Scoliosis and Spinal Deformity
Exercise, Bracing and Beyond

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“Lateral curve of the spine in an otherwise healthy child, for which a currently recognizable cause has not been found” (J.E. Lonstein)
Scoliosis History

TREATMENT - Evolution of Change

Current Treatment Guidelines per Scoliosis Research Society (SRS)

- < 25 Cobb = Observation
- 25-50 Cobb = Bracing
- > 50 Cobb = Surgery

(Lonstein and Carlson 1984)

Challenging Questions:

Can you predict the outcome of one case when L&C study is based on a large subset?

Is “observation” really treatment? “wait and see” vs. “treat and see”


We know current conditions cannot predict future function, what is the rush to do surgery?

Is surgery a worthwhile trade-off to deformity?
Scoliosis History
TREATMENT - Evolution of Change

SOSORT
Society of Scoliosis Orthopedic Rehabilitation and Treatment

- Founded in 2004
- Multi-national board & attendee
- Multi-disciplinary
- Conservative management
- Early intervention
- Annual meetings

“Complex 3D deformity of the spine and the trunk involving morphological as well as geometrical changes, not yet well understood” 2002 (C.E. Aubin - Buffalo, NY, in Studies in Health and Technology and Informatics, vol 91:4. 2002)

“Complex 3D deformity of the spine and trunk, which appears in apparently healthy children, and can progress in relation to multiple factors during any rapid period of growth, or later in life” 2010 (M Rigo - Spain, Th Grivas - Greece, J O’Brien - USA, in Scoliosis 2010)
Scoliosis
Pathogenesis/Pathomechanism

Posterior view
Scoliosis
Goals of Rehabilitation

**Vicious Cycle Theory:**
Asymmetric loading occurring secondary to the spinal curvature is the primary force driving development of a fixed and/or progressive deformity.

Ref: Stokes, 2003
Scoliosis Definition

Scoliosis = Postural component + Structural component (Bone deformity) + Structural component (Soft tissues)
Scoliosis Treatment
Physiotherapeutic Scoliosis Specific Exercise - PSSE

PSSE Basic Philosophy:
1. Early intervention
2. Evidence based, team approach treatment planning
3. Education to the patient about their specific curve and training to stabilize with exercises that include:
   - Auto-elongation/Self-elongation
   - Curve specific correction in 3D
   - Patient specific posture and mechanic training for ADL’s

Scoliosis Treatment

Physiotherapeutic Scoliosis Specific Exercise - PSSE

1. Barcelona Scoliosis Physical Therapy School (BSPTS)
2. Schroth Method - Asklepios (Germany)
3. Scientific Exercise Approach to Scoliosis - SEAS (Italy)
4. Functional individual therapy of scoliosis - FITS (Poland)
5. Side Shift (UK)
6. The Lyon Approach (French)
7. Dobomed (Poland)
Negrini: Literature Review - PSSE 23 articles 1986-2006

Disability and Rehab. 30(10); 2008.

Figure 1. The clinical results (patients improved, unchanged or worsened) reported in all exercises groups in the studies considered in this review are better than those reported in the observational groups. All the observational groups (obs) are listed under the black line, all the exercise groups (ex/con) over this line. The exercise groups include also a control group (con) that performed usual physiotherapy.
Monticone et al. 2013 - RCT

Purpose: To evaluate the effect of active self elongation and task-oriented exercises on spinal deformities and quality of life.

N=110, n= 55 in each experimental and control (traditional PT).

