

# Spinal Orthoses: Principles, Designs, Indications, and Limitations

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*...and the crooked shall be made straight...*

Isaiah 40:4

## What is a spinal orthosis?

The word *orthosis* is derived from the Greek word meaning “straightening.” Spinal orthoses or braces are appliances used in an attempt to correct and support the spine. The application of cervical orthoses was described during the fifth Egyptian dynasty, while thoracic bandages were used in the mid-18th century to correct scoliosis.<sup>51,61</sup>

## How do I determine if I have a trained Orthotist?

An **Orthotist** is a person who is trained to properly fit and fabricate orthoses. The Orthotist is usually credentialed by the American Board for Certification in Prosthetics, Orthotics and Pedorthics (ABC), which was found in 1948. The National Commission on Orthotic and Prosthetics Education (NCOPE) set accreditation standards for entry-level Orthotic and Prosthetic training programs and post-graduate residency training sites.<sup>61</sup>

<https://www.abcop.org/individual-certification/Pages/orthotistandprosthetist.aspx>

## Why are spinal orthoses used in clinical care?

- Stabilization and maintenance of spinal alignment
- Prevention and correction of spinal deformities
  - Promotion of fracture healing
  - May assist with healing of underlying surgical fixation devices
- Relief of pain by limiting motion or weight-bearing
  - The control of the spinal orthosis is based upon the biomechanics of the spine requiring restriction of the sagittal plane of motion, coronal plane of motion, transverse plane of motion or some combination of directional control.
- Reduction of axial loading of the spine

- Elevated intra-abdominal pressure increased by rigidity of the rib cage and compression of the abdominal muscles reduces the forces on the spine. It reduces the net force applied to spine during the act of lifting a weight from the floor and reduces intradiscal pressure approximately 30% in the lumbar spine.
  - Improvement of spinal function
    - Unfortunately, there are no demonstrated benefits on proprioception in healthy subjects wearing lumbosacral orthoses.
  - Provision of effects such as heat, massage, and kinesthetic feedback
- 10,31,35,36,46

### **List the three principal functions of the vertebral column**

- Protect the spinal cord and its nerve roots
- Distribute axial compressive forces
- Provides axis to support the head and translates torque to axis from the limbs.

### **What ARE THE SPINAL ANATOMICAL AND KINESIOLOGICAL CONSIDERATION INVOLVED IN THE AXIAL SKELETON?**

There are 33 spinal vertebrae divided into five regions: cervical, thoracic, lumbar, sacral and coccygeal. Each region has its own characteristics of motion and restrictions. There are 7 cervical vertebrae with 2 considered atypical vertebrae: Atlas (C1) and Axis (C2) with the typical cervical vertebra being C3-7. Fifty percent of cervical flexion and extension occurs at the Occipital Atlantal Joint (OA) and fifty percent from C3 to C7. Fifty percent of rotation occurs from Atlantoaxial joint (AA) and the other fifty percent is from C3-7. Lateral bending and rotation is greatest at C2-3 and C3-4, while the most mobile segments for flexion and extension are at C5-6 and C6-7.

There are 12 thoracic vertebrae. The thoracic vertebral motion is limited by the facets and ribs with mostly rotation allowed. The ribs limit the thoracic flexion and extension. The upper thoracic vertebrae 1-4 allow for mostly rotation>flexion/extension>side bending. The middle thoracic vertebrae T5-8 allows for mostly rotation> flexion/extension>side bending. The lower thoracic vertebra T9-11 allows for flexion/extension>side bending>rotation. The largest fulcrum of motion is at T12/L1. Due to the lack of rib stabilization at this level and the facets being more medial to lateral orientation, this region has more mobility, associated with more injury and degenerative changes.

There are 5 lumbar vertebrae. The lumbar spine, due to its large facets, contributes primarily flexion and extension. There is a small degree of side bending with very little rotation. The lumbosacral junction L5-S1 is the most difficult area to control, unless you limit motion at the hip.

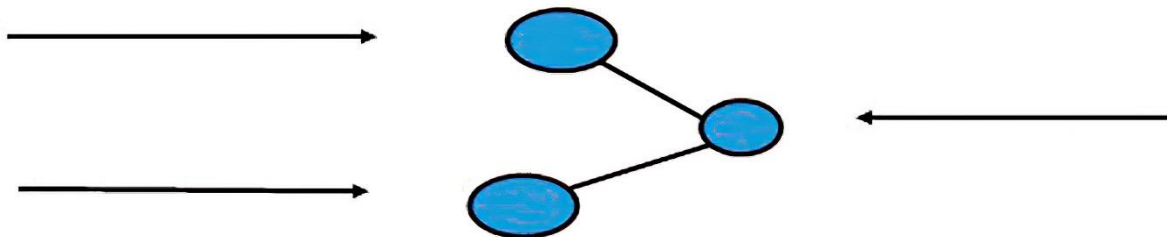
The sacrum has 5 fused segments with limited motion between the innominates. The sacrum has 3 segments that articulate with the sacrum in midline.<sup>37</sup>

## How do spinal orthoses work?

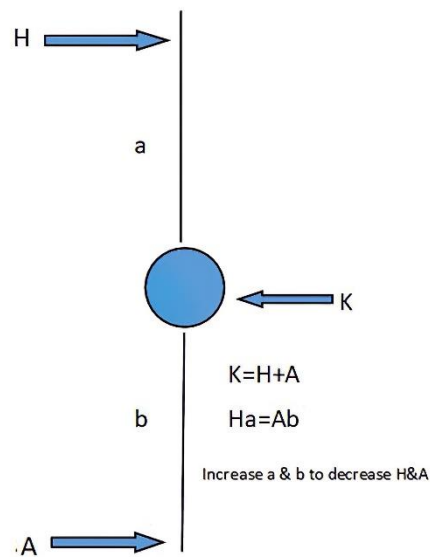
Spinal orthoses, when applied to the body, exert forces on the spine. This is accomplished in one or more of the following ways:

- **Three-point pressure system:** All orthotic devices require a minimum of three-point pressure control. This requires three-points of contact with balanced opposing forces in a particular plane. A corrective moment (force) is created by a three-point pressure system. Based upon the “Law of Equilibrium”, forces on each side of the structure needs to be balanced or equal. There are pressure tolerant tissues, and tissues that are pressure intolerant, such as over nerves or bony prominences. Adjusting the length of the lever arm or changing the size of contact pad can alter the ability to tolerate pressure. Orthotic devices are basically lever arms producing corrective angular forces. Pressure over an area is equal to the total force divided by the area of force application. The greater the area of pad, the less force per area that is applied to the skin.  $\text{Moment} = \text{Force} \times \text{Distance}$ . Moment is angular movement around an axis. Since the pressure to an area is based upon force times the distance, the longer the lever arm the less pressure per square area is required to control the forces around a joint. To simplify; if I want to decrease the pressure on a bony attachment to an orthosis, I can increase the length of lever arm; therefore, increasing the force across the joint with less pressure on the tissue interface.

