Complications in Adult Deformity Surgery

Proximal Junctional Kyphosis: Thoracolumbar and Cervicothoracic

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Key Points

• Readmission and Reoperation are important measures of quality of care and important contributors to cost of care

• Junctional complications are an important challenge in spinal deformity surgery
  – Distal junctional complications include pseudarthrosis and progressive degenerative change below a fusion
  – Proximal Junctional Kyphosis is related to fracture and/or subluxation at or above the UIV
    ▸ Cervicothoracic
    ▸ Thoracolumbar
• Reducing junctional complications may improve durability of outcomes and cost-effectiveness of spine surgery

Junctional Pathology in Spine Surgery

• Adjacent Segment Pathology is among the most important and significant complication in spine fusion surgery
• In over 600,000 spine fusion surgeries per year
  – 12% adjacent segment pathology requiring surgery
  – Rates of symptomatic degeneration up to 50% in spinal deformity procedures

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Definitions

- **Adjacent level degeneration**
  - Radiographic signs of advanced disc degeneration or segmental instability above a fusion
- **Adjacent segment disease**
  - Pathology adjacent to a fusion that creates symptoms of pain and/or nerve compression that leads to revision surgery
- **Proximal junctional kyphosis**
  - Radiographic measure of greater than 5 degrees of progression of segmental kyphosis above a fusion
- **Proximal Junctional Failure**
  - 10° post-operative increase in kyphosis between upper instrumented vertebra (UIV) and UIV+2, along with one or more of the following: fracture of the vertebral body of UIV or UIV +1, posterior osseo-ligamentous disruption, or pull-out of instrumentation at the UIV.
- **Kyphotic Decompensation Syndrome**
  - Progressive sagittal deformity requiring revision surgery for realignment of the spine

Etiology and Pathogenesis

- **Proximal Junctional Kyphosis**
  - **Choice of Levels**
  - **Radiographic Factors**
  - **Biomechanics**
    - Rigidity of Fixation
  - **Patient-specific Factors**
    - Bone Quality
    - Age
    - Neuromuscular Pathology

Proximal Junctional Kyphosis

Debate: Determining the Upper Instrumented Vertebra in the Management of Adult Degenerative Scoliosis
Stopping at T10 Versus L1

Harry Shurtleffer, MD. * Spine 2006
- Stopping at or distal to T11 increases risk of adjacent segment kyphosis (50% PJK)

- Fusions from L1 or L2 to the sacrum have an unacceptable rate of mechanical failure (52/20)

Simmons ED, et al: SRS 2005
- 60% adjacent segment “topping off” in long fusions with cephalad level of L1/L2

- 26% incidence of PJK in long adult deformity constructs. Highest at T3. Little impact on clinical outcome.

Hostin R and ISSG: Spine 2012
- 5.6% incidence of Acute Proximal Junctional Failure (69/1218)
  - Defined as 15° proximal kyphosis coupled at or above UIV
  - Omit need for revision surgery (without fusion)
Restrospective study of 157 consecutive patients with long fusion for deformity

- PJK observed in 32 (20%)
  - Posterior instrumentation
  - Fusion to sacrum
  - Significant sagittal imbalance
    - TK+LL+PI>45 degrees
    - SVA change more than 5cm
  - No association with age, BMI, BMD

Proximal Junctional Kyphosis in Adult Spinal Deformity After Segmental Posterior Spinal Instrumentation and Fusion
Minimum Five-Year Follow-up

- Defining PJK
- 62/161 pts with adult deformity and fusions >5 levels
- 59% within 8 weeks
- Risk factors:
  - Older age (>55yo)
  - Combined AP surgery
  - Pedicle screws (age non-adjusted)
  - LIV at S1 (age non-adjusted)
- Outcome worst with kyphosis >20 degrees
- Rate not dependent upon proximal level

125 adults with proximal fusions T9-L2
- Average 7.1 levels fused
- 3 groups sorted by PIV
  - T9-10: PJK 51% Revision 24%
  - T11-12: PJK 55% Revision 24%
  - L1-L2: PJK 36% Revision 26%
- Recommendation: Choose lowest neutral and stable proximal vertebra

Is the T9, T11, or L1 the More Reliable Proximal Level After Adult Lumbar or Lumbosacral Instrumented Fusion to L5 or S1?

Yongjun J. Kim, MD, Keith H. Bridwell, MD, Lawrence G. Lenke, MD, Seungchul Rhim, MD, and Young-Woo, Kim, MD

- 90 consecutive patients fused from T9-L1 to pelvis
- Average Age: 64.5
- Minimum Follow-up 2 years (2.9 years average)
- Radiographic PJK observed in 37 patients (41%)
- Reoperation in 12 patients (12%)
- Purpose:
  - Defined Risk Factors for PJK
  - Identify Protective Strategies

UCSF Experience:

Mano K, UCSF Spine Service: Spine

- 90 consecutive patients fused from T9-L1 to pelvis
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  - Purpose:
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• 68yo male physician with progressive sagittal and coronal plane deformity
• Lower back pain with limited neurogenic symptoms
Proximal Junctional Kyphosis

Maruo et al: Spine in Press
– 90 consecutive patients fused from T9-L1 to pelvis
– Radiographic PJK observed in 37 patients (41%)
– Reoperation in 12 patients (12%)
– Risk factors:
  • Change in Lumbar Lordosis >30 degrees
  • Pre-operative thoracic kyphosis >30 degrees
  • Preoperative PJA >10 degrees
  • Pelvic incidence >55 degrees
– Protective strategy:
  • Post-op SVA<50mm, PT<20 degrees, and PI-LL+=/-10 degrees

Cervicothoracic Junctional Pathology

• Upper Thoracic vs Thoracolumbar End Vertebra
4 weeks post-op Patient with severe cervicothoracic pain
10 pts with PJK
  5 with UVI collapse and adjacent subluxation
  5 with adjacent fx

Risk factors:
  Osteopenia, Large sagittal plane correction, old age, comorbidities

Decompensation in first 6 mos
High rate 2/5 of neural compromise in pts with UVI collapse and adjacent subluxation
Proximal Junctional Kyphosis

UCSF Experience:

162 consecutive adults with long fusions to the sacrum
- 127 distal thoracic (T9 to L1)
- 35 proximal thoracic (T2 to T5)

Radiographic PJK
- 31% distal thoracic
- 25% proximal thoracic

Kyphotic decompensation disease
- 6.3% distal thoracic
- 5.7% proximal thoracic

Mechanism of distal thoracic decompensation was fracture at UIV
Mechanism of proximal thoracic decompensation was subluxation - 2 cases with neural injury

Evidence-based Approach to Choosing a Level

Indications for Extending Arthrodesis to the Upper Thoracic Spine

- Extension of measured curve to the structural thoracic spine
- Segmental kyphosis at the thoracolumbar junction > 5 degrees
- Thoracic Kyphosis > 30 degrees
- Osteoporosis
- Neuromuscular Disease

• Criteria for revision in PJF:
  - 27/59 patients with PJF underwent revision surgery within 6 months of the index operation
  - Patients with combined posterior/anterior approaches
  - Patients with more extreme PJK angulation
  - Patients sustaining trauma were also significantly more likely to undergo revision
  - Upper thoracic versus thoracolumbar proximal junction did NOT influence decision for revision
Risk Factors for PJK

- Osteoporosis
- Fusion to the sacrum
- Choice of proximal levels
- Supralaminar fixation
- Correction of lordosis >30 degrees w/o PSO
- Mismatch of Lumbar Lordosis and PI
- Pre-operative thoracic kyphosis >30 degrees
  - Pre-op PJA >10 degrees
- Rigidity of construct?

Possible solutions

- Minimize cantilever forces at cephalad end of construct
- Matching Lumbar Lordosis to Pelvic Incidence
  - PI+LL+TK<45°
- Augmentation of proximal fixation
- Augmentation of level above proximal fixation
- Interspinous augmentation/stabilization
- Dynamic stabilization

Vertebral Augmentation and PJK
Transitional rod at UIV results in:
- Reduced nuclear pressure at adjacent disc
- Reduced angular displacement of adjacent segment
- Reduced strain on cephalad screw
Evidence-based Approach to PJK in Deformity Surgery

- Match Lumbar Lordosis and Pelvic Incidence
  - $LL+TK+PI<45$ degrees
- Choice of Levels
  - Extend to upper thoracic spine
    - PJA $>5$ degrees, TK $>30$ degrees, Osteoporosis
- Limit Correction
  - Osteoporosis, Longstanding deformity, Neuromuscular conditions
- Vertebral Augmentation at and/or above UIV
- Dynamic Stabilization of UIV

Conclusions

- Reoperations are an important measure of quality, and contributor to cost of care in adult deformity
- Proximal Junctional Kyphosis is a common cause for reoperation in adult deformity
- Surgical strategies to reduce junctional kyphosis may reduce the cost of care and improve quality of care

Thank you