SPINAL ORTHOTICS

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None

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Learning Objectives

- Understanding Terminology
  - How to name an orthotic device
- Understanding the Mechanisms of Action for spinal orthotics
- What considerations are required for use of spinal orthotics?
- How to write a prescription for an orthotic device
- Understand the various devices and their utility
Terminology

- **Orthosis**: A *singular device* used to aid or align a weakened body part
- **Orthoses**: *Two or more devices* used to aid or align a weakened body part
- **Orthotics**: The field of study of orthoses and their management
- **Orthotic**: An *adjective* used to describe a device
- **Orthotist**: A person trained in the proper fit and fabrication of orthoses
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.61

- The older certification is Board of Certification (BOC)
  - BOCO-(Orthotist)
  - BOCP-(Prosthetist)
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, coronal plane, 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.
    - This mechanism of action on abdominal pressure may be questionable
- 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
Objective of Spinal Orthoses

- **Control of Pain**
  - limiting motion or weight bearing
  - Provides heat to an area
- **Protection against further injury**
  - Limit's motion
    - Promotion of healing of fractures
  - Stabilization of vertebral segment
  - Provides stabilization when soft tissue cannot
- **Assistance for muscle weakness**
- **Serves as a kinesthetic reminder**
Orthotic Mechanisms of Actions

- Three-point pressure system
- Circumferential support
  - Forms a semirigid cylinder
    - Nachemson (1964) - reduction of intradiscal pressure by 30%
    - Spinal pressure not reduced by increasing intraabdominal pressure
- Irritant
  - Kinesthetic feedback
    - Avoiding discomfort
- Skeletal Fixation
  - True limitation of motion
Purpose of Spinal Orthoses

- Prevention and Correction of Deformities
  - By providing external forces
  - Applying corrective forces to abnormal curvatures
  - 3-point pressure system

- Reduction of Axial Loading
  - Morris, 1961 JBJS
    - Elevated intra-abdominal pressure
      - Reduces the net force applied to spine during the act of lifting a weight from the floor
        - May not actually be true
      - Nachemson (1964): Reduces intradiscal pressure approximately 30% in lumbar spine

- Postsurgical Stabilization
  - With or without fracture
Ideal Orthosis

- Functional
- Fits well
- Comfortable
- Light in weight
- Easy to use
- Cosmetically acceptable
- Easily maintained/repaired
- Ideally locally manufactured

Different than the “3H’s” predicting failure

Hot, Heavy, Horrible looking
Complications or Side-effects of Spinal Orthotics

- Weakening of axial muscles
- Trapping of moisture with loss of skin integrity
- Development of pressure area
- Pressure on nerves
- Limit some activities of daily living
- Potential osteopenia though misuse or overuse
- Causes discomfort and emotional distress leading to impaired quality of life
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
Prescription:

Prescriptions should include the following items:
Patient’s name, age, and gender, Current date
Diagnosis
Functional Goal,
Orthotic description
  Area covered
  Flexible or Rigid device
  Custom or Off-the-shelf
Control desired based upon biomechanics of the spine
  Restriction of sagittal plane motion
  Restriction of coronal plane motion
  Restriction of transverse plane motion
Precautions
Physician name and unique physician identifier number
Physician signature, office address, contact phone number.
Custom vs Off-the-shelf

- Tenet of Orthotic classical practice
  - “Customized orthoses more effectively limit or control motion better than prefabricated or off-the-shelf orthoses”
    - More intimate fit with custom
    - Better control of Triplanar Motion with custom
    - Better control of lateral flexion and Rotation with custom
    - Unequal panels from OTS that creates flexion or extension components
    - Rotation not controlled in OTS due to not locking down on ASIS or the rib cage
    - Custom better adjustment for pendulous abdomen
    - Custom more comfortable to wear than OTS

Bernardoni: Comparison between custom and noncustom spinal orthoses: PM&R Clinic NA 12(2006)73-89
Nomenclature/Categories