Forces across a joint that are balanced based upon Law of Equilibrium.



## Three-point pressure system around a joint



**Circumferential support:** When the orthosis encompasses the trunk, it forms a semirigid cylinder surrounding the vertebral column, while bridging the connection from the pelvic brim to the lower rib cage. It also compresses the abdominal contents. The literature does not really support the reduction of spinal pressure due to increasing abdominal pressure. Nachemson in 1964 felt that the use of abdominal binder did reduce intradiscal pressure in the lumbar spine by approximately 30%. Nachemson found intraabdominal pressure were generally low (6kPA) at the most and inconsistently affected by orthosis wearing

- **Irritant:** The orthotic device is constructed so that the wearer is forced into the desired posture to avoid discomfort (kinesthetic feedback) or is reminded to voluntarily restrict motion.
- **Skeletal fixation:** Orthotic devices are documented to limit motion of the various spinal segments.

28,36,43,52

## What are the potential complications or side-effects of spinal orthoses?

Patients may become dependent physiologically and psychologically on the use of the orthotic devices. Since myoelectric activity has been shown to be reduced with use of spinal orthotics, there is a potential weakening of the axial muscles. Soft-tissue contractures could be a problem based upon restriction of motion. The orthotic device can cause trapping of moisture resulting in loss of skin integrity and pressure areas with resultant skin issues such as ulcers. They may not be tolerated in hot, humid climates. They may cause interference with some activities of daily

living. Potential osteopenia through misuse or overuse. The orthotic device can cause discomfort and emotional distress that can influence a person's quality of life that could affect compliance with use of the device.<sup>37</sup>

## **What are some complications that occur with Cervical Orthoses?**

Cervical orthoses can cause difficulty with swallowing, coughing, difficulty breathing and vomiting. It can place pressure on the marginal mandibular nerve resulting in sensory compromise. It can increase intracranial pressure.<sup>8,16,22</sup>

## **What factors require consideration in prescribing the most appropriate orthosis for a specific spinal problem?**

- Baseline musculoskeletal and neurological examination
- The pertinent diagnoses, age, bone development, deformity, prognosis
- The patient's body habitus?
- Projected patient requirement of compliance?
- The intended mechanism and results from the orthotic device?
- The regions that need to be controlled?
- What complications or loss of function may be caused by the device?
- What type of control upon the biomechanics of the region is required?
  - Restriction of sagittal plane motion
  - Restriction of coronal/Frontal plane motion
  - Restriction of transverse plane motion
- From Orthotist standpoint
  - The weight of the device
  - What forces or loads are going to be required by the device
  - The material being utilized for the device
  - Can the material utilized hold up to the forces required to control the body part?
  - Cosmetic appearance of the device
  - Cost, availability and ease of care of the device

## **How are spinal orthoses classified?**

The name of the spinal orthotic device by conventions is by the body regions that they cross. They also go by other eponyms. Orthotics may be rigid, semirigid or flexible depending on the purpose or amount of control desired from the orthotic device.

### **Named by the body region that they cross or by eponyms<sup>20</sup>**

CO: Cervical Orthosis; HCO: Head cervical orthosis

Soft cervical collar

Rigid cervical collar (Philadelphia, Aspen, Miami J, Newport)

CTO: Cervicothoracic orthosis

Halo, Sterno-occipital mandibular orthosis, Minerva

CTLSSO: Cervicothoracolumbosacral orthosis

Milwaukee

TLSSO: Thoracolumbar orthosis

CASH, Jewett, Custom-molded body jacket. Knight Taylor TLSSO

LSO: Lumbosacral orthosis

Chairback, Knight, corsets/binders

SO: Sacral orthosis

Trochanteric belt, sacral belt, sacral corset

## **What considerations are required in developing an Orthotic Prescription?**

There needs to be an appropriate diagnosis and an understanding of the functional goals of the orthotic device. One needs to understand the areas that need to be covered by the orthosis. A decision as to the rigidity or flexibility required to perform the task. Need to determine what motions should be restricted by the device: sagittal plane motion, frontal plane motion and transverse plane motion

## **Is there a difference between Customized and Off-the-Shelf spinal orthotics?**

Tenet of Orthotic classical practice in considering custom versus off-the-shelf orthotic devices. "Customized orthoses more effectively limit or control motion better than prefabricated or off-the-shelf orthoses." They have more intimate fit with the custom device. Has better control of triplanar motions (effect on transverse, sagittal and frontal planes). Better control of frontal

plane motion and transverse plane motion. Custom orthotics are better adjusted for a pendulous abdomen or accommodative to other devices. Custom orthotics have better control due to locking down on the rib cage or Anterior Superior Iliac Spine (ASIS). More comfortable to wear than off-the-shelf. Off-the-shelf orthotics can often be modified to meet the clinical needs of the patient

**What orthoses are utilized for cervical problems?**

- Cervical orthosis (CO)/Head cervical orthosis (HCO)
- Cervicothoracic orthoses (CTO)
- Halo skeletal Fixator
- Minerva HCO
- Sterno-occipitomandibular orthosis (SOMI)

**Are there functional limitations with the use of CO/CTO?**

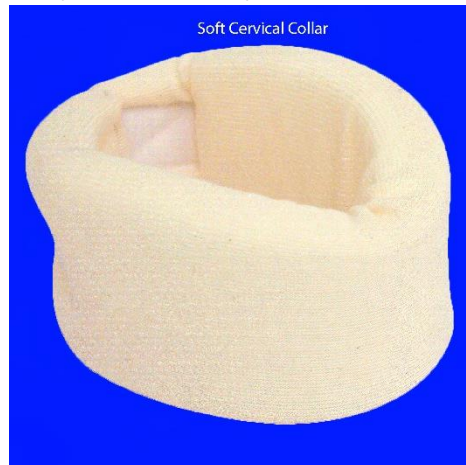
CO and CTO limit cervical motion. This may limit the ability to look down to see and perform bowel and bladder care. It may also adversely affect advanced wheelchair skills and transfer activities.

**What are the relative percentage restriction of motion by the various CO's?<sup>21</sup>**

<b>Restriction of Motion % by Orthosis</b>			
<b>Device</b>	<b>Flexion/Extension</b>	<b>Lateral Bending</b>	<b>Rotation</b>
Halo	96	96	99
Minerva	78	51-90	84-88
Four-Post CTO	79-88	54	73
SOMI	61-72	18-34	29-66
Miami J	60-76	52	65-77
Vista -Aspen	69-90	34-48	74
Philadelphia	59-75	12-34	27-56
Soft Collar	8-26	8	10-17

**What are some commonly utilized types of COs? What is the limited motion afforded by the device? What diagnoses are they utilized?**

**Soft cervical collar:** Made of foam rubber. Limits flexion/extension by 8-26%, lateral bending is limited by 8% with rotation limited 10-17%. Provides partial support of the head reducing paraspinal contraction and spasm. Its true benefit is warmth, psychological reassurance and a kinesthetic reminder to limit motion. The problem is that it gives no true structural cervical spine support. In addition, studies suggest it may not actually reduce the duration or intensity of pain.



