MIS single-position anterior interbody fusion and bilateral pedicle screw fixation: Feasibility and perioperative results

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Introduction

Extreme lumbar interbody fusion (XLIF) is a proven minimally-invasive strategy for anterior lumbar interbody fusion. One impediment to wider acceptance of XLIF: need to flip patient to prone position in order to place supplemental posterior fixation. Average “flip time” at our institution: 25-30 min.
Possible risks: inadvertent extubation, pulling lines and graft migration.
Increased OR costs.
Bilateral pedicle screw fixation is gold standard for supplemental fixation after XLIF (versus unilateral, lateral plate or interspinous fixation.)

Objectives

Preliminary study examining feasibility of placement of bilateral pedicle screw fixation (PSF) in lateral decubitus position after XLIF.
Examine OR and fluoroscopic times for screw placement.
Examine accuracy of placement of bilateral PSF in lateral decubitus position.
Methods

- Prospective cohort study
- Consecutive series of patients who underwent XLIF with bilateral PSF placed in the lateral decubitus position.
- Case time, screw placement time (total and per screw) and fluoroscopic time (total and per screw) collected.
- Postoperative CT scans performed beginning at 6 months to assess screw placement accuracy and presence of fusion.
- Added immediate postoperative CT scans and standing films
- Patient outcomes (VAS) assessed.

Results

- 174 screws placed in lateral decubitus position in 42 consecutive patients after XLIF
- Mean age: 61 years (range: 40-81)
- 55% female
- Mean BMI: 29.6 (range: 20.5-40.2)
- 38 one-level cases and 4 two-level cases
- 83% of cases involved L4/5
- Spondylolisthesis was most common diagnosis (79%)
Results

- Total mean operative time: 84.3 minutes (range 49 – 126).
- Mean total screw time 25.3 minutes (range 17-38); time PER screw:
  - Shin et al, 2015: 3.8 min +/- 4 min per screw
- Total mean fluoroscopy time: 126 seconds (range 58 – 270); mean fluoroscopy time for screw placement: 59.2 seconds (range 30-93); fluoroscopy time PER screw:
  - Mroz et al, 2011: 29s per screw
  - Spitz et al, 2015: 23s per screw
- Mean EBL: 42cc (range 10-100)
- Mean LOS: 1.3 days (range 1-4 days)

Conclusions

- Bilateral pedicle screws were placed in the lateral decubitus position after XLIF in an average of 6.1 minutes per screw and with only 14 seconds of fluoroscopy per screw.
- Although there is an initial learning curve, a reasonable breach rate and lack of screw-related complications suggests that this technique is safe and reproducible.
- This technique allows for increased efficiency for the surgeon as well as increased cost-savings for the hospital.
Thank You!
Background
- ACDF preferred treatment for cervical radiculopathy and myelopathy.
- Bohlman et al. revision rate 11%.
- Hilibrand et al. 2.9% adjacent segment disease per year over 10 years
  - 19% with adjacent segment disease at final follow-up.
- Few large studies with modern day implants.

Objective
To determine the rate of revision surgery and the occurrence of adjacent segment disease of patients undergoing ACDF for cervical radiculopathy and myelopathy utilizing modern day instrumentation techniques.

Methods
- IRB approval obtained: PRO12110298
- All patients undergoing ACDF between 2000 and 2010.
- Indication for surgery:
  - Radiculopathy
  - Myelopathy
  - Myeloradiculopathy
- Failed conservative management
Methods – Surgical Technique
- ACDF (Modified from Robinson et al).
- Disc completely removed, partial or complete resection of posterior longitudinal ligament, endplates left intact.
- Tricortical autograft or corticocancellous allograft inserted into disc space.
- Anterior plate, two fixed angle screws at each level.
- Plates with secondary locking mechanism.

Smith & Robinson, JBJS-Am, 1958
Smith, Kaub, Kang, Inst Course Lec, 2003

Methods – Demographics
- Age
- Sex
- Height
- Weight
- BMI
- Symptoms at presentation (myelopathy vs radiculopathy)
- Number of levels fused
- Graft type
- Smoking status

Methods – Outcomes
- Revision rate.
- Reason for revision surgery.
- Time to revision surgery.
- Plate to disc distance.
- Pseudoarthrosis.
- Presence and grade of adjacent segment degeneration.
- Reporting of symptoms of adjacent segment disease at final follow-up.

Park, JBJS-Am, 2005
Grade Adjacent Segment Degeneration

<table>
<thead>
<tr>
<th>Grade</th>
<th>Disc Space Narrowing</th>
<th>Osteophytes</th>
<th>End Plate Sclerosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>II</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>III</td>
<td>±</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>IV</td>
<td>±±</td>
<td>±</td>
<td>+</td>
</tr>
</tbody>
</table>

Statistics

- Independent t-test and Chi-squared for differences between subjects who did and those who did not require revision surgery.
- Kaplan Meier survival analysis to determine the predicted yearly incidence of adjacent segment disease.

