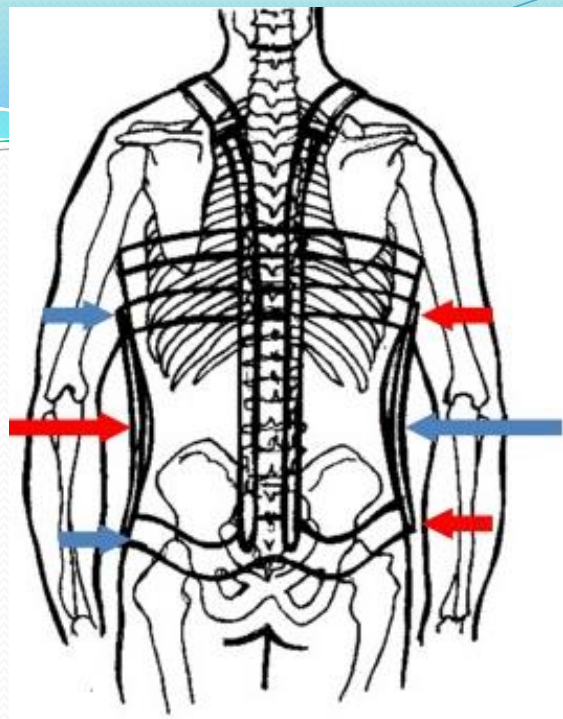


Knight-Taylor type

- Function
  - To provide sagittal plane control (as same as TLSO Taylor type) and coronal plane control
  - To increase intra-abdominal pressure



Knight-Taylor type



- To provide coronal plane (lateral bending)control » Three-point pressure system

1st

- Two leftward forces from top and bottom of right lateral upright
- A rightward force from middle of left lateral upright

2nd

- Two rightward forces from top and bottom of left lateral upright
- A leftward force from middle of right lateral upright

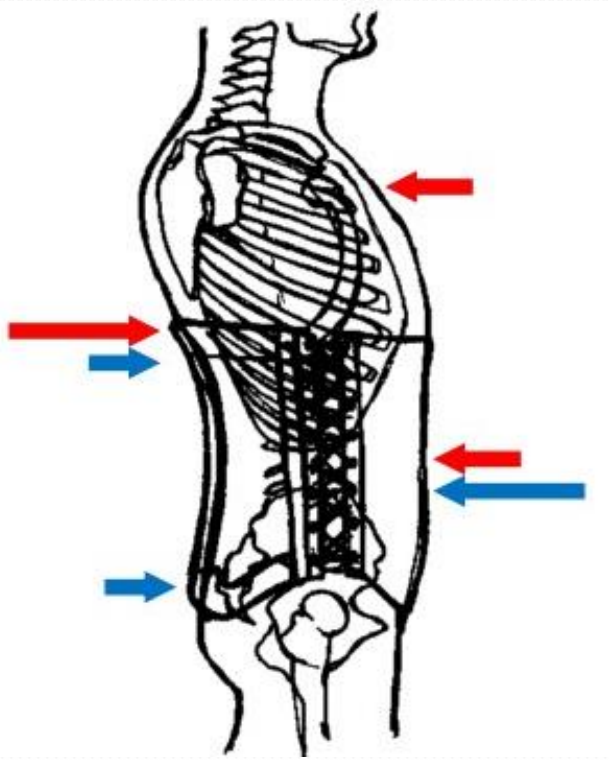
Knight-Taylor type

- Indication
  - same as Taylor types including
    - Stable fractures management
    - Pain due to severe muscle strain
- Contraindication
  - Unstable fracture



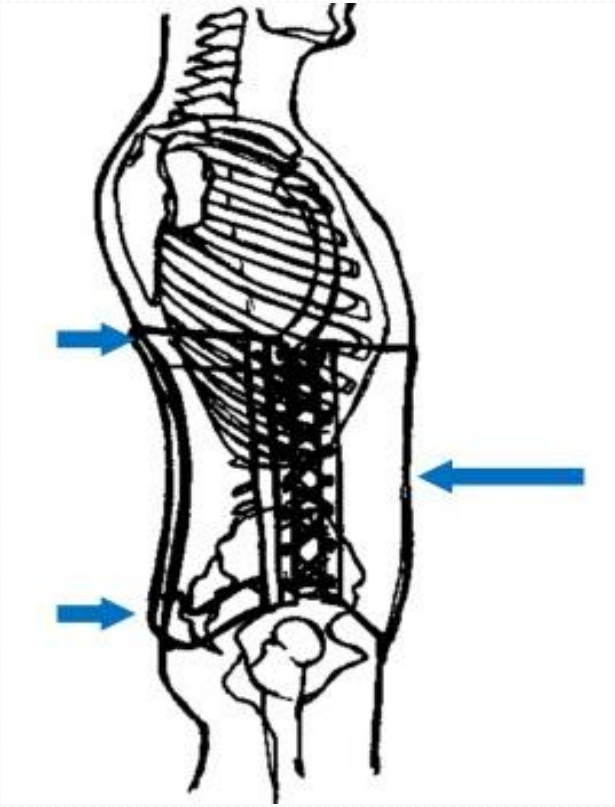
Cowhorn type

- Function
  - To provide sagittal coronal and transverse plane control
  - To increase intra-abdominal pressure