**Miami J Collar/VISTA Collar (semirigid):** It is made of polyethylene plastic. Flexion/extension limited 69-90%, lateral bending limited 34-48% and rotation limited 74%.

- Polyethylene
  - Has tracheostomy opening
  - Custom adjustment height around chin and occiput
  - Lowest level of mandibular and occipital tissue-interface pressure compared to other rigid CO's
  - Lower skin temperature
    - Less sweating
    - Less skin breakdown
- Indications
  - s/p Anterior Cervical fusion
  - Jefferson's Fracture (C1)
  - Hangman's fracture
    - Traumatic spondylolisthesis of C2 on C3
  - Dens type I fracture
  - Anterior discectomy
  - Cervical trauma in unconscious patients
  - Cervical Strain





**Malibu Collar:** Heat moldable kydex shell material with closed-cell foam liner. Flexion/extension limited 55-60%, lateral bending limited 60%, Rotation limited 60%.

2-piece orthosis

Anterior opening for tracheostomy tube

Adjustable chin support

MRI compatible

Indications:

s/p anterior cervical fusion

Dens type I fracture

Cervical trauma in an unconscious patient

Cervical Strain



Malibu Collar

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**Headmaster control CO-** Very light weight flexible collar. Limited control, Low profile and used to support the head

Indicated

ALS

Multiple sclerosis

Dropped Head Syndrome (DHS)

Radiation Fibrosis Syndrome

Motor Neuron Disease

Supports muscle weakness.

Too much botulinum toxin



## **What motion is best prevented with a CO? How do you decide on a particular orthosis?**

All cervical orthotics (CO) tend to control flexion better than extension. Increasing the height of the rigid collar may cause more restrictive motion; however, may lead to increase cervical extension. The Halo CTO is the most effective orthosis for controlling flexion and extension at C1-3, followed by the 4-poster CTO. CTO's are best for use in controlling flexion and extension at C3-T1; whereas, the SOMI is best for use in controlling flexion at C1-5. However, the Halo is the best orthosis for controlling rotation and lateral bending at C1-3. The 4-poster brace is slightly better than the CTO for controlling lateral bending of the cervical spine. The SOMI controls extension less effectively than do other orthoses.

## **What motion is most effectively restricted with the use of most cervical orthotics?**

Flexion/Extension and rotation movements of the cervical spine are more effectively restricted than lateral bending movements by all collars.<sup>17</sup>

## **What cervical device/orthotic is more effective in restricting cervical motion than conventional orthoses?**

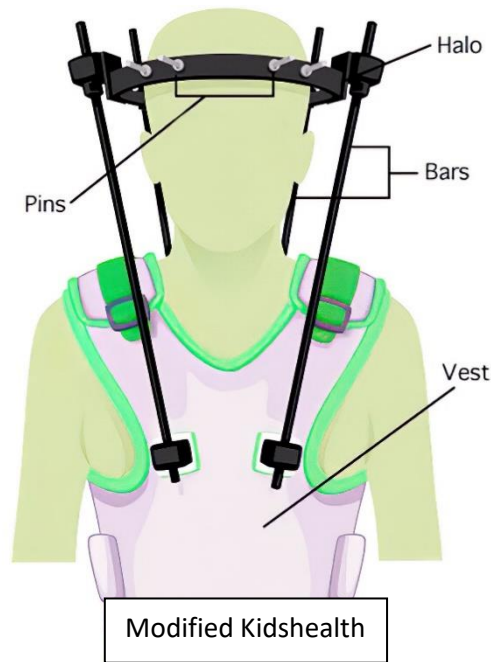
The Halo fixator device.<sup>17</sup>

### **What is the Halo Spinal Fixator?**

It is a 4-poster orthotic that is attached by pins that are placed in the cranial table. It usually controls motion down to T3. It has good control for occiput to C1. The middle cervical region is not as well controlled due to "snaking" with 31% of motion noted at C4-5 level,

Flexion/Ext limited 96% Lateral Bending limited 96% Rotation limited 99%.

Indications: It is often utilized for occipital condyle fractures, C1 ring injuries, odontoid fractures, hangman fractures (C2), facet subluxations, spinal infections, extradural tumor involvement that compromises the spinal alignment or bony stability and subaxial spine injuries.<sup>5,7</sup>



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## Is it mandatory to use a cervical orthosis after a cervical fusion?

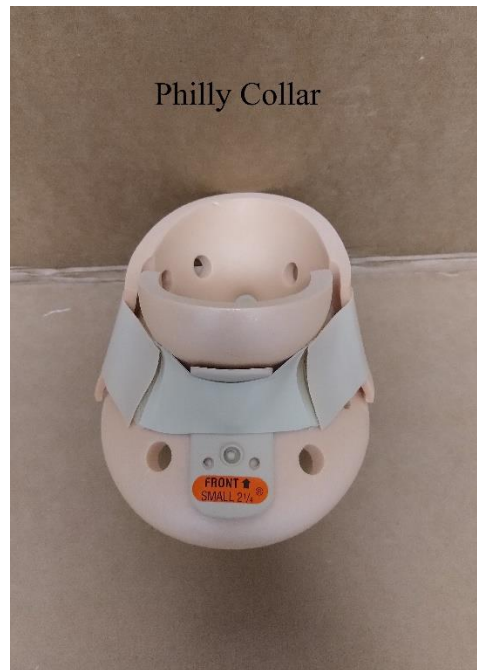
Cervical orthoses have been utilized in patient both pre and postoperatively for anterior cervical discectomy and fusion (ACDF) surgeries with the goal of cervical immobilization. It has been found that even the halo fixator orthoses are more restrictive than other type of orthoses, however “snaking” is often permitted. The use of the cervical orthosis may be surgeon dependent; however, based upon the “highest level of evidence” there is a recommendation against the routine use of external cervical collars after an ACDF.<sup>8</sup>

## What about the Philadelphia collar with thoracic extension?

It is a 2-piece plastizote foam collar. The thoracic support will restrict C6 to T2 with some references reporting down to T5. Cervical flexion and extension is limited 59 to 75%, lateral bending is limited by 12-34% and rotation is limited by 27-56% .

## Is there a problem with use of the Philadelphia Collar?

It is not very well ventilated so that it can increase skin maceration due to production of heat and moisture in an area. It can increase pressure on the mandible, and occiput that may result in tissue ischemia and resultant ulcer.



