Concept

- Patients prefer techniques to reduce recovery time and provide COSMETIC benefit

- Basic principle of surgery is to restrict iatrogenic trauma done to a patient during surgery to a minimum
“MIS” Surgery

- Either the “access surgery” or the “target surgery” can be minimally invasive.

- The majority of minimally invasive techniques in spine surgery refer to the access and not to what is done in the target region.

Principles of MISS

- The surgical route to the target area should be the least traumatic
  - Follow anatomical pathways for approach
  - If not possible for the entire approach (skin–target distance), minimize collateral damage to surrounding tissues.
  - If collateral damage cannot be avoided, it should be reparable
    - negligible effect on the clinical outcome.

Cardinal Rule

- Adequate exposure!!!

  - The target (e.g., disc herniation, site of stenosis) should be clearly visible and identified.

  - The target treatment must be possible without any restrictions due to the small approach.
Spine Pathologies

- Infection
- Tumor
- Trauma
- Deformity
- Degenerative

Surgical Procedures

- Decompression

- Microdiscectomy
  - Standard microdiscectomy, Endoscopic microdiscectomy, Laser discectomy?

- Fusion
  - Posterolateral fusion versus Interbody
  - Instrumentation techniques

- Artificial Disc replacement

Minimally Invasive Spine Surgery

- MISS has been influenced by advances in
  - Magnification of visual fields
  - Image guidance systems
  - Endoscopy
  - Lasers
The primary minimally invasive procedures for the treatment of lumbar disc disease are:
- Chemonucleosis
- Laser microdiscectomy
- Intradiscal electrothermy
- Microdecompression
- Microdiscectomy
- Endoscopic Discectomy
Chemonucleosis

- Percutaneous use of chymopapain to enzymatically dissolve the nucleus pulposus
- Reported success and low morbidity of the procedure

Chemonucleosis

- Mechanism of action
  - Depolymerizes the proteoglycan and glycoprotein macromolecules of the nucleus pulposus
  - Depletion of the high water disc
  - Reductions in intervertebral disc height and disc bulge.

- Chymopapain may also act by reducing the inflammatory response in the affected nerve root

Indications

- Patients with
  - Radicular symptoms
  - Radiological studies confirming a herniated soft disc
  - Failure of conservative nonsurgical treatment.
  - Age more than 60 years of age may not due well
  - Lack sufficient mucoprotein for hydrolysis of the herniated disc.
Chemonucleosis

- Efficacy of chemonucleolysis?
  - Reported to be 74%-77% in double blinded, and retrospective studies

Chemonucleosis

- Why is this procedure not popular?
  - Reputation of chemonucleolysis in the U.S. severely damaged, because of the severity of the complications (<1%)
    - Anaphylaxis
    - Transverse Myelitis
    - Cauda equina

Chemonucleosis

- Why has this procedure not become popular
  - Procedure vs Pathology
Laser Discectomy

- Began in 1986 in Graz, Austria.
  - Peter Ascher MD, Daniel Choy MD.
    - A neodymium:yttrium-aluminum garnet, (Nd:YAG), 1.06-m laser via a 400-nm fiber
    - 18-gauge needle


Laser Discectomy

- Percutaneous laser discectomy
  - an outpatient procedure
  - requiring percutaneous placement of a single needle in the disc space.

Laser Discectomy

- Mechanism of action of the proposed efficacy
  - a reduction in intradiscal pressure.
Laser Discectomy

- With fluoroscopic verification of the level and placement of the needle, laser energy is passed into the disc space.
- The laser energy is transmitted in short bursts, to avoid excessive heating of the adjacent tissue.

Laser Discectomy Patient Selection

- Appropriate for patients with
  - contained disc herniations associated with radicular symptoms.
- Not indicated for patients with
  - uncontained disc extrusions
  - disc fragments outside the disc space.

Laser Discectomy Complications:

- Bowel necrosis, requiring resection, due to perforation of the anterior annulus.
- Nerve root complications.
- Discitis
  - In a series of 333 procedures, described by Choy
Laser Discectomy

- Theoretical complications:
  - Perforation of the
    - Aorta
    - vena cava
    - iliac vessels,
    - abdominal contents
  - Cauda equina syndrome.

Laser Discectomy

A Good Procedure?

- No controlled prospective studies have been performed
- Results in cases involving back and leg pain with disc protrusions are still unclear.
- Controversial!!!

Laser Discectomy

- In 1992 reviewed their results for 333 patients, with follow-up periods of up to 62 months
  - Good to fair responses in 261 patients (78.4%)
  - Poor responses for 72 (21.6%).