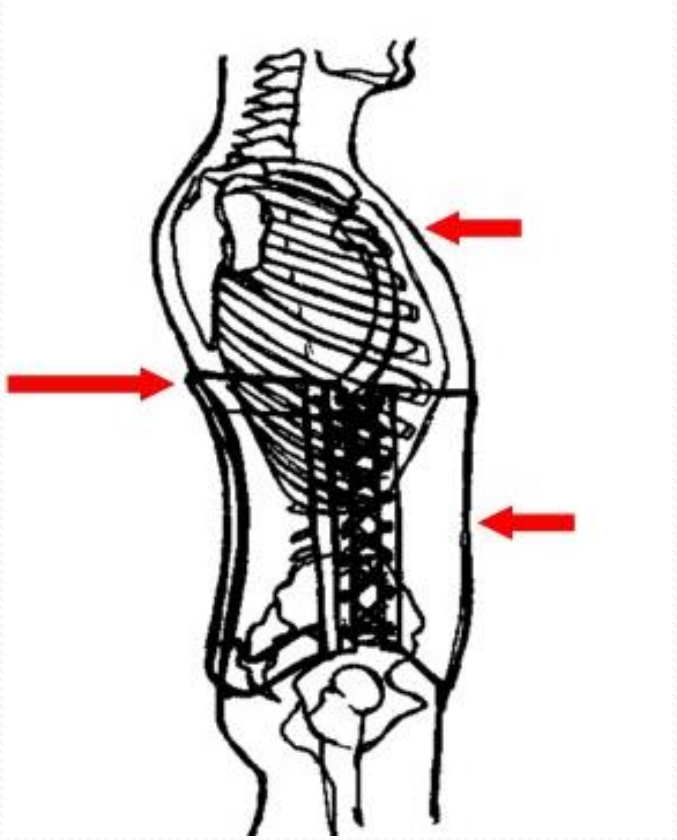
Cowhorn type

- Extension control of lumbar area
  - Two anteriorly directed forces from thoracic and pelvic bands
  - A posteriorly directed force from mid section of abdominal support

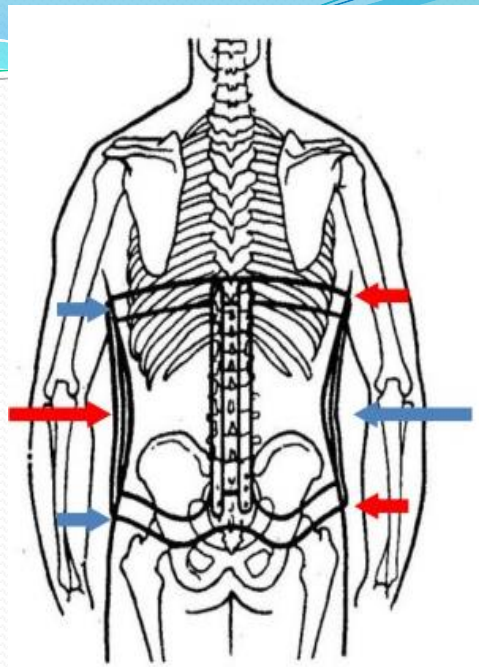


Cowhorn type

- Flexion control of the thoracic and upper lumbar spine
  - Two posteriorly directed forces from subclavicular pads and abdominal support
  - An anteriorly directed force from thoracic band



Cowhorn type



- To provide coronal plane (lateral bending)control » Three-point pressure system

1st

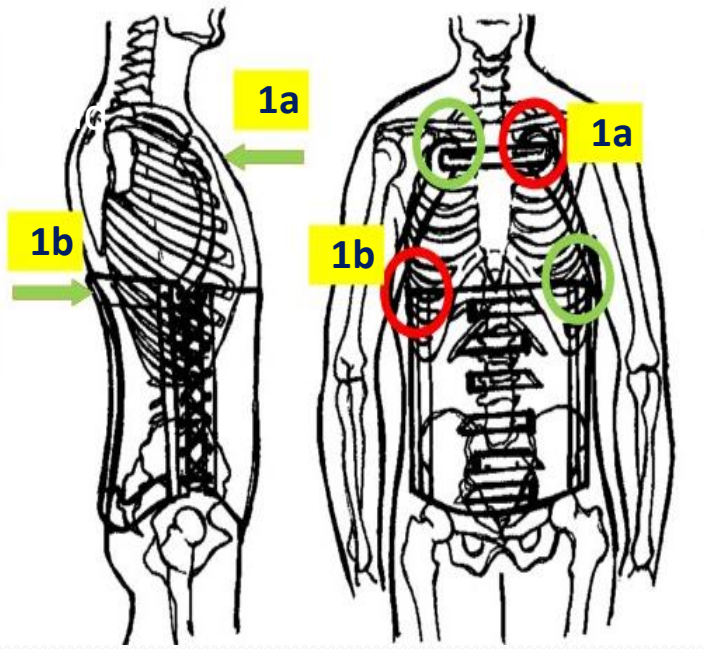
- Two leftward forces from top andbottom of right lateral upright
- A rightward force from middle of left lateral upright

2nd

- Two rightward forces from top and bottom of left lateral upright
- A leftward force from middle of right lateral upright

Cowhorn type

- Rotational control
  1. a) Posteriorly directed force to the pectoral area by subclavicular pad
  2. b) Anteriorly directed force to the contralateral thoracic area by the thoracic band
- This force couple turns the upper trunk in counter clockwise direction



Another set of force will be applied in the same pattern but in the opposite direction