Analysis:
- Cobb
- Quality of life (SRS 22)
- Angle of Trunk Rotation (ATR)
- Skeletal maturity (+1 year after)

Evidence Supporting Goals

Effect on Curve Progression


<table>
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<th>2013 RCT</th>
<th>Group</th>
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<tr>
<td></td>
<td>pre-training</td>
<td>Post-training</td>
<td>1 year follow-up</td>
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<tr>
<td>Cobb (degrees)</td>
<td>Experimental</td>
<td>19.3</td>
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<td></td>
<td>SRS-22 Self image</td>
<td>Experimental</td>
<td>3.6</td>
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<td>Control</td>
<td>3.9</td>
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</table>
Evidence Supporting Goals

Effect of exercise on Bracing, Cobb, ATR

Fewer Braced

![Graph showing fewer braced individuals]

Less Cobb Progression

![Graph showing less cobb progression]

Reduced ATR

![Graph showing reduced ATR]

Evidence Supporting Goals
Effects of Conservative Management and Surgery

Retrospective analysis:

• Goal – To compare surgical intervention outcomes in center with bracing and exercise treatment vs. center with no intervention.

• N=106 cases studied. Of n=97 that followed up, **5.6% went to surgery** …if assumed all 9 other cases went to surgery it would be **14%**.

• **Non-treatment center revealed 28% surgical intervention.**

• Statically different result of different intervention types.

• Conservative Management is a meaningful intervention and can be a viable treatment option for one who doesn’t want surgery.

Evidence-Based Clinical Practical Approach to Idiopathic Scoliosis

2011 SOSORT guidelines: Orthopaedic and Rehabilitation treatment of idiopathic scoliosis during growth

Stefano Negrini1,2, Angelo G Aulisa4, Lorenzo Aulisa5, Alin B Circo6, Jean C de Mauroy7, Jacek Durmala8, Theodoros B Grivas9, Patrick Knott10, Tomasz Kotwicki11, Toru Maruyama12, Silvia Minozzi13, Joseph P O'Brien14, Dimitris Papadopoulos15, Manuel Rigo16, Charles H Rivard6, Michele Romano3, James H Wynne17, Monica Villagrasa16, Hans-Rudolf Weiss18 and Fabio Zaina3

Scoliosis Journal; 2012, 7:3.
SOSORT Guidelines 2011

2011 SOSORT GUIDELINES

Table 5. Final proposal of a possible clinical approach to scoliosis obtained from the previous votes, and sent out for another round. Below, the proposed table of the “Strength” of treatment used for idiopathic scoliosis, as found, as well as the resuming “goal of treatment” table.

<table>
<thead>
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<th>Modifiers</th>
<th>Range indication</th>
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<th>11-15</th>
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<th>26-30</th>
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<td>Obs 3 mo</td>
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<td>SB</td>
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<td>FTRB</td>
<td>FTRB</td>
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<td>Obs 6 mo</td>
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<td>Ex</td>
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<td>FTRB</td>
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<td>Ex</td>
<td>SB</td>
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<td>FTRB</td>
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EXERCISE TREATMENT
Katharina Schroth, 1921 – Active exercises
Scoliosis Treatment
Schroth Therapy History

Asklepios
Katherina Schroth
Klinik
Bad Sobernheim,
Germany

Inpatient
Rehabilitation and
Training Center
Scoliosis History

Barcelona: Institute Elena Salva’

- Elena Salva, PT
- Initiated Outpatient Schroth in Barcelona - 1968
- Continued by daughter Dr. Gloria Quera-Salva MD/DO

- Dr. Manuel Rigo, MD, husband of Gloria is current Director – ‘Institute Elena Salva’
- Initiated Schroth PT courses in English
- Director of Barcelona Scoliosis Physical Therapy School;
  instructors in Spain, Israel, Netherlands and USA
- USA BSPTS instructors: “Scoliosis Education Seminars”
  - www.scoliosiseducationseminars.com
Scoliosis Treatment
Schroth Exercise - Defined

Active Therapeutic Exercise:
“Therapy is a plan of cognitive, sensory-motor and kinesthetic training to teach the patient to improve her/his scoliosis posture in the assumption that scoliosis posture promotes curve progression”

“To integrate and reproduce a new motor program is too difficult to learn with a set of exercises learned superficially in a couple of days…”
Rehabilitation must aim to change the corporal schema of the patient — In the end, EACH the physical + neurophysiological + psychological barriers adapted to a new creating a new sense of “normal”
BSPTS Principles of Correction (POC)

