IOM for Minimally Invasive Lumbar Fusions
Overview of the various methods of MILF surgery
IOM techniques In MILF surgery
Review of current literature dealing with MILF surgeries and IOM
Case studies dealing with MILF surgeries
Lumbar Fusions

- Many different methods for fusing the lumbar spine
- Enough acronyms to make your head spin
- TLIF, PLIF, ALIF, XLIF, DLIF, ILIF, MILF
Lumbar Fusions

- Why so many LIFs?
  - Patient variability
  - Surgeon preference
  - Availability of resources
  - Pathology
  - Instrumentation Gimmicks
Lumbar Spine Surgery

- The goal is to improve the quality of the patient's life
  - Decompression of neural structures
  - Bone fusions of unstable segments
Traditional Lumbar surgery involves exposure of the Lumbar spine
  - Large amounts of Blood loss and many other complications are involved
Decompression of neural structures and Bone fusions were thought to be only possible with an open exposure.

Lumbar Spine Surgery
Lumbar Spine Surgery

- Minimally Invasive Lumbar Surgery
  - Treat pathology with the least amount of soft tissue disruption
  - Design procedures that are minimally invasive through smaller, controlled surgical corridors
Lumbar Spine Surgery

- Goals of Minimally Invasive Lumbar Surgery
  - Reduce complications of open procedures
  - Shorter hospital stay and better patient outcomes
  - Treat pathology completely (without recurrence or reoperation)
Lumbar Spine Surgery
Fig. 1. Chronological timelines showing technical and procedural milestones in spine surgery using traditional techniques (first column) and MAST (second and third columns).

- 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 microdiscectomy (Yasargil)
- 1982: Transforminal 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 (Obenheim)
- 1993: Percutaneous facet fusion (Wang)
- 1994: MIS-thoracic discectomy (Horowitz)
- 1995: MIS-ALIF (Mathews, Zucherman)
- 1997: Microendoscopic discectomy – MED (Foley)
- 1998: Lateral transposas approach–DLIF, XLIF (McAfee, Pimenta)
- 1999: MIS-cspine-odontoid screw placement (Horgan)
- 2000: Intradiscal electrothermal–iDET (Saul)
- 2000: MIS-cervical laminoforaminory (Roh)
- 2000: Kyphoplasty (Wong)
- 2001: Sextant percutaneous pedicle screw system (Foley)
- 2002: MIS-lumbar laminectomy 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)
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Lumbar Spine Surgery

- Making Minimally Invasive Lumbar Fusions better
  - Imaging and Stereotactic Navigation
  - Intraoperative Monitoring
    - addition of EMG to the lateral approach has contributed to decrease the complication rate from 30% to less than 1% (20)
  - Improved Lumbar instrumentation technologies
Problems with MILF and IOM

- Instrumentation systems are designed without proper IOM considerations
- Surgeons and sales representatives are stimulating and using devices incorrectly
- Unforeseen challenges and complications develop in practice
New Technologies

Impact On IOM
The O-arm (Medtronic TM)

- Portable CT machine
- Gives the surgeon the axial view of the vertebral bodies/pedicles
- Ensures proper medial/lateral screw position
  - Overpriced
  - Over kill
  - My god this takes forever
New Technologies

- The O-arm (Medtronic TM)
  - Has its own navigation system with trays of equipment
  - Usually concurrent with our IOM
  - May NOT always Correlate
  - Don’t let the rep discount your monitoring
New Technologies

- The O-arm (Medtronic TM)
  - Seen this somewhere before...
  - No... that’s not it
New Technologies

- The O-arm (Medtronic TM)
  - Yeah... that's it
New Technologies

- **NeuroVision M5** (NuVasive, Inc.)
  - Uses Accelerometers and lasers to co-register data from pre-operative scans
New Technologies

- **NeuroVision M5** (NuVasive, Inc.)
  - Attaches to the end of the C-arm
  - Uses similar presentation method to the O-arm (Medtronic TM)
New Technologies

- **NeuroVision M5** (NuVasive, Inc.)
  - EMG triggered in unison with the navigation
Lateral Interbody Fusion Systems

DLIF (TM Medtronic, Inc.)
XLIF (TM NuVasive, Inc.)
Oracle (TM Synthes, Inc.)
Cougar LS (TM Depuy, Inc.)
Lateral Interbody Fusion

- DLIF (Direct Lateral Interbody Fusion) (TM Medtronic, Inc.)
Lateral Interbody Fusion

- XLIF (Extreme Lateral Interbody Fusion) (TM NuVasive, Inc.)
Cougar LS
(TM Depuy, Inc.)
IOM for Lateral Interbody Fusion

- **DLIF (TM Medtronic, Inc.), Cougar LS (TM Depuy, Inc.), Oracle (TM Synthes, Inc.)**
  - Depend on in-house IOM staff (you)
  - Communication with sales representatives is absolutely crucial
IOM for Lateral Interbody Fusion

Monitoring Tools
- Certified IOM technologist (CNIM)
- Neuromonitoring Machine
- Stimulation Probes
- Communication skills
IOM for Lateral Interbody Fusion

- Monitoring Modalities
  - Triggered EMG
  - Spontaneous EMG
  - Ptn SSEP
  - TcMEP (8)
Getting Started