- Therefore the motion in transverse plane is limited

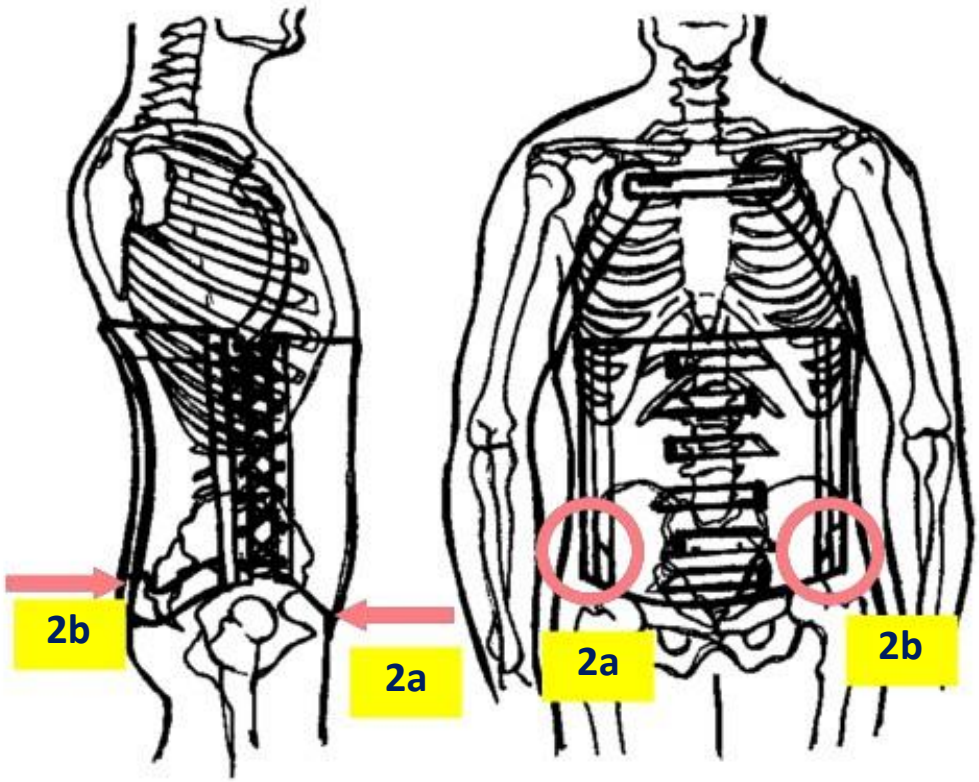
Cowhorn type

- Rotation control

2a) Posteriorly directed force to the pelvis by the lower portion of the abdominal support on the side opposite to the operative subclavicular pad

2b) Anteriorly directed force to the pelvic band on the same side as the operative subclavicular pad

- This force couple turns the lower trunk in clockwise direction

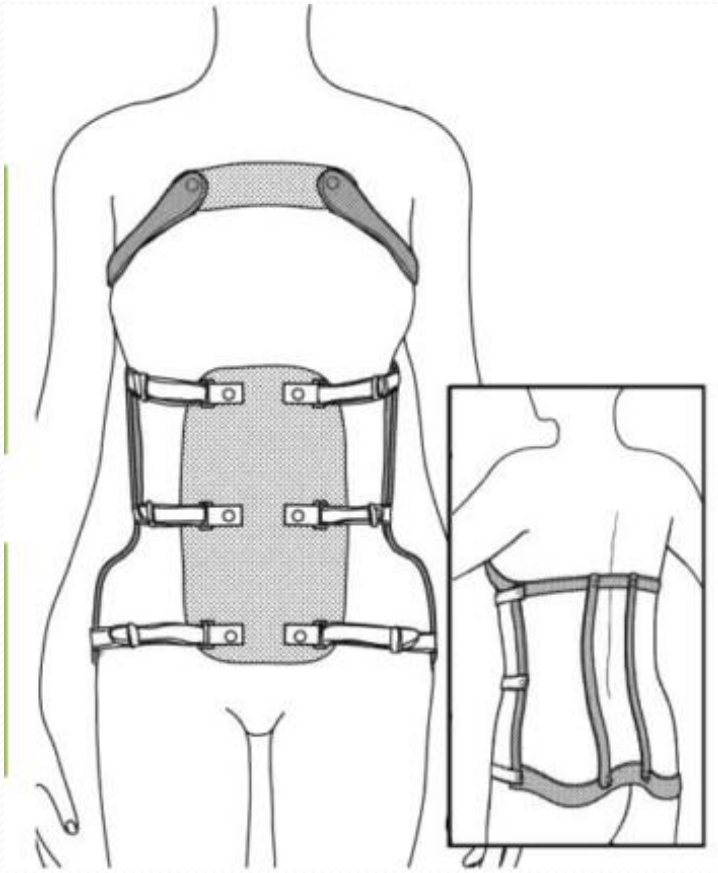


Another set of force will be applied in the same pattern but in the opposite direction

- Therefore the motion in transverse plane is limited

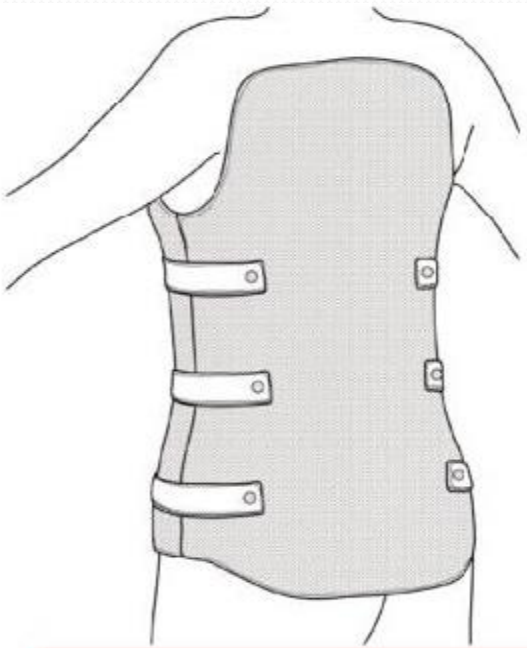
Cowhorn type

- Indication
  - Fracture management of thoracic and lumbar spine
- Contraindication
  - High thoracic injuries