## What are the indications for the Miami J with thoracic extension ?

- s/p Anterior cervical fusion
- Dens type I fracture
- Anterior Discectomy
- Cervical trauma in the unconscious patient
- Cervical strain
- High thoracic injury



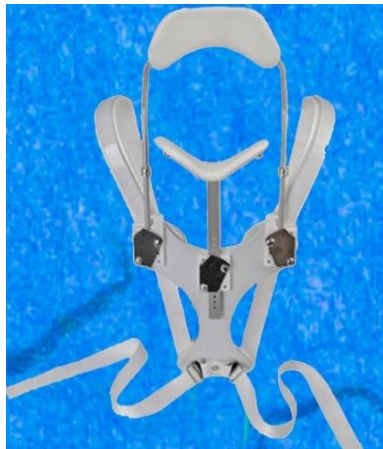
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## What is the SOMI (Sternal-occipital-mandibular orthosis)?

It is a 3-poster CTO. It has an anterior chest plate that extends to the xiphoid process. It has a removeable chin strap. Flexion/Extension is limited 61-72%, lateral bending by 18-34% and rotation is limited 29-66%. It controls flexion of C1-3. It controls extension less than with other cervical orthotics.

## What is the indication for the SOMI?

Atlanto-axial instability such as in Rheumatoid Arthritis  
Neural arch fractures of C2 due to flexion instability.<sup>56</sup>



## What is the CTO-Cervical-Thoracic Orthosis?

CTOs provide significantly more restriction of intervertebral flexion and extension than CO's  
Controls motion down to around T5



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## **What is a halo Fixator vest orthosis?**

This CTO consists of two parts. The halo portion is a circular band of steel attached to the skull via threaded pins. Adjustable rods connect the halo to a vest that encircles the trunk. This device provides the most rigid fixation of the cervical spine and is the orthosis most widely used after upper cervical fractures. This brace makes early mobilization possible and immediate rehabilitation of the patient after spinal surgery, while maintaining a stable spine.

## **Where do you position the pins in a Halo device?**

Anteriorly the pins are placed 1 cm above the lateral rim of the orbit

Posteriorly it is 1 cm above the top of the ear and below the largest diameter of the skull. When placing the Halo device need to make sure that the pin does not puncture the supraorbital nerve medially or the temporal artery laterally. <sup>32</sup>



## **How do you care for the Halo Device?**

When the patient is in the hospital, the pin should be cleaned every 8 hours. It can be done twice-a-day after discharge. Need to check for any crusting, drainage, redness or swelling. Should use a sterile “Q-tip” with antimicrobial soap and

normal saline to clean the skin. Do not use Betadine, Hydrogen Peroxide or Alcohol since this could cause pin corrosion or disruption of wound healing.

When checking position or movement of the device, you need to obtain lateral X-rays in the horizontal position, then with the bed elevated at 45 degrees. If the alignment remains intact, x-rays are obtained with the head of bed at 90 degrees.

The torque wrench should remain with the Halo Vest at all times in case of an emergency.<sup>32</sup>

### **What are the Torque Wrench Settings for the Halo Pins?**

Adult should be 6 to 8 inch-pounds of pressure, with children it should be 2-5-inch pounds of pressure.

Due to loosening of the pins being one of the most common problems associated with the Halo system, need to monitor the torque after the pins are placed, 24 hours and 48 hours post placement. Need meticulous monitoring for loosening. It has been reported that pin loosening occurs in up to 36 to 60% of patients.<sup>5</sup>

### **What are the rehab precautions with the Halo device?**

When the chest plate is loosened the patient should be laying down. The patient should keep shoulder abduction  $\leq 90$  degrees. Should not do any activity with the arms over the shoulder height. The patient needs to avoid shoulder shrugging for it will create distraction forces on the cervical spine. Do not lift, turn or move the patient by pulling on the vest, rods or superstructure.<sup>5</sup>

### **What complications can occur with the Halo Device?**

Pin loosening is often detected. There can be a clicking, grating or creaking type sound. The patient may detect a sensation of looseness. There could be pain at the pin site. There could be development of Halo Vest movement. This could lead to loss of spinal reduction while wearing the Halo Vest. Patient may develop pin site infection, scaring, nerve injury (supraorbital, supratrochlear and abducens nerve), dural penetration, intracranial abscess and seizures. Patient may have dysphagia. Placement of the pin too laterally may compromise the temporalis muscle and the zygomaticotemporal nerve causing loss of sensation in the temporal region.<sup>5</sup>



## **What are the contraindications to utilizing the Halo fixation Device?**

The absolute contraindications are cranial fractures, bone deficiency, sepsis or severe soft-tissue injury.

Patients that are unable to tolerate the Halo system are the elderly, patient with mental illness and those with cognitive disabilities.

Relative contraindications include severe chest trauma, such as pulmonary contusion, pneumothorax, and penetrating chest injury. Obesity and barrel-shaped chest does not allow for appropriate fitting of the vest. <sup>5</sup>

## **What are the potential causes of diplopia and inability to fully close eyelids after placement of the halo device?**

Pin placement may be problematic if placed improperly. During the Halo pin placement, the patient needs to keep their eyes closed. This will reduce tethering of the skin and avoid the inability to close the eyes. The most common injured cranial nerve with the halo device is traction injury to the abducens nerve. This causes weakness of the lateral rectus muscle. <sup>5,6,7</sup>

## **Why do patients have dysphagia with the Halo Device?**

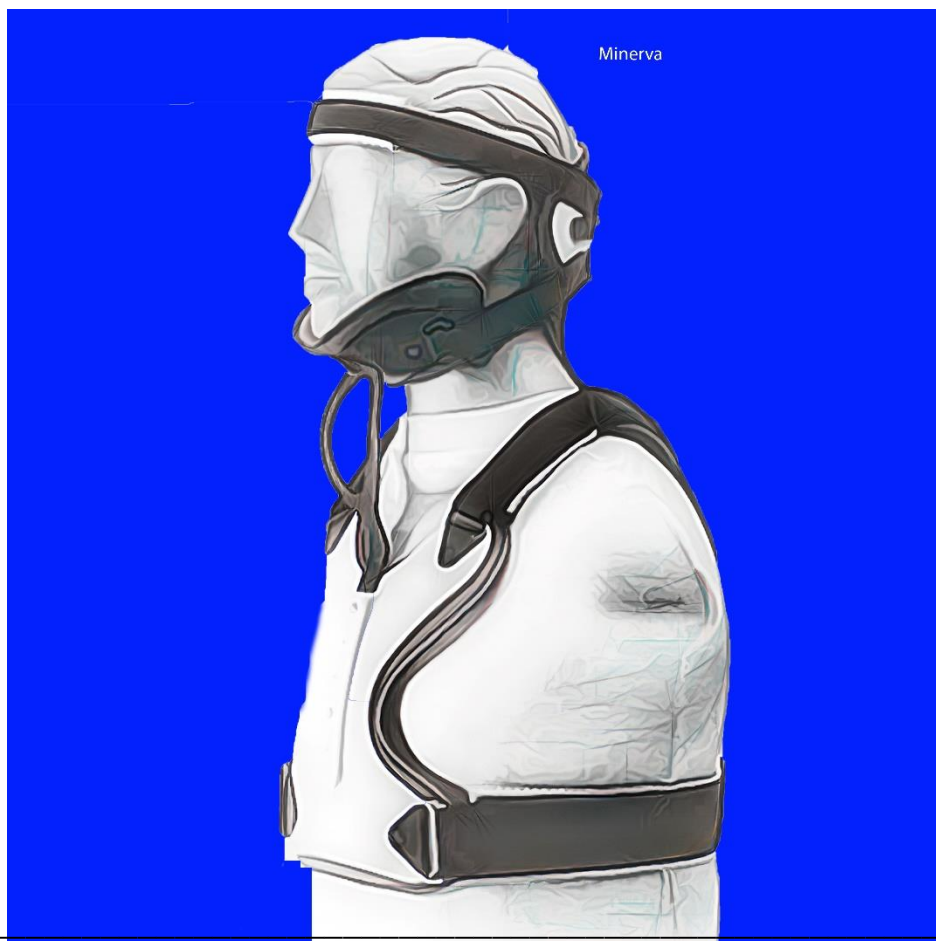
The traditional problem was due to positioning of the cervical spine in hyperextension. Repositioning of the cervical spine with less extension did not cause loss of reduction of the cervical fracture and resulted in improvement of eating and swallowing. <sup>19</sup>

