Minimally Invasive Spine Surgery for Back and Leg Pain

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Differential Diagnoses for Low Back and Leg Pain
### Differential Diagnoses for LBP

#### Extra-Spinal

- **Generalized Disease**
  - Viral Illness
  - Psychological

- **Cardiac / Vascular**
  - Angina
  - Aortic Aneurysm

- **Gastrointestinal**
  - Peptic Ulcer
  - Cholecystitis
  - Pancreatitis
  - Appendicitis

- **Genitourinary / Gynecological**
  - Kidney Stones
  - Pelvic Inflammatory Disease
  - Endometriosis
  - Prostate Disorders

#### Differential Diagnoses for LBP

**Extra-Spinal Conditions**

- **Often elicited in the history**
  - Fever, malaise, weight-loss
  - Abdominal pain, nausea, dyspepsia
  - Chest pain, palpitations
  - Dysuria, pelvic pain, perimenstrual pain
  - Depression, psychiatric illness
Differential Diagnoses for LBP

Spinal
- Neoplastic
  - Multiple Myeloma
  - Metastatic
  - Primary
- Spondyloarthropathies
  - Ankylosing spondylitis
  - Reiter’s Syndrome
- Infectious
  - Discitis
  - Vertebral Osteomyelitis
- Traumatic
  - Muscle/ligament Strain
  - Disc Injury
  - Fracture (traumatic)
- Degenerative
  - Disc Degeneration
  - Herniated Disc
  - Facet Arthritis
  - Stenosis
  - Instability

Degenerative Conditions that Cause Low Back and Leg Pain
Spinal Degeneration

“I’ll be back”

Spinal Degeneration

“Oh my back”
5 Degenerative Lumbar Conditions

- Degenerative Disc Disease
- Herniated Disc
- Facet Arthritis
- Stenosis
- Instability

Disc Degeneration

- Decreased vascularity and hydration with fibrosis of the nucleus
- Degeneration of the inner annulus causes disruption of the fibers and radial tears
- Loss of disc height
- Bulging of the outer wall (annulus fibrosus)
Discogenic Pain

Pathophysiology

- Various Neurotoxic Agents in the Nucleus
  - Interleukins
  - Prostaglandins

- Neurotoxic agents
  - Produce Pain
  - Sensitize Nerve Endings
    - Mechanical Stimulation That Was Previously Not Painful Now is

Disc Bulging, Herniation, & Radiculopathy

- Annular tears weaken the wall

- Posterior annulus is ½ the thickness of the anterior annulus

- Annular bulging and herniation create nerve root irritation and radiculopathy
Facet Degeneration

Disc degeneration
- Circumferential tears
- Radial tears
- Disc narrowing
- Spondylophyte formation

Facet joint degeneration
- Synovial reaction
- Capsular laxity
- Subluxation
- Osteophyte formation

Lumbar Stenosis

- Hypertrophy/buckling of ligamentum flavum
- Disc degeneration with thickening/bulging of annulus
- Facet arthropathy with hypertrophy and spurring
- Synovial cysts
3 Zones of Lumbar Stenosis

- Superior capsular hypertrophy
- Proximal migration of the inferior facet
- Leads to foraminal stenosis and radicular pain
Spinal Instability

Degenerative Spondylolisthesis

• Disc collapse leads to annular laxity
• Facet degeneration leads to capsular laxity
• Forward slip creates foraminal and lateral recess stenosis

Evaluation and Treatment of LBP
Evaluation and Treatment of Acute LBP

General Approach

• The majority of acute, nontraumatic LBP is benign, self-limiting, and best treated without the delay of making a pathologic diagnosis.

• Contrary to most medical problems, the exact diagnosis does not have to be determined before initiating treatment.

Evaluation and Treatment of LBP

• Diagnostic work-up follows hand-in-hand with 3 phases of treatment options, becoming more targeted, and more invasive as patients fail each phase of treatment.
3 Phases of Evaluation & Treatment

- **Phase I** (< 6 weeks)
  - Rule out “bad things”
  - Medications
  - Therapy
  - Ice/heat

- **Phase II**
  - MRI to focus on possible pain generators
  - Injections

- **Phase III**
  - Positively identify pain generator
  - Surgery

**Initial Evaluation – Phase I**

**Goals**

1. **Identification of Serious Conditions (H&P)**
   - Serious Extraspinal Conditions
   - Tumor
   - Infection
   - Fracture (Traumatic, Osteoporotic, Neoplastic)
   - Significant Neurologic Deficits

2. **Reassurance and Elimination of Fear**

3. **Elimination of Pain and Return to Function**
Initial Evaluation – Phase I

Critical Exclusionary Diagnoses

- Significant Neurologic Deficit – warrants MRI
  - Foot Drop
  - Gait Dysfunction
  - Cauda Equina Syndrome

