MIS Spinal Surgery
- Where Are we?
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Four pillars of Minimally Invasive Spinal Surgery
- Access: Percutaneous Mini-Open
- Microsurgery: Microscope Endoscope
- Navigation: 2D 3D
- Instrumentation: percutaneous Mini-open

MIS Spine
- A procedure that by virtue of the extent and means of surgical techniques results in ...
  - less collateral tissue damage,
  - measurable decrease in morbidity and
  - more rapid functional recovery than traditional exposures,
  - without differentiation in the intended surgical goal

MIS Spine: Where are we?

- "Targeted MIS" based on clinical presentation and radiology findings
  - Treat pathology
  - Minimize overtreatment
  - "Surgical Strike" vs. "Carpet Bombing"

- MIS technique principles
  - Contralateral decompression
  - Minimize iatrogenic instability
  - Indirect decompression

- Minimize fusion need
- "Total Navigation"

MIS Principles

- Avoid muscle injury by ...
  > Muscle splitting self-retaining retractors
  > Limiting the width of the surgical corridor
  > Using known anatomic neurovascular and muscle planes

- Do not disrupt tendon attachment of key muscles, particularly at the spin
The (cool) tools we use in MIS surgery...

- Tubes
- Microscopes / Endoscopes
- 3D Navigation System “GPS of the Spine”
- Implants

• Sorry…no lasers!

Anterior and Posterior MIS Approaches

Spinal MIS

• Three Principles of Spinal MIS:
  1. Contralateral Decompression
  2. Minimize Instability
  3. Indirect Decompression
1. Principle

• **Contralateral Decompression:**
  - You can perform a bilateral decompression and a contralateral foraminotomy through a unilateral minimally invasive approach

### Bilateral Decompression via Unilateral Approach

Unilateral Laminotomy for Bilateral Decompression of Lumbar Spinal Stenosis
Part I: Anatomical and Surgical Considerations

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Conclusions

Decompression of the lumbar spinal canal is practicable via unilateral laminotomy, bilateral laminotomy, and foraminotomy. This minimally invasive approach preserves the spinous processes, the asymptomatic facets, and the integrity of the physiological musculature. Assessment of the operative site. A further evaluation of this surgical method is necessary in technical studies.
Bilateral decompressive surgery in lumbar spinal stenosis associated with spondylolisthesis: unilateral approach and use of a microscope and tubular retractor system
4.2.1 Bilateral decompression in lumbar spinal stenosis through a minimally-invasive, monolateral approach

**MIS Tubular Laminectomy (Laminotomy)**

- **Class III evidence**
  - Faster recovery
  - Mobility
  - Return to work
  - Improved perioperative clinical outcomes
  - EBL, LOS
  - Equivalent patient reported long term outcomes
  - Decreased hospital cost/societal cost
Contralateral Decompression

81 y/o M with left L4 radiculopathy

L4/5

Caudal

Medial

Lateral

Cranial
Patients presenting with unilateral radicular pain

32 patients / 44 levels

Mean age: 64

Median EBL: 10 (0 ; 200)

Median length of stay: 1 (0 ; 5)

Mean clinical follow-up: 12.3 +/− 1.7 months

Minimally Invasive Foraminotomy Through Tubular Retractors via a Contralateral Approach in Patients With Unilateral Radiculopathy
Clinical outcome

![Graph showing VAS pain scores on the pathology side and on the approach side.](image)

* P < 0.05 vs. preoperative value

Next Steps

1. Principle

- **Contralateral decompression:**
  - You can perform a bilateral decompression and a contralateral foraminotomy through a unilateral minimally invasive approach
2. Principle

- **Minimalize Instability:**
  - Minimally invasive spinal decompression can reduce iatrogenic instability and reduce the need for instrumentation and fusion.

**Decompression or Decompression / Fusion?**

60 y/o F with stenosis & Grade I Spondylolisthesis

Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine:
- Part I: Fusion in patients with stenosis and spondylolisthesis.
62 y/o F with stenosis & Grade I Spondylolisthesis

Routine Fusion is not indicated in all patients with LSS and spondylolisthesis.
Lumbar spinal stenosis associated with degenerative lumbar spondylolisthesis: A systematic review and meta-analysis of secondary fusion rates following open vs. minimally invasive decompression

- MIS laminotomy is associated with lower reoperation and fusion rates, less slip progression, and greater patient satisfaction than open surgery.