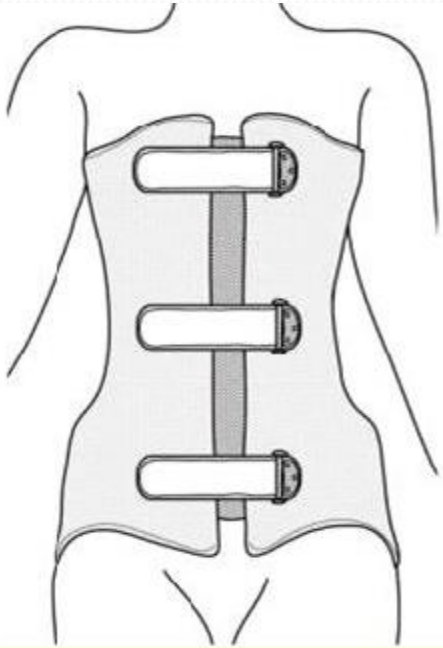
Plastic TLSO

Custom-fabricated body jecket



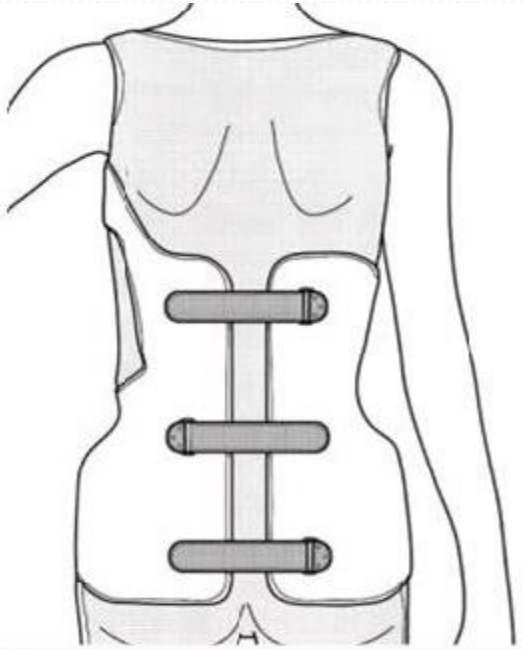
Bivalve design

For volume change accommodation



Anterior opening

For easily donning and doffing



Posterior opening

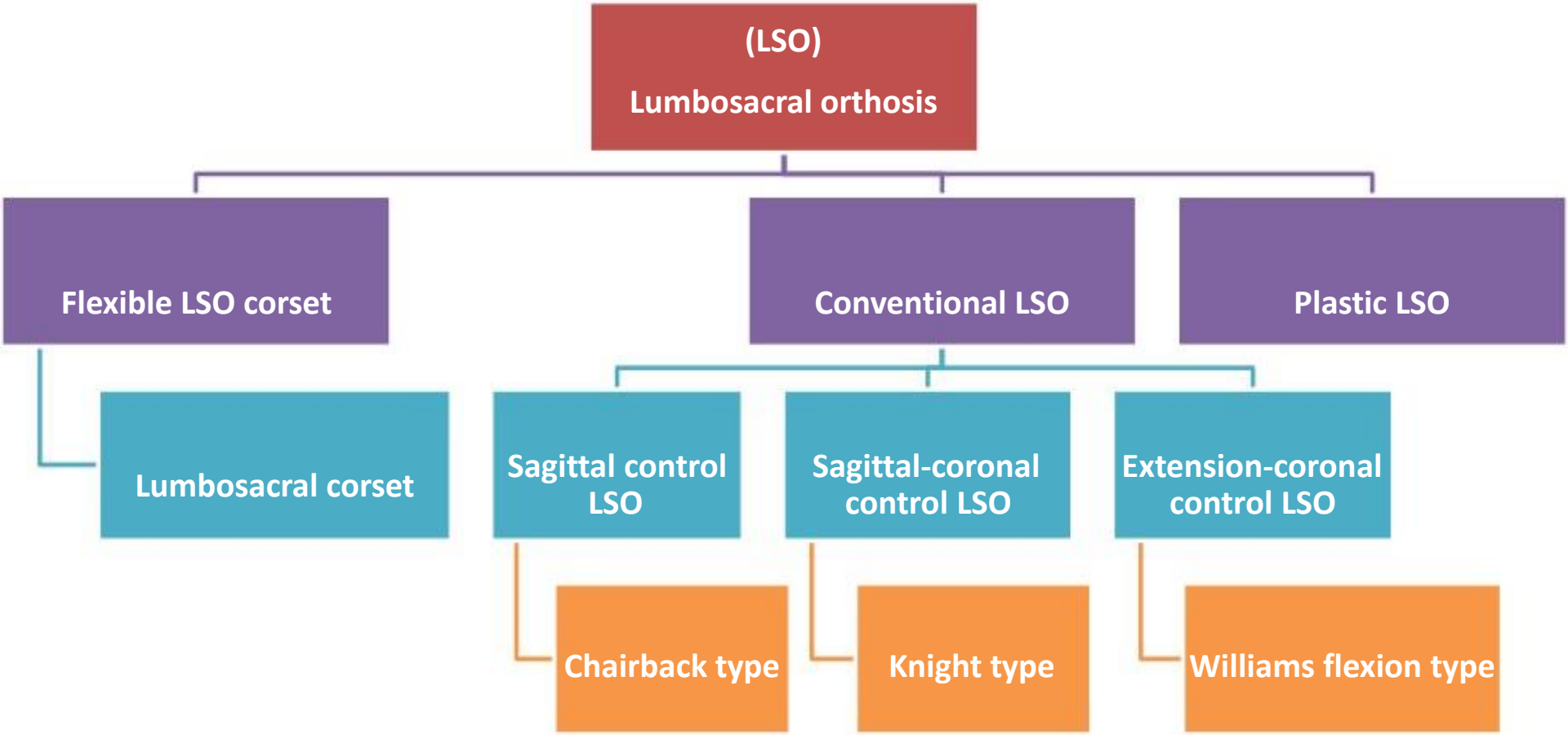
Plastic TLSO

- Indication
  - Traumatic or postsurgical fracture management
  - Low back pain
  - Disc herniation
  - Disc surgery
  - Post-surgical fusion
  - Osteoporosis
  - Spondylosis
  - Spinal caries
  - Fracture of the spine
- Contraindication
  - Skin sensitivity
  - Heat sensitivity



Lumbosacral orthosis

Variations of LSO



Flexible corset

Flexible LSO

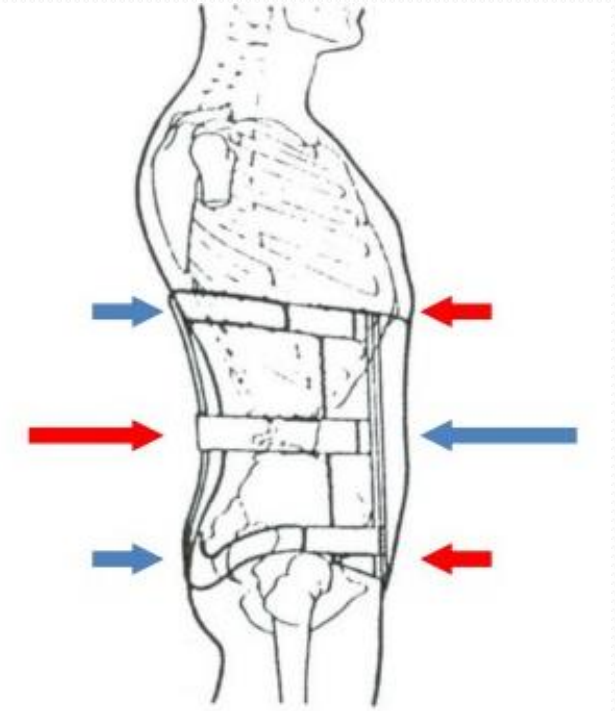