- Diminished reflex not necessarily a significant deficit in absence of muscle weakness or severe radicular pain

Critical Exclusionary Diagnoses

- Cauda Equina Syndrome
  - Acute, severe LBP
  - Saddle anesthesia
  - Profound/progressive neurologic deficit
  - Loss of bowel and bladder control
Initial Treatment – Phase I

- Activity modification
- Self-applied Thermal modalities
- Medications
- Physical Therapy/Manual Therapy
- Follow-up as required in 4-6 weeks
Secondary Treatment – Phase II

- Symptoms present for 4-6 weeks or more
- No response to conservative treatment
- Development of progressive neurologic symptoms or neurologic deficit
Radiographic Evaluation

MRI

- Gold-standard to identify tumor or infection

Disc Degeneration

- Decreased T2-signal
- High intensity zone (HIZ) in the posterior annulus
- Diffuse disc bulge (“flat tire”)
- Modic end-plate changes
MRI

Disc Herniation

MRI

Facet Arthritis

Facet Cyst
MRI

Stenosis

MRI

Instability
Secondary Treatment – Phase II

Spinal Injections

• Epidural Injections
• Facet Joint Injections
• Sacroiliac Injections
• Type of injection is based on patient’s symptoms, exam, and MRI findings

Surgical Treatment – Phase III
Surgical Treatment – Phase III

Indications for Surgery and Surgical Options Vary Depending on the Condition and Symptoms

- Disc Herniation
- Stenosis
- Disc Degeneration
- Facet Arthritis
- Instability

Minimally Invasive Spine Surgery
Minimally-Invasive Spine Surgery

Key Concepts

What is Minimally-Invasive Spine Surgery?

Philosophy

- Targeting the appropriate pathology while minimizing collateral damage
Traditional “Open” Surgery

Collateral Damage

- Muscle damage from crush injury
- Unnecessary bone resection
  - Spinal instability

Muscle Injury

- Necrosis
- Fibrosis
- Atrophy
- Systemic Inflammation

Traditional “Open” Surgery

Problems

• Self-retaining retractors generate large forces on the muscle tissue

• Rely on pressure to hold in position

Key MIS Concepts

Concept #1: Avoid Muscle Crush

• Avoid self-retaining retractors

• Table-mounted tubular retractors
  – Gradually dilate muscle tissue
  – Maximize the surface area
  – Allow for direct path to surgical target
### Retraction Pressure

**OPEN**

4.7 kPa - Continuous

**MIS**

1.4 kPa - Transient

Stevens JSDT 2006

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### MIS Concept #1: Avoid Muscle Crush

**Systemic Markers of Muscle Damage in MIS vs. Open**

- Also significant difference in systemic levels of IL-1, IL-8, IL-6, IL-10

Kim et al. Spine 2006
Key MIS Concepts

Concept #2: Avoid Damage to Multifidus Muscles

- Do not detach from midline spinous processes
- Avoid midline laminectomy
- Use paramedian approach

Concept #2: Avoid Damage to Multifidus Muscles

Muscle Damage

- What do these muscles do?
- Why do we care if they are injured?

FUNCTION
Concept #2: Avoid Damage to Multifidus Muscles

Multifidus Muscles

• Most medially located paraspinal muscles

• Attach to the spinous processes in the midline

• Key stabilizer of the lumbar spine
Post-Op Lumbar Extension Strength

Kim et al. 2004

Key MIS Concepts

Concept #3: Avoid Unnecessary Bone Resection

- Avoid midline laminectomy
- Use unilateral approach for bilateral decompression
- Reach over top of dural tube to contralateral side
Traditional “Open” Surgery

Unnecessary bone resection

• Traditional approach uses the strategy of starting in the midline and working “out” laterally

Unnecessary bone resection

• More bone resection leads to decreased stability
Minimally-Invasive Spine Surgery

Clinical Benefits

- Less damage to surrounding muscle and soft tissues
- Decreased pain and reduced need for pain medication
- Quicker recovery and faster return to regular activities
- Shorter hospital stays
- Risk of postoperative infection is decreased
- Blood loss is reduced
- Small incisions, cosmetically more appealing
MIS Benefits

Decreased Blood Loss

- In three prospective studies, mean intraoperative blood loss ranged from 150 to 456 ml for MIS fusion versus from 517 to 961 ml for open fusion.4-6

- These differences were statistically significant ($p < 0.05$).

Decreased Hospital Stays

- Mean length of stay in three prospective studies was shorter for patients who received MIS fusion, ranging from 4 to 9 days versus 7 to 13 days for patients who received open lumbar fusion.

