My 17 Year Clinical Experience in Evolving Minimally Invasive Spine Surgery (MISS)

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“Saludos desde CSI”

你好
Kính Mội
“Bonjour”

“Buenos Dias”
“Guten Tag!”

“Konnichi wa”

“Ciao”

안녕하세요.

Calif. Center for Minimally Invasive Spine Surgery
Overview:

1. MISS being **disruptive technology** with **dilatation technology** e.g. microdecompressive endoscopic lumbar discectomy

2. MISS with limited visualization requires **GPS** for navigation and **advancement of bio-technology**

3. **DOR** facilitates MISS with “**digital technology convergence and control**” (SurgMatix US Patent)

4. **Patient centric IOM** to provide **surgical safety** and prevent undue neuro trauma

5. **Precise** and clever functioning **MISS spinal instruments**

6. **Education, technology training, surgical anatomy, hands on training, meticulous imaging and preoperative planning** further MISS
Introduction:

What is Minimally Invasive Spine Surgery (MISS)?

- Surgery is trending toward minimally invasive surgery worldwide including spine surgery
- Advancements in instrumentation, fiber optics, laser technology, fluoroscopic imaging, high resolution video imaging endoscopy, along with the accumulated experience in endoscopic laser spine surgery made MISS possible
- MISS requires more precise, delicate and effective method for spinal decompression
- MISS does not de-stabilize the vertebral segments
- Can safely treat multiple level symptomatic spinal discs, spinal stenosis and high risk spinal patients
Introduction:

- Endoscopic **MISS is a technologically dependent surgery**, requiring utilization of advanced endoscopic surgical instruments, imaging-video technology and tissue modulation technology, in a digital operating room (DOR)

- It requires **seamless connectivity** and **control** to perform the surgical procedures in a precisely orchestrated manner.

- Therefore a new integrated **technological convergence and control system (SECS)** *SurgMatix*® *(US Patent)* was created by myself and Professor HK Huang, USC MC to facilitate MISS

- This system **facilitates** MISS with “**organized control instead of organized chaos**” in an endoscopic DOR suite and **enables a safer, precise and more effective surgery**
Surgical Indication for MISS
Introduction:

Herniated Spinal (lumbar) Discs Causing Nerve Impingement - Radiculopathy

- If conservative treatment fails, and continue to have persistent significant symptoms affecting their daily activities and ability to work this can lead to the need for surgical decompression of the disc.

- In the past, the only method was open traumatic lumbar surgery with cutting of the muscle, bone and the disc, and even spinal fusion, which are associated with long periods of recovery, wound healing, blood loss, hospitalization, and others.
MISS Surgical Indications:

- **Herniated discs**/degenerative spine disease
- **Post fusion Junctional Disc Herniation Syndrome** (JDHS) or Adjacent Segment Disease (ASD)
- **Vertebral compression fracture** (Osteoporotic and post-traumatic)
MISS Surgical Indications:

Symptomatic lumbar post fusion disc herniation

- Lumbar post fusion Junctional Disc Herniation Syndrome (JDHS) or Adjacent Segment Disease (ASD)
- JDHS - large L3-4 disc herniation into right lateral recess and neural foramen of 8mm in size
MISS Surgical Indications:

For treatment of:

- **Lumbar spinal stenosis** and spondylolisthesis
- **Cervicogenic headache** and discogenic pain
- **Intraspinal lesions**
  - Synovial cyst and degenerative cyst
  - Intraspinal tumor, lipoma
- Others
Challenges Facing Traditional - Current Open Spine Surgery/Fusion
Challenges Confronting Open Traditional Spine Surgery/Fusion, Spinal Arthroplasty and Disc Replacement

- **Obvious challenges:**
  - **Larger surgical incision** – longer healing time
  - **More traumatic** than MISS and more **blood loss**
  - Often is performed under **general anesthesia**
  - **Higher risk** and **complication** rate
  - **Long** and **painful recovery** time
  - **Higher long term complication rate** including post fusion junctional disc herniation syndrome (JDHS 19-49% after 4-5 years)
  - Alarming high rate of "failed back syndrome"
  - **Long term benefit** and outcome in question by numerous studies published
  - **Disc replacement technology/arthroplasty** is **yet to be proven** – only time will tell (another 8-15 years)
  - **More difficult** in **high risk patients** with morbid obesity, cardiac pulmonary disease, advanced diabetes, elderly
  - **Affecting spinal segmental motion**
Logical Evolution of Spine Surgery

Endoscopic and other MISS
Logical Algorithm for Spine Care:

The modern concept - algorithm of spine care like walking up a staircase

For treatment of degenerative and herniated spinal discs, and spinal stenosis

Conservative Treatment

Pain Management Injectional Therapy and RF

MISS and NFT

Minimally Invasive (Laser) Spinal Surgery

Spinal Arthroplasty Disc Replacement Artificial Disc

The last resort

Open Spinal Surgery Fusion

Maybe
Advantages of MISS

Obvious advantages of Endoscopic MISS:

- An out patient or "same day surgery", no hospitalization
- Less traumatic
- Small or tiny incision
- Costs less - approximately 40% less than a open spinal surgery/fusion
- Economic savings for the employee and employer are significant due to earlier return to work
- Done under local anesthesia except occasional brief general anesthesia
- Early post – op exercise one day after surgery
- Surgical triad approach and critical "fan-sweep maneuver" further facilitate the disc decompression and improves surgical result
- Multiple level spinal discectomy can be performed at one sitting with minimal risk
- Can be done for high risk anesthesia patients with morbid obesity, emphysema, and cardiac conditions under local anesthesia/IV sedation at much less risk
- Intra-operative neurophysiological/EMG monitoring, and direct visualized endoscopic significantly reduces the chance of inadvertent injury of neural structure
- Preserves spinal motion

Obviously “less is better – less is more” for MISS
MISS Surgical Procedure:

Preparing for MISS – Anesthesia
(requiring technological monitoring and precision)

- Anesthesia: Local/IV conscious Sedation
- Intra-operative neurophysiological monitoring (IOM), – EEG, EMG of vital signs (pulse rate, BP, RR), pulse oxymetry CO₂ content, on intra-operative wave form display/monitor
- To insure safety and to facilitate MISS
Types of MISS
(Requiring precision, navigation and monitoring)
LUMBAR ENDOSCOPIC MISS TECHNIQUE:

Posterio-lateral and posterio–median surgical approaches

- Patient **positioning and localization**
  - Patient in **prone** position
  - Or in lateral **decubitus** position
  - Localization – **skin marking** for **portal of entry** and placement of needle
  - Under **fluoroscopic guidance**
Lumbar Endoscopic MISS Technique:

Localization of skin incision and portal of entry
Provocative discogram

- Under **fluoroscopic guidance**
- Provocative discography **to confirm** the damaged herniated disc
- Point of incision – by placing the “bull’s-eye” target device to determine the portal of entry and skin incision
Surgical Plane/Approach/Technique:

Right posterolateral approach - prone position

for endoscopic lumbar MISS
Surgical Plane/Approach/Technique:

Left lateral decubitus position for right posterolateral endoscopic lumbar MISS
Surgical Plane/Approach/Technique: With GPS

- Extreme obese patient had successful left posterolateral endoscopic lumbar discectomy with application of geometric line/plane and GPS system
Grid Position System (GPS) in Endoscopic Lumbar MISS

Fluoroscopic monitoring to provide safe and precise lumbar spine surgery by using GPS

- Lumbar spine has neuro foramen and intra-lamina foramen openings restricting MISS at a portal of entry
- Critical structures within the foramen – DRG, neural structure
- GPS provides a precise and safe path to reach the lesion and to avoid trauma to the nerve vessels, DRG, dura and even the spinal cord
- The grid – the GPS System – Zones (in A,B,C, D and 1,2,3) provides an accurate navigation map for MISS surgeons
Surgical Instrument and Equipment

Mini Endoscopic Spinal Surgical Instruments for MISS

Close up view

- **Duck bill tubular retractor** with dilator to enter the GPS for lumbar disc surgery to protect **dural** and **neurovascular** injury

- **Under endoscopy and fluoroscopy**, spinal **instruments** of trephine forceps, curette, rasp, knife, discectome, and laser can safely be utilized for MISS surgery and laser thermodiskoplasty
Surgical Instrument and Equipment

• For bony decompression:
  – Round ball tip drill avoids neural and tissue trauma
Surgical Instrument and Equipment

• For lateral lumbar stenosis decompression:
  – With serial progressive drills – with round ball tip drill avoids undue neural and tissue trauma
Surgical Instrument and Equipment

Application of Tissue Modulation Technology in Endoscopic Laser MISS

- Holmium YAG laser equipment for Laser Thermodiskoplasty (LTD)

*Trimedyne*
Holmium YAG laser generator

Right angle (side firing) laser probe
GPS (Grid Position System) for Endoscopic Lumbar MISS

Fluoroscopic/imaging and endoscopy to provide safe and precise lumbar MISS and foraminoplasty
Lumbar Endoscopic MISS Technique: step by step

Fluoroscopic/imaging and endoscopic monitoring to provide safe and precise application of endoscopic microdiscectomy and laser thermodiskoplasty
Lumbar Endoscopic MISS Technique:

Additional advanced MISS surgical instruments

- Small spinal **discectome** for rapid disc removal
Lumbar Endoscopic MISS Technique:

Posterio-lateral approach vs. posterio–median aproach

- **Under fluoroscopy - With dilatation technology**
- Introduction of **dilator** and then a **tubular retractor/working cannula** are passed over the stylette
- **Foraminoplasty** and **decompressive discectomy** performed with trephines, forceps, ronguers, discectome and Holmium laser

(Requiring precision, navigation and monitoring)
Lumbar Endoscopic MISS Technique:

Endolumbar paramedium approach  
(SMART Endo System)

For larger extruded herniated lumbar discs (red arrows)

(Requiring precision, navigation and monitoring)
Illustration Case I Lumbar MIss

26 yo “Extreme Athlete”, Motorcycle, Rally car X-games gold medalist
Severe posttraumatic L4-5 disc herniation
Excellent relief from outpatient endoscopic MIss
Return to rally car racing in two weeks
Illustration Case II
Decompression of Lateral Lumbar Stenosis

Bilateral decompression of lateral lumbar stenosis gives complete relief of severe neurogenic claudication.
Illustration Case III Lumbar MISS
Case Illustration IV
LUMBAR INTERSPINOUS PROCESS/LAMINA SPACER (COFLEX-F) FIXATION

Treatment for Multiple Level Lumbar Spinal Stenosis with Minimally Invasive Spinal Decompression, Coflex-F Fixation, and Lumbar Facet Fusion

- 3 level lumbar stenosis caused by:
  - Disc herniation
  - Anterior offset of L4 over L5 hypertrophy of the ligamentum flavum
  - Neuro-foraminal stenosis

- Successfully treated with MISS microdecompression Coflex-F interspinous spacer/fixation & lumbar facet fusion with relief of neurogenic claudication & correction of stooped posture

59 year old office manager with severe L2-3, L3-4 & L4-5 lumbar stenosis, stooped posture & neurogenic claudication relieved by MISS, Coflex-F fixation & lumbar facet fusion
Severe lumbar stenosis

- 73 yo with severe rapid progressive (in 6 mos.) neurogenic claudication, leaning on grocery cart syndrome
- Successfully treated with microdecompressive discectomy and interspinous spacer Coflex-f with facet fusion
- Able to stand and walk unassisted and straight
CERVICAL ENDOSCOPIC MISS TECHNIQUE:

Illustrated with

Anterior Endoscopic Cervical Microdiscectomy

- **Cervical discectomy** – begins with **anterior medial approach** for needle and stylette insertion into the disc under monitoring (fluoroscopy, EMG) aided by **GPS System**

Cervical GPS
(Requiring precision, navigation and monitoring)
Surgical Indications:

- **Neck with arm pain** (radicular pain) associated with paresthesia, sensory loss, muscle weakness and/or decreased reflexes
- Intractable **cervicogenic headache**
- **Discogenic pain**
- At least **12 weeks** of failed conservative therapy
- **MRI or CT** scan positive for disc herniation
- Positive **EMG** considered helpful
- Positive provocative discogram
- **Multiple discs** can be treated at one sitting
- **Post fusion junctional disc herniation** syndrome
- **Positive 3 legs of bar stool** – symptoms, physical findings, EMG, imaging and provocative discogram
Surgical Indications:

In addition, Post Spinal Fusion - Junctional Disc Herniation Syndrome (JDHS), Adjacent Segment Disease (ASD)

- Post ACF fusion C4 – C6 JDHS
- MRI showing junctional discs at C3-4 and C7-T1
- Anterior endoscopic cervical microdiscectomy (AECD) provides relief
AECD Surgical Instruments and Equipment:

- Endoscopic surgical instruments for AECD
AECD Surgical Instruments and Equipment:

- Advanced endoscopic micro flexible forceps, bone ronguer and navigable dissecting probe
AECD Surgical Instruments and Equipment:

- Advanced anterior cervical endoscopic instruments
AECD Surgical Instruments and Equipment:

- Anterior cervical endoscopic instruments
  - Discectomes, working channel sets
  - Tri-chip digital camera with cervical 6°endoscope and forceps
  - Endoscopic laser fibers and Instruments
- Holmium YAG laser equipment
- Laser Thermodiskoplasty (LTD)
Surgical Procedure/Technique:

- **Instruments for tissue modulation**
- **Percutaneous MIST interventional procedures:**
  - **Injectional,** non ablative and ablative tissue modulation technology, **laser, RF** (radiofrequency), ultrasound, **cryogenic** and others
  - **MISS surgeons should be familiar** with injectional and RF facet denervation procedures and others
  - **MISS surgeons are uniquely suited to perform** these for the care of the spinal pain
Surgical Procedure/Technique:

Injectional and tissue modulation technology, RF treatment for:

- **Selective nerve blocks**, epidural block and cervical sympathetic nerve block
- **Facet** arthralgia (medial branch of posterior primary rami)
- **Spinal discogenic** pain (related to sinu-vertebral nerve)
- **Cervicogenic** headache
Intraoperative Neurophysiological Monitoring - IOM

- **Trend of spinal surgery** is toward less or minimally invasive spine surgery (MISS)
- MISS aims at being less traumatic, with less morbidity and improved surgical outcome
- The **obvious challenge** of MISS is **limited visualization and exposure** of the relevant anatomy in spite of fluoroscopy and endoscopy to work with, and potentially placing the **relevant neural** structures at **increased risk** of trauma
- **INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING (IOM)** of neural structure, direct visualization with fluoroscopy and endoscopy creates safer endoscopic MISS procedures
- **Spontaneous EMG monitoring**, at times SSEP and MEP can provide the surgeon with useful feedback to avoid neural trauma during MISS
- Intra-operative **surface EEG/neurophysiological monitoring optimizes the anesthesia** for MISS
AECD Surgical Technique:

- **Small** 3mm skin incision
- The *spinal needle* with *a thin stylette* is introduced into the *center of the disk*
- Under *fluoroscopy*
- Provocative *discogram* is often done first
- The working *cannula/dilator* are passed over the stylette gently *(dilatation technology)*
- *Mechanical microdecompressive discectomy* to follow
- Completed with *laser thermodiskoplasty (LTD)* to shrink and to tighten the disc besides sinu-vertebral denervation
AECD Surgical Technique:

Endoscopic/fluoroscopic/imaging monitoring to provide safe and precise application of aggressive micro grasper forceps, drill, curette, discectome, and bony ronguer for microdecompression.
AECD Surgical Technique:

Cervical Foraminoplasty
Cervical Foraminal Decompression for Foraminal Disc and Stenosis

- Mechanical decompressive discectomy foraminoplasty for osteophytes/stenosis under fluoroscopy, endoscopy and IOM
AECD Surgical Technique:

Endoscopic Microdiscectomy – Laser Thermodiskoplasty (LTD)

- Mechanical *microdecompressive discectomy*
- Herniated disc *fragment removal*
- **Laser Thermodiskoplasty** – disc shrinkage and tightening
AECD Surgical Technique:

“Fan Sweep Maneuver”

- For maneuvering instrument to precisely increase the area for microdecompressive discectomy
AECD Surgical Technique:

Protocols for laser thermodiskoplasty (LTD)

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<thead>
<tr>
<th>Level</th>
<th>Stage</th>
<th>Watts</th>
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<td>First Stage</td>
<td>8</td>
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<tr>
<td>Cervical</td>
<td>Second Stage</td>
<td>5</td>
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Holmium YAG laser with photo thermal effect and mechanism:

- Absorbed by water
- A pear shaped cavitation bubble formed by vaporization of water molecules, undergoes expansion and collapse - resulting in acoustic and shock wave emission
- Simultaneously a vapor channel is formed that effectively conducts laser energy to the target with a pressure effect
- Continuous cold saline irrigation is necessary
AECD Surgical Technique:

Surgical technique of LTD, fan sweep maneuver and endoscopic views of disc shrinkage

Side fire laser probe in action

“Fan sweep maneuver” of instrument increased disc removal and shrinkage

Laser used to shrink and tighten the disc besides “purse string” of the disc defect
Case Illustrations: Case I

- 44 year old female with increasing intractable neck and upper extremity pain and numbness of fingers, mild spastic gait and weakness of hand grip, mild hyperreflexia, and hypoesthesia
- **AECM** - post operatively rapid improvement and disappearance of all symptoms

Pre operative MRI scan - Large 5 mm herniated C5-6 disc compressing spinal cord with myelopathic changes of the spinal cord
Case Illustration II:

50 yo female under went successful endoscopic microdecompressive cervical discectomy for a large herniated C5-6 disc
Case Illustration III:

English rock star had successful endoscopic cervical discectomy C3-4 with hypoplastic odontoid
Case Illustration IV:

81 yo NS Professor underwent successful laser endoscopic cervical discectomy in spite of transient extreme bradycardia (30), detected, monitored and corrected with atropine in the DOR. Discharged on hour later.