1. Minimal Correction

Starting position: stable legs, pelvis and trunk

2. Maximal Correction

a. Auto/axial/self elongation - “TALL”
b. Asymmetrical Sagittal Straightening – specific AP “WIDTH”
c. Frontal Plane Correction – specific laterally “WIDTH”
d. Rotational Angular Breathing – perturbations to the posture
e. Stabilization – added challenge/resistance/instability to posture
Principles of Correction
Auto Elongation (AE)

Strategy: Caudal to cranial forces

If you are trying to elongate without stable and fractioned caudally pelvis, you will be using trunk extensors and flexors: the pelvis will go into anteversion and the collapses will remain collapsed.
Graphics of Patient performing POC

a.

b.

c.
Scoliosis Treatment
Overview

End result is achieving the best alignment of the blocks.
BSPTS Principles of Correction

Sitting

ONLY after lumbar prominence contained
Dorsal to ventral

“Tall and wide”
Gravity assisted exercise

Goals:
- Teach self elongation
- Better spinal geometry
- Sagittal profile control
- Scapular stability
- Lumbo-pelvic-hip control
- Not highly corrective in 3D
- Inhale-diaphragm goes down
  stimulate elongation /”growing tall”
Schroth Basic Exercises
Prone on Stool

Left Single Lumbar or TH/L
Schroth Basic Exercises
Sidelying Position

3 Curve/ Major Thoracic: Note belt and pad for overcorrection

- Elongation
- Convexities SCT (forward - inward)
- ST
- Concavities (outward – backward)
Advanced Schroth Exercises

Rotational Angular Breathing ("Chest Twister")

Pelvic correction
Advanced Standing Schroth Exercises

Muscle Cylinder

“Best” exercises for double major curve/4C

Convexities SCT (forward - inward)

Elongation

Concavities (outward – backward)

ST

Pelvic correction

Strict role: WP up
And leg elevated high
BSPTS Exercise Guidelines

AIS

Outpatient physical therapy to complete growth:

• Regimen BSPTS/Schroth exercises and trunk mobilizations.
• 1-2x/week, 1 hour sessions; ave16-20 visits.

Home care and exercise program (HEP):

• 30 min/day.
• 5-6 days/week.

Brace: 23 hours/day.

Exercise equipment:
wall bar, physioball, passive corrections ‘rice’ bags, poles, elastic band.
Neutral Posture and Body Mechanics

Bending promotes rotation and torsion.
General Exercises - Danger – hyperkyphosis/lordosis
Neutral Posture and Body Mechanics

Wt. bearing on convex side

Wt. bearing on concave side
Neutral Posture and Body Mechanics

Sleeping

Incorrect

Correct
ADL, RECREATION, SPORTS BRACING

CurvyGirlsScoliosis
@CGoScoliosis
Finding Balance

Once you understand scoliosis, it is easier to accept.

Accepting scoliosis means taking care of your back so you can live the life you want to live.
SOSORT 2005 Consensus paper:

1. **Why** do we treat adolescent idiopathic scoliosis?

2. **What** do we want to **obtain** and **avoid** for our patients.

*Scoliosis* 2006, 1:4

**“Why” Results:** We treat our patients for what they need for their **future** (Breathing function, Needs of further treatments in adulthood, Progression in adulthood), and their **present** too (Aesthetics, Disability, Quality of life).

Includes assessment of:

a. Aesthetics  
b. Quality of Life/Disability  
c. Psychological Well-being
Conservative Management and Psychology

PURPOSE:
1. To determine the effect of compliance to the Rigo System Cheneau (RSC) brace and a specific exercise program on IS curvature;
2. Compare the QOL and psychological traits of compliant vs. non-compliant subjects.

