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AOSpine Advanced Symposium—Managing the complex cervical spine

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BJ Palmer (1882-1961)
Introduction

• Fixed sagittal deformity at the cervicothoracic junction results in high disability.
• Osteotomies can correct this disability
• Smith-Petersen osteotomy, Vertebral column resections (VCR) and pedicle subtraction osteotomies (PSO) are commonly performed at or below the mid thoracic to lower lumbar spine for sagittal imbalance
• Initially described by Simonds for ankylosing spondylitis.
• In comparison with the Smith-Petersen procedure, PSO is theoretically more stable
  • Shortens the spine
  • Bony contact at the osteotomy site

Etiology of cervical kyphosis.

- Most common cause is iatrogenic (i.e., postsurgical, laminectomy).
- Advanced degenerative disease.
- Drop Head Syndrome.
- Posttraumatic.
- Radiotherapy in the neck.
- Neoplastic disease.
- Infection (Sequels of Pot’s disease..).
- Systemic arthritis.
  - Ankylosing spondylitis.
  - Rheumatoid arthritis.
- Others (syndromic, congenital).
Clinical presentation.

- Unable to maintain horizontal gaze
- Ventral compression
- Swallowing difficulties
- Respiratory compromise
- Neurological deficits.
  - Radiculopathy
  - Myelopathy
- Mechanical neck pain: Worst with activity.
Indications of PSO.

- Patients with a **fixed** cervical kyphotic deformity >30°.
- Chin-on chest deformity.
- Progressive kyphosis.
Indications.

- **Semi-rigid kyphosis w/our w/o neurologic symptoms**: Multilevel Smith-Petersen Osteotomy with Posterior Stabilization

- **Rigid subaxial kyphosis w neurologic symptoms**: Circumferential Osteotomy with a double approach, or anterior only in cases without posterior ankylosis of the facet joints

- **Rigid subaxial or cervicothoracic kyphosis w/o neurologic symptoms**: Open wedge osteotomy or Pedicle subraction osteotomy.
Preoperative evaluation.

- Medical evaluation prior to surgery
- Complete history of prior spine surgeries
- Full-length radiographs
- Flexion-extension and lateral bending views
- High-resolution CT scan
- Magnetic resonance imaging
- Preop angio CT
Osteotomy Planning

- The chin-brow angle (correction to a slightly flexed position, usually 15 to 20°)
- To calculate the amount of correction needed we prefer to use the preoperative CT scan:
  - Local sagittal angle
  - Cervical lordosis: C2-C7 Angle
  - Cervical plumbline
  - C2-C7 CSVA
  - T1 Slope
Osteotomy Planning
Surgical technique: anesthesia and patient positioning

- General anesthesia. Complex intubation.
- Neurological monitoring, including both somatosensory evoked potential (SSEP) and motor evoked potential (MEP) techniques
- Mayfield head clamp.
- Maximum amount of reverse Trendelenburg
Surgical technique

Level: C7

- Fairly safe position of the vertebral artery
- Size of the spinal canal
- Mobility of the spinal cord
- Preservation of reasonable hand function in the event of C8 nerve root injury

Extension of instrumentation:

- Minimum six points of fixation above and below osteotomy
- Preserve mobile occipitocervical and atlantoaxial joints whenever possible
Surgical technique

- The lateral masses are exposed in their entirety.
- Lateral mas screws and pedicle screws.
- Place the screws in a straight line.
- Laminectomy at C7, and the half of C6 and T1.
- The facets must be completely excised, including the caudal aspect of the inferior facet of C6 and the cranial aspect of the superior facet of T1.
Surgical technique

- Expose de C7 and C8 roots
- Decancellation of vertebral body throught the C7 pedicles (Tap / Curette)
- Remove bony wall of pedicles
- Remove the lateral wall of vertebral body.
- Impact the dorsal cortex of vertebral body.
Surgical technique