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Biomechanical Effects of a Unilateral Approach to Minimally Invasive Lumbar Decompression

- A minimally invasive, unilateral approach to treat lumbar stenosis produces significantly less biomechanical instability than a traditional midline laminectomy in all modes of testing.

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Selektive, mikrochirurgische „Cross-over“-Dekompression mehrsegmentaler lumbaler Spinalstenosen

- Die „Slalom“-Technik
MIS = “Minimally Invasive Spine Surgery”
...or...
“Minimal Instrumentation Surgery”

Case Example: Spinal stenosis and facet joint cyst
- 65 y/o M with leg pain and neurogenic claudication
- Failed PT and epidural steroid injections
Safer resection from contralateral side
No fusion

“Tubology” Approach
Pearls

- Foraminal stenosis with radiculopathy
  - Contralateral approach
- Central stenosis with neurogenic claudication
  - Right-sided approach for right-handed surgeon
  - Left-sided approach for left-handed surgeon
  - 1-2 levels: one incision
  - 3-4 levels: “slalom” technique
- Lateral recess stenosis
  - Approach as above
- Unilateral disc herniation
  - Ipsilateral approach
- Synovial cyst
  - Contralateral approach

MIS laminectomy causes less instability than open laminectomy

Laminectomy adjacent to L4/5 Fusion
MIS decompression instead of fusion...

1. Lumbar spinal stenosis with stable spondylolisthesis
2. Unilateral foraminal stenosis
3. Lumbar stenosis adjacent to a level that requires fusion

MIS = “Minimally Invasive Spine Surgery”
...or...
“Minimal Instrumentation Surgery”

1. Principle

• Contralateral decompression:
  - You can perform a bilateral decompression and a contralateral foraminotomy through a unilateral minimally invasive approach
2. Principle

- **Minimalize Instability:**
  - Minimally invasive spinal decompression can reduce iatrogenic instability and reduce the need for instrumentation and fusion.

3. Principle

- **Indirect decompression:**
  - Minimally invasive spinal surgery allows indirect decompression of central and foraminal stenosis in selected patients.
Lateral access / Transpsoas Surgery / ELIF / XLIF

Indirect Decompression

Indirect Decompression
67 y/o Male with right L3/4 radicular pain, minimal back pain

Right L3/L4 Foraminal Stenosis

L3/L4
Indirect Decompression

15 months postoperative

15 months postoperative
Pre vs. 15 months postoperative

• 23 patients with unilateral leg pain and foraminal stenosis
• 1 year follow-up
• Single-level XLIF is an effective procedure for unilateral foraminal stenosis & radiculopathy
Foraminal Height and Leg Pain

Concomitant improvement of the FIH and VAS scores on the stenotic side

LIMITATIONs of MIS

Class I: MIS surgery with decompression only or fusion of a pathologic level.
Class II: MIS surgery with decompression and interbody fusion of apex of the curve or the entire Coronal Cobb of the curve.
Class III: Open surgery with osteotomies +/- extension of fusion to the thoracic spine.

Images of thoracic spine X-rays and MRI.
Intraoperative 3D CT Navigation
“TOTAL” Navigation
We eliminate fluoroscopy in 70% of our cases
✓ Skin incision
✓ Screw size and planning (no K-wires)
✓ Screw placement
✓ Tubular retractor placement
✓ Decompression
✓ Cage placement
✓ Rod measurement
✓ Final CT check
• Other indications → localization
  – Cervical foraminotomies
  – Spinal tumor
  – Thoracic disc herniations

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• “Targeted MIS” based on clinical presentation and radiology findings
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  – “Surgical Strike” vs. “Carpet Bombing”
• MIS technique principles
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  – Minimize iatrogenic instability
  – Indirect decompression
• Minimize fusion need
• “Total Navigation”

It's a team sport:
Weill Cornell Spine Center
• Care: Clinical Excellence
• Discover: Research
• Teach: Education
Types of back pain

• Neurogenic claudication  
  – Lumbar stenosis

• Radicular pain  
  – Lateral recess  
  – Disc herniation  
  – Foraminal stenosis