Laser Discectomy

- Why has this procedures not become popular?
  - Procedure vs Pathology

Intradiscal electrotherapy (IDET)

- Radiofrequency lesioning:
  - Therapeutically designed to treat internal disc disruption.
    - Painful disc due to development of radial fissures extending into the outer one-third of the annulus fibrosis.

IDET

- Radiofrequency lesioning:
  - Involves percutaneously threading a flexible heating electrode into the disc
  - Electrode passes circumferentially around the inner surface of the disc.
IDET

Produces pain relief via two different mechanisms:

- Thermal coagulation of nociceptors
- Contraction of collagen Type I fibers, increasing the stability of the disc.

IDET Patient Selection

- IDET is intended for psychologically stable motivated patients with chronic function-limiting low back pain
- documented discogenic source of pain
- failed to an aggressive exercise-based rehabilitation program.
**IDET vs Fusion**

- Back Pain
  - Recent RCT demonstrated pain improvement of only 30% in 60% of cases


**IDET**

- Why has this procedure not become popular?
  - **Procedure vs Pathology**

**Minimally Invasive Surgery**

- Why have these procedures not become popular?
Minimally Invasive Surgery

- Why have these procedures not become popular?
  - paucity of long-term results
  - potential
  - complication rates
  - learning curve.

Indications

- Laser discectomy
  - No application in cases with extruded or sequestered fragments
  - Limited patient selection

Indications

- Although percutaneous techniques have reported to yield high success rates
  - to date no studies has shown any of these techniques to be superior to microsurgical discectomy.
Minimally Invasive Surgery

- Endoscopic Discectomy vs Standard Microdiscectomy
  - Similar skin incision
  - Muscle-splitting rather than subperiosteal approach to the lamina
  - Similar postoperative pain
  - Similar hospital discharge
  - Similar return to employment

Microsurgical Discectomy

- "Microsurgical discectomy"
  - Removal of herniated parts of intervertebral disc material through a posterior approach
    - with the use of a surgical microscope and microsurgical instruments.

Microsurgical Discectomy

- Indications
  - Disc herniations of all kinds associated with lateral or central spinal stenosis
  - Medial, paramedian, intra- and extraforaminal herniations

- Contraindications
  - None
**Microsurgical Discectomy 280**

- 11 retrospective clinical studies performed 1977-1993 (n = 3,543 patients)
  - Clinical success rates of microdiscectomy between 76% and 100%
    - F/u 6 months and 5.5 years

**Endoscopic versus Open Microdiscectomy**

- Surgeon Preference
- Marketing!!
Minimally Invasive Lumbar Decompression

- Wide laminectomies
  - Still are considered to be the treatment of choice in degenerative spinal stenosis without instability

- "Less-invasive" approaches
  - Due to the risk of destabilization of the motion segment


Minimally Invasive Lumbar Decompression

- Advantages:
  - Decreased trauma to paravertebral muscles on the ipsilateral side
  - Minimal trauma to paravertebral muscles on contralateral side.
  - Bilateral decompression of the spinal canal through a unilateral approach.

Minimally Invasive Lumbar Decompression

- Advantages:
  - Preservation of facet joint of the contralateral side
  - Preserves the posterior tension band, spinous processes and paraspinal muscles on the contralateral side.
Minimally Invasive Lumbar Decompression

Indications:
- Uni- or bilateral symptoms in the legs
  - Weakness or heaviness in the lower extremities particularly when walking.
- Sensory deficits or paresthesias
- The symptoms usually get better when the patient stops walking, or leans over “shopping cart sign.”

The MILD® Procedure

- New method of spinal decompression
- Less invasive approach
- Performed through a single 6 gauge portal site utilizing a stab wound incision
  - less patient trauma
  - increased potential for a rapid recovery time

Inherent disadvantages:
- Small field of vision
  - danger of creating indirect lesions to nerves of blood vessels
- Training (learning by doing) necessary for surgeons who are not educated in microsurgery
Minimally Invasive Lumbar Decompression
The MILD® Procedure

- Advantages:
  - conducted under a combination of local anesthetic and monitored anesthesia care (MAC),
  - Short hospital stay
    - Same day discharge home following a short period of observation.

