The Evolution of Minimally Invasive Spine Surgery and applications in Complex Spine Surgery

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Disclosures – None
Minimally Invasive Surgery

- Developed from dissatisfaction of excessive exposure, postoperative pain or scarring.
- Has led to shorter length of hospitalization, less blood loss, and greater patient satisfaction.
- Minimally invasive principles shared with many other specialties
  - Laparoscope/Robotics
  - Natural orifice translumenal endoscopic surgery (NOTES)
Minimally Invasive Spine Surgery
Collaboration with Industry
Clear delineation of surgical goals:
- Neural decompression
- Postoperative Pain
- Complications
- Blood Loss
- Intraoperative time
- Length of Hospital stay
Is Minimally Invasive Spine Surgery worth the hype?

- Touted features:
  - Less muscle damage
  - Less postoperative pain
  - Shorter hospital stay
  - “Focused” exposure

- Necessary to examine the type of surgery being performed
  - Diverse surgeries with different objectives
  - For example, unilateral lumbar microdiscectomy vs. lumbar fusion vs. scoliosis correction
Lumbar Microdiscectomy

- First reported in 1934 by Mixter and Barr
- More understanding of local anatomy/comfort with operation
- 1997, Foley & Smith described microdiscectomy utilizing tubular retractors

Tubular Diskectomy vs Conventional Microdiskectomy for Sciatica
A Randomized Controlled Trial

JAMA. 2009;302(2):149-158

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Bart W. Koes, PhD
Ronald H. M. A. Bartels, MD, PhD
Wilco C. Peul, MD, PhD

for the Leiden-The Hague Spine Intervention Prognostic Study Group (SIPS)
Microdiscectomy
Open vs. MIS

Arts, et al.
- 328 patients (161 MIS, 167 open)
- Functional outcomes at 8 wks and 1 year:
  - Primary Outcome: Roland-Morris Disability Questionnaire (RDQ) for sciatica
  - Secondary Outcome:
    - 100-mm visual analog scale for leg pain and back pain
    - Patient’s self-report of recovery measured on the 7-point Likert scale
    - Functional and economic scores on the Prolo scale
    - Bodily pain and physical functioning scores on the ShortForm36
    - Bothersomeness Index scores
    - Complication and reoperation rates

### Table 2. Operative Characteristics of Patients

<table>
<thead>
<tr>
<th>Operative Characteristic</th>
<th>Tubular Diskectomy (n = 166)</th>
<th>Conventional Microdiskectomy (n = 159)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General anesthesia</td>
<td>160 (95)</td>
<td>149 (94)</td>
<td>.31</td>
</tr>
<tr>
<td>Fluoroscopic localization</td>
<td>166 (100)</td>
<td>123 (77)</td>
<td>.18</td>
</tr>
<tr>
<td>Removal of herniated disk fragments&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Unilateral translavial</td>
<td>142 (86)</td>
<td>126 (79)</td>
<td>.11</td>
</tr>
<tr>
<td>Unilateral translavial with bony decompression</td>
<td>24 (14)</td>
<td>31 (19)</td>
<td></td>
</tr>
<tr>
<td>Bilateral translavial</td>
<td>0</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>Visual aid</td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Microscope</td>
<td>162 (98)</td>
<td>43 (27)</td>
<td></td>
</tr>
<tr>
<td>Loupe</td>
<td>4 (2)</td>
<td>102 (64)</td>
<td></td>
</tr>
<tr>
<td>Nothing</td>
<td>0</td>
<td>14 (9)</td>
<td></td>
</tr>
<tr>
<td>Operation time, mean (SD), min</td>
<td>47 (22)</td>
<td>36 (18)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Weight of disk removal, mean (SD), mg</td>
<td>6104 (3555)</td>
<td>6877 (3573)</td>
<td>.08</td>
</tr>
<tr>
<td>Blood loss &lt;50 mL</td>
<td>150 (90)</td>
<td>135 (85)</td>
<td>.08</td>
</tr>
<tr>
<td>Total intraoperative complications&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>.27</td>
</tr>
<tr>
<td>Dural tear</td>
<td>14</td>
<td>7</td>
<td>.18</td>
</tr>
<tr>
<td>Nerve root injury</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Exploration started at wrong level</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Other&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total postoperative complications&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19 (11)</td>
<td>14 (9)</td>
<td>.47</td>
</tr>
<tr>
<td>Wound hematoma</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wound infection</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Urinary tract infection</td>
<td>0</td>
<td>1</td>
<td></td>
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<tr>
<td>Cerebrospinal fluid leakage</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Micturition disturbances (catheter required)</td>
<td>3</td>
<td>2</td>
<td></td>
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<tr>
<td>Deep venous thrombosis in leg</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Increase of sensory deficit</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Increase of motor deficit</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Other&lt;sup&gt;e&lt;/sup&gt;</td>
<td>11</td>
<td>1</td>
<td></td>
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<tr>
<td>Timing of mobilization</td>
<td></td>
<td></td>
<td>.68</td>
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<tr>
<td>Same day of surgery</td>
<td>76 (48)</td>
<td>80 (50)</td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>86 (53)</td>
<td>73 (46)</td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>2 (1)</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>&gt;-Day 2</td>
<td>0</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>No. of days in hospital, mean (SD)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>3.3 (1.2)</td>
<td>3.3 (1.1)</td>
<td>.82</td>
</tr>
<tr>
<td>Repeated surgery within 1y</td>
<td>17 (10)</td>
<td>11 (7)</td>
<td>.33</td>
</tr>
<tr>
<td>Recurrent disk herniation</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Stenosis</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fibrosis</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cerebrospinal fluid leakage</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Instrumented fusion</td>
<td>1</td>
<td>0</td>
<td></td>
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</tbody>
</table>