• Mechanical back pain  
  – Instability  
  – Facets  
  – imbalance
Minimally Invasive Thoracic Decompressions

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The Spine Clinic of Los Angeles
At Good Samaritan Hospital
An Affiliate of the University of Southern California

DISCLOSURES OF CONFLICT

Major: Zimmer, Globus, Spineguard, Medacta

Minor: Aesculap, Mallinckrodt

Case Presentation

Surgical Technique

- 58 yo RH physician
- Sudden onset of thoracic pain
- No history of trauma
- 6 wk history of progressive gait sx
- Bladder incontinence
- Rt sided trunk / leg numbness
- 3+ DTR, ataxia, dec rectal tone
- 8/10 mid thoracic pain
Ventrolateral Approaches

- Advantages
  - Ventrolateral exposure of disc space and ventral spinal canal
  - Midline, densely calcified discs and intradural fragments
  - Ventral dural repairs and reconstruction
  - Multiple discs

Thoracotomy - Disadvantages

- Approach morbidity of 14% in large multicenter study (Spine 1995), n=770
  - Post thoracotomy syndrome
  - Abdominal relaxation
  - Poor cosmesis & rib deformity

- High overall morbidity (24%):
  - Wound infection, radiculopathy, aortic laceration,
    Horner’s syndrome, pleural effusion, pneumothorax, hemothorax,
    chylothorax, brachial plexus injury, lung herniation, renal failure,
    pneumocephalus and chronic pain

Minimally Invasive Extracavitary Thoracic Discectomy and Fusion (MI-ECTDF)

- Provides good angle of decompression
- Decreased Neural Retraction
- Combine with minimally invasive technologies and principles
Oblique docking of the portal on lateral facet

Drilling of Lateral Facet Complex

Skeletonize the superior aspect of the pedicle & transverse process
Discectomy with minimal retraction of the spinal cord

Insertion of Soft PLIF material, followed by interbody cage (to prevent pain and recurrence)

Postop Course
- OR time 2 hours
- EBL 25cc
- Full motor recovery
- Residual mild rt numbness
- Bladder issues resolved
- 24 month followup
- No further back pain
Minimally invasive extracavitary approach for thoracic discectomy and interbody fusion: 1-year clinical and radiographic outcomes in 13 patients compared with a cohort of traditional anterior transthoracic approaches

Patients & Methods

- Prospective, non-randomized study
- Class II / III study, Single surgical group
- All with cord compression / myelopathy
- Mean duration sx - 4.2 months
- Total of 24 patients, 1 year f/u
- Two arms:
  - 11 – Open mini-thoracotomy (52.5y, 5 men, 6 women)
  - 13 – Min Invasive EC-TDF (51.8y, 4 men, 9 women)

Key Words: minimally invasive surgery - thoracic discectomy - extracavitary approach - transthoracic approach - interbody fusion
Operative data

- Fusion: 93% MI-ECTDF, 91% Open
- Stay (days): 3.00 MI-ECTDF, 5.80 Open
- EBL (dl): 0.33 MI-ECTDF, 2.95 Open
- OR Time (hrs): 1.55 MI-ECTDF, 2.92 Open

Summary

Complications

- MI-ECTDF
- Open
- CSF leaks: 1 MI-ECTDF, 3 Open
- Radicular Numbness: 1 MI-ECTDF, 9 Open
- Trunk wall weakness: 1 MI-ECTDF, 6 Open
- Trunk wall hyperesthesia: 1 MI-ECTDF, 4 Open
- Wound Infection: 1 MI-ECTDF, 3 Open

Peri-operative Course

- MI-ECTDF
- Open
- (4.2x risk ratio, p<.01)
- Chest Tube Drainage: 0 MI-ECTDF, 11 (1.5d) Open
- Early Wound Infection: 0 MI-ECTDF, 2 Open
- Pts in ICU postop: 0 MI-ECTDF, 7 (1.25d) Open
- Transfusion: 0 MI-ECTDF, 4 Open
- Pneumonia: 0 MI-ECTDF, 3 Open
- Urinary Tract Infection: 1 MI-ECTDF, 4 Open
- DVT: 1 MI-ECTDF, 3 Open
- Cardiac Events: 1 MI-ECTDF, 2 Open
- Hematoma: 0 MI-ECTDF, 1 Open
- Prolonged Ileus: 0 MI-ECTDF, 2 Open
Results – Pain Outcomes