- In all cases these differences were statistically significant.
MIS Benefits

Decreased Postoperative Pain

• Shunwu et al found patients who received MIS fusion experienced greater relief of postoperative back pain than those who received open fusion


MIS Benefits

Decreased Postoperative Pain

• Peng and colleagues noted patients who received MIS fusion had less pain and required less analgesia (morphine) during the immediate post-operative period than those who received open fusion

MIS Benefits

Decreased Postoperative Infection

- In one study, the incidence of post-operative infection was similar for one-level fusions, but was significantly lower for 2-level MIS versus open fusions (30/652 [4.6%] vs. 151/2,157 [7.0%], respectively, \( p = 0.030 \))


Minimally-Invasive Spine Surgery

Clinical Indications
MIS Spine Surgery

Indications

• Neurologic Compression ➔ Decompression
• Spinal Instability ➔ Stabilize
• Spinal Deformity ➔ Realign & Stabilize

Same as Open!

MIS Options for Back and Leg Pain

• Microdiscectomy
  – Neurological Decompression

• Endoscopic Discectomy and Foraminotomy
  – Neurological Decompression

• Minimally-Invasive Lumbar Microdecompression (MILM)
  – Neurological Decompression

• MIS TLIF (Minimally-Invasive Fusion)
  – Neurological Decompression
  – Realignment
  – Stabilization
Lumbar Microdiscectomy

Conditions
- Herniated disc

Indications
- Intolerable leg pain
- Progressive neurologic deficit
- Cauda equina syndrome
- Persistent pain despite 6 weeks of conservative management
Lumbar Microdiscectomy

Surgical Technique

- Outpatient
- General anesthesia
- 2 – 2.5 cm incision
- Muscle tissue retracted from lamina and ligamentum flavum
- Laminotomy to gain access to epidural space

- Compressed nerve is retracted as disc material is removed
- Removal of partially-extruded nucleus allows tear in annulus to close and heal
- Incision is closed
Lumbar Microdiscectomy

Post-Op Protocol

- Patient is discharged within a few hours
- Normal, sedentary activities immediately
- Physical therapy at 2 weeks
- Full activities at 6 weeks

Transforaminal Endoscopic Discectomy
Transforaminal Endoscopic Discectomy

Conditions
- Foraminal disc herniations
- Foraminal stenosis

Indications
- Intolerable leg pain
- Progressive neurologic deficit
- Persistent pain despite 6 weeks of conservative management
Transforaminal Endoscopic Discectomy

- Utilizes “hidden zone” of McNab
- Allows access to these pain generators:
  - Disc
  - Exiting nerve
  - Traversing nerve
  - Epidural space
  - Superior Facet
  - DRG
  - Foraminal Osteophytes

Able to accommodate a 1 cm cannula

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**YESS Discoscope (Wolf Medical)**

- 7mm outer cannula
- 4.2 mm working channel endoscope
Transforaminal Endoscopic Discectomy

Surgical Technique

• Patient awake with light sedation and local anesthetic
• Disc is targeted using fluoroscopy and skin is marked
• Discography is performed with indigo carmine blue
  – Nuclear material is stained blue
  – Nerve and other structures not stained

• Guide-wire placed into disc
• 7mm cannula placed over wire into disc
• Working channel endoscope inserted through 7mm cannula
Transforaminal Endoscopic Discectomy

Laser Facet Decompression

Post-Op Protocol

- Patient is discharged within 1-2 hours
- Normal, sedentary activities immediately
- Physical therapy at 2 weeks
- Full activities at 6 weeks
Transforaminal Endoscopic Discectomy

Complications

- Total complication rate of 3.5% in 3,000 cases. Gradual decrease in occurrence with experience. Yeung Spine 2001.
  - Dysasthesias 5%–15% (usually temporary)
  - Persistent sensory deficit 1%
  - Persistent motor weakness 2%
  - Discitis 0.03%
  - Dural tear 2%
  - Thrombophlebitis 0.5%
  - Bowel injury 1/3000 (0.003%)
  - Vascular injury 0%

Benefits

- Outpatient
- No general anesthesia
- Less tissue destruction
- Less postoperative pain
- Quicker recovery
- Minimal out of work time
- Earlier Rehabilitation
- Minimal scar tissue formation
Minimally-Invasive Lumbar Microdecompression (MILM)

Indications

- Intolerable leg pain
- Progressive neurologic deficit
- Persistent pain despite 6 weeks of conservative management

Conditions

- Lumbar Stenosis
  - Central and lateral recess
Minimally-Invasive Lumbar Microdecompression

Surgical Procedure

• Outpatient
• General anesthesia
• 2 – 3 cm incision
• 18mm tubular retractor to dilate muscle
• Laminotomy to gain access to epidural space