## **Do you have an alternative to the Halo Fixator Device?**

Yes, we do: The Minerva Body Jacket. It is lighter than the Halo, it has no pins and has less risk of infection or slippage. There is less control of motion than the Halo Fixator device for Atlanto-occipital motion. However, for intersegmental control it may be better.

## **What are the Indications for the Minerva Body Jacket?**

It is good for unstable cervical spine issues. It needs to be utilized in a compliant patient who will not just remove it. Can be utilized in patients with skull fractures, while the Halo Fixator is contraindicated in skull fracture patients. It is often used in preschool children due to its decreased weight and increased comfort. It appears to have effectiveness for mid-to-lower cervical spine injuries and stable upper cervical spine injuries. It is really not that effective for Occipital and C1 level control. Some say it is valuable for C2-T3 stable fractures and cervical muscular and ligamentous injury at or below C2. It is a non-invasive device; however, there are problems with patient tolerance, skin care and provides limited patient positioning. It provides flexion, extension and lateral bending control.



### **Is there another noninvasive Halo device for children?**

The **Lerman noninvasive halo** was developed for cervical spine immobilization that was less invasive than the Halo Fixator device. The device was “breathable” and held the head with skin-adherent silicone composite pads. It was found to have

successful control of flexion-extension, lateral bending and rotation of the cervical spine. It was indicated for positioning of stable fusion, C1-C2 rotary subluxation, odontoid fracture and postoperative positing following sternocleidomastoid release from congenital muscle torticollis. It is contraindicated in structurally unstable cervical spine or in an unreliable patient or family.<sup>48</sup>



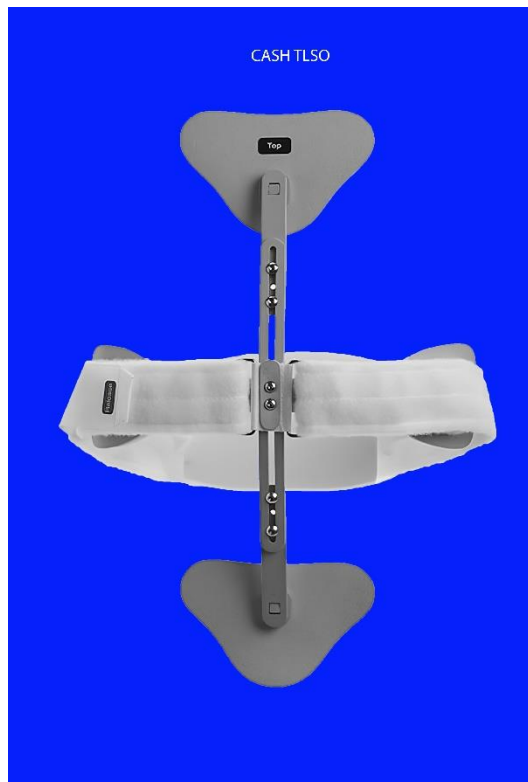
## **What are the most commonly utilized TLSO's? How should I approach the type of Orthoses based upon Biomechanical Control Desired?**

### **FLEXION CONTROL:**

**Cruciform Anterior Spinal Hyperextension Brace (CASH):** It has an anterior cross-bar with pads at the four ends of the cross. This orthosis adjusts posteriorly with straps held closed with Velcro. It is lightweight but may require frequent repositioning.

This is a much more comfortable design; however, it is at the expense of the amount of control. It limits flexion from T6 -L1. It is easy to don and doff. It does not limit lateral bending or rotation. When loss of vertebral height exceeds 85%, the orthosis does appear to effectively prevent progression of the deformity.

Indications: Thoracic and lumbar vertebral body fracture and kyphosis reduction in osteoporosis.



**JEWETT Hyperextension Brace:** There is a sternal and pubic pad anteriorly with single posterior adjustable band. This orthotic has a little more control than the CASH orthosis with a little more difficulty in donning and doffing. It allows for flexion control, but does not limit lateral bending or rotation. When loss of vertebral height exceeds 85%, the orthosis does appear to effectively prevent progression of the deformity.

**Indications:** T6-L1 with thoracic and lumbar vertebral body fractures. It can help with reduction of kyphosis due to osteoporosis. It has been utilized for postoperative stabilization of thoracolumbar fractures.

**Contraindications:** Unstable 3-column vertebral fractures. Compression fractures above T6 for there is increased motion above the pad. Where extension is prohibited for it can cause excessive hyperextension forces on the posterior elements.



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### **FLEXION -EXTENSION CONTROL**

**Taylor Brace:** Is a type of TLSO that controls the thoracic spine, lumbar spine and sacral spine. It has two posterior paraspinal bars that are attached to a pelvic band with axillary straps. There is an abdominal corset that is reported to increase intracavitary pressure. It has Axillary straps to help control the upper thoracic region. Due to its long posterior bands it limits extension and flexion of the spine. Its benefit is for the mid to lower thoracic spine and lumbar spine. There are no rigid lateral support bands, so less control of lateral bending. It is prescribed for counteracting kyphosis and produces extension in the sagittal plane.



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## Soft TLSO with no shoulder straps



### **FLEXION-EXTENSION-LATERAL CONTROL**

**Knight-Taylor TLSO:** This TLSO consists of a thoracic band, pelvic bands, paraspinal bars, lateral bars, interscapular bands and axillary straps. Due to the thoracic and lateral bars there is control of flexion, extension and lateral flexion of the thoracic and lumbar spine. It is the addition of subclavicular extensions anteriorly called “cowhorn projections” that allows for some transverse plane of control. This has more rigidity and support than the Taylor design.

**Indications:** Anterior compression fractures of the vertebral body, used for osteoporosis with kyphotic curves and trauma. Utilized for Spinal Extension weakness. Postoperative and nonsurgical management of stable thoracic and lumbar fractures or post scoliosis surgery. Truncal Paralysis. Usually controls from T6 to L3-4 region. The shoulder straps may allow for control up to T4-5 region.



