MINIMALLY INVASIVE & ENDOSCOPIC SPINE SURGERY
Why Minimally Invasive Spine Surgery?

• A basic tenet of surgery is to effectively treat pathology with minimal disturbance of normal anatomy: leaving “the smallest footprint.”
  - Minimizes tissue trauma, post-operative pain & hospital stay
  - Better cosmesis
MISS-Advantages:

• Reduced post-operative pain
• Tiny scars
• Shorter recovery time
• Shorter hospital stay
• Surgery \(\rightarrow\) Tissue damage

• Tissue Damage \(\rightarrow\) Pain/Function

• MIS \(\rightarrow\) Less Pain/Better Function
• Kawaguchi et al (Spine; 1998): Effect of retraction on back muscles in rats

• Three comparison groups:
  2-hour continuous retraction,
  5-minute retraction release after 1 hour of retraction
  5-minute release at every 40 minutes of retraction.
• Kawaguchi et al (Spine; 1998)
• Histochemical examination at 48hrs, 1 week, 6 weeks
• Serum CPK MM measurement at 48 hrs
• Results: Muscle degeneration max. in group 1
  CPKMM highest in group1
  Regenerated muscle fibres of smallest diameter in group1
• Taylor H et al (Spine; 2002): Impact of self retaining retractors on paraspinal muscles

• Twenty patients; Intramuscular pressure measurement 5, 30, 60 min. into the surgery

• Muscle biopsies before and after retraction studied using ATP birefringence.

• Results:
  
  Significant increase in IMP during retraction
  Reduced function following retraction (decreased ATP)

• Twenty patients; continuous monitoring of IMP & IPP

• VAS, ODI, SF-36 Health survey

• Results:
  
  Rapid/sustained rise in IMP with retraction; IPP → 0
  
  VAS, ODI, SF-36 at 6 months worse with retraction > 60 min; no relation to retractor type, IMP/IPP, surgeon, wound length
• MISS circumvents iatrogenic surgical morbidity decreasing tissue injury and blood loss, and thereby reduce length of hospitalization, perioperative pain, analgesic usage, and recovery times.

• In many cases, MISS has converted simple decompressive operations into outpatient procedures.
  
  Thus capturing the interest of surgeons and patients alike.
Milestones in Spine Surgery

1829 - Lumbar Laminectomy for Discectomy (Smith)
1893 - Lumbar Laminectomy for Stenosis (Lane)
1911 - Lumbar Fusion (Albee, Hibbs)
1925 - Cervical Laminectomy for Discectomy (Elsberg)
1933 - Anterior Lumbar Interbody Fusion – ALIF (Burns)
1939 - Internal Spine Fixation (Hadra)
1952 - Posterior Lumbar Interbody Fusion – PLIF (Cloward)
1955 - ACDF (Robinson)
1958 - ACDF (Cloward)
1966 - Lumbar Artificial Disc Replacement – ADR (Fernstrom)
1967 - Lumbar Microdisectomy (Yasargil)
1982 - Transforaminal Interbody Fusion – TLIF (Harms)
1983 - Thoracic Discectomy (Benjamin)
1969 - Chymopapain Chemonucleolysis (Smith)
1975 - Percutaneous Nucleotomy (Hijikata)
1982 - Percutaneous Pedicle Screws (Magerl)
1984 - Laser Percutaneous Discectomy-LPD (Ascher)
1985 - Automated Percutaneous Lumbar Discectomy-APLD (Maroon, Onik)
1987 - Lumbar Arthroscopic Discectomy (Kambin)
1987 - Vertebroplasty (Galibert)
1991 - Laparoscopic Anterior Lumbar Discectomy (Obенchen)
1993 - Percutaneous Facet Fusion (Wang)
1994 - MIS-Thoracic Discectomy (Horowitz)
1995 - MIS-ALIF (Mathews, Zucherman,)
1997 - Microendoscopic Discectomy – MED (Foley)
1998 - Lateral Transpsoas Approach-DLIF,XLIF (McAfee, Pimenta)
1999 - MIS-Cspine-Odontoid Screw Placement (Horgan)
2000 - Intradiscal Electrothermy-IDET (Saul)
2000 - MIS-Cervical Laminoforaminory (Roh)
2000 - Kyphoplasty (Wong)
2001 - Sextant Percutaneous Pedicle Screw System (Foley)
2002 - MIS-Lumbar Lamineotomy for Stenosis (Guiot, Khoo, Palmer)
2002 - MIS-PLIF (Khoo)
2003 - Tubular Discectomy using Microscope-METRX (Foley)
2004 - Transaxial Approach (Cragg)
2004 - MIS-Cervical Laminoplasty (Perez-Cruet)
2006 - Interspinous Device-XSTOP (Kondrashov)
2006 - MIS-TLIF (Holly)
2008 - MIS-ACDF (Ruetten)
2008 - MIS-Cervical Nucleoplasty (Li)
Types of Spinal Minimally Invasive Procedures