OVERALL RESULTS: Compliance to a specific exercise program and wearing the RSC brace can improve curvatures and signs and symptoms of AIS. AND………………

## Conservative Management and Psychology

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<tr>
<th></th>
<th>Compliant</th>
<th>NON-compliant</th>
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<tbody>
<tr>
<td>Cobb</td>
<td>improved $10.19^\circ(\pm 5.5)$</td>
<td>deteriorated $5.52^\circ(\pm 4.3)$</td>
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<tr>
<td>Peak flow</td>
<td>20% ($p = 0.001$)</td>
<td>9%</td>
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<tr>
<td>Scoliometer</td>
<td>Significantly more reduced ($p = 0.001$)</td>
<td>Same or increase</td>
</tr>
<tr>
<td>QOL</td>
<td>Significantly higher ($p = 0.001$)</td>
<td>Same or decrease</td>
</tr>
<tr>
<td>Personality trait</td>
<td>“More Mature” ($p = 0.001$)</td>
<td>Less Mature pre-treatment</td>
</tr>
</tbody>
</table>

Tools used to assess:
HSPQ or the SA92/16PF (South African norms) during and after treatment

ASSESSMENT
Main Indication:
1. Adolescent Idiopathic (AIS)
2. Adult / AIS and Adult onset
3. Juvenile kyphosis
4. Postural hyper-kyphosis
5. Hyper-lordosis
Secondary Indications:

1. Idiopathic Scoliosis:
   - infantile (<3 yo)
   - juvenile (3-10 yo)

1. Congenital Scoliosis

2. Syndromic and NM with Idiopathic like pattern.
Assessment
Indications

Precaution:
(Limited to PTs with long experience in PSSE)
1) Syndromic and NM with non ‘idiopathic like pattern’
2) Painful degenerative adult scoliosis
3) Age (infantile and Juvenile)
4) Osteoporosis
5) Post-surgery
6) Spondylolisthesis
7) Inflammatory disease during the non-active phase
8) Other trunk deformities
Contraindication:
1) Reactive scoliosis
2) Active phase of inflammatory disease
3) Psychiatric problems (hysteria, psychosis, others)
Assessment Overview

Assessment tools

• Functional and QOL Assessment Tools
• Clinical - Adams forward bend test and Angle of Trunk Rotation (ATR)
• Radiological: X-ray-2D and EOS-3D
• Non-Radiological: Formetric-Surface Topography
Assessment
Function – QOL - Self perception

QOL TOOLS

• **SRS-22**: Function, Pain, Self-image, Mental Health
• **SRS-36sf**
• **Trunk Appearance Perception Scale (TAPS)**
• **BrQ**

Rigo: [http://www.scoliosisjournal.com/content/8/S1/O55](http://www.scoliosisjournal.com/content/8/S1/O55)
Assessment
Angle of Trunk Rotation

- Bunnell Scoliometer
- Measures surface “angle of trunk rotation” (ATR)
- Must be present for definition of structural curve
- For screening: > 5 deg. = (+) screen
- *Note: 2013 SRS recommendation = 7 deg ATR

Assessment
X-ray Imaging – Pediatrics

- Cobb
- Risser
- Rib Index
- Growth plates in hand
## Assessment

**Risser**

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<tr>
<th>US</th>
<th>Risser</th>
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<tr>
<td>0</td>
<td>immature &lt; 11; Growth spurt</td>
</tr>
<tr>
<td>1</td>
<td>first menarche 11-13 yr</td>
</tr>
<tr>
<td>2</td>
<td>½ year after</td>
</tr>
<tr>
<td>3</td>
<td>1 yr after</td>
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<tr>
<td>4 &gt;</td>
<td>2 yrs after, less growth potential</td>
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<tr>
<td>4/5</td>
<td>growth complete</td>
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Radiological Evaluation
Simplified Staging System

Digital Capping Staging
1-8

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<tr>
<th>Correlations with actual Curve Acceleration Phase</th>
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<tr>
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<td>Greulich and Pyle Bone Age</td>
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<td>Chronological age</td>
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<td>Timing relative to the PHV</td>
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<td>Bone specific Alkaline Phosphatase</td>
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Radiological Evaluation

**DRCS**

Double Rib Contoure Sign (DRCS) =
Assessment of transversal plane correction.