- Fix the prebended road to cervical screws.
- Extend the neck to close the osteotomy. Mayfield/Halo Manipulation
- Check the roots.
- Close the instrumentation.
- Check the neuromonitoring signals.
- Lateral X-ray
- Autografts.
- Wound closure
- Hard cervical collar.
Case 1

- 70 year-old male.
- Neoplasm of larynx 10 years ago. Treated with laryngectomy, chemotherapy and radiotherapy.
- Fracture of C7 treated initially conservatively, and after with posterior arthrodesis C4-T2.
- After 3 months, Pull-out of the cervical screws
Case 1

- Chin-brow axis 45°. Postraumatic rigid Cervical kyphoses 38°.
Case 1

- Pedicle subraction osteotomy at C7.
- Postoperative global lordosis $15^\circ$
Case 1

- Chin-brow axis -5°
Case 2

- 64 year-old male.
- Car accident. Fractures of T1-T2 and both clavicles
- Posterior Fusion C4-T4.
- Failure of cervical fixation.
- Postraumatic kyphoses.
Case 2

- Progressive postraumatic kyphosis 95°
Case 2

- Chin–brow axis of 80 degrees.
Case 2

- C7 pedicle subtraction osteotomy
Case 2

- Radiological outcome: Kyphoses 32°
Case 2

- Clinical outcome: Chin-brow axis 10 degrees.
Results

Literature review on severe chin-on-chest deformities due to ankylosing spondylitis

- Six retrospective clinical studies
- Indication for surgery was primarily loss of horizontal gaze.
- The most common surgical technique was based on the original Simmons osteotomy at C7–T1.
- The complication rate was high, 26.9% to 87.5%.
- Mortality rate of 2.6%
- Permanent neurologic complication rate was 4.3%.
- All patients had improvement in horizontal gaze and chin-brow to vertical angles
- Patient satisfaction after surgery appeared high.
Results

- PSO has produced gratifying results in this series of cervical osteotomy for fixed cervico-thoracic kyphosis patients.

- Pedicle subtraction osteotomy can provide excellent sagittal correction while simultaneously forming a stable construct and minimizing neural compression.

<table>
<thead>
<tr>
<th>N</th>
<th>year</th>
<th>Restoration forward gaze</th>
<th>Mean lordosis correction</th>
<th>Sagittal balance</th>
<th>Inmoriyng CVA</th>
<th>complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2007</td>
<td>8</td>
<td>57°</td>
<td>-----</td>
<td>35°</td>
<td>2 infection</td>
</tr>
<tr>
<td>8</td>
<td>2010</td>
<td>8</td>
<td>35,6°</td>
<td>2,74 cm</td>
<td>32°</td>
<td>2 radicular</td>
</tr>
<tr>
<td>11</td>
<td>2011</td>
<td>11</td>
<td>49°</td>
<td>4,5 cm</td>
<td>36,7°</td>
<td>1 Disphag</td>
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<td></td>
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</tbody>
</table>

- Conclusions. The cervicothoracic junction PSO is a safe and effective procedure for the management of cervicothoracic kyphotic deformity. It results in excellent correction of cervical kyphosis and CBVA with a controlled closure and improvement in health-related quality-of-life measures even at early time points.
Results

35 patients, 31 anterior vs. 4 PSO.
- Greater angular correction.
- Greater translational correction.
- Similar clinical outcomes.