- Minimally invasive procedures and technologies can be broadly characterized as:
- Traditional open procedures through small incisions (open microdiscectomy),
- Endoscopy (thoracic/lumbar discectomy, deformity management, and trauma management),
- Tubular retractor–muscle dilation (MED, METRx, XLIF, Sextant, Mantis, and Longitude),
- Fine needle procedures (chemonucleolysis, nucleotome procedures, vertebroplasty, and kyphoplasty), and
- Miscellaneous technologies (laser-assisted percutaneous discectomy, X-STOP, and AxiaLIF).
Keys to MISS

• Smaller incisions

• Muscle splitting instead of muscle cutting

• Fluoroscopic and image-guided navigation
MISS-Lumbar Spine Disease

- MI Discectomy
- Anterior Lumbar Interbody Fusion (ALIF)
- Posterior Lumbar Interbody Fusion (PLIF)
- Transforaminal Lumbar Interbody Fusion
- eXtreme Lateral Interbody Fusion
- AxialIF for Degenerative L4-S1 Disc Disease
- Kyphoplasty/Vertebroplasty
Retractor Systems

- METRx
- MIRA
- AccuVision Minimally Invasive spine System
- NAPA Minimally Invasive Retractor System
- Serengeti Retractor System
- Luxor Minimally Invasive Retractor System
Microlumbar discectomy

- Entry point is through the interlaminar window
- Microscope provides better visualization
Microlumbar discectomy

Indications:
- Single level disc herniation
- Adjacent bisegmental herniation
- Dessicated disc with bony root entrapment/
lateral canal stenosis

Contraindications:
- Spinal canal stenosis
- > 2 level disc
- Bony bridging of interlaminar space
Microendoscopic discectomy

• First developed in 1997
• Muscle splitting approach with serial tubular dilators
• Tubular retractor and special endoscope used to perform discectomy
MED-Advantages

• It reduces tissue trauma, less traumatic than standard microdiscectomy
• Integral visualization and illumination of the operative field through the endoscope
• Allows direct visualization of the nerve root and disc disease, and
• Enables bony decompression.
MED-Limitations

• There is a learning curve to using the system efficiently and safely
• Complications like dural tear, if occur can be difficult to repair
• Delicate instruments with risk of instrument failure
MED vs Open Lumbar discectomy

- Righesso O et al (Neurosurgery; 2007)
- Randomized controlled trial
- 40 patients with sciatica/lumbar disc disease; 24 months follow-up
- Statistically significant variables amongst many studied:
  - Length of incision: Greater in OD
  - Length of hospital stay: Greater in OD
  - Operative time: Greater in MED
MISS-Degenerative Disease of Spine

• Advances in imaging, instrumentation, bone graft substitutes have allowed development of MISS

• Much of the developmental trends in MISS and in spine surgery in general have been driven by the challenge of achieving arthrodesis in the lumbar spine.
MISS-Degenerative Disease of Spine

• The chronology of open techniques for accessing the disc space
  
  1933: Burns-ALIF
  1952: Cloward-PLIF
  1966:Fernstrom ADR
  1982: Harms & Rolinger-TLIF
• 1991: Obenchain- Anterior laparoscopic disc removal
• 2002: Khoo- First MIS–PLIF procedure
• 2006,:Holly and Schwender MISTLIFs using tubular retractors.
• 2008: Park & Foley- Percutaneous reduction screws (CD Horizon Sextant, Medtronic, Inc.) along with PEEK interbody spacers to perform MISTLIF procedure in patients with Grades I and II isthmic spondylolisthesis.
Minimally Invasive Percutaneous Posterior Lumbar Interbody Fusion
Sextant System

**Sextant**- An instrument used to measure the altitude of an object above horizon
The scale has a length of 1/6 of a full circle

**Principle:** Any two points in proximity can be considered part of a circle
Anterior Lumbar Interbody Fusion

• Iatrogenic trauma- the main contributor to complications and morbidity associated with open anterior approach to the lumbar spine and lumbosacral junction