## **FLEXION-EXTENSION-LATERAL-ROTARY CONTROL**

**BODY JACKET:** This design is a custom molded TLSO made of polypropylene or plastic. It is fit as a body jacket with the anterior shell being  $\frac{1}{2}$  inch above the symphysis pubis to the sternal notch. The posterior shell is from the spine of the scapula to the sacrococcygeal junction. It has the best control of thoracic and lumbar spine in all planes. It will increase intracavitary pressure to help offload the spinal column. It will distribute pressures throughout the surface of the device; therefore, it is ideal for neurological injuries. It will reduce myoelectric activity of the erector spinae muscles. It is best for T3 to L3 regions.

**Indications:** Immobilization for thoracic compression fractures from osteoporosis. Immobilization after surgical stabilization for spinal fractures. Use for idiopathic scoliosis. Immobilization for unstable spinal disorders of T3-L3.



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## **What are the types of Lumbosacral Orthoses (LSO's)?**

- Flexible LSO such as corsets or binders
- Chairback TLSO
- Williams flexion LSO
- Knight LSO
- Custom-molded LSO

## **How should I approach the type of Lumbosacral Orthoses based upon Biomechanical Control Desired?**

### **FLEXIBLE LSO**

These are typically corsets or binders. They have limited motion restriction, but they increase kinesthetic feedback.

Indications: Pain relief, postural support, reduces excessive lumbar lordosis, vasomotor and respiratory support in the spinal cord patient.





Soft LSO

## FLEXION-EXTENSION CONTROL

**Chairback TLSO:** This has a posterior rigid frame design with abdominal apron/corset. There is a butterfly pelvic band at the sacrococcygeal junction and a thoracic band below the inferior angle of the scapula. It will limit flexion and extension for L1-4. There is minimal limitation of rotation. Lateral bending is limited by 45%.

Indication: Back pain or weakness, Arthritis, s/p lumbar laminectomy



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## EXTENSION-LATERAL CONTROL

**Williams Flexion LSO:** This is a rigid LSO with butterfly-type pelvic band, thoracic band and lateral uprights with pivotable attachments, no posterior upright and abdominal apron. It has a tendency to create lumbosacral flexion.<sup>15</sup>

Indications is spondylolysis and spondylolisthesis.



Fig. 9B: Williams Brace—side.

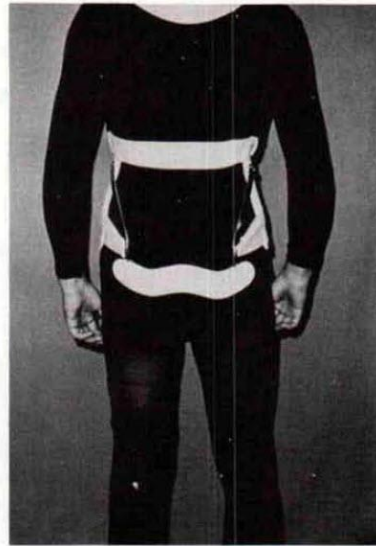


Fig. 9C: Williams Brace—rear.

From Edmonson: Spinal Orthotics

### **What are the proposed mechanisms for use of LSO's?**

Morris in 1961 felt that elevated intraabdominal and intrathoracic pressure reduced the net force applied to the spine during the act of lifting a weight from the floor.<sup>35</sup> It is felt that the spinal column is attached to the side of and within two chambers, the abdominal and the thoracic cavities. Muscle activity converts these chambers into rigid-wall chambers. This results in decreasing the load on the spine itself. The problem with abdominal corsets is that it reduced the activity of the abdominal muscles. Nachemson in 1964 showed that a tight inflatable corset reduced disc pressure about 25 %.<sup>36</sup> Lantz showed variable effects on myoelectric activity of abdominal muscles and extensor muscles of the spine.<sup>29</sup>

### **How do I limit lumbosacral junction motion with an LSO?**

When we look at LSO's the lumbosacral junction is really not controlled well. Investigation of lumbosacral movements has demonstrated that the lower lumbar vertebrae are best immobilized when there is fixation of the pelvis (via the

extended thigh piece). To limit the lumbosacral motion, one needs to limit motion of the hip with a thigh extension component attached to the LSO. The Lumbosacral spica provide the most effective way of immobilizing the lower lumbar spine. This is made of thermomoulded plastic that extends from 2 cm below the inferior angle of the scapula to the sacrum. A unilateral side piece extends distally, usually immobilizing the hip in 15 to 20 degrees of flexion to allow for partial sitting. This orthosis is useful for postoperative immobilization and unstable lower spine fractures.<sup>26,53</sup>

## **What are the types of SO? What does the SO do?**

Sacro-iliac joint (SIJ) belts or pelvic stabilization orthoses are devices that fit directly superior to the greater trochanters of the femurs and below the iliac crests. They may be water-resistant tape, cinch-type belts or three-point pelvic stabilization devices. It is utilized to provide confidence and proprioceptive awareness for sacroiliac joint dysfunction sufferers. It may provide partial relief of ligament strain, albeit minimally. It may decrease sacroiliac joint rotation around the transverse axis. It may decrease the forces on the sacrospinous and sacrotuberous ligaments. It is important to note that the underlying pathomechanics and efficacy of these devices remain controversial. Generally speaking, it is recommended that these orthoses are used in combination with an appropriate strengthening, stretching, and posture education program.<sup>14,18,49</sup>



## **Does a single-column anterior compression fracture require orthotic use?**

Up to 30% of single-column anterior compression fractures may be treated with early ambulation in addition to hyperextension exercises, while an orthosis is not required.<sup>56</sup>

## **How are stable T10-L2 burst fractures treated in the neurologically intact patient?**

TLSO treatment compared to surgical treatment showed less disability, lower pain scores, higher physical functioning scores, less complications with lower cost. The functional outcome at 2 years were similar for surgery and non-surgical treatment.<sup>30,48,60</sup>

## **How are T10-L2 burst fractures that are unstable treated?**

In an unstable thoracic fracture, acute surgical decompression of the spinal cord and spinal fusion at the thoracic (and sometimes lumbar) level is performed. A custom clam-shell TLSO is prescribed for up to 3 months. The patient is instructed to wear this at all times, removing it only for purposes of hygiene and when spine is supported in bed.<sup>3</sup>

## **What are some possible orthotic devices that may be helpful in stable vertebral compression fracture management with any support for their use?**

Posture-training supports (PTS)

Spinomed orthosis( Thoracolumbosacral orthosis)

## **What is the Posture-Training Support orthosis?**

It is consider a “weighted kypho-orthosis” or “Rucksack Orthosis”. It has weights that are suspended posteriorly to just inferior to the scapula. The weight encourages back extension and limits flexion. The posterior pocket can hold up to 2.5 lbs. This device is intended to encourage back extension with resultant increase in strength of the paraspinal muscles.<sup>45</sup>

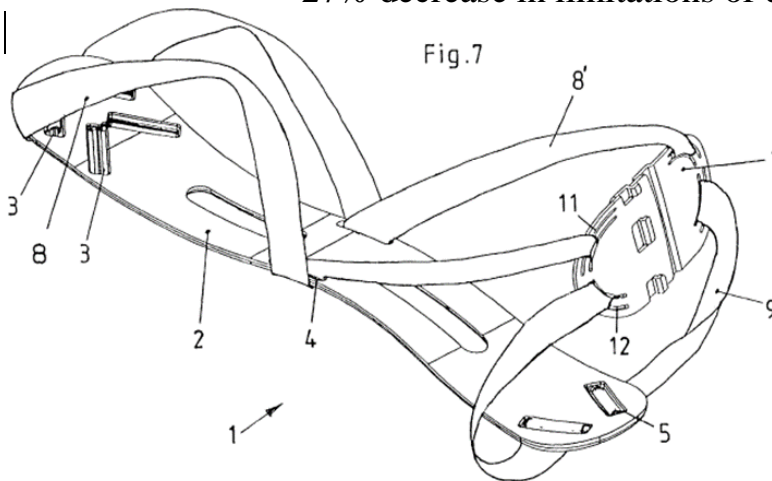


## What is the Spinomed Orthosis?

This is a semirigid TLSO- sagittal plane control. It is lightweight and activates the paraspinal muscles to straighten the dorsal spine with resultant decrease in kyphosis. It is utilized to treat vertebral compression fractures. <sup>41</sup>

Wearing the orthosis for 6-mo period, 2 hours per day

- 73% increase in back extensor strength
- 58% increase in abdominal flexor strength
- 11% decrease in angle of kyphosis
- 25% decrease in body sway
- 7% increase in vital capacity
- 38% decrease in average pain
- 15% increase in well-being
- 27% decrease in limitations of daily living.



## **What are the Proposed Mechanisms of Action for Lumbar Supports in Low Back Pain?**

According to Mireille, there may be some limitation of spinal motion of trunk flexion-extension and lateral bending while using a lumbar support. It can prevent excessive trunk motion, improve body posture, and obstruct extreme postures. There are thoughts that this will increase intraabdominal pressure with reduction of forces on the spine and prevent muscle fatigue; unfortunately, this has not been consistently substantiated.

LSO can actually decrease muscle activity in the thoracic and lumbar erector spinae muscles. This may actually help patients with low back pain performing potential tasks.<sup>2,9,29,33,44,</sup>

## **Do Spinal Orthoses have high evidence for use in Low Back Pain?**

There have been controversies as to the use of lumbar spinal orthoses for low back pain. There are some thoughts that use of spinal orthoses can help with muscle spasm in letting the spinal muscle relax. The American College of Physician Guideline (ACP)2017 stated “low-quality evidence showed no difference in pain or function between lumbar supports added to an educational program compared with an educational program alone or other active interventions in patient with acute or subacute low back pain.” In chronic low back pain, the ACP guidelines 2017 reported “low-quality evidence showed no difference between a lumbar support plus exercise (muscle strengthening) versus exercise along for pain or function at 8 weeks or 6 months.”

In studies by Lantz reviewing TLSO and LSO devices there was loss of electromyographic activities of the lumbar muscles. Lumbar orthosis utilization is mechanically effective only sometimes; however, the load reductions on the spine are not dramatic even when it works, therefore it may be counterproductive. Some studies do not fully support the loss of electromyographic activity. Another study by Cholewicki, concluded that there was limited potential of these orthoses to restrict spine motion. This may be supported by the lack of benefits from the use of orthosis as an adjunct to spine fusion surgery. Surgeon preference may be the defining factor in the use of an orthotic device after spinal fusion to assist with healing.<sup>2,9,29,33,44</sup>

## **Should Lumbar Supports be utilized in Low Back Pain?**

LSO may be utilized to treat and prevent low back pain; however, high level studies are lacking to definitively support the use. Lumbar Orthotics have no evidence that supports that it prevents the recurrence of back pain. There are some studies that support the use of lumbar bracing for acute low back pain, but not chronic back pain. It was felt that if orthotics are required, then rigid orthotics offered some benefit over flexible, soft orthotics. One of the fears was the risk of muscular atrophy with use of an LSO. Studies have supported that with just 2 weeks of use, there is no atrophy noted of the lumbar erector spinae muscles.

In review of the literature by Dailey, “Lower-level evidence suggests that the prophylactic use of braces does not reduce the incidence of low back pain or decrease the amount of lost productivity in the general working population. Yet in a select population of laborers with a history of back injury and pain, bracing appears to decrease the number of workdays lost due to back pain.”<sup>13</sup>

Lumbar supports do have some localized benefits. It can improve proprioception and lead to more spinal stabilization. It provides heat that can lead to hyperemia and cause relaxation of tense muscles.

Proposed mechanisms of action of lumbar support.

There are several proposed therapies for the potential effectiveness in using LSO for Low back pain. LSOs improves proprioception or kinesthetic sensation and increases stiffness of the trunk that limits range of trunk motion. The trunk stiffness could reduce the muscle forces utilized for activities of daily living. This prevents fatigue that can compound the low back pain symptoms. There is prevention of excessive spinal motion either by physically blocking motion extremes or providing sensory stimuli to prevent extreme bending of the spine. It could potentially increase intraabdominal pressure; however, not seen consistently.<sup>13,21,25,34,47</sup>

## **Based solely upon the evidence, can Lumbar Supports be utilized in Acute Low Back Pain and is it utilized in common practice?**

In today’s climate of limiting opioids for chronic low back pain, we must often compromise our dogma of orthotic use. Treating acute or chronic low back pain may require use of less than full evidence-based medicine: There is no harm or side-effects with the short-term use of LSO’s.

*“Acute and acute exacerbations of chronic low back pain are often common and challenging situations for the rehabilitation team. Effective and responsive person-centered care that manages the pain experience with maximal function typically requires a multimodal intermittent intervention design with intensive patient education. Individually designed protocols for self-management occasionally include lumbosacral bracing for accomplishing: total snug pressure and semirigid support over affected dermatomes, a reduction in paraspinal muscle spasm, postural cuing and a cue for prescribed exercises for recovery. With proper prescription, fitting and patient and family education bracing accomplishes pain control, a reduction in anxiety, a dampening of movement to prevent triggered spasm, and an improvement in active function for life activity.”* –Steven Stiens MD editor PM&R Secrets

In the short-term use (2 weeks) of an inelastic LSO there was some benefit over the standard control group of medications and PT for low back pain. <sup>13,25,34,47</sup>

## **Is a spinal orthosis required as an adjunct to or substitute for a lumbar fusion?**

The use of orthotics “following instrumented posterolateral fusion is not recommended, since equivalent outcome have been demonstrated with or without the application of a brace.” The issue may be one of surgeon preference. <sup>13</sup>