- Name by the body regions that they cross/ Eponyms
  - CO: Cervical Orthosis, HCO: Head cervical orthosis
    - Soft or rigid (Philadelphia, Aspen, Miami, Newport)
  - CTO: Cervicothoracic orthosis
    - Halo, SOMI, Minerva
  - CTLSO: Cervicothoracolumbosacral orthosis
    - Milwaukee
  - TLSO: Thoracolumbosacral orthosis
    - Custom-molded body jacket, CASH, Jewett
  - LSO: Lumbosacral orthosis
    - Chairback, Knight, corsets/binders
  - SO: Sacral orthosis
    - Trochanteric belt, sacral belt, sacral corset

- Rigidity
  - Rigid
  - Semirigid
  - Flexible
Need to understand Spinal Anatomy and Motion

Very limited discussion
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.
Vertebral Motion - Cervical

- **Atypical Cervical Vertebrae**
  - Atlas (C1) and Axis (C2)
  - Provides 50% of flexion/extension (OA) (AA) rotation of cervical spine

- **Typical Cervical Vertebrae**
  - C3-C7
  - Provides 50% of flexion/extension and rotation of cervical spine
  - Maximum flexion/extension C5-6
Vertebral Motion-Thoracic

- Thoracic spine
  - All limited by facets and ribs all direct/ Mostly Rotation
  - Upper (T1-4)
    - Rotation> flexion/extension>sidebending
  - Middle (T5-8)
    - Rotation> flexion/extension>sidebending
  - Lower (T9-11)
    - Flexion/extension>sidebending>rotation
Lumbar Vertebral Motion

- Lumbar spine
  - Major motion is flexion/extension
    - Small degree of sidebending and very little rotation
  - Thoracolumbar Junction (T12-L1)
    - Most mobile section of the spine
  - Miodlumbar (L2-4)
  - Lumbosacral Junction (L5-S1)
    - Area more difficult to control
Range of Motion Spinal Area

Combined flexion-extension (x-axis rotation)
One-side lateral bending (z-axis rotation)
One-side axial rotation (y-axis rotation)

Cervical
C0-C1
C2-C3
C4-C5
C6-C7
T1-T2
T3-T4
T5-T6
T7-T8
T9-T10
T11-T12
Thoracic
Lumber
L1-L2
L3-L4
L5-S1

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Braddom 3rd edition
Soft Cervical Collar

- Foam Rubber
- Benefit
  - Warmth
  - Psychological Reassurance
  - Kinesthetic reminder to limit motion
  - No structural support

*May not reduce duration of intensity of pain*

Flexion/Ext limited 8-26% Lateral
Bending limited 5-10% (8%)
Rotation limited 10-17%
Miami J Collar

- Polyethylene
  - Has tracheostomy opening
  - Custom adjustment 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 Fx (C1)
  - Hangman’s fracture
    - Traumatic spondylolisthesis of C2 on C3
  - Dens type I fracture
  - Anterior diskectomy
  - Cervical trauma in unconscious patients
  - Cervical Strain

Flexion/Ext limited 60-76%
Lateral Bending limited 52%
Rotation limited 65-77%
Malibu Collar

- 2-piece orthosis
  - Anterior opening for tracheostomy
  - Adjustable chin support
  - MRI compatible
  - Heat moldable Kydex

- Indications
  - s/p Anterior Cervical fusion
  - Dens type I fracture
  - Anterior diskectomy
  - Cervical trauma in unconscious patients
  - Cervical Strain

Flexion/Ext limited 55-60%
Lateral Bending limited 60%
Rotation limited 60%
Headmaster control CO

- Light weight and flexible
- Very limited control of motion
- Low profile
- Supports head

Indications
- ALS
- Multiple Sclerosis
- Dropped Head Syndrome (DHS)
- Radiation Fibrosis Syndrome
- Motor Neuron Disease
- Muscle relaxation due to too much Botoxin
Use of CO for Axial Neck Pain