- Function
  - To increase intra-abdominal pressure
  - To reduce overall gross trunk motion
  - To restrict pelvic motion in frontal
- Indication
  - Low back pain (Acute phase)
  - Muscle strain
- Contraindication
  - Severe respiratory problem



Conventional LSO

- ✓ Chairback type
- ✓ Knight type
- ✓ Williams flexion type

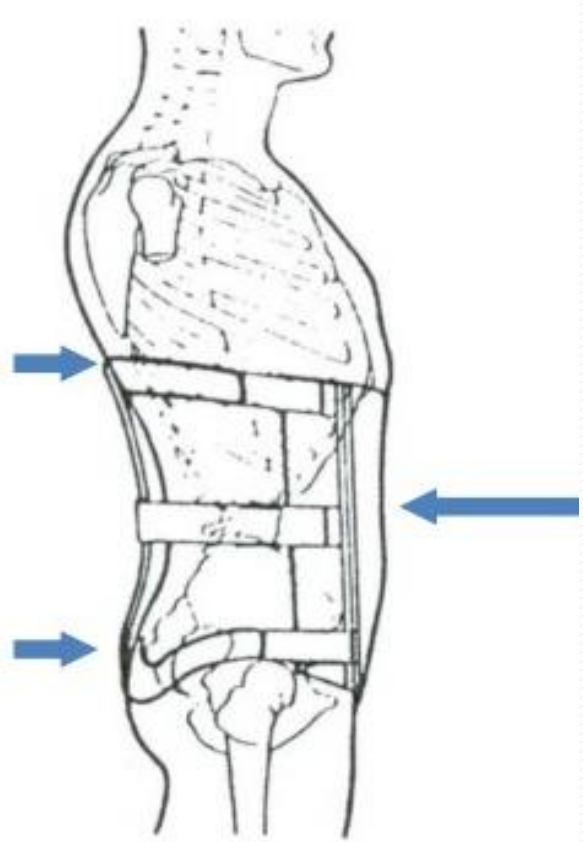
Chairback type



- Function
  - To provide sagittal plane control by three-point pressure system
  - To allow some limitation of lateral flexion
    - By the rigidity of posterior uprights (paraspinal bars) attached to thoracic and pelvic bands
  - To increase intra-abdominal pressure
    - By the corset/ abdominal support