Results

- 672 patients.
- Average follow-up: 31 months.
- 45% male.
- Age 48 years (19-85).
- BMI 29 ± 7.
- 48% smokers.
- 88.4% radiculopathy, 8.8% myelopathy, 2.8% both.
- 37% 1-level, 58% 2-level, 5% 3-level.
- 95% autograft, 5% allograft.
101 patients (15%) underwent revision surgery.

**Reason for revision surgery:**
- adjacent segment disease in 47 (47.5%)
- pseudarthrosis in 45 (45.5%)
- new problem at a non-adjacent level in 7 (7.1%)

Revision ~ 34 months after the index procedure.

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**Levels of Pseudoarthrosis / ASD**

<table>
<thead>
<tr>
<th>Level</th>
<th>Number of times pseudarthrosis occurred (% of total)</th>
<th>Number of times adjacent segment disease occurred (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3-4</td>
<td>1 (2%)</td>
<td>10 (11%)</td>
</tr>
<tr>
<td>C4-5</td>
<td>2 (3%)</td>
<td>25 (28%)</td>
</tr>
<tr>
<td>C5-6</td>
<td>26 (39%)</td>
<td>24 (26%)</td>
</tr>
<tr>
<td>C6-7</td>
<td>35 (53%)</td>
<td>25 (28%)</td>
</tr>
<tr>
<td>C7-T1</td>
<td>2 (3%)</td>
<td>6 (7%)</td>
</tr>
<tr>
<td></td>
<td>66 (100%)</td>
<td>90 (100%)</td>
</tr>
</tbody>
</table>

Revision for pseudarthrosis ~ 21.5 months.

Additional 8 patients with radiographic evidence of pseudarthrosis were asymptomatic.
Results - Pseudoarthrosis

- Overall, 7.5% of patients developed symptomatic pseudoarthrosis
  - 3.2% 1 level fusions
  - 9.2% 2 level fusions
  - 3.0% 3 level fusions

Results - Adjacent Segment Disease

- Higher pre-operative grade of radiographic degeneration at the cranial or caudal level did not predispose to revision surgery (p = 0.691, p = 0.158, respectively).
- The revision rate per number of levels:
  - 1 level 8.0%
  - 2-level 6.7%
  - 3-level 2.9%

Results - Adjacent Segment Disease

- 422 patients (66%) had radiographic degeneration at final follow-up.
- 103 (15.3%) developed symptoms
  - 47 underwent revision surgery
  - 56 treated conservatively
- Kaplan Meier survival analysis: 4% per year.
Results - Risk Factors

- Revision surgery risk was not affected by:
  - Patient age
  - Sex
  - Height, weight, BMI
  - Graft type
  - Smoking status
  - Symptoms at presentation
  - Plate to disc distance

Discussion

- 15% Revision rate unchanged from historical studies.
  - ASD, pseudoarthrosis and new disease included.
- Only 85% of patients with pseudarthrosis were symptomatic.
- No difference between autograft and allograft.
- No effect of age, sex, number of levels fused, smoking status on the risk for revision surgery.

Samartzis, Spine J, 2003
Jawahar, Spine J, 2010

Discussion

- Plate to disc distance did not increase the risk for symptomatic adjacent segment disease.

<table>
<thead>
<tr>
<th></th>
<th>3.5mm</th>
<th>3.2mm</th>
<th>3.7mm</th>
<th>P= 0.090</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate to disc (cranial)</td>
<td>5.7mm</td>
<td>5.6mm</td>
<td>5.9mm</td>
<td>P= 0.236</td>
</tr>
</tbody>
</table>
The revision rate after ACDF is 15%.

No specific risk factors for revision surgery were identified in this study.

Limitations:
- Retrospective chart review study.
- Average f/u 31 months (ranged to 150 months).
- Bias: longer follow-up more likely to have problem.
An internally randomized controlled trial of radiation exposure using ultra-low radiation imaging (ULRI) versus traditional C-arm fluoroscopy for patients undergoing single-level minimally invasive transforaminal lumbar interbody fusion (TLIF)

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Introduction

• Transforaminal lumbar interbody fusion (TLIF) is a common surgical approach to treatment of spinal instability, spinal canal stenosis, and neuroforaminal stenosis
• Minimally invasive TLIF was first pioneered in last 20 years
  • Advantage: smaller incision, less blood loss, faster recovery, less dependence on opioid analgesics
  • Disadvantage: minimal visualization of anatomy
    • Requires heavy use of c-arm fluoroscope