- No evidence for rigid or soft CO
- Only thing beneficial is therapeutic exercise
- In “whiplash” injury could prolong return to work
  - 34 days vs. 17 days (p<0.05)

Crawford, Early Management and outcome following soft tissue injury of the neck: A random controlled trial *Injury*: 2004;35 (9) 891-895
Philadelphia Collar with Thoracic Extension

- 2-piece Plastizote Foam
  - High capillary closing pressure
  - Increase skin temp
  - Increase sweating
  - Increase risk of ulcer

- Indications
  - s/p Anterior Cervical fusion
  - Dens type I fracture
  - Anterior diskectomy
  - Cervical trauma in unconscious patients
  - Cervical Strain

Thoracic support adds restricted motion C6-T2
Some say to T5

Flexion/Ext limited 65-70%
Lateral Bending limited 30-35%
Rotation limited 60-65%
Sternal-occipital-mandibular Orthosis (SOMI)

- 3-Poster CTO
  - Ant chest plate to xiphoid process
  - Removable chin strap
- Control of Motion
  - Flexion
    - C1-3
  - Extension
    - Less control than other CO’s
- Indications
  - AA instability-RA
  - Neural arch fx C2
    - Due to flexion instability

Flexion/Ext limited 61-72%
Lateral Bending limited 18-34%
Rotation limited 29-66%
CTOs provide significantly more restriction of intervertebral flexion and extension than CO’s.

- Controls motion down to around T5.
Halo Device

- **4-Poster Control**
  - Controls down to T3
  - Usually worn 8-12 weeks
  - Good control Occiput to C1
  - Poor control mid-cervical region

- **Indications:**
  - Occipital condyle fracture
  - C1 ring fracture
  - C2 facet subluxation
  - Spinal infections

Flexion/Ext limited 96%
Lateral Bending limited 96%
Rotation limited 99%
Halo Device Positioning

- **Anteriorly**
  - 1 cm above orbital rim lateral orbit

- **Posteriorly**
  - 1 cm above the top of the ear/below largest diameter of skull

- **Avoiding**
  - Supraorbital nerve-medially
  - Temporal artery-laterally
  - Zygomaticotemporal nerve too lateral
Halo Device

Problem

- Intersegmental “snaking”
  - Flexion of one vertebral segment with extension of the adjacent vertebral body
  - Koch + Nichel: 31% of normal motion at lower cervical level (C4-5)
- Lind: 2-17° C2-C6
  - Most OA articulation

Complications

- Pin site infection
- Scarring
- Nerve injury
  - Supraorbital nerve/supratrochlear nerve and abducens nerve
- Dural penetration
- Intracranial abscess
- Seizures
- Dysphagia

Precautions

- Avoid Shoulder Abduction $\leq 90^\circ$
- Avoid Shoulder Shrugging
  - Distraction forces
- DO NOT!!!!
  - Lift, turn, move patient by pulling on vest/rods or superstructure
Halo Device

- **Pin Care**
  - Every 8 hours in hospital
  - Bid after discharge others qd
  - Check for crusting, drainage, redness, swelling

- **Pin Cleaning daily**
  - Sterile Q-tip
  - Antimicrobial soap and Normal saline
    - Not Betadine, Hydrogen peroxide, or alcohol
      - Pin corrosion
      - Disruption of Healing

- **When placed**
  - Check Lateral X-ray alignment
    - Horizontal position
    - Bed elevated 45 degree
    - Bed elevated 90 degree

Sandra Mangum RN, A comprehensive guide to the halo brace-application, care, patient teaching
AORN J Sept 1993, Vol 58, #3
Halo Device Complication

- Pin loosening
  - Clicking/grating/creaking sound
  - Sensation of looseness
  - Pain in pin site
  - Headache
  - Halo vest movement

- Torque Wrench setting
  - Adult
    - 8 inch-pound
  - Children
    - 2-5 inch-pound