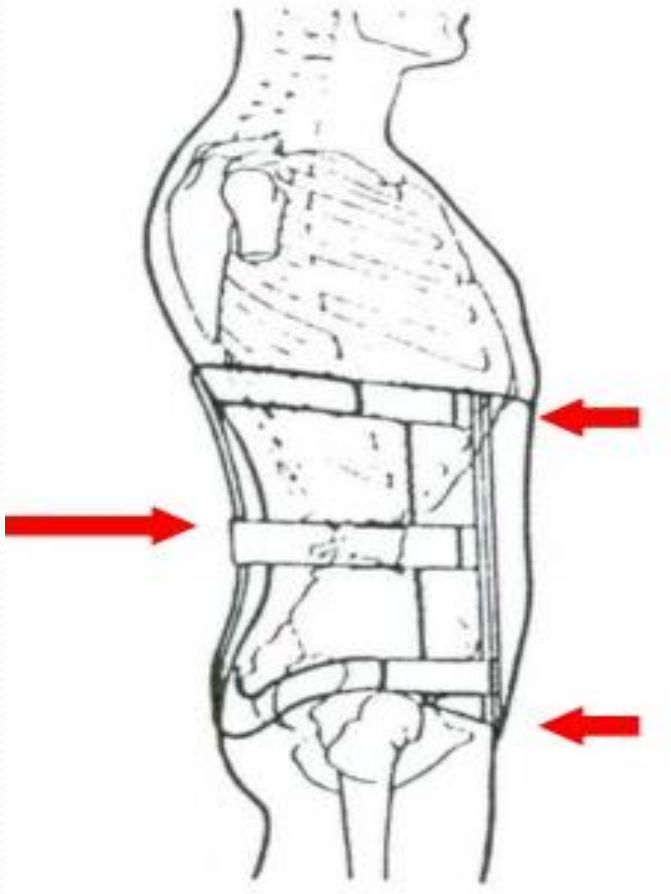
Chairback type

- Sagittal plane control
  - **Extension control of lumbar spine**
    - Two anteriorly directed forces from thoracic and pelvic bands
    - A posteriorly directed force from midsection of abdominal support



Chairback type

- Sagittal plane control
  - Flexion control of the lumbar spine
    - Two posteriorly directed forces from pelvic and thoracic straps
    - An anteriorly directed force from posterior uprights at lumbar area



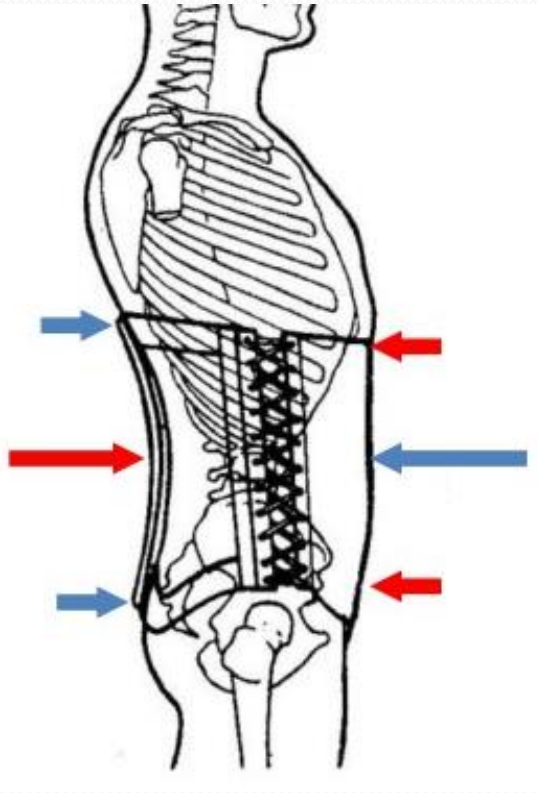
Chairback type

- **Indication**
  - Low back pain
  - Disc herniation
  - Stable mid-lumbar non-compression fractures
- **Contraindication**
  - Thoracolumbar/Lumbosacral fractures
  - Compression fracture of spine
  - Unstable fracture of spine



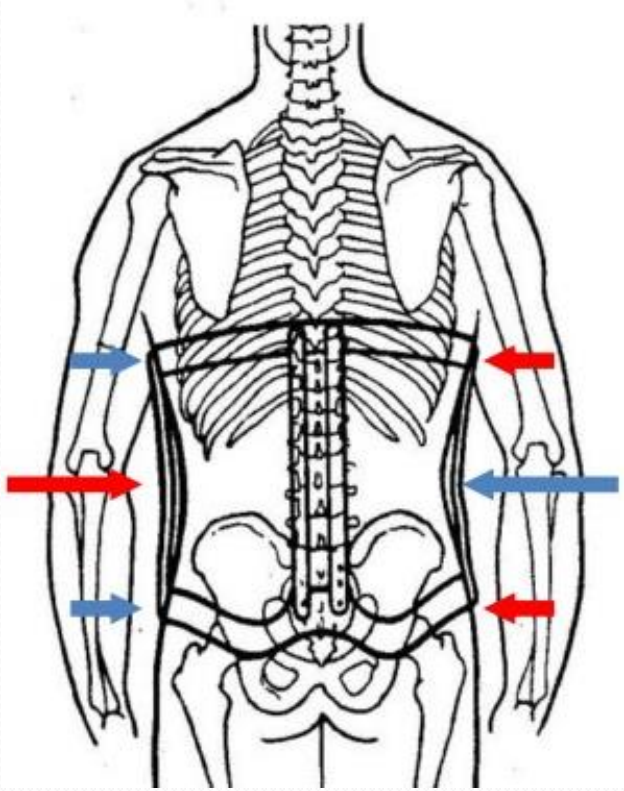
Knight type

- Function
  - To provide sagittal and coronal plane control by three-point pressure system same as chair-back LSO
  - To increase intra-abdominal pressure



Knight type

- Coronal plane (lateral bending) control is from addition of lateral bars » Three-point pressure system



1st

- Two leftward forces from top and bottom of right lateral upright
- A rightward force from middle of left lateral upright

2nd

- Two rightward forces from top and bottom of left lateral upright
- A leftward force from middle of right lateral upright