Introduction

• Increased reliance on intraoperative C-arm fluoroscopy → increased radiation exposure
  • MIS TLIF associated with 2.4x increased radiation compared to open TLIF (Kim et al.)
  • Patients experience 1.4-2.4% increase in lifetime risk of solid tumor per minimally invasive surgery (Presciutti et al.)
  • Spine surgeon performing 140 MIS TLIF /yr will reach occupational radiation hazard limit within 10 years (Haque et al.)
Introduction

• Thus, methods to decrease fluoroscopic radiation exposure during MIS TLIF will provide substantial health benefit to patient, surgeon, and operating room staff
• Problem: decreasing radiation output from C-arm fluoroscope reduces image quality
• Unsafe
• LessRay (SafeRay Spine, LLC) software is a fluoroscopic adjuvant meant to enhance low-radiation images based on high-quality composite images taken preoperatively
  • Allows enhancement of low radiation imaging to the point where one can visualize pertinent anatomy

Introduction
Introduction

- Purpose: randomized control trial comparing radiation exposure between LessRay enhanced ultra-low radiation imaging and conventional C-arm fluoroscopy for patients undergoing MIS-TLIF

Methods

- Prospective inclusion criteria:
  - Adult
  - Single-level MIS-TLIF
- Procedure divided into 5 intervals:
  - 0) Preoperative imaging
    - Localize spinal level and establish composite
  - 1) L-sided pedicle cannulation and k-wire placement
  - 2) R-sided pedicle cannulation and k-wire placement
  - 3) Bilateral screw placement
  - 4) Interbody graft and rod placement

Methods

- Heads:
  - Interval 0: Traditional C-arm
  - Interval 1: ULR
  - Interval 2: Traditional C-arm
  - Interval 3: ULR
  - Interval 4: Traditional C-arm
- Tails:
  - Interval 0: Traditional C-arm
  - Interval 1: Traditional C-arm
  - Interval 2: ULR
  - Interval 3: Traditional C-arm
  - Interval 4: ULR
Methods

- Personnel radiation exposure measured via pocket dosimeters:
  - At the end of all intervals
  - For members of the operating room:
    - Surgeon
    - Scrub Nurse
    - Circulator
    - Anesthesiologist
- Total Radiation production was measured by c-arm
- Time recorded for each interval
- Statistical comparison between radiation exposure for traditional C-arm vs. ULRI

Results (24 total patients)

Table 1: Demographic data for patients undergoing single-level MIS TLIF

<table>
<thead>
<tr>
<th>Total</th>
<th>Heads</th>
<th>Tails</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD)</td>
<td>59.4 ± 16.0</td>
<td>61.7 ± 11.3</td>
<td>56.6 ± 20.4</td>
</tr>
<tr>
<td>Male (n)</td>
<td>17</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>BMI (mean ± SD)</td>
<td>29.5 ± 4.1</td>
<td>29.2 ± 4.5</td>
<td>29.9 ± 3.7</td>
</tr>
<tr>
<td>Levels</td>
<td>24</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>L3-4</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>L4-5</td>
<td>17</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>L5-S1</td>
<td>5</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>TLIF Side (right)</td>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 2: Interval comparison of radiation emitted by standard-dose fluoroscopy and ULRI

<table>
<thead>
<tr>
<th></th>
<th>Standard-dose (mGy)</th>
<th>Using ULRI (mGy)</th>
<th>% Change</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval 1 and 2 Average</td>
<td>39.15</td>
<td>10.23</td>
<td>-73.9%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Interval 3</td>
<td>39.76</td>
<td>4.26</td>
<td>-89.1%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Interval 4</td>
<td>24.76</td>
<td>10.71</td>
<td>-56.7%</td>
<td>0.019*</td>
</tr>
<tr>
<td>Cumulative</td>
<td>143.20</td>
<td>35.02</td>
<td>-75.5%</td>
<td>-</td>
</tr>
</tbody>
</table>
### Results

**Table 3a:** A comparison of radiation exposure to surgeon and scrub nurse between standard-dose fluoroscopy and ULRI

<table>
<thead>
<tr>
<th></th>
<th>Surgeon</th>
<th></th>
<th>Scrub Nurse</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard-dose (mrem)</td>
<td>ULRI (mrem)</td>
<td>% Change</td>
<td>p</td>
</tr>
<tr>
<td>Interval 1 and 2 Average</td>
<td>1.46</td>
<td>0.36</td>
<td>75.2%</td>
<td>0.001*</td>
</tr>
<tr>
<td>Interval 3</td>
<td>3.16</td>
<td>0.16</td>
<td>84.8%</td>
<td>0.002*</td>
</tr>
<tr>
<td>Interval 4</td>
<td>0.56</td>
<td>0.12</td>
<td>81.8%</td>
<td>0.150</td>
</tr>
<tr>
<td>Cumulative</td>
<td>6.61</td>
<td>1.09</td>
<td>-81.5%</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 3b:** A comparison of radiation exposure to circulator and anesthesia personnel between standard-dose fluoroscopy and ULRI