Konstantinos 2015 http://www.scoliosisjournal.com/content/10/S2/S9

**2013 RI:** 2.88

**2014 RI:** 2.37
### Example: Clinical Outcome Summary

**X-ray and ATR**

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<th>2013 Kate Before</th>
<th>2014 Kate After</th>
<th>2013 Talia Before</th>
<th>2014 Talia After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic Cobb (out of brace)</td>
<td>51°</td>
<td>40°</td>
<td>45°</td>
<td>39°</td>
</tr>
<tr>
<td>Lumbar Cobb (out of brace)</td>
<td>37°</td>
<td>25°</td>
<td>30°</td>
<td>24°</td>
</tr>
<tr>
<td>ATR</td>
<td>12°</td>
<td>8°</td>
<td>14°</td>
<td>9°</td>
</tr>
<tr>
<td>Rib index</td>
<td>2.88</td>
<td>2.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Graphs showing Thoracic Cobb, Lumbar Cobb, ATR, and Rib Index before and after treatment for Kate and Talia.](image-url)
Assessment

Imaging - Gold Standard but……..

Imaging and breast cancer
National Cancer Institute X-ray Study

• Multi-site study; N = 5,500 women with PMHx AIS
• Mean # of x-rays during course of tx: 24.7
• Follow up: 40 years

Outcomes

• 70% higher chance of developing breast CA than general population
• Those who received >50 films had double the number of cases of CA as expected
• Breast tissue known to be more radio-sensitive

Luo, D. Spine Deformity. 3(2), 2015.
Assessment
Imaging – What can you do?

1. Measure the deviations with a scoliometer BEFORE referring to x-ray
2. You don’t need highest resolution to calculate Cobb
3. Filter (shield):
   Lead or Metal Shields on breast and reproductive organs
4. >= 6 ft. from Machine – reduce radiation
5. AP 8X higher radiation than PA
6. Narrow Beam – amount of radiation around the spine
**EOS** – standing 3D imaging:

- Biplane X-ray system – slot scanning technology
- Proposes that there is 2-3 X less than a general X-ray and 20 times less than basic CT scans

Formetric

• 3D/4D optical spine and posture analysis
• Pioneer in 4D scan technology
• Fast, contactless, marker-free Radiation-free
• Based on scientific research

Assessment
Imaging – Alternative to radiation

• Geometric reconstruction of surface topography from photos
• Mathematical Reconstruction
• Does not visualize Spine and Ribs
• Cannot Calculate Cobbs
• Is motion-sensitive
Assessment
Imaging - Formetric

Formetric 4D

Doctor communication: Optical spine and posture analysis

Sagittal  Frontal  Rotation
Assessment

Imaging - Formetric

Formetric 4D

Patient Education: Optical spine and posture analysis

• Provides patient with tangible evidence
  – Collapses
  – Prominences
  – Asymmetries
  – Gait

• Therapist can use as teaching tool
  – Before and after can be powerful
Case with Formetric

<table>
<thead>
<tr>
<th>OUTCOMES</th>
<th>Admission Oct 2012</th>
<th>Follow up Feb 2013</th>
<th>Follow up April 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Numeric Pain Scale (hip)</strong></td>
<td>5/10</td>
<td>1/10</td>
<td>1/10</td>
</tr>
<tr>
<td><strong>Formetric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal trunk imbalance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Rotation lumbar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scoliosis Angle lumbar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracic kyphosis angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>62 mm Right</td>
<td>15 mm Right</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.6 deg</td>
<td>5.0 deg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 deg</td>
<td>5 deg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>54 deg</td>
<td>46 deg</td>
<td></td>
</tr>
<tr>
<td><strong>X-ray</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracic Cobb</td>
<td>30 deg</td>
<td></td>
<td>27 deg</td>
</tr>
<tr>
<td>Lumbar Cobb</td>
<td>21 deg</td>
<td></td>
<td>21 deg</td>
</tr>
<tr>
<td>L4-5 listhesis</td>
<td>5 mm</td>
<td></td>
<td>5 mm</td>
</tr>
<tr>
<td>Pelvic height asymmetry</td>
<td>10 mm</td>
<td></td>
<td>6 mm</td>
</tr>
</tbody>
</table>