- Check pin once a month

- Signs of Brain Abscess
  - Psychosis
  - Scalp pin cellulitis
  - Headache
  - Eye pain
  - Fever
  - Seizure
Minerva Body Jacket

- Lighter than halo
  - No pins
  - No risk of infection or slippage
- Less restriction than Halo for OA
- Better control intersegmental than Halo
- Indication
  - Adherent Patient
  - Unstable cervical spine
  - Compliant patient
  - Patient with skull Fx
  - Preschool children
    - Decrease weight
    - Increase comfort
  - C2-T3 stable fractures
  - Cervical muscular and ligamentous injury at or below C2

Flexion/extension limited 78%
Lateral bending limited 51-90%
Rotation limited 84-88%
Alternative to Halo/Minerva

- Lerman noninvasive halo system
  - Use in children
  - Better for C1-2 rotary subluxation
  - Contraindicated
  - Unreliable patient/family
  - Unstable cervical spine
## Relative percentage restriction of motion by the various CO’s

<table>
<thead>
<tr>
<th>Device</th>
<th>Flexion/Extension</th>
<th>Lateral Bending</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halo</td>
<td>96</td>
<td>96</td>
<td>99</td>
</tr>
<tr>
<td>Minerva</td>
<td>78</td>
<td>51-90</td>
<td>84-88</td>
</tr>
<tr>
<td>Four-Post CTO</td>
<td>79-88</td>
<td>54</td>
<td>73</td>
</tr>
<tr>
<td>SOMI</td>
<td>61-72</td>
<td>18-34</td>
<td>29-66</td>
</tr>
<tr>
<td>Miami J</td>
<td>60-76</td>
<td>52</td>
<td>65-77</td>
</tr>
<tr>
<td>Vista -Aspen</td>
<td>69-90</td>
<td>34-48</td>
<td>74</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>59-75</td>
<td>12-34</td>
<td>27-56</td>
</tr>
<tr>
<td>Soft Collar</td>
<td>8-26</td>
<td>8</td>
<td>10-17</td>
</tr>
</tbody>
</table>
Efficacy of Cervical Orthoses
Limited Numbers

<table>
<thead>
<tr>
<th>Study</th>
<th>Motion Tested</th>
<th>Braces Tested</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gavin et al 8</td>
<td>F/E</td>
<td>Aspen, Miami J, Aspen 2-post CTO, Aspen 4-post CTO</td>
<td>20 volunteers</td>
</tr>
<tr>
<td>Richler et al 10</td>
<td>F/E, LB, AR</td>
<td>Softcollar, Miami J, Minerva, halo vest</td>
<td>Cadaver specimens, intact and unstable (type II odontoid fracture)</td>
</tr>
<tr>
<td>Alberts et al 11</td>
<td>F/E, AR, LB</td>
<td>Nebraska, Philadelphia, SOMI, Lehman-Minerva brace</td>
<td>14 volunteers</td>
</tr>
<tr>
<td>Askins and Elmont 12</td>
<td>F/E, LB, AR</td>
<td>NeckLoc (Osso), Miami J, Philadelphia, Aspen, Stithneck (Laerdal, Amonk, NY)</td>
<td>20 volunteers</td>
</tr>
<tr>
<td>Sandler et al 13</td>
<td>F/E, LB, AR</td>
<td>Softcollar, Philadelphia, Philadelphia with thoracic extension, SOMI</td>
<td>5 volunteers</td>
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<tr>
<td>Rosen et al 14</td>
<td>F/E, LB, AR</td>
<td>NeckLoc, Philadelphia</td>
<td>15 volunteers</td>
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<tr>
<td>McGuire et al 15</td>
<td>F/E, translation</td>
<td>NeckLoc, Stithneck, Philadelphia</td>
<td>C4-5 destabilized cadaver specimens</td>
</tr>
<tr>
<td>Benzel et al 16</td>
<td>F/E</td>
<td>Minerva, halo vest</td>
<td>10 patients with unstable cervical spine fractures</td>
</tr>
<tr>
<td>Kaufman et al 17</td>
<td>F/E, LB, AR</td>
<td>Softcollar, NeckLoc, Philadelphia</td>
<td>10 volunteers</td>
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<tr>
<td>Johnson et al 18</td>
<td>F/E, AR, LB</td>
<td>Softcollar, Philadelphia, SOMI brace</td>
<td>44 volunteers</td>
</tr>
</tbody>
</table>