<table>
<thead>
<tr>
<th></th>
<th>Circulator</th>
<th></th>
<th>Anesthesia</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard-dose (mrem)</td>
<td>ULRI (mrem)</td>
<td>% Change</td>
<td>p</td>
</tr>
<tr>
<td>Interval 1 and 2 Average</td>
<td>0.11</td>
<td>0.38</td>
<td>66.7%</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Interval 3</td>
<td>0.00</td>
<td>0.01</td>
<td>-0.287</td>
<td>0.03</td>
</tr>
<tr>
<td>Interval 4</td>
<td>0.13</td>
<td>0.04</td>
<td>-93.8%</td>
<td>0.047*</td>
</tr>
<tr>
<td>Cumulative</td>
<td>0.35</td>
<td>0.12</td>
<td>-86.3%</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 4:** Operation time between standard-dose fluoroscopy and ULRI

<table>
<thead>
<tr>
<th></th>
<th>Standard-dose Fluoroscopy (min)</th>
<th>ULRI (min)</th>
<th>% change</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval 1 and 2 Average</td>
<td>10.6</td>
<td>11.0</td>
<td>3.9%</td>
<td>0.781</td>
</tr>
<tr>
<td>Interval 3</td>
<td>11.5</td>
<td>11.38</td>
<td>-1.0%</td>
<td>0.062</td>
</tr>
<tr>
<td>Interval 4</td>
<td>56.4</td>
<td>61.4</td>
<td>8.8%</td>
<td>0.438</td>
</tr>
<tr>
<td>Cumulative</td>
<td>89.4</td>
<td>107.3</td>
<td>20.0%</td>
<td>-</td>
</tr>
</tbody>
</table>
Conclusions

• Significant reduction in radiation production seen using ULRI coupled with image enhancement
  • ~75% reduction
• Significant reduction in radiation exposure for surgeon, scrub tech, and circulator
  • 61.6-83.5% reduction
• No incidents of complication, no abandonment
• No statistically significant increase in time
• This study is the first to demonstrate safe usage of ULRI in any surgical procedure in humans
The Effect of Iatrogenic Lordosis and Laminectomy Width in the Development of Post-operative C5 Palsy After Posterior Cervical Laminectomy and Fusion

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Disclosures
- None

Collaborators
- Christopher R. Brown, MD
- Charles Sheets, PT
- Lindsay T. Kleeman, MD
- Mitchell R. Klement, MD
- Michael A. Gallizzi, MD, MS
- Robert E. Isaacs, MD
Background

- Posterior cervical laminectomy and fusion (PCLF) established treatment for spondylotic myelopathy
  - Reliable improvement in myelopathic symptoms
  - Direct decompression
  - High rates of fusion
- Known complications with PCLF:
  - Junctional kyphosis
  - Post-laminectomy instability
  - Neurologic deterioration
  - Post-op infection
  - C5 Palsy

Post-operative C5 Palsy

- Estimated incidence of 6.7% (range: 0-30%)1
  - Rates vary by technique and definition
  - Transient palsy >> permanent deficit
- Can occur after anterior or posterior approach
- Undetermined etiology of palsy development
  - Posterior drift back of the cord2
    - Traction on anatomically shorter C5 roots
    - Iatrogenic direct nerve injury
    - Heat from burr
    - Compression/friction
    - Foraminal stenosis
    - Spinal cord ischemia

Predicting and/or Prevention of Post-operative C5 Palsy

- Radcliff et al. JSD&T 2014
  - Higher rates of palsy with larger/wide decompression → greater opportunity for posterior cord drift
  - Recommended reducing laminectomy width
  - No prospective data
- Lubelski et al. The Spine Journal 2015
  - Assessed anterior-posterior diameter (APD), foraminal diameter (FD), and cord-lamina angle (CLA) to predict C5 Palsy
  - Proposed 3-part model
    - Every mm T of APD → 69% decrease in palsy rate
    - Every mm T of FD → 98% decrease in palsy rate
    - Every 1° of CLA → 43% increase in palsy rate
    - logit(p) = -0.81 - 1.16(APD) - 4.00(FD) + 0.35(CLA)
    - No prospective data
Potential Role of Lordosis

- Posterior vertebral body is fulcrum of flexion and extension in spine
- Increased cervical lordosis
  - Would theoretically permit further posterior drift back of cord as slack develops after laminectomy
  - Could compress posterior elements → foraminal stenosis

Purpose

- Assess cervical lordosis and laminectomy width as predictors of post-operative C5-palsy development
  - Confirm findings of Radcliff et al. using post-operative CT (vs. MRI)