**Digital Posture Photo Outcome** - (12 visits)

- Admission: October, 2012
- Discharge: May, 2013
ADULTS TREATMENT
Adults

Group I: Adults w/ adolescent onset (AIS)

Group II: Adults w/ adult onset (AS)

no pain
- pain (spinal)
- pain (spinal + neuro)
- pain + degeneration
- pain + degeneration + uni-plane listhesis
- pain + degeneration + multi-plane listhesis
- pain + degeneration + (listhesis) + junctional curve

BSPTS Guidelines
Adult Exercise

With increasing modifiers present:
- Focus on function, not Cobb
- Assess co-morbidities
- Treat for stability over mobility
- Build internal volume
- Auto elongation without hanging
- Avoid use of external passive corrections (belts + poles)
- Do not create external junctional zones of de-torsion
BSPTS
Adult Exercise
BSPTS
Adult Exercise

FOTO
Eval: 76
Re-EVAL: 98

Cobb: 38°
Case “Z”

PMhx – Patient was diagnosed with scoliosis at 10 years old, Risser 0, Cobb; Right Thoracic 17 degrees and Left Lumbar 15 degrees. What would you recommend for treatment?

a. Observe
b. Exercise
c. Exercise + Brace
d. Surgery
Case “Z” Natural History Study

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COBB</td>
<td>Upper T</td>
<td>20°</td>
<td>20°</td>
<td>19°</td>
</tr>
<tr>
<td></td>
<td>Main T</td>
<td>17°</td>
<td>15°</td>
<td>20°</td>
</tr>
<tr>
<td></td>
<td>Lumbar</td>
<td>15°</td>
<td>Not Measureable</td>
<td>21°</td>
</tr>
</tbody>
</table>
After 2014 x-ray – (Risser 0, Cobb 30°, 40°, 38°.)

What would you do now?

a. Observe
b. Exercise
c. Exercise + Brace
d. Surgery
Case “Z”

Treatment:
1. Wood-Cheneau-Rigo (WCR) brace FT
2. PT visits 10 in 3 months.
3. PSSE 5 x per week at home.

(Current POC: 1x each 6-8 weeks for HEP upgrades)
Case “Z” with WCR brace
Case “Z”
Natural Hx 2014 to PSSE followed by IB/OOB x-rays
Case “Z” Summary

Albeit growth and maturation;
+ Height (2 inches)
+ Risser (0→2)
+ Cosmesis
+ Cobb reduced to non-surgical levels:
  Upper thoracic = no increase
  Main thoracic = -12°
  Thoracolumbar = -10°
Case “A” 2012

January – WWYD?
Cobb: T22 L21 // R:1

June – WWYD?
Cobb: T28 L25 // R:2

July
Cobb: T14 L24 // R:2

November
Cobb: T22 L21 // R:3
Case “A” 2013

May – WWYD?
Cobb: T29 L30 // R:4

August - WWYD?
Cobb: T32 L21 // R:4
Case “A” 2014

August 2013
Cobb: T32 L21 // R:4

January 2014
Cobb: T41 L40 // R:4

June 2014
Cobb: T41 L31 // R:4
Initiation of PT: August
Case “A” 2014

New brace; ATR 11 T and 7 L, sp 7 mos. menses
Case “A” 2015 Summary

Pre-tx Xray  Post-tx x-ray  Pre-tx cosmesis  Post-tx cosmesis
Radiological Changes:

Cosmetic Changes:

Scheuermann

55 deg.  45 deg
Resources

- Scoliosisjournal.com
- Scoliosiseducationseminars.com
  - Schroth Method Courses
  - Schroth Certified Therapist
- SOSORT.org
- BSPTS.net
- Amy’s email: asbihli@orthopaedicsplus.com