• The application of microsurgical principles and philosophy could overcome these technique-associated disadvantages.
Anterior Lumbar Interbody Fusion

- Retroperitoneal microsurgical approach (L2-3, L3-4, L4-5)
Anterior Lumbar Interbody Fusion

• Midline microsurgical approach to L5-S1
Anterior Lumbar Interbody Fusion

  20% reduction in operative time
  50% reduction in blood loss
No significant difference in clinical outcome & complication rates
eXtreme Lateral Interbody Fusion-XLIF

- Retroperitoneal approach
- Lateral flank incision
- Microscope/Endoscope
eXtreme Lateral Interbody Fusion-XLIF

- Patient starts walking within few hours
- Discharged after 24 hours
- Rapid return to normal activity, within weeks rather than months
eXtreme Lateral Interbody Fusion-XLIF

• XLIF can be performed for a variety of conditions:
  • Degenerative disc disease,
  • Recurrent disc herniation,
  • Spondylolisthesis,
  • Pseudoarthrosis, osteomyelitis/discitis, and post-laminectomy syndrome.
  • Anterior and lateral tumors of the thoracolumbar spine
  • Debilitating spinal deformity (scoliosis).
eXtreme Lateral Interbody Fusion-XLIF

• Patient selection is important –

Severe canal stenosis secondary to facet hypertrophy &
Dorsal compressive disease require posterior approach
AxiaLIF

- Developed by Cragg, 2004
- Safe, reproducible, pre-sacral approach
- Minimally invasive access
AxiaLIF

- Soft-tissue sparing
- Annulus remains intact
- Restoration of disc height
- Immediate rigid segmental fixation and stability of L4-S1
- Virgin corridor for a previously operated segment
- Enables fusion of L5-S1 without removing implants from rostral previously implanted segment
AxiaLIF-Complications

• Hemorrhage
• Bowel Perforation
• Infection
• Hardware failure
Vertebroplasty/Kyphoplasty

- An image-guided, minimally invasive, non-surgical therapy used to strengthen a broken vertebra
- Indications:
  - Pain caused by osteoporotic compression fractures.
  - Pain caused by fractures due to vascular malformations.
  - Pain caused by fractures due to tumors, which have invaded the vertebral body
Vertebroplasty/Kyphoplasty

• Contraindications:
• Recent systemic/spinal infection
• Uncorrected bleeding diathesis
• Insufficient cardiopulmonary health
• Fracture related canal compromise with myelopathy/radiculopathy
Vertebroplasty-Complications

- Incidence :< 10%
  - Increased pain,
  - Radiculopathies,
  - Cord compression,
  - Infection,
  - Rib fracture,
  - Adjacent level vertebral body collapse,
  - Venous embolism
  - Cement migration(radiculopathy-4%;cord compression-0.5%)
Vertebroplasty-Complications

• Cement migration can be prevented by partial filling of VB(<30% by vol of VB)
• Liebschner et al (Spine; 2001)- Only 15% volume fraction is needed to restore stiffness to predamaged levels.
Video Assisted Thoracoscopic Surgery

• Indications:
  - Disc herniation
  - Sympathectomy
  - Vertebral biopsy
  - Vertebrectomy
  - Bone graft/instrumentation
  - Anterior release for spinal deformity correction
VATS-Surgical approach

• Side selection:
  Lateralization of pathology
  Eccentric placement of aorta

• Anaesthesia:
  Single lung ventilation/bronchial blockers
VATS-Surgical approach

• Position: Lateral decubitus
• Port placement:
  Reverse L pattern
  10mm (3-18mm); 3-4 portals
  First port - Anterior axillary line 6th/7th ICS.
  One port caudal & another rostral central to the area of interest
VATS-Thoracic Discectomy

- VATS vs Open Thoracotomy
VATS-Thoracic Discectomy

• Thoracoscopy Vs Costotransversectomy (CT) & Open thoracotomy for thoracic discectomy

*Rosenthal & Dickman (1999):*

Fresh neurological deficits - None in thoracoscopy & thoracotomy group; 7% in CT group

Intercostal neuralgia -
Thoracoscopy-16%; CT-20%; Thoracotomy -50%
VATS-Thoracic Discectomy

• One hour reduction in operative time
• 50% reduction in blood loss, narcotic use & hospital length of stay
• Neurological improvement-27/36 (myelopathy); 19/19 (radiculopathy)
• Neurological stabilization in all