Materials & Methods: Lordosis

- Retrospective case-control study: 54 patients
  - ICD-9 for cervical spondylotic myelopathy and CPT for multilevel cervical laminectomy with fusion (no foraminotomies)
  - Charts reviewed for post-operative decrease in motor strength of deltoid or biceps of at least 2 motor grades vs. pre-op
  - 13 palsies (24%)
    - All but 1 resolved
    - Avg. duration: 6mo. – yr.
### Materials & Methods: Lordosis

- **Radiographic measures**
  - MRI (pre-op): anteroposterior diameter (APD), foraminal diameter (FD), cord-lamina angle (CLA)
  - XR (pre- & post-op):

### Materials & Methods: Laminectomy Width

- Laminectomy width measured at each surgical level on postoperative axial CT scans
- Measured at middle of the posterior vertebral body of the level in question on the sagittal image and the corresponding line placed through the middle of the vertebral body on the axial image
- Measured smallest distance from the medial-most edge of one lamina to the medial-most edge of the other

### Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Time point</th>
<th>No palsy</th>
<th>C5 Palsy</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum FD</td>
<td>Preoperative</td>
<td>3.66 ± 4.87</td>
<td>1.97 ± 7.5</td>
<td>0.05</td>
</tr>
<tr>
<td>APD</td>
<td>Preoperative</td>
<td>9.58 ± 3.76</td>
<td>7.32 ± 1.67</td>
<td>0.006</td>
</tr>
<tr>
<td>Right CLA</td>
<td>Preoperative</td>
<td>33.43 ± 10.59</td>
<td>37.58 ± 8.73</td>
<td>0.19</td>
</tr>
<tr>
<td>Left CLA</td>
<td>Preoperative</td>
<td>32.17 ± 7.43</td>
<td>36.61 ± 6.69</td>
<td>0.07</td>
</tr>
<tr>
<td>Neutral</td>
<td>Preoperative</td>
<td>11.48 ± 14.77</td>
<td>12.37 ± 9.59</td>
<td>0.82</td>
</tr>
<tr>
<td>Flexion ROM</td>
<td>Preoperative</td>
<td>14.77 ± 12.16</td>
<td>13.59 ± 11.61</td>
<td>0.78</td>
</tr>
<tr>
<td>Extension ROM</td>
<td>Preoperative</td>
<td>22.68 ± 15.15</td>
<td>25.57 ± 11.66</td>
<td>0.53</td>
</tr>
<tr>
<td>Ishihara Index</td>
<td>Preoperative</td>
<td>8.12 ± 25.03</td>
<td>2.54 ± 13.71</td>
<td>0.42</td>
</tr>
<tr>
<td>Cervical Spine Angle</td>
<td>Preoperative</td>
<td>8.07 ± 15.41</td>
<td>12.08 ± 12.77</td>
<td>0.36</td>
</tr>
<tr>
<td>Segmental Lordosis</td>
<td>Preoperative</td>
<td>0.17 ± 5.01</td>
<td>1.64 ± 8.06</td>
<td>0.54</td>
</tr>
<tr>
<td>Postoperative Ishihara Index</td>
<td>2.05 ± 6.45</td>
<td>3.63 ± 10.83</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Cervical Spine Angle</td>
<td>Postoperative</td>
<td>7.82 ± 13.12</td>
<td>12.07 ± 13.91</td>
<td>0.34</td>
</tr>
<tr>
<td>Segmental Lordosis</td>
<td>Postoperative</td>
<td>0.09 ± 5.22</td>
<td>2.45 ± 2.77</td>
<td>0.03</td>
</tr>
<tr>
<td>Cut-off AUC + LR Probability of C5 palsy</td>
<td>Minimum FD</td>
<td>2.40 ± 0.70 (0.64 - 0.95)</td>
<td>3.90 ± 0.55 (0.64 - 0.95)</td>
<td>0.80</td>
</tr>
<tr>
<td>Number of positive results (below cut-off)</td>
<td>Sensitivity</td>
<td>0.92</td>
<td>0.68</td>
<td>2.80</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.50</td>
<td>0.97</td>
<td>18.50</td>
<td>0.86</td>
</tr>
<tr>
<td>Cut-off AUC + LR Probability of palsy</td>
<td>1 or more</td>
<td>0.50</td>
<td>0.97</td>
<td>18.50</td>
</tr>
<tr>
<td>NDI</td>
<td>Preoperative</td>
<td>4.05 ± 10.03</td>
<td>-2.45 ± 8.80</td>
<td>0.07</td>
</tr>
<tr>
<td>Maximum VAS arm</td>
<td>Preoperative</td>
<td>1.± 2.75</td>
<td>-1.71 ± 2.93</td>
<td>0.06</td>
</tr>
<tr>
<td>Ishihara Index</td>
<td>Preoperative</td>
<td>8.74 ± 25.21</td>
<td>1.09 ± 13.40</td>
<td>0.17</td>
</tr>
<tr>
<td>Cervical Spine Angle</td>
<td>Preoperative</td>
<td>0.24 ± 10.11</td>
<td>0.02 ± 13.93</td>
<td>0.96</td>
</tr>
<tr>
<td>Segmental Lordosis</td>
<td>Preoperative</td>
<td>1.73 ± 4.13</td>
<td>0.44 ± 5.74</td>
<td>0.30</td>
</tr>
<tr>
<td>JOA</td>
<td>Preoperative</td>
<td>2.38 ± 1.41</td>
<td>2.33 ± 0.50</td>
<td>0.92</td>
</tr>
<tr>
<td>SF -12M</td>
<td>Preoperative</td>
<td>4.24 ± 12.82</td>
<td>2.16 ± 4.03</td>
<td>0.50</td>
</tr>
<tr>
<td>SF -12P</td>
<td>Preoperative</td>
<td>5.8 ± 8.92</td>
<td>3.31 ± 11.05</td>
<td>0.53</td>
</tr>
<tr>
<td>VAS neck</td>
<td>Preoperative</td>
<td>0.75 ± 3.89</td>
<td>0.88 ± 2.23</td>
<td>0.92</td>
</tr>
</tbody>
</table>
Width of Laminectomy Trough