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Microdiscectomy
Open vs. MIS

- Arts, et al.
  - Conclusions:
    - Tubular microdiscectomies were associated with statistically significantly more leg and back pain as compared to open.
      - Leg/Back VAS pain p<0.05
    - No differences in size of incisions
    - Patients less satisfied with MIS
    - May still be appropriate for morbidly obese.
Postoperative Leg and Back Pain

- Does less tissue damage mean less pain?
  - Muramatsu, et al. evaluated for postoperative enhancement as a sign of scar formation and found no difference in open versus MIS.
  - Arts, et al. evaluated the MRI T2 signal intensity of the multifidus muscle and measured serial CPK of compared open vs. MIS at 1 year.
    - No advantage to MIS on VAS, CPK
    - MRI T2 intensity of MIS discectomy was significantly lower (p=0.04).

- We don’t have a clear corollary for postoperative back pain.


What About Complications?

- Metaanalysis of MIS lumbar decompression and MIS lumbar fusions
  - No difference in rate or magnitude of complications

- O’Toole, et al. reported an impressively low rate of infection after MIS spine surgery
  - 0.22% (3/1338), thought to be due to less tissue damage/devascularization.


What about more complex scenarios?
MIS Lumbar Fusions

Prospectively studied 59 patients, open vs. MIS PLIF
Evaluated T2 intensity on Pre- and Post-Op MRI, CK, VAS Back/Leg
Patients allowed to choose approach
MIS with less T2 damage on MRI
MIS had a statistically significant improvement in VAS at one year
- 10.7 vs. 21.2
- P<0.001

MIS Lumbar Fusions

An analysis of the differences in the acute hospitalization charges following minimally invasive versus open posterior lumbar interbody fusion

Presented at the 2009 Joint Spine Section Meeting

Clinical article


Department of Neurological Surgery, University of Miami Miller School of Medicine, Miami, Florida

- Wang, et al. compared 1 or 2 level open vs. MIS lumbar fusions
  - Unilateral symptoms received MIS, Bilateral with open
  - MIS offered improved
    - EBL p<0.065
    - LOS p=0.017 (single level), 0.259 (2-level)
    - Hospital charges p=0.027 (single level), 0.071 (2-level)
    - Lesser need for discharge to rehab with MIS

- Similar results from Ntoukas and Muller
  - Statistically significant improvements in EBL, hospitalization, and VAS (p<0.001)
  - Also statistically significant more radiation exposure, and surgical time (p<0.001)


Thoracic Spine Surgery

- 1958, Thoracic discectomy performed via transthoracic approach.
- Benefits include:
  - Direct visualization of offending pathology
  - No need for retraction/manipulation of neural elements
- Downfalls:
  - Large incision
  - Need for chest tube
  - Thoracic neuralgia/post-thoracotomy pain syndrome
    - May be as high as 50%


Thoracic Discectomy

- Dissatisfaction with thoracotomy led to innovation of other approaches:
  - Transpedicular discectomy
  - Costotransversectomy/LECA
  - Thoracoscopic Discectomy
    - Multiple portals
    - Better three-dimensional understanding
    - Dual-Lumen intubation
    - Steep learning curve, McAfee, et al.
    - “Learn to operate with chopsticks”
  - Minithoracotomy
    - “Minimally-Invasive” (pathology-guided dissection)
    - Option for transpleural or retropleural
    - May obviate the need for chest tube
    - Dramatically decreased risk of intercostal neuralgia
    - Option for corpectomy and expandable cage from same approach, Keshavarzi, et al.

Thoracic Discectomy

Mini-Thoracotomy or Thoracoscopic Treatment for Medially Located Thoracic Herniated Disc?