Intra operative monitor shows severe dropping of heart rate.
Due to tight and confined anatomical relationship at thoracic spine of the spinal cord and spinal canal, the use of laminectomy, and various thoracic spinal surgical approaches for the treatment of herniated thoracic discs has been associated with an unacceptable high rate of pulmonary and neurological complications.

(Requiring precision, navigation and monitoring)
Indications for Endoscopic PTD Surgery:

- Intractable **thoracic spinal pain**, numbness and paraesthesia of the chest wall due to **herniated thoracic disc** or other lesions (e.g. intra-spinal cyst, lipoma, osteophytes or tumor)
- Positive **MRI or CT** scan or CT myelogram findings
- At least **12 weeks of failed conservative therapy**
- Positive pre- or intra-op **provocative discogram** and/or pain provocation disc injection test
- **EMG** maybe helpful
- **Positive 3 Legs of bar stool** – symptoms, physical findings and testing (e.g. EMG, imaging and provocative discogram)
Material and Methods:
Demographics of Herniated Thoracic Discs (559)

Level of disc herniation

- T-1: 11%
- T-2: 11%
- T-3: 7%
- T-4: 1%
- T-5: 8%
- T-6: 4%
- T-7: 1%
- T-8: 3%
- T-9: 21%
- T-10: 86%
- T-11: 84%
- T-12: 103%

15%
Material and Methods:

- Since 1996, **448 patients** with **559 herniated thoracic discs** (39 extruded) at T-1 through T-12 had endoscopic PTD with laser thermodiskoplasty

- **Males: 278**
- **Females: 170**
- **Age: average 44.7**
  (16-72)

- Each failed at least 12 weeks of conservative care
Thoracic Endoscopic MISS Technique:

Fluoroscopic/imaging monitoring to provide safe and precise Posterolateral Endoscopic Thoracic Discectomy

- Patient Positioning, localization and portal of entry
  - PETD is performed under local anesthesia and conscious sedation
Thoracic Endoscopic MISS Technique:

GPS (Grid Position System)

Fluoroscopic/imaging monitoring to **insure safe** and **precise endoscopic** thoracic discectomy **via GPS** within the **grid**
Thoracic Endoscopic MISS Technique:

POSTEROLATERAL ENDOSCOPIC THORACIC DISCECTOMY

Herniated Thoracic disc

Disc fragments Removed
Thoracic Endoscopic Technique:

Endoscopic PTD Surgical Instruments

Flexible cutter grasper forceps

Endoscopic flexible dissector
Surgical Procedure/Technique

Endoscopic PTD

- After removal of the needle, a dilator with a working cannula are passed over the stylette
- **Under fluoroscopy endo-microdiscectomy** is performed with mini spinal instruments
Surgical Procedure/Technique:

Endoscopic PTD

- **Under fluoroscopy** and **endoscopy microdiscectomy** is performed with mini spinal instruments
- **Aggressive** trephines, drill, burr and laser application are used for removal of **osteophyte for decompression**
Surgical Procedure/Technique:

Endoscopic PTD

Video Recording

- Microdiscectomy and LTD for disc shrinkage and tightening

Microdiscectomy with micro forceps
Side firing laser probe for LTD
Disc fragment removal
Surgical Procedure/Technique:

Endoscopic PTD

Herniated thoracic disc

Disc fragments Removed

Disc removal under the intercostal nerve
Surgical Procedure/Technique:

Endoscopic PTD

• Surgical technique using Holmium YAG laser, with fan sweep maneuver for disc shrinkage

"Fan sweep maneuver" (25 degree from side to side) of instrument increased disc removal and shrinkage

Laser used to shrink and tighten the disc besides "purse string" of the disc defect
Case Illustration I
Endoscopic PTD for University Student

24 yr old University Student with congenital 13 ribs suffered severe post traumatic T10 & T12 herniated disc symptoms successfully treated with endoscopic PTD

Subsidence of T10 and T11 disc herniation after endoscopic thoracic discectomy
Case Illustration II
Endoscopic PTD for F-22 Fighter Pilot

27yr old F-22 fighter pilot suffered severe T7 herniated disc symptoms as a result of tremendous G-Force at 12 successfully treated with endo-MISS
Discussion

Potential Complications and their Avoidance

Pearls, Tips and Tricks
Potential Complications and their Avoidance:

All potential complications of open approaches are possible for endoscopic MISS, but rare or much less frequent

• **Infection:**
  - Avoided by sterile technique and intraoperative I-V prophylactic antibiotics
  - Aseptic discitis: can be prevented by aiming the laser beam in a “bowtie” fashion to avoid damaging the endplates