<table>
<thead>
<tr>
<th>Level</th>
<th>Control width (mm)</th>
<th>C5 palsy width (mm)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3</td>
<td>21.85±2.72</td>
<td>21.20±2.91</td>
<td>.507</td>
</tr>
<tr>
<td>C4</td>
<td>23.77±2.39</td>
<td>23.40±2.34</td>
<td>.885</td>
</tr>
<tr>
<td>C5</td>
<td>23.36±2.56</td>
<td>23.11±2.20</td>
<td>.762</td>
</tr>
<tr>
<td>C6</td>
<td>23.24±2.20</td>
<td>21.53±2.56</td>
<td>.073</td>
</tr>
<tr>
<td>C7</td>
<td>18.58±2.16</td>
<td>18.41±2.93</td>
<td>.888</td>
</tr>
<tr>
<td>Overall average</td>
<td>22.25±1.85</td>
<td>21.78±2.15</td>
<td>.507</td>
</tr>
</tbody>
</table>

Conclusions
- APD, FD, and increased segmental lordosis is correlated with post-operative C5 palsy
  - Iatrogenic foraminal stenosis
  - Posterior drift back of cord
- Combining cut-offs for APD and FD:
  - 1 positive: 92% sensitivity, 68% specificity
  - 2 positive: 50% sensitivity, 97% specificity
- Identify patients at increased risk
- Combining cut-offs for APD and FD:
  - 1 positive: 92% sensitivity, 68% specificity
  - 2 positive: 50% sensitivity, 97% specificity
- Intra-operative XR can be used to assess changes segmental lordosis
  - Limit degree of sagittal correction
  - Potential role of foraminotomy when greater correction desired
- Laminectomy width not associated with higher rates of C5 palsy

Thank You
Initial Surgical Management of Subaxial Cervical Spine Septic Facet Arthritis: A Report of Two Cases

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2 Wake Orthopaedics, Raleigh, NC

Disclosures

• I have no relevant financial relationships with the manufacturers of any commercial products and/or providers of commercial services discussed in this CME activity.

• I do not intend to discuss any unapproved or investigative use of commercial products or devices.

Background

• Septic cervical facet arthritis is a rare entity with only 7 cases reported to date
  » 4 involved the alanto-axial joint
    • 2 (50%) underwent operative management
  » 3 involved the subaxial spine
    • 1 (33%) underwent operative management

• Most common presenting symptoms are neck pain and fever
  » Diagnosis is often delayed given vague symptoms

• All reported cases had an elevation in either ESR or CRP
Non-Operatively Treated

<table>
<thead>
<tr>
<th>Reference</th>
<th>Diagnosis</th>
<th>Immobilization</th>
<th>Outcomes</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sasaki et al. J Spinal Disord Tech 2006</td>
<td>Left C1/2</td>
<td>Halo for 15 weeks</td>
<td>Resolution of infection</td>
<td>5 year</td>
</tr>
<tr>
<td>Michel-Batot et al. Joint Bone Spine 2008</td>
<td>Left C4/5</td>
<td>Noted for 1 month followed by cervical collar for 2 months</td>
<td>&quot;Favorable Outcome&quot;</td>
<td>No follow-up reported</td>
</tr>
<tr>
<td>Sasaki et al. J Spinal Disord Tech 2006</td>
<td>Left C1/2</td>
<td>No immobilization reported</td>
<td>Resolution of infection</td>
<td>6 months</td>
</tr>
<tr>
<td>Stetch et al. Iowa Orthop J 2010</td>
<td>Right C6/7</td>
<td>No immobilization reported</td>
<td>Improving symptoms</td>
<td>No follow-up reported</td>
</tr>
</tbody>
</table>

Operatively Treated

<table>
<thead>
<tr>
<th>Reference</th>
<th>Diagnosis</th>
<th>Indication for Surgery</th>
<th>Surgery</th>
<th>Outcomes</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halla et al. Arthritis Rheum 1991</td>
<td>Right C1/2</td>
<td>Failure of IV antibiotics with hemiparesis</td>
<td>Transoral debridement, odontoidectomy, and Halo placement for 6 months</td>
<td>Resolution of infection</td>
<td>2 years</td>
</tr>
<tr>
<td>Michel-Batot et al. Joint Bone Spine 2008</td>
<td>Bilateral C3/4 and C4/5</td>
<td>Epidural abscess with tetraparesis</td>
<td>Details not reported</td>
<td>Mortality due to multi system organ failure</td>
<td>Mortality</td>
</tr>
<tr>
<td>Compas et al. Eur Spine J 2015</td>
<td>Left C1/2</td>
<td>Failure of IV antibiotics with persistent pain and fever</td>
<td>Debridement, C1/2 left laminectomy, C1-3 instrumented fusion</td>
<td>Resolution of infection</td>
<td>1 year</td>
</tr>
</tbody>
</table>

Case 1

- 71 year old male with diabetes, hypertension, and coronary artery disease who presented to his PCP with axial neck pain after painting his house.
- Initially treated conservatively by PCP until 1 month later when he developed low grade fevers with continued pain and presented to the ED.
  - Temp: 99.2 °F
  - WBC 22.3K, ESR 40mm/hr
  - Neurologically intact
Case 1

- Ultrasound guided aspiration:
  - 7ml frank purulence
  - Gram stain: Gram positive cocci in pairs and chains
- Taken to the operating room the following day
Post-Operative Course

- Discharged home on POD 5
- No collar or other immobilization used
- Microbiology:
  - Streptococcal Viridans – no clear etiology
  - 6 weeks IV Ceftriaxone
  - 2 months of oral antibiotics
- 1 year follow up
  - Resolution of neck pain with mild persistent stiffness
  - Normalization of ESR/CRP

Case 2

- 48 year old male with schizophrenia and rheumatoid arthritis on chronic prednisone and etanercept who presented to the emergency department with sepsis and altered mental status
  - Temp: 103.8°F
  - WBC: 12.5K
  - No ESR/CRP done pre-op
  - Neurologically intact
- During his workup for possible meningitis an MRI of the entire spine was obtained
Case 2

- Ultrasound guided aspiration was deferred given sepsis
- Taken urgently to the operating room

Post-Operative Course

- Complicated by an abscess associated with an infected total hip arthroplasty discovered on POD 1
  - Required I&D of hip
- Discharged POD 8 to Acute Inpatient Rehabilitation
- No collar or other immobilization used
- Microbiology:
  - Methicillin Resistant Staph Aureus – Primary infection possibly infected total hip arthroplasty
  - 8 weeks IV Vancomycin followed by doxycycline suppression for peri-prosthetic infection
Post-Operative Course

- ESR/CRP did not normalize during our follow up period due to multiple recurrent infections at distant sites
  - Improving in the initial post-operative period

- 8 month follow up:
  - Neck pain had returned to baseline
  - No signs of symptoms of recurrent infection
  - Continued on suppressive antibiotics for peri-prosthetic infection
  - Currently being treated for pneumonia

Conclusions

- Cervical spine septic facet arthritis is a rare and likely under-reported entity
- High index of suspicion in patients with neck pain and reported fevers
- While not all patients may require surgical intervention, we believe those with large abscesses and bacterial burden may benefit from early surgical intervention
- Successful experience in both of our patients with early surgical intervention without prolonged immobilization

References

**Patients as Consumers Customers of Healthcare**

**consumer n.**
One that consumes, especially one that acquires goods or services for direct use or ownership rather than for resale or use in production and manufacturing

What’s happening to healthcare …
What is moving us along this paradigm…
**Government intervention ...**

**Patient Protection and Affordable Care Act (PPACA)**
- Decrease the number of uninsureds
- Reduce the cost of healthcare
- Cover all applicants
- Offer same rates regardless of gender or pre-existing conditions

**MACRA and Value-Based Care**
- CMS modifications and shift to value based care
- MIPS and APM
- Bundled Payment Arrangements
- ACO’s and Clinically Integrated Networks
Health Insurance Exchange

• Primarily what the health insurance exchange will do is bring together private health insurance companies along with a government health insurance option to compete for business among individuals and small businesses. To be in the health insurance exchange the health insurance policies offered cannot exclude someone for pre-existing conditions.

"The Marketplace will offer much more than any health insurance website you've used before," HHS Secretary Kathleen Sebelius wrote in a blog post.