## **So why would a surgeon want to use an orthosis after surgical fusion?**

Many surgeons opt to utilize postoperative orthoses for other reason than stability. There may be an ability to participate in earlier activities. In the spinal cord patient with loss of sensation, the orthosis can substitute for pain to limited motion. Proprioceptive feedback from an orthosis may remind the patient to be careful with activities and limit range of motion. It can help to manage pain postoperatively by allowing muscle to relax and not spasm. The orthotic devices are often worn for 4-12 weeks. <sup>21</sup>

## **Are cervical orthoses beneficial in axial neck pain?**

There is no evidence to support the use of rigid or soft cervical orthosis for axial neck pain. The only thing that is beneficial is therapeutic exercise vs orthotics. In patients with “whiplash” injuries there is an average prolonged return



to work with the use of cervical orthoses of 34 days verses 17 days in a random control trial of patients ( $p < 0.05\%$ ).<sup>11</sup>

### **Are TLSO's used only in scoliosis?**

No. Accommodative TLSO that can be fabricated from pelite and reinforced with kydex or rigid plastic may be utilized to assist with positioning in a wheelchair or for fixed alignments. It can be utilized to help level the shoulders, reduce or minimize shear forces and allow for the patient to increase upper extremity use by supporting the trunk. Insuring good positioning in the wheelchair by utilizing a TLSO may actually enhance mobility by providing a stable base of support.<sup>54,57,59</sup>



### **What are my choices of orthotics in scoliosis?**

Once the decision to place someone in a TLSO for scoliosis, there needs to be an understanding of the level of curve that needs to be addressed. This would mean we need to consider cervical control or just thoracolumbar control.

High thoracic curves require the use of the Milwaukee brace. Curves with apices at T-8 or lower may be treated with orthotics that can be under the arm: Wilmington brace or the Boston Brace.

### **What is the Boston Brace?**

This is a prefabricated standardized modular orthosis. The modular component is a term referring to the ability to change the pad placement or alter its shape. It fits under the arms. The patient is taught to actively pull away from the corrective pad

to add active correction to the already passive correction from the device. It is not utilized for apex of curve above T10 or curves greater than 40 degrees.



### **What is the Wilmington brace (custom made)?**

This is a total contact fabricated TLSO. Elongation of the spine with traction and three-point pressure system in the frontal plane assists with correction of the deformity.

Wilmington Orthosis



### **What is the Charleston Bending Brace?**

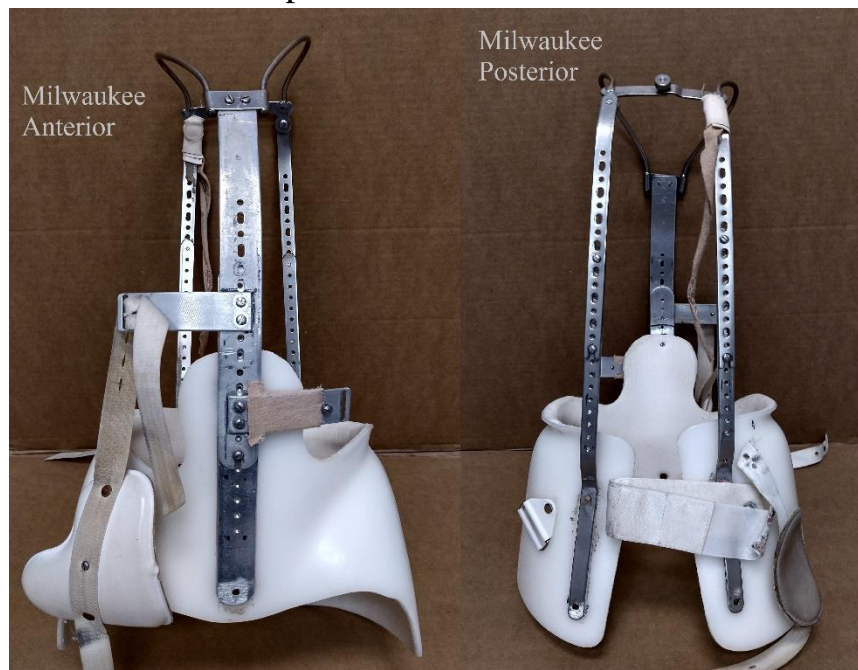
This is a nighttime only TLSO utilized for treatment of scoliosis. It relies on overcorrecting the patient's curve and unloading the vertebral end plates on the concave side of the curve; thereby, decreasing asymmetrical bone growth. It takes advantage of the "Heuter-Volkman Law" that states "that growth is retarded by increased mechanical compression and accelerated by reduced loading in

comparison of normal valgus. It is only worn at nighttime for 8-10 hours per day. It is not considered as effective as other styles or TLSO's.



## What is the Milwaukee Brace?

This is the classic CTLSO. It is a metal vertical superstructure with pelvic foundation. It is utilized for high thoracic curves. It is rigid plastic pelvic girdle connected to the neck with a ring. There are two posterior paraspinal bars. The cervical ring has mandibular and occipital bars that rest 20-30 mm inferior to the occiput and mandible. Pads a place to correct the curves.



## **What is the principle treatment with orthotics in scoliosis?**

Large curves are more readily straightened by elongation.

Smaller curves are more readily straightened by application of lateral forces.

There will usually be a pad below the apex of the curve allowing for a lifting force.

In the supine position the TLSO will have more effective forces than being upright, this is the key to using orthotics at night.

The elongation of the curve:

Reducing the lumbar lordotic curve is more effective in treating scoliosis in the lumbar and thoracic spine. The reduction of lumbar lordosis results in flattening of the thoracic kyphotic curve.

## **When do I utilize an orthotic device for scoliosis?**

- Supple curves (20°-40°)
  - 20°-30° observe initially, if curve progresses by 5° then brace
  - 30°-40° prompt use of orthosis
  - 40°-50° requires surgery, but orthoses may retard progression long enough to allow further trunk growth prior to fusion
  - Indicated Risser  $\leq 2$
- Stabilization of congenital spinal curvatures
- Prevention of progression
  - There is usually same curve beginning and end of use
  - *Moe + Winter* “purpose of bracing is to “keep small curves from getting bigger, not to make big curves smaller”

## **How long do you need to wear the device in scoliosis?**

- Used full-time
  - 16-20 hrs/day until skeletal maturity
  - -Optimum is 23 hrs/day

## **How does the patient wean from a device for scoliosis?**

A slow wean is the optimum approach. When you change the wearing schedule the goal is to allow only up to 3 degrees of loss.

Off 2 hours per day then repeat X-ray in 3 months

Off 4 hours per day then repeat X-ray in 3 months

Off 8 hours per day then repeat X-ray in 3 months

Off 12 hours per day then repeat X-ray at 3 months

Use the TLSO at “night only” for minimum of 1 year

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Figure 38-1 Three-point pressure as applied in a hyperextension thoracolumbosacral orthosis.
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