• **Hematoma (subcutaneous and deep):**
  - May occur but is minimized by careful technique
  - Not prescribing aspirin or NSAID’s prior to surgery
  - Applying digital pressure or an I-V bag over the operative site after surgery
Potential Complications and their Avoidance:

- **Operating wrong level:**
  - A major complication of all spine surgery
  - Avoided by using digital C-arm fluoroscopy for accurate anatomic localization
  - Provocative discogram verifies level

- **Dural Tear:**
  - Gross dural tear very rare
  - Dural injury evidenced by spinal headache and presumed CSF leak (less than 1%)
  - No surgery required to repair a CSF leak
  - Spinal headache responds to epidural blood patch

3 cases of rare 13 vertebral body ribs can be a problem in counting
Potential Complications and their Avoidance:

Operating wrong level

- Lumbarization of S1 to have L6 Vertebra
- L3, L4 and L5 discectomy can be mistakenly operated at L2, L3 and L4 level
Potential Complications and their Avoidance:

- **Discitis:**
  - Prophylactic antibiotics
  - Continuous irrigation of the interspace
  - Introduction of instruments through a cannula without contact with the skin

- **Aseptic discitis:**
  - Aim the laser in a “bowtie” fashion to avoid damaging the endplates (at 6 and 12 o’clock)
Potential Complications and their Avoidance:

- **Endoscopic Cervical Spine Surgery:**
  - *Esophageal and tracheal injury* avoided by careful surgical technique, identifying and retracting these structures by careful digital palpation
  - Placing a **nasogastric tube** into the esophagus aids in identifying and retracting that structure by palpation
Potential Complications and their Avoidance:

- **Vascular Injury - Cervical:**
  - Extremely rare when care is taken to locate and protect the carotid artery, the vertebral artery in the foramen transversarium laterally, and other vessels
  - No carotid artery injury reported in the US but can occur
  - Avoided with thorough knowledge of surgical anatomy of the neck
  - If carotid arterial pulsation is hard to palpate, it can be augmented by I.V. Ephedrine

Proximity of Endoscopic Instruments – Cutter, Forceps, Trephine, and Burr – to neuro vascular structure
Potential Complications and their Avoidance:

- **Vascular Injury – Thoracic:** extremely rare
  - The thoracic aorta/segmental branches, the intercostal artery and vein, the azygos system of veins are at risk
  - Strict adherence to technique and knowledge of surgical anatomy prevents complication
  - Working in the “safety zone” of the disc, (with interpedicular line medially and rib head laterally) at neuro foramen, to prevent it from penetrating the intercostal nerve and vessels, and the pleura
  - All instrumentation stays confined within the disc interspace and foramen

Surgical approach for endoscopic thoracic discectomy
Potential Complications and their Avoidance:

- **Vascular Injury – Lumbar extremely rare:**
  - Avoiding aorta, vena cava, femoral arteries and veins by accurate placement of all instruments
  - Strict adherence to technique and the applicable foraminal anatomy, and the "triangular working zone"
  - Instruments to be kept within the disc space, foramen and the epidural space under direct endoscopic vision
  - No vascular injury reported since the early experience with percutaneous procedures
Potential Complications and their Avoidance:

Proper patient Positioning and localization of portal of entry

- To facilitate endoscopic spine surgery and avoid potential complications
Potential Complications and their Avoidance:

• **Neural Injury:** extremely rare
  - No spinal cord injuries reported
  - Nerve root and spinal cord injury, though possible, but avoidable
  - With **neurophysiologic monitoring** (EMG/NCV)
  - Root injury avoided by introducing instruments in the “safety zone”
  - And direct **endoscopic visualization**
  - By frequent use of intra-operative **C-arm fluoroscopy**
Potential Complications and their Avoidance:

- **Neural injury continued:**
  - Recurrent laryngeal nerve injury, is extremely rare
  - Postoperatively one case of transient hoarseness (out of 1200 cervical cases)
  - One case with transient hiccup

- **Sympathetic nerve injury:**
  - Rare but can occur from injury to cervical sympathetic and Stellate Ganglions
  - One post-operative transient Horner syndrome or oculo sympathetic dysfunction occurred
Potential Complications and their Avoidance:

- **Dorsal Root Ganglion Injury:**
  - A common complication for posterior lateral lumbar approach with dysesthesia (mostly transient, permanent less than 1%)
  - Careful endoscopic technique and knowledge of foraminal anatomy
  - C-arm fluoroscopic monitoring
  - Using cannulae and endoscope that fit the foramen
  - Careful using laser in the foraminal area

Lumbar laser foraminoplasty with steerable spinoscope with proximity to dorsal lumbar root ganglion
Potential Complications and their Avoidance:

- Excessive sedation:
  - Continuous conscious EEG monitoring with the new computerized SNAP™ monitoring (SNAP index) improves anesthesia and reduces drug requirement
  - Local anesthesia with conscious sedation provides a responsive patient to facilitate endoscopic MISS and prevents potential complications

Surface EEG monitoring (SNAP™)
Potential Complications and their Avoidance With IOM:

- **Trend of spinal surgery** is toward less or minimally invasive spine surgery (MISS)
- MISS aims at being less traumatic, with less morbidity and improved surgical outcome
- The **obvious challenge** of MISS is limited visualization and exposure of the relevant anatomy in spite of fluoroscopy and endoscopy to work with, and potentially placing the relevant neural structures at increased risk of trauma
- **INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING (IOM)** of neural structure, direct visualization with fluoroscopy and endoscopy creates safer endoscopic MISS procedures
- **Spontaneous EMG monitoring**, at times SSEP and MEP can provide the surgeon with useful feedback to avoid neural trauma during MISS
- Intra-operative **surface EEG/neurophysiological monitoring** optimizes the anesthesia for MISS
Potential Complications and their Avoidance:

- **Pneumothorax**: potential complication for all approaches to thoracic discs
  - Introduction of the micro instruments through the “safety zone” as described previously prevents complication
  - Chest x-ray is obtained immediately after completing the operation to rule out pneumothorax

*Posteriorlateral Endoscopic Thoracic Discectomy*

*Endoscopic Instruments and Intercostal Nerve*
Potential Complications and their Avoidance:

- **Bowel and ureteral injuries:** extremely rare
  - Ureteral injuries not reported with MISS
  - Bowel perforation in the early experience with percutaneous lumbar discectomy
  - None in recent multiple center study of 32,100 cases
  - Knowledge of the surgical anatomy avoids potential complications
Digital Technology in the DOR
(SurgMatix®)
Surgical ePR Control System (SECS)

- To facilitate and to avoid potential risks and complications in MISS

- The Surgical ePR Control System (SECS) (SurgMatix®) being patient transparent provides a complete clinical picture with live “real time” data of a patient in a DOR it consolidates key clinical and surgical data which can be instantly accessed and viewed.

- This patient centric system enhances and improves the quality and safety of patient care, and provides significant data for clinical analysis, education, training, further development of MISS.
 Goals of SurgMatix® SECS integration system to facilitate and control MISS

- Provides a **complete picture** of the patient’s medical history and status by consolidating data from multiple IT and OR systems – **patient transparent**
- **Improves patient safety** by converging pre-op, intra-op and post-op data and OR control – **patient centric**
- Offers a complete “**real-time**” picture of the patient’s medical status, including vital signs, wave form and biosensor data
- Promotes **workflow efficiency** in the DOR, reducing personnel and other costs, leading to a significant economic saving in an “organized control instead of an organized chaos” environment
- **Enhances quality of patient care** by providing information available to all OR staff and facilitating communication in the DOR
- **Facilitates post-surgical care** and **trend analysis** through increased data collection during surgery
Current Digital **Endoscopic DOR** suite facility

Courtesy of: Dr. John Chiu, California Spine Institute

- Video Endoscopy Monitor
- Image Manager - Report
- MRI Image - PACS
- C-Arm Images
- C-Arm Fluoroscopy
- EMG Monitoring
- EEG Monitoring
- Laser generator
- MD's
- Staff
- RN,
- Tech
- Teleconferencing - telesurgery

Left side of OR
DOR - Surgical ePR Control System (SECS)

**SurgMatix**® TO FACILITATE MISS

With **Image acquisition, Display, Manipulation and Document Historical and Live Data** on **two Opposite Large Screens**

**Intra-op 52” LCD**
- 132 Surgical Video Camera / Display
- 133 Video Mixing Equipment
- 136 Endoscope Display / Storage
- 139 Vital signs and Display
- 138 EEG/Display
- 141 EKG/Display
- 131 Neuro Physio (SSEP)
- 142 Laser Generator

**Pre-OP 52” LCD**
- 143 Selected Imaging/Dictation system
- 137 Authoring document module
- 138 EEG/Display
- 140 EMG/Display
- 133 Fluid Intake/Output
- 135 Pt Biom ID
- 141 EKG/Display
- 139 Vital signs and Display
- 136 Endoscope Display / Storage
SurgMatix® SECS was created by an innovative team for seamless connectivity and teamwork in a MISS DOR.