"Insurers will compete for your business on a level playing field, with no hidden costs or misleading fine print."

Get Ready, Get Set …
Capitalism at its finest ...


Insurance is changing ...

Movement is occurring...

**TABLE 4**

<table>
<thead>
<tr>
<th>Number of employees</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>All employers (10+ employees)</td>
<td>17%</td>
<td>23%</td>
<td>22%</td>
<td>23%</td>
<td>27%</td>
</tr>
<tr>
<td>All large employers (100+ employees)</td>
<td>23%</td>
<td>32%</td>
<td>36%</td>
<td>39%</td>
<td>46%</td>
</tr>
<tr>
<td>Large employers (20,000+ employees)</td>
<td>51%</td>
<td>48%</td>
<td>59%</td>
<td>63%</td>
<td>72%</td>
</tr>
</tbody>
</table>


---

**Movement is occurring …**

- Consumerism taking hold as enrollment in CDHPs jumps to 23%
- High deductibles are meant to give employees a financial incentive to shop more carefully for health services
- Cigna Spokesperson Joseph Mondy told Workforce. “Why? Because they work. CDHPs will cost you less as an employee and as an employer, but you’ll see improvements in health outcomes. We have seven years of data to support that.”

---

**Thinking inside the big box**

- “UnitedHealth means to capitalize on the fact that retail is a “significant portion of individuals’ lives” by creating new retail partnerships to make it easier for the consumer to access all aspects of the insurance industry.”
- “Insurers could, say, team up with grocery stores to help increase health awareness and wellness purchasing among their consumers. Or they could partner with technology companies to help inform consumers’ wellness goals, including walking, weight management and diet.”

Jumping the curve ...

Nature's Timeless Principle

Definition of a Customer

cus·tom·er noun (ˈkəs-tə-mər)

Definition of CUSTOMER
1: one that purchases a commodity or service
2: an individual usually having some specified distinctive trait <a real tough customer>

Examples of CUSTOMER
She is one of our best customers.
She's a pretty cool customer.

Origin of CUSTOMER
Middle English custumer, from costume First Known Use: 15th century

What is a customer?

- Advocate
- Apathetic
- Assassin

*Satisfaction: How Every Great Company Listens to the Voice of the Customer, 2006, Chris Denove and James D. Power IV
Why are customers important?
• It costs 5 times as much to attract a new customer than to keep an existing one. (Source: seohosting.com)
• 68% leave because they are upset with the treatment they’ve received. (Source: U.S. Small Business Administration)
• On average, loyal customers are worth up to 10 times as much as their first purchase. (Source: White House Office of Consumer Affairs)
• 48% of customers who had a negative experience told 10 or more others. (Source: Harvard Business Review)

Why are customers important?
• 64% of customers cited shared values as the primary reason for a strong brand relationship.
  – Source: Corporate Executive Board
• 68% quit because of the attitude of indifference toward the customer by the owner, manager or some employee.
  – Source: Michael LeBoeuf, “How to Win Customers and Keep them for Life”
• 3 in 5 Americans (59%) would try a new brand or company for a better service experience.
  – Source: American Express
• 89% of consumers began doing business with a competitor following a poor customer experience.
  – Source: RightNow

Most important reason …
• I believe that the customer pathway will drive quality and value at a faster pace than the government or employers can.
• Let’s explore my basis for this…
Let's look at things differently …

What do customers want?

- A novel question asked by other industries … does healthcare ask that question?

2015:

- Uber: the world’s largest taxi company owns no vehicles
- Facebook: the world’s most popular media company creates no content
- Alibaba: the world’s most valuable retailer has no inventory
- Airbnb: the world’s largest accommodation provider owns no real estate
Speed and Convenience

Use Technology Efficiently ...

Who has an iPhone?

Knowing I can be in and out of the store in three minutes flat, purchase in hand, is a major incentive to buy more stuff.
Speed and convenience … but still some service

Still want to be involved …

Are patients ready for different …
What do customers want?

- A novel question asked by other industries … does healthcare ask that question?

And yet, healthcare is lagging.

Patients are demanding more convenient access to care.
This portion of our program prefers interaction ...

Is there a wait?

Did you know that I text?
Do I have to come to your office?

Rethinking your front desk ...

Why do all of this ...

The landscape is changing fast! We have to keep up ...
Keep it simple …

Ideas for Retention …
Why do you keep … ?

• Why do you bank at…?
• Why do you eat at…?
• Why do you get your teeth cleaned at…?
• Why do you buy your groceries at…?
• Why do you buy your books online? At a bookstore? What happened to the library?
• Where do you go for your mammogram?
• Where do you take your kids for a check up?
• Who does your hair?
• What church do you attend? Why?

Thank you for your time!

Contact
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919-960-0336