Minimally-Invasive Lumbar Microdecompression

Surgical Procedure

• Midline laminectomy avoided
• Unilateral approach utilized for bilateral decompression
• Tube is angled to reach over the top of dura to decompress contralateral side
Minimally-Invasive Lumbar Microdecompression

Post-Op Protocol

• Patient is discharged within a few hours

• Normal, sedentary activities immediately

• Physical therapy at 2 weeks

• Full activities at 6 weeks

Minimally-Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF)
Minimally-Invasive Fusion (MIS TLIF)

**Conditions**
- Lumbar Stenosis or Herniated Disc *with* Instability or Severe disc degeneration

**Indications**
- Intolerable leg pain
- Progressive neurologic deficit
- Persistent pain despite 6 weeks of conservative management

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**Minimally-Invasive Fusion (MIS TLIF)**

- Tubular retractors allow access to the spine by dilating the muscle instead of cutting
- Less Tissue Disruption
- Decreases morbidity
- Faster Recovery
MIS TLIF

Surgical Technique

Skin Marking

- C-arm fluoroscopy is used to mark the skin based on anatomic landmarks
- Mark for incision is approximately 1 cm from the lateral border of pedicle depending on patient size
- Less than 1” incisions for a single-level fusion
Surgical Technique

Ipsilateral Guide-Wire Placement

- Skin incision
  - Single skin and fascial incision
- Hemostasis with Bovie

- Palpate the starting point for each pedicle screw at the junction of the TP and the facet joint

- Done prior to facetectomy and TLIF
  - Facet protects the exiting and traversing nerves while placing Jamshidi
Surgical Technique

Ipsilateral Guide-Wire Placement

- Advance guide-wire into vertebral body
- Use cannulated depth-gauge to measure screw length.

Surgical Technique

Facetectomy and Ipsilateral Decompression

- Place dilating tubes and tubular retractor
Surgical Technique

Facetectomy and Ipsilateral Decompression

- Target the lateral facet with a 45° - 60° angle

Surgical Technique

Facetectomy and Ipsilateral Decompression

- Facetectomy with 3mm neuro burr
Surgical Technique

Facetectomy and Ipsilateral Decompression

- Facetectomy with 3mm neuro burr

Surgical Technique

Facetectomy and Ipsilateral Decompression

- Thin the superior articular process of inferior level with a burr and complete its removal with a Kerrison
Surgical Technique

Facetectomy and Ipsilateral Decompression

- Assistant protects the exiting nerve with a root retractor

Surgical Technique

TLIF

- Discectomy
  - Disc is “debulked” with shavers and pituitarys
Surgical Technique

Endplate Prep

- Endplate shavers
- Box currettes
- Rasps

- Oversized shavers can lead to endplate violation and future subsidence
- Angled currettes

Bone Grafting

- InFuse sponge placed anteriorly into disc-space

- 8mm diameter funnel used to pack bone graft behind sponge
Surgical Technique

TLIF Cage

• Ergonomic design
• Lordotic options
• Adaptive sizing
• Large internal graft volume

Cage Placement

• Cage distracts endplates as cage is impacted
Surgical Technique

Cage Placement

- Cage distracts endplates as cage is impacted
Surgical Technique

Cage Placement

- Cage distracts endplates as cage is impacted

Surgical Technique

Contralateral Decompression if needed

- Tube is angled to reach over the dura and decompress across the midline to the contralateral foramen if needed
Surgical Technique

Ipsilateral Screw Placement

- Screw over the guide-wires

Surgical Technique

Rod Insertion
Minimally-Invasive Fusion (MIS TLIF)

Post-Op Protocol

- Patient is discharged within a few hours
- Normal, sedentary activities immediately
- Physical therapy at 3 months if x-rays show fusion
- Full activities following physical therapy
MIS TLIF for Deformity

Case Example: 81 yo F w/ LBP and LLE pain

MIS TLIF for Deformity

Case Example: 81 yo F w/ LBP and LLE pain
Surgical Plan

81 yo F w/ LBP and radicular leg pain

- MIS TLIF from Left at L4-5, L5-S1; from Right at L2-3, L3-4

MIS TLIF for Deformity

Surgical Technique

- Guide-wires placed at Left L2, L4, L5, and S1

- Left L5-S1 decompression and TLIF followed by decompression and TLIF at L4-5
MIS TLIF for Deformity

Surgical Technique

• Screws placed at Left L2, L4, L5, and S1

• Guide-wires placed at Right L2, L3, L4, and S1

• MIS TLIFs from Right at L2-3 and L3-4

• Screws placed at Right L2, L3, L4 and S1
MIS TLIF for Deformity

Surgical Technique
- Rod placed into screws bilaterally

Compression and distraction used for deformity correction
MIS TLIF for Deformity

Surgical Technique

- Final alignment checked with c-arm
MIS TLIF for Deformity

Final Construct

Thank You