Ronald H. M. A. Bartels, MD, PhD,* and Wilco C. Peul, MD††

- Bartels et al., 2007
  - Compared Thoracoscopic vs. Mini-Thoracotomy for excision of centrally-located thoracic disc hernations
  - Mini-thoracotomy had:
    - Shorter duration of surgery
    - Less blood loss
    - Shorter duration of ICU stay
    - Shorter duration of chest tube
  - Less steep learning curve with mini-thoracotomy than with thoracoscopic.
Spinal Deformity
“Life is a Kyphosing Event”
Presentation

- Patients with adult degenerative scoliosis present with back pain and disability in 85% cases.
- Pain may be from:
  - Degenerative disc disease and nerve root compression/irritation, especially on the concave side.
  - Facet arthropathy.
  - Central canal stenosis and neurogenic claudication.
  - Sagittal malalignment and curve progression.
Presentation

- Contributing & Associated Factors
  - Degenerative Disc Disease
  - Osteoporosis
  - Segmental instability
  - Iatrogenic (spinal surgery/fusion)
Presentation
Sagittal Balance

- Visibly balanced; a vertical line from the midpoint of the C7 body to the posterior superior corner of the sacrum
Sagittal Cobb Angle

Cobb Angle

- Thoracic Kyphosis
  - T5-T12
  - 20-40 degrees > thoracic kyphosis

- Lumbar
  - T12-S1
  - 40 degrees–Lordosis
Treatment Options

- Conservative: Medication, Physical Therapy and Physical Medicine, Bracing

- Not as effective as in other back pain conditions

- No Substantial Evidence for any nonsurgical treatment in adult scoliosis

Surgical Considerations

- **Indications**
  - Persistent pain despite conservative treatment
  - Progression of deformity
  - Progressive neurologic deficit

- **Risks**
  - Morbidity higher than adolescent scoliosis
  - Secondary to stiff curves and need for complex reconstruction (osteotomies)
  - Medical including cardiopulmonary
  - Bone quality
Surgical Options

- Decompression alone
- Decompression and Posterior Instrumented Fusion
- Decompression and Anterior/Posterior Fusion

- Can have favorable results with all approaches depends on goals and patient expectations
CONTROVERSY

- Role of decompression alone or limited fusion
- Role of combined anterior and posterior
- Choice of fusion level (how high & how low)
Surgical Principals

“The goals of surgery on the adult deformity patient are to treat pain and relieve neurological problems while maintaining or achieving three-dimensional balance. The absolute degree of coronal curve correction in an adult deformity patient is less important than maintaining good sagittal balance.”

Heary, Neurosurgery Supplement. 2008;63(3):69-76
Anterior vs Posterior vs Both

- **Anterior**
  - Severe Coronal Deformity >60’

- **Posterior**
  - Osteotomies with segmental posterior instrumentation (anterior column can be addressed TLIF)

- **360° Fusion**
  - Old ways with high morbidity
  - New modalities show very good promise
    - Far Lateral
    - Endoscopic anterior release
Minimally-Invasive Deformity Surgery

  - 23 patients with degenerative scoliosis, combined direct lateral release/interbody fusion, posterior percutaneous instrumentation
    - Preop Cobb 31.4°
    - Mean number of levels 3.7 corrected
  - Correction of deformity: Cobb 11.5° (+19.9°), improved sagittal balance by 8 cm.
  - Significant improvement in VAS back (p<0.001)
  - 29% Pseudoarthrosis rate
    - Compares with Spinal Deformity Study Group
    - Occurred at the TL and LS junctions.

- Promising for ligamentous sparing in long constructs in attempts to prevent PJK/DJK
- Still leaves a lot to be desired for pseudoarthrosis rates
- Limited options if/when construct needs to extend to ilium.

Cases
Case Presentation (Trauma)

- 75 year old retired aeronautical engineer had a five foot fall from ladder.
- No neurological deficits
- Severe midline back pain
- No calcium supplementation, non-smoker
- History of HTN, CAD
Case Presentation

- TLICS: 4 pts
- TLISS: 4 pts
- 70% Canal compromise, 30% height loss
- Surgical Options??


Case Presentation

- Minimally invasive retroperitoneal, transpsoas L2 corpectomy
- Posterior L1-3 fusion
Postop photograph
Case Presentation (Trauma)

- 81 year old female who fell off a ladder while pruning her roses
  - Severe back pain
  - Left leg weakness, right femur fracture
  - Previous L4-5 TLIF for spondylolisthesis
71 year old male with severe back pain and neurogenic claudication

- Back pain made better with lying supine
- Claudication made better by flexed posture
- Now unable to ambulate more than 30 yards
Preoperative Xrays

- Right lumbar scoliosis 23°
- Flattening of lumbar lordosis
Intraoperative Fluoroscopy – Stage 1
Intraoperative Xrays – Stage 2
Case Presentation (Flat Back Syndrome)

- 73 year old female with severe back pain and neurogenic claudication, progressive over the last 15 years
  - Previous L4-5 fusion 1988
  - Severe pain when standing up straight
  - Recently confined to her wheelchair from pain
Preop Xray
Preoperative scoliosis Xrays

- 16cm positive sagittal balance
- 19.5 degree right lumbar scoliosis
Preoperative MRI
Case Presentation
(Spinal Metastasis)

- 69 year old with metastatic renal cell carcinoma to T7
  - Followed initially on surveillance studies, and received radiation
  - Eventually progressed with the amount of back pain and spinal cord compression
Preoperative MRI and CT
Thank You
References