Neurological Outcomes (p<.05)

Conclusions

At 1 year followup, Mi-ECTDF has become the standard approach in our armamentarium for paracentral and soft midline thoracic herniated discs causing spinal cord compression and myelopathy for the following reasons:

- Improved operative time + blood loss (p<.01)
- Improved perioperative complications (p<.01)
- Improved 6 wk, 3, 6 mo pain scores (p<.01)
- Equivalent neurological outcomes (p<.01)
MIS Posterior Thoracic Extracavitary Corpectomies

Minimally invasive lateral extracavitary corpectomy – Cadaveric evaluation model and report of three clinical cases

Zachary A. Smith, M.D., Zhemzhou Li, M.D., Nan-Fu Chen, M.D., Dan Raphael, PA-C, Larry T. Khoo M.D.

J Neurosurgery Spine: December 2011 (accepted pending)

Table 1: Radiographic Measurements in 6 Cadavers

<table>
<thead>
<tr>
<th>Patient No</th>
<th>Level</th>
<th>Anterior Height</th>
<th>Posterior Height</th>
<th>Cobb Angle</th>
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<tbody>
<tr>
<td></td>
<td>Pre-op</td>
<td>Post-op</td>
<td>Pre-op</td>
<td>Post-op</td>
</tr>
<tr>
<td>Patient 1</td>
<td>T12</td>
<td>2.67 cm</td>
<td>3.03 cm</td>
<td>2.93 cm</td>
</tr>
<tr>
<td>Patient 2</td>
<td>T12</td>
<td>2.80 cm</td>
<td>3.17 cm</td>
<td>2.71 cm</td>
</tr>
<tr>
<td>Patient 3</td>
<td>T12</td>
<td>2.91 cm</td>
<td>3.30 cm</td>
<td>3.05 cm</td>
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<tr>
<td>Patient 4</td>
<td>T12</td>
<td>2.05 cm</td>
<td>2.76 cm</td>
<td>2.26 cm</td>
</tr>
<tr>
<td>Patient 5</td>
<td>T12</td>
<td>2.76 cm</td>
<td>4.02 cm</td>
<td>2.76 cm</td>
</tr>
<tr>
<td>Patient 6</td>
<td>T12</td>
<td>2.57 cm</td>
<td>3.14 cm</td>
<td>3.00 cm</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.94 cm</td>
<td>3.41 cm</td>
<td>3.13 cm</td>
</tr>
</tbody>
</table>
83 yo frail Asian Male
4 month h/o upper back pain
10 day history of Acute BLE
paraplegia in legs 1/5 strength
loss of bowel bladder control
T9 sensory level with
numbness below

BONE SCAN T4/5 LESION
TB PPD / PCR: + TB

T4/5 Pathological Fracture-Dislocation
3 Col Injury-CT, kypotic angulation

42°
T2.3 to T6.7 MIS mini-open pedicle screws; Placed 5.5mm x 35mm screws in right T2,3 and T6,7 pedicles. Then nitinol wires only after prepared pedicles on left T2,3,6,7 pedicles.

Placed expandable type mini-open multiblade retractor for MIS approach to left sided T4 and T5.
Neuro unchanged 1/5 BLE strength. Surgery length 4 hrs 30 minutes, ebl 450cc. No csf leak. Chest tube placed. POD #4 LLE 4/5, RLE 2/5 proximally and 3/5 distally

Minimally Invasive Thoracic Corpectomy
Through Posters lateral (Costotransversectomy) Approach
LT Khoo, ZA Smith, ZZ Li, D Raphael

THE FAR LATERAL POSTERIOR EXTRACAVITARY APPROACH CORRIDOR

- Provides good angle of decompression
- Decreased Neural Retraction
- Key is actual an OBLIQUE approach to the anterior spine
- Combine with minimally invasive technologies and principles
THANK YOU

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An Affiliate of the University of Southern California
Indications and Techniques for Minimally Invasive Cervical Laminoforaminotomy using a Tubular Retractor

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Disclosures

- Consultant to Medtronic
- Royalties from Medtronic
- BOD member and stockholder for BioD, Discgenics, & TrueVision
- Ownership (stock) in Medtronic, NuVasive, and SpineWave

History

Historically, surgery for cervical radiculopathy was posterior.