AR = axial rotation, CTO = occi-thoraco-oral orthosis, F/E = flexion/extension, LB = lateral bending, SOMI = sternal-occipital-mandibular immobilizer

Agabegi: Spinal Orthoses JAAOS, November 2010, Vol 18, #11
Summary Best CO

- All orthoses tend to control flexion better than extension.
- Increasing height of the rigid collar more restricted motion
  - May also lead to increase cervical extension (undesirable)
- The halo is the most effective orthosis for use in controlling flexion and extension at C1-C3, followed by the 4-poster brace and then the CTOs.
- CTOs are best for use in controlling flexion and extension at C3-T1, whereas the SOMI is best for use in controlling flexion at C1-C5.
- The CTO brace is the second best orthosis for use in controlling rotation and lateral bending in the cervical spine.
- The SOMI controls extension less effectively than do other orthoses.
- The halo is the best orthosis for use in controlling rotation and lateral bending at C1-C3.
- The 4-poster (Halo) brace is slightly better than the CTO brace for use in controlling lateral bending in the cervical spine.
Summary Best CO

- **Miami J Collar**
  - Lowest level of mandibular and occipital tissue-interface pressure compare to other CO’s

- **Cervical Collars**
  - Increase intracranial Pressure in TBI
  - Swallowing effected
    - Narrowing of Pharynx
    - Extension or Hyperextension of C-spine

- **Rigid CO**
  - Less control
    - Occiput to C2
    - C6-7
  - Good control
    - Mid cervical (*better than Halo*)

- **Philadelphia Collar**
  - Not well ventilated
    - Increased skin maceration
  - Increased pressure on chin, mandible, occiput
    - Increased risk of tissue ischemia and ulcer
Thoracolumbar Orthosis (TLSO)

- 3-point pressure system
  - Supplies anterior abdominal pressure
    - Increase intracavity pressure
    - Decrease lumbar lordosis
    - Decrease load on the vertebra and disc
  - Restricts trunk and intervertebral motion
    - Control of motion categories
      - Flexion
      - Flexion-extension
      - Flexion-extension-lateral bending
      - Flexion-extension-lateral bending-rotation
  - Supports/aligns spine
  - Most restricted motion cephalad region
    - Least control at L/S junction
Usual Indications and Studies for TLSO’s
T10-L2 Burst fracture Treatment

- Non-Operative group (n=23):
  - Significantly less disability
  - Significantly lower pain scores
  - Significantly higher physical functioning scores
  - Lower cost ($11k vs. $49k)

- Complications more frequent in Op group
- All patients remained neurologically intact

- Braces/Casts avoid surgical complications

Operative Compared with Nonoperative Treatment of Thoracolumbar Burst Fracture without Neurologic Deficit: A Prospective, Randomized Study. Wood et al. JBJS Am 2003
T/L Burst Fractures without Neurological Deficit: RCT Operative vs. Brace

- N=80
- Op: Posterior 3-level fixation
  - earlier pain relief and partial kyphosis correction (gradually lost)
  - Earlier pain relief
- Non-op: Hyperextension brace
- FUNCTIONAL OUTCOME AT 2 YEARS SIMILAR
- Safe treating burst fx with TLSO*

Li-Yang Dai: Conservative Treatment of Thoracolumbar Burst Fracture: Spine Vol 33, No 23 pg 2536-2544 2008*

Compression Fractures (<30%): Bracing vs. No external support

- T12-L5; Mostly L1

- One-column fractures of the thoracolumbar spine with <30% compression can be treated with early ambulation and hyperextension exercises