- It provides not only digital connectivity but also integration of all OR systems including, sophisticated surgical instruments, equipment, complex high tech systems for “digital technological convergence, and efficient DOR control system.”
- In order to facilitate and to perform a safer and better MISS.
2nd Generation Integrated (SECS) SurgMatix®

Schematic diagram of 2nd generation of SurgMatix® integrated SECS, two types: in a mobile unit, or in a tower

SurgMatix® mobile unit

SurgMatix® tower
DOR Technology Convergence and Control System SECS - SurgMatix®

Technological data convergence To facilitate and to insure safe and precise MISS

Patient: Jane, Doe W.  Patient ID: 01234566789  DOB: 01/01/1945
Procedure: Discectomy

BP: 92/65  BIS: 95.7  IVF: 37.5
PulseOx: 80.7  pCO2: 40.4

Cautery: YAG LASER
Repetition Rate: 10 Hertz
Power: 25.0 Watts

Energy: 0.500 Joules
Total: 876 Joules
Pulse Mode: SGL
Set Time: na Seconds

INTRAOPERATIVE MONITOR with live data/”real time” image/data - vital signs, 0² sat , EMG, laser, endoscopic and fluro images
Post Operative Care and Surgical Outcome
Post Operative Care:

- **Ambulatory within one hour** and discharged subsequently
- May **shower** the following day
- May use a **cervical collar** in a vehicle or on a flight as needed (for cervical **AECD**)
- **Ice pack** is helpful
- Mild **analgesics** and muscle relaxant are required at times
- **Progressive spine exercise** second post operative day on
- Postoperatively on average, **resumed usual activity** in a **few days** and in 2-5 weeks resumed full active lives, **providing no heavy work**
Surgical Outcome:

Minimally Invasive Laser Endoscopic Spine Surgery (MISS)

- 5336 patients (10,255 discs), average age 44.8 (16-94)
- Average follow-up 46.5 months (6 to 75 months)
- **Response to treatment** evaluated by using: MacNab, modified Mac Nab criteria, Oswestry disability score/index (ODI), visual analogue pain scale (VAS), patient satisfaction scoring, pain diagram and/or patient target achievement score (PTA)
- Average **satisfactory score** 5024 (93.5%) patients
- **Good to excellent** results in 4889 (91%) patients (for single level), fair result in 215 (4%) patients
- 269 (5%) patients with persistent residual pain and paresthesia although overall their pain lessened
Surgical Outcome: (symptomatic improvements) 5336 patients

Minimally Invasive Endoscopic Laser Spine Surgery (MISS)

- Severe Spine Pain: 4536
- Mild Spine Pain: 600
- Required Analgesics: 5336
- Muscle Weakness: 1601
- Muscle Spasm: 3735
- Persistent Numbness: 107

Pre-Op vs Post-Op: 3900 vs 3000
RESEARCH, DEVELOPMENT, EDUCATION AND TRAINING IN MISS
R&D for MISS:

Robotic aided endoscopic spine surgery and image guided technology on the horizon

- **Microphone headset**
- **Voice activated**
- **Advanced 3D Image guided system** is being developed and will be applied to enhance and navigationally to guide the surgical robot

- **Surgical robotics** can improve endo-MISS with better surgical precision and minimal trauma

Image guided endo-MISS
Further Application of SECS - SurgMatix® for all Surgeries

- With utilization of the digital technological convergence and control system, MISS can be successfully performed in a less traumatic manner leading to excellent results, faster recovery, and significant economic savings.
- This system SECS(SurgMatix®) could be utilized to facilitate and benefit all fields of surgery and medicine.
Education/Training for Endoscopic MISS:

- Thorough knowledge of the surgical anatomy and the surgical procedure
- Specific endoscopic MISS training
- Hands-on experience in a laboratory including cadaveric
- Meticulous pre-operative surgical planning
- Working closely with an experienced endoscopic spine surgeon through the steep surgical learning curve
- Fluoroscopy as “The 3rd Eye” or “Eye of Wisdom” for confirmation of location of instruments; endoscopy alone is not enough
- Use of digital imaging system PACS, enhanced 3D visualization, and use of SurgMatix® in DOR

- **Training is critical** in order to perform endoscopic MISS effectively, safely and avoid potential complications
Conclusion:

- Endoscopic MISS has advanced as a result of the past spinal surgical experience, advancement of bio-technology and instrumentation.
- The convergence, utilization and control of science and technology is a must for furthering MIST and MISS.
- MISS performed in a patient centric, seamless DOR is an effective, safe, less traumatic and easier spine surgery.
- MISS is a smart way to perform spine surgery.
Hope you enjoyed this presentation!

“Gracias por su amable atención!”

谢谢
اللهم
Danke schön
Thank you
Merci

Дикую.
안녕히 계세요.
“Arigato”
“Cam ón”
“Gracias”

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California Spine Institute
References:

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References: