Adjacent Segment Disease and Cervical Pseudarthrosis

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ACDF
Can we do better?

- Excellent Results
- Predictable
- Low Morbidity
- High Patient Satisfaction
- Long Term?
RESULTS OF FUSION
SUPERB

- Bohlman et al JBJS 1993
- Klein, Vaccaro, Albert Spine, 2000 (SF-36)
RESULTS OF LAMINOFORAMINOTOMY

SUPERB

HENDERSON

SCOVILLE
ACDF – Potential Pitfalls

• Surgical Morbidity
  – Pseudarthrosis
  – Graft problems
    • Donor site pain, complications
    • Allograft disease transmission
    • Graft dislodgement
  – Plate prominence, loosening
  – Screw placement, loosening
Consequences of Fusion
Adjacent Segment Disease (ASD)

- **Adjacent segment degeneration** = radiographic findings at levels adjacent to spinal fusion

- **Adjacent segment disease** = clinical symptoms that correspond to radiographic changes adjacent to spinal fusion
What causes adjacent disease?

- Natural History
- Fusion
• **2.9% per year** in 10 years following anterior cervical arthrodesis
  – 25.6% will have new symptomatic ASD within 10 years

• Multilevel arthrodesis (12%) **less likely** to have ASD than a single level fusion (18%)
  – Multi-level fusions more likely to include at-risk segments (C5-C7) → lower ASD with multiple fusion levels

**Hilibrand et al., 1999, JBJS**
Adjacent Segment Disease

Conclusions of the Study

- Adjacent segment disease common
- Most likely reflects natural history
- Include all symptomatic levels
Adjacent Segment Disease (ASD): Cervical Arthrodesis

• **Natural history versus result of fusion?**
  - Review of literature showed similar rates of ASD for ACDF, discectomy with and without fusion, and posterior foraminotomy without fusion

<table>
<thead>
<tr>
<th>Author</th>
<th>Procedure</th>
<th>Overall ASD</th>
<th>Incidence of ASD</th>
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</thead>
<tbody>
<tr>
<td>Bohlman et al.</td>
<td>ACDF</td>
<td>9%</td>
<td>1.5%</td>
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<tr>
<td>Gore &amp; Sepic</td>
<td>ACDF</td>
<td>14%</td>
<td>2.8%</td>
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<td>Williams et al.</td>
<td>ACDF</td>
<td>17%</td>
<td>3.8%</td>
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<td>Lunsford et al.</td>
<td>Cervical discectomy w/ or w/out fusion</td>
<td>7%</td>
<td>2.5%</td>
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<tr>
<td>Henderson et al.</td>
<td>Posterior foraminotomy w/out fusion</td>
<td>9%</td>
<td>3%</td>
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*Hilibrand & Robbins, 2004, Spine Journal*
Consequences of ACDF

Clinical Follow-Up Studies

- Prevalence ↑ with longer F/U
- Annual incidence 1.5% - 4%

Is it the “fusion” surgery?

Is it the natural history of cervical spondylosis?
Consequences of ACDF

Non-Fusion: Clinical Follow-Up

• < 3 yr F/U of 334 pts (ACD ± F) (Lunsford et al.)
  – 22 pts with adjacent segment disease
  – prevalence = 6.7%
  – annual incidence ~ 3%

• No difference: ACD vs ACDF
Consequences of ACDF

Non-Fusion: Clinical Follow-Up

• 2.8 yr F/U of 846 pts
  (Henderson et al.)
• Posterior foraminotomy
• No fusions
  – 79 pts adjacent segment disease
  – prevalence = 9%
  – annual incidence ~ 3%
Same-segment and adjacent-segment disease following posterior cervical foraminotomy

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Departments of ¹Neurosurgery, ²Biostatistics, and ³Orthopedics, Mayo Clinic, Rochester, Minnesota

• Retrospective review of 303 patients between 1972-1992 with single-level PCF for cervical radiculopathy:
  – 4.9% had symptomatic ASD
  – 2.9% had reoperation
  – 0.7% incidence of ASD with 10-year rate of 6.7%

Clarke, 2007, J Neurosurg Spine
Consequences of ACDF

Non-Fusion: Clinical Follow-Up

- Similar results to ACDF
- Annual incidence ~ 3%
- New disease at adjacent segments

Is it the “fusion” surgery?

Is it the natural history of cervical spondylosis?
Adjacent Segment Disease (ASD) Theories

- **Part of natural aging process:** diffuse spondylotic disease – unfused segments continue to degenerate
- **Increased biomechanical stress adjacent to fusion:** Fusion-induced mechanical and shearing motion from lever moment
- **Surgical technique:** needle into wrong disc space for identification of fusion level, excessive dissection, plating techniques, undersizing interbody graft?
Fusion - Altered Mechanics

- Increased forces at adjacent segments
- Increased motion at adjacent segments
- Poor Plating techniques
Cervical Allignment
Increase Adjacent Forces

• Hwang et al., Spine J. 2007
  ↑ Motion/↓Spacer/↓Lordosis/↑ASD
• Eck et al Spine 2002 27:2431-5
  – Cadaveric specimens; C5-6 plating
  – 73.2% increase C4-5 (p = 0.002)
  – 45.3% increase C6-7 (p = 0.006)
  – Increased motion at adjacent segments
• Dmetriev Spine 2005 30:1165-72
  – Cadaveric C5-6 allograft, allo+plate
  – Increased intradiscal pressure (p<0.05)
Anterior Cervical Plating

• Anterior cervical plating >5mm away from adjacent disk space to avoid ALOD
  Park et al., JBJS 2005

• High risk of progression of ASD with a plate to adjacent disk space distance of <3mm
  Dubois et al., Spine J. 2007
  Koller et al., Spine J. 2009
Rationale for arthroplasty
ASD Occurs After CDA

Yi Surg Neurol 2009

9/72 Adjacent Segment Degeneration (12.5%)

Preoperative
POD 7d
POD 1mo
Rate of Adjacent Segment Disease in Cervical Disc Arthroplasty Versus Single-Level Fusion

Meta-analysis of Prospective Studies

Kushagra Verma, MD, MS,* Sapan D. Gandhi, BS,† Mitchell Maltenfort, PhD,* Todd J. Albert, MD,* Alan S. Hilibrand, MD,* Alexander R. Vaccaro, MD, PhD,* and Kristin E. Radcliff, MD*

• Meta-Analysis of TDA vs. ACDF: 1,586 patients from 6 prospective studies
  – Adjacent segment surgery at 2-5 years f/u: not statistically significant
    • ACDF: 6.9% (2.4±1.7% per year)
    • TDA: 5.1% (1.1±1.5% per year)

Verma, 2013, Spine
Diagnosis of Pseudarthrosis

Clinical

- Pain is usually driving symptom to evaluate for non-union
- Initial improvement following surgery, then pain
Pseudarthrosis
Clinical Dilemma

• Is a pseudarthrosis present?
• Is the pseudarthrosis the cause of the patient's complaints?
• Presence of radiographic pseudarthrosis ≠ patient's symptoms
Wrong Operation
Wrong Patient
Wrong Surgeon

“Am I in over my head?”
Can I anticipate and handle the expected complications?”
Risk factors for Pseudarthrosis

- Nicotine products (reduction of vascularity)
- Location in spine (cervical vs lumbar)
- Type of fusion (interbody vs lateral)
- Number of levels to be fused
- Quality of bone (osteoporosis, use of steroids)
- Diabetes, collagen vascular disorders
- Patient “protoplasm”
- Use of NSAIDS, antimetabolites
- Reason for fusion (degenerative vs trauma vs cancer)
- Use of instrumentation
- Type of fusion material (autograft vs allograft vs synthetics)
Cervical Pseudarthrosis

- Pseudarthrosis
  - More than 2 mm of motion between spinous processes in flex/ext views
  - Hardware loosening
  - CT scan showing absence of bone
  - FDA Guidelines: 4° motion

Hipp, J et al., Spine 2005
Clinical Study

Pseudoarthrosis rates in anterior cervical discectomy and fusion: a meta-analysis

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17 eligible articles
Absence of continuous bridging trabecular bone,
FLEXION/EXTENSION >3 mm translation or >2 degree
Widening of Spinous processes
Different definitions in different Scenarios
Relative Risk Calculations
Allograft-4.8%, Autograft-0.9%

Overall Average rate in Single Level ACDF- 3.7%
Pseudarthrosis Management: Does It Matter?

Management of anterior cervical pseudarthrosis

Michael G. Kaiser, M.D.,¹ Praveen V. Mummaneni, M.D.,² Paul G. Matz, M.D.,³ Paul A. Anderson, M.D.,⁴ Michael W. Groff, M.D.,⁵ Robert F. Heary, M.D.,⁶ Langston T. Holly, M.D.,⁷ Timothy C. Ryken, M.D.,⁸ Tanvir F. Choudhri, M.D.,⁹ Edward J. Vresilovic, M.D., Ph.D.,¹⁰ and Daniel K. Resnick, M.D.¹¹

• Some studies show similar clinical outcomes for cervical fusion and nonfusion:
  – White et al. (1973): no significantly different success rate for fusion (75% success) vs nonfusion (53%)
• Other studies correlate clinical results with fusion:
  – Brunton et al. (1982): significant different success rate for fusion (76% success) vs nonfusion (5% success)
• If successful fusion matters for clinical outcomes, which approach is best?

Kaiser et al., 2009, J Neurosurg Spine
Pseudarthrosis Management: Anterior Approach

- Lack of evidence for anterior approach: 3 case series
  - Pros of posterior approach: 1) avoid scar tissue from prior anterior approach, 2) provide fresh surface for fusion, and 3) avoid dysphagia and recurrent laryngeal palsy
- Zdeblick et al. (1997): 35 patients; iliac crest autograft or fibular autograft
  - 83% excellent outcome
  - Complications: recurrent laryngeal palsy (1), graft harvest wound drainage (2), CSF leak (1)
- Coric et al. (1997): 19 patients; allograft bone and plate stabilization
  - 100% fusion with 83% excellent outcome
  - Complications: transient hoarseness (2)
- Tribus et al. (1999): 16 patients; single level w/ iliac autograft and plate stabilization
  - 69% had good or excellent outcome
  - Complications: dysphagia (1)

Kaiser et al., 2009, J Neurosurg Spine
Pseudarthrosis Management: Posterior Approach

- **Contraindications:** graft dislodgement or kyphotic deformity
- **Disadvantages:** ↑EBL, ↑LOS, ↑ complications
- **Kuhns et al. (2005):** retrospective case series; 33 patients
  - Posterior decompression (n=18)
  - All had posterior stabilization (lateral mass fixation, spinous process wiring, arthrodesis w/ autograft)
  - Used validated outcomes (SF-36, CSOQ, AIMS2), but only 25/33 completes questionnaires and no pre-op assessment for comparison
  - 100% arthrodesis rate, but…
    - Pain: absent/mild (52%), discomfort (20%), severe (28%)
- **Lowery et al. (1995):** retrospective case series; 37 patients – compared 3 approaches
  - Pain: greater axial and appendicular pain relief in posterior than anterior or circumferential
  - Solid arthrodesis: posterior (94%), anterior (45%), and circumferential (100%)

*Kaiser et al., 2009, J Neurosurg Spine*
Pseudarthrosis Management: Meta-Analysis – Anterior vs Posterior

• McAnany et al. (2015): mostly level 3 evidence (16 studies)
  – Fusion rates: p=0.028 (pooled data), p<0.001 (matched cohorts)
    • Anterior: 86% (pooled data), 64.2% (matched cohorts)
      – Moderate heterogeneity
    • Posterior: 97.1% (pooled data), 96.0% (matched cohorts)
      – Homogenous data
  – No difference in clinical outcomes
  – Concluded that either anterior or posterior approach can be used
    • Posterior has better fusion rates
    • No clinical difference
    • Poor overall quality of studies

McAnany et al., 2015, Global Spine J
Pseudarthrosis Management: BMP?

• None of the studies for managing cervical pseudarthrosis assessed BMP

• BMP in ACDF:
  – **Lu, et al. (2013)**: Case control of 100 ACDF cases with and 50 cases without BMP
    • BMP group (n=100) vs Non-BMP (allograft, n=50)
    • BMP group: 13% complications (vs 8% in allograft), **NO pseudarthrosis** (vs 16% in allograft)

• BMP and cancer?
  – **Cahill et al. (2015)**: review of literature; cancer occurrence with BMP (20/694) vs non-BMP (8/608)
    • 24 months: sig. difference in cancer risk (RR= 3.45)
    • 48 months: no sig. difference in cancer risk (RR=1.82)
    • Variable results – relatively low risk, but need larger studies

*Cahill et al., 2015, J Neurosurg Spine*
325 pt were smokers (48%)
Duration of f/u 31 mos
388- 2 level, 249- single level, 35- 3 level
635 pt ICBG, 37- allograft

45(7%)/66 revision surgery for Pseudarthrosis
- 8- 1 level surgery, 36- 2 level surgery
  - *highest pseudo level C6-7- 35
  - 47(7%) revision surgery for ASD

442 pt had some evidence of ASD on X ray, 133 had symptoms, 47 underwent surgery
- 20(43%) after 1 level, 26 (55%) after 2 level
Conclusion

• ASD after ACDF is a multifactorial process
• Altered mechanical stresses, natural history, iatrogenic soft tissue injury may all play a role
• Role of disk replacement in reducing the incidence of ASD although intuitive are unproven
Conclusion

• Pseudarthrosis are best addressed by preventive measures at the index procedure
• Critical factors: stability, host, and graft type
• Recurrence Symptoms ≠ Pseudarthrosis
• History/Physical and Imaging studies helpful
• Operative repair can be successfully performed anteriorly or posteriorly
Thank you