- Stookey B. Compression of the spinal cord due to ventral extradural cervical chordomas: diagnosis and surgical treatment. Arch Neurol Psychiat 1928; 20: 279-291
Posterior Cervical Discectomy

**Indications**

- Cervical radiculopathy recalcitrant to nonoperative management
- Disc herniation, osteophyte, or foraminal stenosis producing nerve root compression that correlates with the patient’s clinical presentation
- No evidence of instability

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Posterior Cervical Foraminotomy
Posterior Cervical Discectomy
Contra-indications

- Central compressive lesion (disc and/or osteophyte)
- Ventral spinal cord compression
- Cervical spine instability
- Significant mechanical neck pain

Advantages: Posterior vs. Anterior

- Maintain functional motion segment
  - Minimize adjacent level disc degeneration
- Excellent visualization of nerve root
- Avoid certain anterior complications
  - Recurrent laryngeal nerve injury, Horner's syndrome, esophageal injury, carotid injury, graft-related complications
- Avoid post-op neck immobilization
Disadvantages: Posterior vs. Anterior

- Post-op incisional neck pain
- Unable to address central disc/osteophyte
  - Pre-op MRI or CT-myelogram to exclude
- Need for neural retraction
  - Can minimize
- Positioning a bit more cumbersome
- Risk of instability?
- Risk of recurrence?

Instability After Posterior Cervical Discectomy/Foraminotomy

- Rare
  - "minor" increase in motion over normal spine

Recurrent HNP After Posterior Cervical Discectomy/Foraminotomy

- Rare
- 1/2032 patients in Collias’ and Roberts’ series (.05%)
Results

  - Hemilaminectomy & discectomy, prone
  - 648 patients, 96% good/excellent results
  - 1% recurrence rate
- “The results of this operation are better than those of any other operation in neurosurgery”

Minimally Invasive Posterior Cervical Discectomy/Foraminotomy

- Extension of the “classical” open technique
- Operation is identical except for approach
- Minimally invasive approach via tubular retractor minimizes post-op pain
- Can be routinely performed on an outpatient basis

Minimally Invasive Microdiscectomy Surgical Technique

- [Diagram of surgical instruments: Introducer Set, Flexible Arm Assembly, Dilators, GuideWire]
Minimally Invasive Posterior Cervical Discectomy

- Prone or sitting position
  - Reverse Trendelenberg if prone
- Fluoroscopic localization—use AP if shoulders block lateral view
- Incision 1.5 cm lateral to midline
- NO K-WIRE! Perforate fascia with sharp iris scissors, spread fascia bluntly with Metzenbaum’s
- 14mm or 16mm diameter tube
Tubular Retractor: Minimally Invasive Posterior Cervical Discectomy Results
- 100 consecutive patients with cervical radiculopathy
- Decompression via tubular retractor (MED)
- D/C 3 hours post-surgery
- Mean F/U 14.8 months
- 91 excellent, 6 good, 2 fair, 1 poor (re-op at 18 months)
- Return to work and/or full baseline activity 1 day to 4 weeks (mean 1.9 weeks) post-op
  Adamson TE, J Neurosurg (Spine) 95:51-57, 2001

Tubular Retractor: Minimally Invasive Posterior Cervical Discectomy Results
- 222 consecutive patients with cervical radiculopathy, mean F/U 26 months
- Decompression via tubular retractor, prone position
- Mean surgery time 63 minutes, mean EBL 71 cc
- 188 excellent, 22 good, 9 fair, 3 poor (all re-op with ACDF)
- LOS data for 191 patients - same day (167) or overnight (24)
- Complications: 1 infection, 2 dural tears (Duragen/Tisseel)

Fig. 4. Bar graph showing return to work/full activity in 100 postoperative patients.
Conclusions

- Minimally invasive posterior cervical discectomy/foraminotomy using a tubular retractor is a safe and effective procedure.
- Minimally invasive approach allows for routine outpatient surgery and quicker RTW/activity than the conventional open procedure.