Flexion Control
Cruciform Anterior Spinal Hyperextension Brace (CASH)

- Flexion control
  - Does not limit lateral bending or rotation
  - Easy to don/doff

- Indications
  - Thoracic/lumbar vertebral body Fx
    - Vertebral height loss >85%
    - Does not prevent progressive deformity
  - Kyphosis reduction/osteoporosis

- Contraindication
  - Unstable Fracture
  - Where extension is prohibited
    - Can cause excessive hyperextension forces of the posterior elements

Flexion limit T6-L1
Jewett Hyperextension Brace

- Flexion control
  - Does not limit lateral bending or rotation

Indications (T6-L1)
- Thoracic/lumbar vertebral body Fx
- Kyphosis reduction/osteoporosis
- Post op stabilization of TL Fx

Contraindication
- Unstable Fracture
  - 3-column fractures
- Compression Fx above T6
  - Increased motion above pad
- Where extension is prohibited
  - Can cause excessive hyperextension forces of the posterior elements
Flexion-Extension Control
Taylor Brace

- Limited motion of Mid to lower thoracic to upper lumbar region-? Sacral spine
  - No lateral rigid lateral supports so less lateral control
  - Counteracts kyphosis
    - Produces extension in sagittal plane
Flexion-Extension-lateral Control
Knight Taylor Brace

Limited motion of Mid to lower thoracic to upper lumbar region

- Increase motion Upper thoracic and lower lumbar & LS junction
- More scapular band than Taylor
- Poor rotary control

Indication

- Anterior compression Fx of Vertebral body
  - Stable Thoracic-Lumbar
- Osteoporosis w Kyphotic curve and trauma
- Spinal extension weakness
- Truncal Paralysis

Controls T6 to L3-4
Possible T4-5 with shoulder straps
Flexion-Extension-Lateral-Rotary Control
Custom-Molded Body Jacket

- Polypropylene or Plastic
  - Best control all planes
    - Increases intracavity pressure
    - Diffuse distribution of pressures
      - Ideal for Neurologic Injuries
      - Reduces myoelectric activity of erector spinae muscles
  - T3-L3 areas
- Anterior shell
  - ½ inch above pubic symphysis to sternal notch
- Posterior shell
  - Spine of scapula to sacroccocygeal junction
Lumbosacral Orthoses

(LSO) Flexible or Rigid

• Elevated intra-abdominal and thoracic pressure reduces net force applied spine during the act of lifting a weight from floor
  • Use of corset decreased the activity of the abdominal muscles
  
  Morris: Role of trunk in stability of the spine. JBJS, 1961; 43:327-351

• Tight brace can reduce intradiscal Pressure in lumbar spine by ≈25%

  Nachemson, JBJS, 1964; 46:1077-1092

• Variable Effect on myoelectric activity of abdominal muscles/Extensors of spine

  Lantz, Spine Vol(11), No 8 1986 838-842

• No benefit for Low back pain

  Consensus statement APTA Guidelines LBP 2012/ACP Guidelines 2017
  Steven Stiens MD, editor PM&R secrets
  “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.”
Flexible LSO

- Corsets or binders
  - Indications
    - Pain relief
    - Postural support
    - Vasomotor support
      - SCI
    - Respiratory Support
      - SCI
Flexion-Extension Control
Sagittal Plane

- Limits Flexion-Extension
  - L1-L4
- Minimal limitation of rotation
- Lateral bending by 45%
- Unloads intervertebral disc

Chairback
Components

- Paraspinal bars
- Lateral uprights
- Pelvic band
- Thoracic band
- Abdominal support

- Tightening the abdominal support creates intra-abdominal pressure which effectively reduces lordosis by distending the lumbar spine.

