Choosing Your Osteotomy in Posterior Deformity Correction

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disclosures

• None
PCO vs. 3CO

- Posterior Column Osteotomies (PCO)
  - Ponte, Smith Peterson
  - Type II

- Three Column Osteotomies (3CO)
  - Pedicle subtraction, extended pedicle subtraction, Vertebrectomy resection
  - Type III, IV, V, VI

Anatomic Classification System of Spinal Osteotomies

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Posterior Column Osteotomies (PCO)

- Posterior Column Osteotomies (PCO)
  - Posterior shortening procedure
  - Generally produces about 10° of sagittal plane correction
  - Involve total facet resection, ligamentum flavum resection, inferior laminectomy
    - Smith-Peterson
      - Original description in 1945 for correction of flexion deformities in RA and AS
      - Disrupts the ALL \(\rightarrow\) lengthening of anterior column and shortening of posterior column
    - Ponte
      - Deformity correction is through the unfused disc space and ALL is left intact

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Frank Schwab, MD, Benjamin Blondel, MD, Edward Chay, BA, Jason Demakakos, MS, Lawrence Lenke, MD, Patrick Trupiano, MD, Christopher Ames, MD, Justin S. Smith, MD, PhD, Christopher I. Shaffrey, MD, Jean-Pierre Farcy, MD, Virginie Lafage, PhD. The Comprehensive Anatomical Spinal Osteotomy Classification. Neurosurgery. Volume 74, Issue 1, January 2014, Pages 112–120.
Posterior Column Osteotomies (PCO)

- **Effective**
  - Thoracic PCO increased ROM
    - Flexion-extension: 33%, 56%, 69% for 1-, 2-, or 3-level
    - Axial Rotation: 16%, 29%, and 65%
  - Multilevel PCO can achieve similar correction to 3CO
  - Improved correction of scoliosis compared to inferior facetectomies
  - Increased loosening effect on periapical segments

- **Safe**
  - AIS: 0.37% neurologic complication rate with PCO, 0.17% without PCO
  - Increased blood loss and operative time
    - But significantly less than 3CO

Three Column Osteotomy (3CO)

- All three columns of the spine are destabilized
  - Temporary fixation is necessary
  - Able to correct through rigid or fused deformities
  - About 30° correction with a PSO more with a VCR

- Pedicle subtraction osteotomy (PSO) (type 3)
- Extended Pedicle subtraction osteotomy (type 4)
- Vertebral Column Resection (VCR) (type 5)
- Multilevel Vertebral Column Resection (type 6)

References:
Three Column Osteotomy (3CO)

- **Blood loss**
  - 643-2984 mL average EBL for PSO
  - 900-6680 mL average EBL for VCR

- **Neurologic Injury**
  - New neurologic deficit rates after 3CO reported between 8.6%-40.3%
  - Scoli-Risk-1 (75% 3CO) → 22.18% neurologic decline from baseline at discharge

- **Pseudoarthrosis**
  - 10% pseudoarthrosis rate for PSOs
  - Up to 27% implant failure
    - Improved with supplemental rods


Factors Affecting Decision Making Between

- **Anatomic Considerations**
  - Flexibility
  - Bone Quality

- **Alignment Considerations**
  - Deformity Angular Ratio
  - Location of the deformity and restoration of spinal shape

- **Patient Specific Considerations**
  - Age
  - Medical Comorbidities (frailty)
Flexibility

- Supine XR or Scout Views from CT
  - Flexible
    - Significant correction of the deformity with dynamic imaging
  - Rigid
    - Ankylosed spine but still some correction through open disc spaces
  - Fused
    - Typically requires a 3CO

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Bone Quality

- Preoperative DXA
  - Hip and/or wrist

- Elliptical ROI
  - Limited by Heterogeneity of threshold value to diagnose osteoporosis/osteopenia
  - HU < 135 has been proposed as a reasonable threshold

- Stronger Bone → better fixation → more force can be transmitted to the spine to get correction


Bone Quality (What can we do about it)

- Anabolic agents
  - Teriparatide
    - fully active (1-34) amino active sequence of human parathyroid hormone (PTH)
  - Abolparatide
    - a synthetic analog of parathyroid hormone-related peptide (PTHrP)
  - Increased insertional torque for pedicle screws in patients treated with at least 1 month of Teriparatide preoperatively.

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Teriparatide increases the insertional torque of pedicle screws during fusion surgery in patients with postmenopausal osteoporosis

Clinical article

Bone Quality (What can we do about it)

- Anabolic agents
  - Teriparatide
    - fully active (1-34) amino active sequence of human parathyroid hormone (PTH)
  - Abloparatide
    - a synthetic analog of parathyroid hormone-related peptide (PTHrP)

- Postoperative Teriparatide reduced pedicle screw loosening for 1-2 level fusions in osteoporotic women.
  - 7-13% with Teriparatide
  - 13-26% with risedronate
  - 15-25% in controls


Mean 2 months of preoperative Teriparatide continued 8 months postop had fusion rate of 82% in Teriparatide vs 68% in risedronate.

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Deformity Angular Ratio (DAR)

- DAR = Cobb angle divided by the number of vertebrae involved in the curve
- Total-DAR = Coronal-DAR + Sagittal-DAR
  - T-DAR > 25
  - S-DAR > 15

- Increased risk for intraoperative SCM events and new postoperative neurologic deficits in patients undergoing vertebral column resection
- Also helpful to determine type of osteotomy
  - Short angular curve \(\rightarrow 3CO\)
  - Long sweeping curve \(\rightarrow\) multiple PCOs

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Spinal Shape

Spinal Shape

- Failure to restore normal shape according to Roussouly Classification → mechanical complication RR 3 (CI 1.5–4.3; p < 0.001)

- 13.5% PJK when postoperative sagittal apex of the lumbar curve was identical to the theoretical apex
  - 41.4% PJK in cases where the theoretical and actual apex were different

- Spinal Shape: Does spinal shape correlate with functional outcome?
- Is it worth the increased risk of 3CO if that is the only way to restore spinal shape?
- Is spinal shape as important when the fusion is extended to the upper thoracic spine?

75 yo woman with medical comorbidities, presenting with myelopathy from a thoracic disc and severe back pain

T12-L3 & L5-S1 PCOs

SVA: 13 cm → 1.5
PI: 45°
LL: 0° → 43°
PT: 32° → 14°

Roussouly type II with post op apex of kyphosis at L2-3 and doing very well at 2 years.
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Age Adjusted

- Sagittal spino-pelvic alignment varies with age
- Operative realignment targets should account for age
- Younger patients require more rigorous alignment objectives

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<th>Age Group</th>
<th>% in Database</th>
<th>Mean Age in Database</th>
<th>ODI US-Norm*</th>
<th>PT</th>
<th>PI–LL</th>
<th>LL–TK</th>
<th>SVA</th>
<th>TPA</th>
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</table>

*value extrapolated using the PCS-US-norm.
Age Adjusted Normative Sagittal Alignment Values

- Sagittal spine-pelvic alignment varies with age
- Operative realignment targets should account for age
  - Younger patients require more rigorous alignment objectives.


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Adult Spinal Deformity Frailty Index (ASD-FI)

- ASD-FI is a component of preoperative risk stratification
- Health deficits documented by the physician
- Patient reported questions
- Frailty is strongly associated with risk of complications after surgery
- Invasiveness of surgery may be modified based on pre-operative risk stratification


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Thanks!