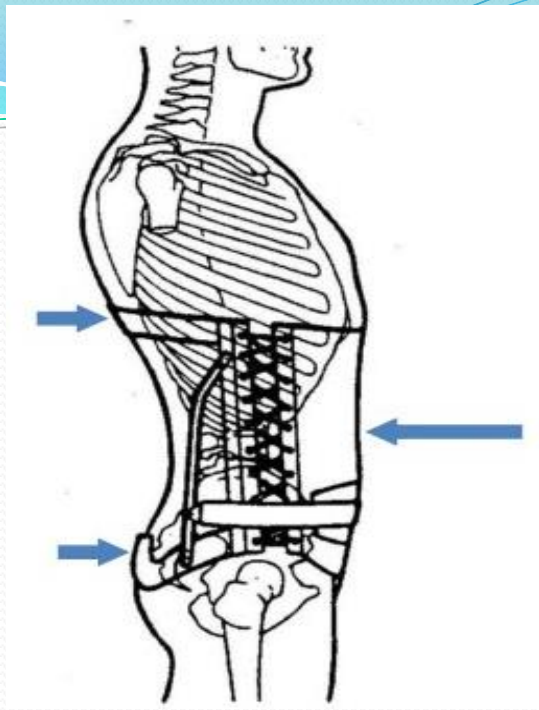
Knight type

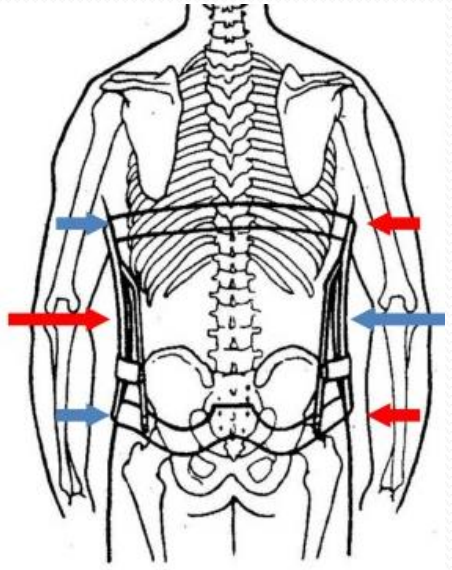


- **Indication**
  - Tuberculosis
  - Low back pain
  - Disc herniation
  - Mid-lumbar, stable, non-compression-type fractures
- **Contrindication**
  - Thoracolumbar injuries
  - Lumbosacral injuries thar require complete immobilization

Williams flexion type

- Function
  - To provide coronal plane and control trunk extension control
    - By the non-articulated connections between lateral uprights and the pelvic band, reinforced by oblique bars and snugly fit with inelastic pelvic strap
  - To allow trunk flexion motion
    - By the articulation between the thoracic band and the lateral uprights
  - To increase intra-abdominal pressure





Williams flexion type

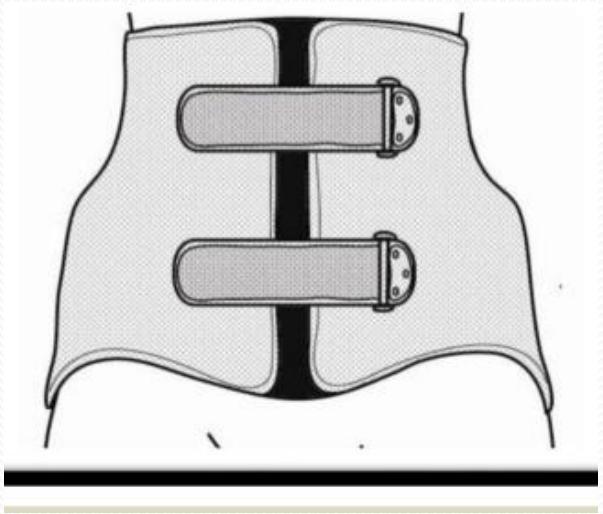
- **Indication**
  - Spinal stenosis
  - Spondylolysis
  - Spondylolisthesis
- **Contraindication**
  - Traumatic compression fractures



Plastic LSO

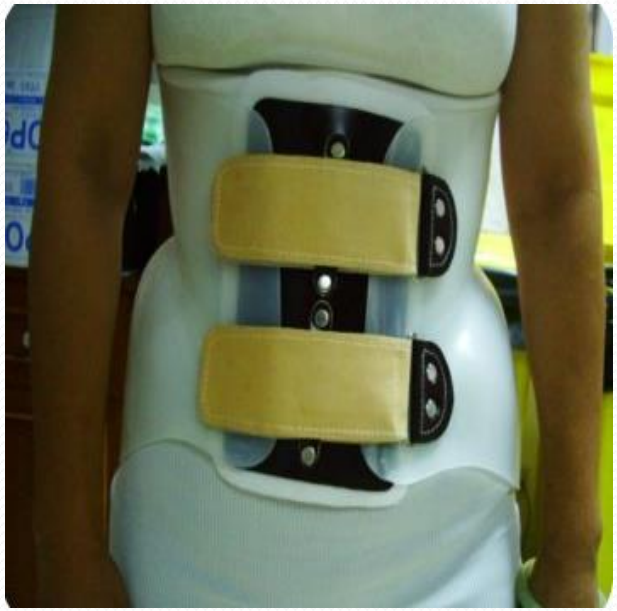
Plastic LSO

- Function
  - To immobilize of the spine in all three planes of motion
    - Level of stabilization : Determined by the height of LSO
- Custom-molded or custom fitted from the prefabricated device