Indications:
- Lower back weakness or pain
- Arthritis
- Need for immobilization of the lumbosacral region
Chairback LSO Sagittal Plane

- Paraspinal bars
- Butterfly pelvic band
  - Sacrococcygeal junction
- Thoracic band
  - Below inferior angle of scapula
- Abdominal support
  - Tightening the abdominal support creates intra-abdominal pressure, which effectively reduces lordosis in the lumbar spine

- Indications
  - Lower back weakness or pain
  - Sacroiliac pain
  - Arthritis
  - s/p Lumbar laminectomy
Extension-Lateral Control
Williams Flexion LSO
Sagittal and Coronal Plane Control

► Components
  ► Pelvic band
  ► Thoracic band
  ► Lateral uprights
    ► Pivotable attachments
    ► No posterior upright

► Indications:
  ► Creates Lumbosacral flexion
    ► Includes extensor activity of hip
      and spine
    ► Relieves postural imbalance in
      low back pathologies with
      lordosis
    ► Spondylolysis
    ► Spondylolisthesis

Edmonson: Spinal Orthotics, 1977
Williams Flexion LSO
Sagittal and Coronal Plane Control

- Tightening the abdominal support
  - creates intra-abdominal pressure?
  - It connects the thoracic and lumbar cavities as rigid wall “chambers”
  - increases lumbosacral flexion
Flexion-Extension-Lateral Control
Custom-molded, plastic LSO

- More rigid support
Sacroiliac Joint Belt (SO)

- Provides confidence and proprioceptive awareness to the SI joint
- Only minimal relief of strain of the SI joint ligaments
  - Sacrotuberous ligaments
  - Sacrospinous ligaments
- Decreases sacroiliac joint rotation around the transverse axis
Orthotic Treatment Compression Fracture

- Only 2 Orthotics scientifically studied for efficacy:

- Spinomed®-activates back muscles to straighten the dorsal spine and decrease kyphosis to treat chronic VCFs

http://www.spsco.com/press/07-12-06c.html
Pfeifer M, AJ PMR 2004
Increased back weakness?

- Lantz and Schultz, _Spine_ 1986
  - Increase electrical activity of back muscles when LSO worn
  - Principle effect may be a biofeedback mechanism

- Pfeifer M, AJPMR 2004
  - Females with one clinical vertebral fracture caused by osteoporosis and an angle of kyphosis of 60 degrees as measured by stereophotomorphometry.
  - Noted: Significant increase in trunk muscle strength
    - Increase muscular activity while wearing the LSO
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.

Overall tolerability of the orthosis was good

- no side-effects were reported
- drop-out rate of 3% was rather low.
Rucksack Orthosis for Osteoporosis

Characteristic postures arising from weakened back muscles and improved walking posture with rucksack spinal orthosis
Postural Training Support (PTS)

- Encourages back extension through the addition of weights
  - Limits flexion
  - Posterior pocket holds 2.5 lb weight
    - Allows progressive build up of weight
- Adjustable straps to accommodate fitting
  - Sizing done by shoulder measurement
  - Weights made of vinyl with steel fillers
  - Velcro closure for easy donning/doffing
### Spinal Orthosis Options by Spinal Segment

<table>
<thead>
<tr>
<th>Region</th>
<th>Brace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper cervical spine (occiput-C1, C1-C2)</td>
<td>Miami J (Ossur, Paulsboro, NJ)/Minerva Halo vest</td>
</tr>
<tr>
<td>Mid cervical spine (C2-C6)</td>
<td>Miami J or any rigid collar</td>
</tr>
<tr>
<td>Cervicothoracic junction (C6-T5)</td>
<td>Miami J/Aspen (Aspen Medical Products, Irvine, CA) with thoracic extension SOMI Minerva Custom-molded cervicothoracic orthosis Halo</td>
</tr>
<tr>
<td>T6 and T7</td>
<td>Off-the-shelf TLSO Custom-molded TLSO CTLSO Halo-TLSO</td>
</tr>
<tr>
<td>T8-L2</td>
<td>Dorsal lumbar corset Jewett brace CASH brace (sternal pad adjusted high for higher fracture) Custom-molded TLSO</td>
</tr>
<tr>
<td>L3 and L4</td>
<td>Off-the-shelf LSO Custom-molded LSO</td>
</tr>
<tr>
<td>L5 and lumbosacral junction</td>
<td>Off-the-shelf LSO with high extension Custom-molded LSO with high extension</td>
</tr>
</tbody>
</table>