Table 2  Radiographic and clinical outcomes from baseline to latest follow-up

<table>
<thead>
<tr>
<th>Parameters/groups</th>
<th>Anterior osteotomy group 1 (n = 31)</th>
<th>Pedicle subtraction osteotomy group 2 (n = 4)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographic parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative cervical lordosis (°)</td>
<td>24.8</td>
<td>4.3</td>
<td>0.73</td>
</tr>
<tr>
<td>Pre-operative basion PL (cm)</td>
<td>−1.5</td>
<td>4.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Post-operative cervical lordosis (°)</td>
<td>−5.0</td>
<td>−16.2</td>
<td>0.03</td>
</tr>
<tr>
<td>Post-operative basion PL (cm)</td>
<td>−1.6</td>
<td>2.4</td>
<td>0.02</td>
</tr>
<tr>
<td>Total angular correction (range)</td>
<td>27.7 (9.0–66.0)</td>
<td>48.8 (38.4–68.3)</td>
<td>0.03</td>
</tr>
<tr>
<td>Total translational correction (range)</td>
<td>1.8 (0.1–2.4)</td>
<td>2.8 (0.1–5.6)</td>
<td>0.56</td>
</tr>
<tr>
<td>Clinical outcome—Neck Disability Index (NDI)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative NDI</td>
<td>26.0</td>
<td>25.2</td>
<td>0.99</td>
</tr>
<tr>
<td>Post-operative NDI</td>
<td>21.5</td>
<td>20.5</td>
<td>0.99</td>
</tr>
</tbody>
</table>
Results

Comparison of Smith-Petersen Osteotomy Versus Pedicle Subtraction Osteotomy Versus Anterior-Posterior Osteotomy Types for the Correction of Cervical Spine Deformities

Han Jo Kim, MD,* Chaiwat Piyaskulkaew, MD,† and K. Daniel Riew, MD‡

<table>
<thead>
<tr>
<th>Groups/Radiographical Parameters</th>
<th>Total Mean Angular Correction (°)</th>
<th>Angular Correction per Level (°)</th>
<th>Total Mean Translational Correction (cm)</th>
<th>Translational Correction per Level (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPO (n = 13)</td>
<td>19.4</td>
<td>10.1 (range, 1.0°–24.9°)</td>
<td>3.5</td>
<td>1.8 (range, 0.5–4.0 cm)</td>
</tr>
<tr>
<td>PSO (n = 10)</td>
<td>44.8</td>
<td>34.5 (range, 28.2°–80.0°)</td>
<td>2.8</td>
<td>2.5 (range, 0.2–5.6 cm)</td>
</tr>
<tr>
<td>ATO (n = 16)</td>
<td>22.4</td>
<td>17.1 (range, 3.5°–32.1°)</td>
<td>1.3</td>
<td>1.0 (range, 0.1–3.0 cm)</td>
</tr>
<tr>
<td>ATO + SPO (n = 22)</td>
<td>32.5</td>
<td>27.8 (range, 3.7°–66.7°)</td>
<td>3.6</td>
<td>3.1 (range, 0.2–7.0 cm)</td>
</tr>
</tbody>
</table>

*SPO indicates Smith-Petersen Osteotomy; PSO, pedicle subtraction osteotomy; ATO, anterior osteotomy.

**Conclusion.** Posteriorly based osteotomies provided better translational correction than ATOs. The angular correction achieved by 1 PSO was similar to ATO + SPOs. ATO + SPOs provided equal or better corrections than isolated PSOs, with equal length of stay and less estimated blood loss.
Complications

- Technically challenging procedure and had a 4% of mortality rate.
- **Wound complications**: hematoma formation, necrosis, postoperative infection, wound dehiscence, and poor cosmesis.
- **Neurological complications**: The overall rate of neurological injury is approximately 23%.
  - In most cases, neurological complications are transient, and C8 nerve root palsy seems to be the most commonly encountered problem.
- **Vascular complications**: There is also a risk of injury to the vertebral artery, but this is minimized by performing the procedure at C7 and appropriate intraoperative awareness of the local anatomy.
- **Mechanical complications**: Hardware failure or pseudoarthrosis.
- **Dysphagia** has been reported by several authors after cervical extension osteotomy but appears to be a transient phenomenon.
Conclusions

• Complex reconstructive procedure.
• Right indication: fixed cervical kyphotic deformity
• Exhaustive preoperative planning
• Meticulous operative technique.
• Multiple complications associated.
• The safety has been enhanced by the use of modern methods of anesthesia, neurological monitoring, and spinal instrumentation.
• Cervicothoracic junction PSO being a safe, reproducible and effective procedure for the management of cervicothoracic kyphotic deformities.