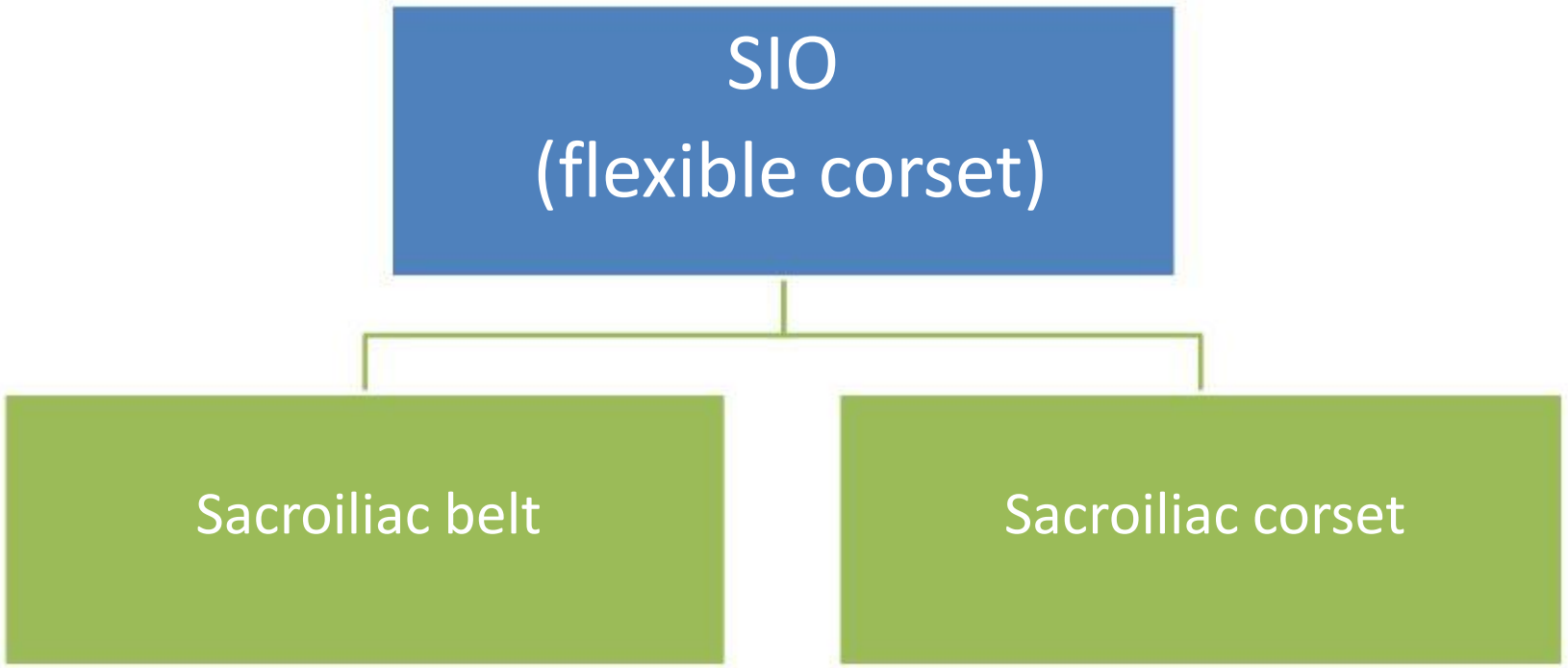
Plastic LSO

- Indication
  - Burst vertebral fracture
  - Postoperative care of patients with traumatic vertebral fracture or spinal cord injuries
  - Fusion or instrumented surgeries at lumbar-sacral level



Sacroiliac Orthosis (SIO)

Sacroiliac Orthosis



Sacroiliac belt

- Function
  - To stabilize sacroiliac joints
- Indication
  - Postpartum
  - Traumatic separation of sacroiliac symphysis pubis
  - Post surgery of symphysis resection



Sacroiliac corset

- **Function**
  - Less effective in restricting motion
  - More effective in elevating intra-abdominal pressure
- **Indication**
  - Postpartum
  - Post-traumatic stabilization of pelvic joints





SO for Spinal deformity

Milwaukee brace

- Features
  - Less chest restriction and more ventilation and comfort
  - Adjustable to growth and curve change
  - Noncosmetic
- Component
  - A Contour Girdle
  - Bar (One anterior and two posteriors)
  - Pads (Occipital pad, Chin pad, and lateral pad)
- **Indication**
  - Curves up to 40-45 degrees
  - More effective for high curves





Boston brace

- Feature
  - Pre- fabricated one piece polypropylene with soft liner
  - Posterior opening
- Trimline
  - Extend anteriorly from Xyphoid process to the pubic
    symphysis, with posterior and lateral trim lines varied
    for each curve pattern
- Indication
  - Design for lower scoliosis condition, below T7
  - Often use for curve between 20-45 gegrees





Wilmington orthosis

- Features
  - Custom molded TLSO
  - Casting with Risser Frame
  - One piece of thermoplastic with anterior opening
- Trimline
  - Extend anteriorly from sternal notch to the pubic
    symphysis, with bilateral height to axilla
- Indication
  - Scoliosis curves measuring 40 degrees or less





Cheneau brace

- Feature
  - This brace is designed for use with the Schroth physical therapy method
  - Hyper corrected positive plaster model, asymmetrical (build in pad)
  - allowing the patient to move, to breathe and to
    grow towards the open spaces.
- Indication
  - Used for patients of all degrees of severity and
    maturity.



Charleston Bending brace

- Features
  - Night time bending orthosis
  - Molded in maximal reverse bending
- Indication
  - Single, thoracolumbar curves
  - 12-14 years of age (before structural maturity)
  - Flexible curves in the range of 25-35 Cobb degrees.



Providence brace

- Features
  - Night time orthosis
  - Apply direct correctiveforces to the patient before casting by acrylic frame
- Indication
  - AIS (recommended for Single L and TL) major curves < 35 degrees
  - Apex < T8
  - Also effective for obese, juvenile and neuromuscular patients.

