Vertebral body stapling in children with idiopathic scoliosis < 10 years of age with curve magnitude 30-39 degrees

Alexander A. Theologis, MD; Patrick Cahill, MD; Mike Auriemma, BS; Randal Betz, MD; Mohammad Diab, MD

58th Annual LeRoy C. Abbott Society Scientific Program
34th Annual Verne T. Inman Lectureships

Department of Orthopaedic Surgery, UCSF
March 11, 2013

Financial Disclosures

- Theologis: none
- Cahill: DePuy Synthes Spine
- Auriemma: none
- Betz: Medtronic, DePuy Synthes Spine, Orthocon, SpineGuard, MiMedx
- Diab: none

Early Onset Idiopathic Scoliosis

- Skeletally immature child
  - Infantile: < 3 years
  - Juvenile: 3-10 years

- Challenging
  - Growth potential?
  - Age
  - Curve magnitude
  - Unpredictable

The Unpredictable

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 45 degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 45 degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Management?
- Prevent curve progression
- Prevent surgical fusion
Nonoperative

- **Observation vs. Bracing**
  - Conflicting data
  - No difference in surgical rates (22% vs. 23%) (Dolan et al. 2007)

- **Curve magnitude at onset of puberty is the only important factor** (DiMeglio 2011)

<table>
<thead>
<tr>
<th>Cobb angle</th>
<th>&lt; 20</th>
<th>20 - 30</th>
<th>&gt; 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk of fusion</td>
<td>16%</td>
<td>75%</td>
<td>100%</td>
</tr>
</tbody>
</table>

The Dilemma

- **< 10 years old with curves > 30 degrees**
  - Curve too severe to be controlled with a brace
  - Patient too young to be fused
    - Crankshaft phenomenon
    - Limit growth of spine

- **Fusionless surgical alternatives?**
  - Improve curve
  - Prevent progression & fusion

VBS

- **Vertebral body stapling**
  - Adopted from long bone growth modulation (Blount)
  - First use 1954: congenital scoliosis (Smith)

Evolution

- **Nitinol staples**
  - Shape memory alloy
  - Cold: straight prongs
  - Warm: curved prongs

- **Indications**
  - Age < 13 (girls); < 15 (boys)
  - Thoracic curves: < 35 degrees
  - Lumbar curves: 25-45 degrees
Literature

- Betz et al. 2003
  - 21 pts (11.9 yrs; 10-14 years)
  - Thoracic: 60% success for 18° to 55° curves (minimum 1 year f/u)

- Betz et al. 2010
  - 28 pts (9.4 yrs; 4-13); minimum 2 year f/u
  - Lumbar: 87% success for 25° to 45° curves
  - Thoracic: 79% success for 25° to 35° curves

- Laituri et al.
  - Thoracic: 71.4% success for curves 25° to 41°
  - Thoracoscopic only
  - 7 children (8-11 years old)

Improved success with narrower curve magnitudes and/or age criteria?

Objective

- To determine whether VBS may arrest or slow curve progression in order to avoid fusion in children < 10 years of age with scoliosis 30 to 39°

Methods

- Retrospective case series
  - UCSF
  - Shriners Philadelphia

- Inclusion
  - < 10 years old
  - Idiopathic scoliosis
  - Cobb angle 30 – 39 degrees
  - Minimum 2 year follow-up

- Outcome variables
  - Intra-operative and hospital data
  - Complications
  - Definitive fusion for curve progression (greater than 10 degrees)
  - Need for re-operation for any indication

Surgical technique

- Open

- Thoracoscopic
Patients

<table>
<thead>
<tr>
<th>Curve Type</th>
<th>Age at surgery</th>
<th>Pre-op (Cobb angle)</th>
<th>Latest follow-up (Cobb angle)</th>
<th>Latest follow-up (Age)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T</td>
<td>9.65</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>T</td>
<td>7.48</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>T</td>
<td>7.03</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>T</td>
<td>7.13</td>
<td>31</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>6.44</td>
<td>35</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>T</td>
<td>6.28</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>T</td>
<td>8.51</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>8</td>
<td>T</td>
<td>8.44</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>T</td>
<td>8.15</td>
<td>34</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>L</td>
<td>8.15</td>
<td>33</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>L</td>
<td>8.88</td>
<td>31</td>
<td>22</td>
</tr>
<tr>
<td>12</td>
<td>L</td>
<td>8.31</td>
<td>38</td>
<td>0</td>
</tr>
</tbody>
</table>

Average 7.85 33.4 19* 23* 11.25

T = thoracic; L = lumbar
* Significantly less than the curve magnitude at pre-operative evaluation (p<0.05).

Operative Data

<table>
<thead>
<tr>
<th>Thoracic (n=9)</th>
<th>Lumbar (n=4)</th>
<th>All patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of surgery (mins)</td>
<td>281 (110-407)</td>
<td>381 (179-525)</td>
</tr>
<tr>
<td>Estimated blood loss (mL)</td>
<td>153 (10-500)</td>
<td>191 (15-600)</td>
</tr>
<tr>
<td>Number of staples used</td>
<td>7.7 (3-11)</td>
<td>5.0* (4-7)</td>
</tr>
<tr>
<td>Intra-operative neuromonitoring change</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chest tube duration (days)</td>
<td>1.82 (1-4)</td>
<td>2.0 (1-4)</td>
</tr>
</tbody>
</table>

Complications

- Pneumothorax: 1
- Symptomatic pleural effusion: 1
- Staple complications: 0

Results

- Curve progression
  - Thoracic: 0%
  - Lumbar: 0%

- Need for fusion: 0%

- Revision surgery: 0%
Conclusions

- Children < 10 years old with idiopathic scoliosis 30° to 39° may significantly benefit from immediate VBS without observation or bracing.

- This treatment may ultimately prevent the need for surgical fusion at a later age.

- Unknowns!
  - Lower age limit?
  - Children between 10 and puberty?
  - Effect on growth?
  - Overcorrection?
  - Larger curves (>40-45°)?

Larger curves

- Vertebral tethering
  - Original use in the lumbar spine as a “dynamic stabilizer”
  - Titanium pedicle screws
  - Polyethylene flexible tether: compresses adjacent screws when tightened

Vertebral tethering

Future Directions

- Exciting!

- The future
  - Biomechanical comparisons
  - Surgical indications? (age, curves, etc)
  - Larger cohorts
  - Longer follow-up
  - Patient outcomes
References

12. Betz RR.

VBS Biomechanics

1) Staple placement restricts ROM in axial rotation and lateral bending.
2) There is no mechanical difference between one double-prong staple and 2 single-prong staples.
3) An anterior staple significantly reduces the overall flexion-extension ROM of the thoracic spine.
4) Staple fixation does not result in significantly elevated adjacent segment motion.

Fusionless Alternatives

- Growing rods
- Shilla
- VEPTXR

- High complication rate
  - Broken rods
  - Infection
  - Multiple surgeries
  - Cost