- Indications:
  - Patients with central canal lumbar stenosis suffering from symptoms of claudication having failed conservative management

- Contraindications
  - disc procedures
  - not intended to be used near the lateral neural elements.
    - Lateral recess stenosis

- Technique
  - Epidurogram utilizing a myelographically compatible contrast.
    - Fluoroscopically confirmed
  - Guiding portal and inner trocar percutaneously inserted at the inferior lumbar segment and lateral to the spinous process margin
Minimally Invasive Lumbar Decompression
The MILD® Procedure

- Technique
  - Trocar secured against the skin
  - Decompression performed with specialized instruments
    - Confirmed through repeat epidurogram with changes in contrast flow

Minimally Invasive Lumbar Decompression
The MILD® Procedure

- New Image-Guided Ultra-Minimally Invasive Lumbar Decompression Method: The mild® Procedure
  - TR Deer MD, L Kapural MD. Pain Physician 2010; 13:35-41. ISSN 1533-3159
  - Observational Study

Minimally Invasive Lumbar Decompression
The MILD® Procedure

- 14 treating physicians in 9 states
  - 90 consecutive patients who underwent the mild procedure

- Results
  - No complications
  - No adverse events
Minimally Invasive Lumbar Decompression
The MILD® Procedure

- MiDAS I (Mild Decompression Alternative to Open Surgery): a preliminary report of a prospective, multicenter clinical study.

Minimally Invasive Lumbar Decompression
The MILD® Procedure

- MiDAS I
  - Cohort of 78 patients treated
  - no major device or procedure related complications
    - dural tears, nerve root injury, hematomas, and infections.

Minimally Invasive Lumbar Decompression
The MILD® Procedure

- MiDAS I
  - 6 weeks follow-up
    - Significant improvements in all clinical outcomes:
      - VAS pain score (p<0.0001)
      - ODI functional mobility (p<0.0001)
      - ZCQ pain and function (p<0.001)
      - SF-12v2® quality of life physical and mental component scores.
Minimally Invasive Lumbar Decompression
The MILD® Procedure

- Reservations
  - paucity of long-term results
  - potential of complication rates
  - learning curve.

INDICATIONS

- MILD
  - Limited ability to address other pathology frequently encountered
  - lateral recess
  - foraminal stenosis
  - Hypertrophy ligamentum flavum
  - osteophytes

Expanded Applications

- Fusion (PLF, TLIF, ALIF, ILIF)
- Instrumentation (percutaneous, fluoro, o-arm)
- Artificial Disc Replacement
- Nucleus Replacement
Interbody Techniques

Image Guidance

Radiation Exposure!!!

- Fluoroscopically assisted thoracolumbar pedicle screw placement
- exposes the spine surgeon to significantly greater radiation levels than other, nonspinal musculoskeletal procedures
- Dose rates are up to 10-12 times greater.

Image-Guided Assistance: Answer to Exposure?

- Use of image-guided systems for pedicle screw placement has improved placement accuracy.
- The system relies on precise localization of the pedicles with computed tomography.

Image Guidance Systems

[Image of image guidance system]

http://www.sentara.com/HospitalsFacilities/Hospitals/BeachGeneral/Pages/OrangeSystem.aspx
<table>
<thead>
<tr>
<th>Diagnostic Procedure</th>
<th>Typical Effective Dose (mSv)</th>
<th>Number of Chest X rays (PA film) for Equivalent Effective Dose</th>
<th>Time Period for Equivalent Effective Dose from Natural Background Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x ray (PA film)</td>
<td>0.02</td>
<td>1</td>
<td>2.4 days</td>
</tr>
<tr>
<td>Skull x ray</td>
<td>0.1</td>
<td>5</td>
<td>12 days</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>1.5</td>
<td>75</td>
<td>682 days</td>
</tr>
<tr>
<td>I.V. urogram</td>
<td>3</td>
<td>150</td>
<td>1.0 year</td>
</tr>
<tr>
<td>Upper G.I. exam</td>
<td>6</td>
<td>300</td>
<td>2.0 years</td>
</tr>
<tr>
<td>Barium enema</td>
<td>8</td>
<td>400</td>
<td>2.7 years</td>
</tr>
<tr>
<td>CT head</td>
<td>2</td>
<td>100</td>
<td>243 days</td>
</tr>
<tr>
<td>CT abdomen</td>
<td>8</td>
<td>400</td>
<td>2.7 years</td>
</tr>
</tbody>
</table>
Artificial Disc Replacement

Future Strategies

- Nucleus Reconstruction by Autologous Chondrocyte Transplantation
- Autologous Disc Chondrocyte Transplantation
- Minimally Invasive Nucleus Pulposus Replacement

MIS Surgery

- Microsurgical and endoscopic surgical techniques have improved.
  - Results are now more reliable and predictable.

- "Semi/ultra minimally-invasive" techniques
  - mainly for the treatment of low back pain,
  - Evidence-based data concerning efficacy is lacking
MIS Surgery
- Total disc replacement
  - innovative implants are being tested in various clinical studies
  - Short-term results have been promising
- Biologic regeneration strategies
  - Autologous percutaneous disc chondrocyte
  - Stem cell therapy???

Minimally Invasive Surgery
- The 3 P's of success:
  - Pathology dependent
  - Patient dependent
  - Procedure
- Surgeon familiarity
- RESULT dependent!!!!