* In order of increasing rigidity

CASH = circumferential spinal hyperextension, CTLSO = cervicothoracolumbosacral orthosis, LSO = lumbosacral orthosis, SOMI = sternal-occipital-mandibular immobilizer, TLSO = thoracolumbosacral orthosis
Scoliosis Orthoses

TLSOs:
Accommodative and Corrective
Accommodative TLSO

- Fabricated of soft pelite
  - Reinforced with Kydex or rigid plastic
- Ambulatory and non-ambulatory patients
- Fixed alignments
Accommodative TLSO

- Maintain head and trunk over pelvis
  - Level shoulders
  - Reduce or minimize shear forces
- Allows patient to increase upper extremity use or decrease dependence
Accommodative TLSO

- Key to good positioning!
  - Enhances mobility base
  - Assists patients with pulmonary compromise
  - Used with fixed position wheelchair, tilt in space, or molded seats
Idiopathic Scoliosis

Milwaukee-style CTLSO
Biomechanic in Scoliosis

- Large curves are more readily straightened by elongation
- Smaller curves are more readily straightened by application of lateral forces
  - Usually placing pad below the apex causing lifting force
- Supine more effective force of TLSO than upright
  - Key to using bracing at night
- Elongation of curve
  - Reducing lumbar lordosis more effective in treating scoliosis in lumbar and thoracic spine
  - Reduction of the lumbar lordotic curve at the expense of flattening the thoracic kyphotic curve (may be problem)
  - Correct coronal plane motion but much less 3-D motion

Watts, Bracing in Spinal Deformities 1979
Corrective TLSO

- Progressive correction of idiopathic spinal curvatures
  - 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 <2

- Stabilization of congenital spinal curvatures

- Prevention of progression
  - 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”

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

Apophysis closes from anterior to posterior
Spinal Orthotics in Scoliosis

- Curves w/ apices T-8 or lower may be treated w/ underarm braces
  - Wilmington brace (custom made)
  - Boston brace (prefabricated)

- High thoracic curves may require the Milwaukee Brace
  - “Metal vertical suprastructure with pelvic foundation”
Charleston Brace

- Prescribed for part-time wear, usually 8 hours at night
- Is designed to ‘unbend’ the scoliotic curve
- Few long-term follow-up studies

“Heuter-Volkmann Law”

- “That growth is retarded by increased mechanical compression and accelerated by reduced loading in comparison of normal valgus”
Boston vs. Charleston

Katz: 1996
- compared the effectiveness of the TLSO Boston brace versus the TLSO Charleston brace
- Both were statistically comparable in preventing curve progression and surgery in single curves of 25-35°
- Boston brace was more effective in treating curves 36-45° and multiple curves

Watts 1977
- Boston not use if apex above T10 or curves greater than 40°
Scoliosis Orthoses
Weaning from TLSO in Scoliosis

- Slow wean is the best
  - Want no loss of correction up to 3 degrees
    - Off 2 h/day then Repeat X-ray 3 months
    - Off 4 h/day then repeat X-ray 3 months
    - Off 8 h/day then repeat X-ray 3 months
    - Off 12h/day then repeat X-ray 3 months
    - Use TSLO “night only” for minimum of 1 year

Orthotics for Spinal Deformity, Robert Winter: Clinical Orthopaedics & Related Research No:102, July-August 1974 pg 72-91
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- Cholewicki, Jacek The effects of a 3-week use of lumbosacral orthoses on proprioception in the lumbar spine, J Orthop Sports Phys Ther, Volume 36 No 4 april 2006 pg 225 to 231
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