- Pre-positioning traces are recommended
- Patient is positioned laterally
  - Bed may be broken/extended
- **SSEP and sEMG baselines** are acquired as soon as possible
- Optimal dual plane X-ray or O-arm is obtained
- Pt is prepped and draped
IOM for Lateral Interbody Fusion

- Getting Started
  - Navigation may or may not be used with tEMG
IOM for Lateral Interbody Fusion

- **Incision**
  - Identifying the psoas
  - Psoas and transverse process identified with finger sweep
  - Posterolateral incision may be necessary
Establishing the Surgical Corridor

- Lumbar Plexus
  - Motor nerves reside in the Posterior 1/3 of the disc space in 95% of the population (13)
  - Target area of penetration is the anterior 2/3 of the disc space
Lumbar Plexus

- The further down the spine, the more prevalent the plexus becomes
Lumbar Plexus
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Lumbar Plexus
- The further down the spine, the more prevalent the plexus becomes
IOM for Lateral Interbody Fusion

- Monitoring Through the Psoas
  - Live, real-time feedback must be given to the surgeon during dissection

![Image of monitoring equipment and surgical scene]
IOM for Lateral Interbody Fusion

- Dissecting Psoas
  - The Surgical corridor is established while adhering to alarm/alert criteria
  - If necessary, probe re-direction is performed to obtain favorable monitoring signals
Into the disc Space
- Surgical Corridor is established
- Probe sheath is used as a guide for dilators
- NOTE: If dilators are not insulated, tEMG will not yield valid thresholds due to current shunting
Retractor Placement

- Stimulation of the docking pin-holes is encouraged (DLIF)
- Stimulation/mapping of the retracted corridor is recommended (posterior portion)
Discectomy and Fusion
- sEMG and SSEPs are continually monitored
- Disc is prepared
- Trials inserted
- Graft placed
- Closure
IOM for Lateral Interbody Fusion

Suggestions for Alarm Criteria
Monitoring Through the Psoas

- **Steady State** (static) Triggered EMG monitoring
  - A pre-determined stimulation threshold is set
  - Surgeon is informed when a CMAP is elicited
Monitoring Through the Psoas
- Dynamic Triggered EMG monitoring
  - Stimulation threshold is varied over time to obtain a CMAP
  - Threshold values are relayed to surgeon in real time

IOM for Lateral Interbody Fusion
tEMG Alert/Alarm criteria

- ‘Studies have shown that thresholds of 5mA or less may indicate direct contact with nerve tissue. Experience has suggested that threshold values greater than 10mA indicate a distance that allows for both continued nerve safety and ample working space.’

* Courtesy of Nuvasive inc
### More tEMG Alert/Alarm criteria

<table>
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<tr>
<th>Summary of Alert and Alarm Criteria</th>
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<tbody>
<tr>
<td>Alert Criteria (any of)</td>
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<tr>
<td>Decrease in T-EMG threshold by &gt;5 mA or to below 10 mA while establishing surgical corridor</td>
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<tr>
<td>S-EMG bursting or spike waveforms</td>
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<tr>
<td>30-50% amplitude reduction in SSEP amplitudes</td>
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<tr>
<td>Alarm Criteria (any of)</td>
</tr>
<tr>
<td>Approaching T-EMG 5 mA threshold while establishing surgical corridor</td>
</tr>
<tr>
<td>S-EMG train or neurotonic discharges</td>
</tr>
</tbody>
</table>

*Courtesy of Impulse Monitoring Inc.*
Free Run or Spontaneous EMG (sEMG)
- sEMG running throughout psoas dissection and lateral discectomy/fusion
- Nuerotonic discharges could be missed otherwise
IOM for Lateral Interbody Fusion

- Monitoring SSEP
  - Ptn SSEP and Median/ulnar SSEP
  - Standard Alarm Criteria *
    - 50% Amplitude
    - 10% Latency

*AEEGS guideline 12*
Other types of Monitoring
- Femoral SSEP
- Cremaster tEMG and sEMG
- Monitors the genitofemoral nerve
IOM for Lateral Interbody Fusion
Working with automated EMG systems

For more information visit www.XLIF.com.
IOM for Lateral Interbody Fusion

- **NeuroVision M5** (TM NuVasive, Inc.)
  - NuVasive will almost always use their own tEMG and sEMG
  - Communication about IOM is still vital
If you are concurrently monitoring SSEPs...
- You will be asked to turn stimulation off
- Get traces as soon as you can
- I have seen Ptn needles create less stim artifact with neurovision EMG
IOM for Lateral Interbody Fusion

- **NeuroVision Triggered EMG Stimulation Technique** (TM NuVasive, Inc.)
  - Dynamic Triggered EMG monitoring
    - Non-linear algorithm that continually searches for CMAP thresholds
IOM for Lateral Interbody Fusion

Complications and problems with lateral Lumbar approach and Automated systems
Problems with Lateral Lumbar Approach

- Are the dissection Tools being used Insulated?
Problems with Lateral Lumbar Approach

- The Dilators/Jamshidi MUST be insulated \(^{(21)}\)
- Minimizes current shunting
- Isolated electrode at the distal tip acts as the stimulation source
Problems with Lateral Lumbar Approach

- Insulated Jamshidi
- Minimizes current shunting

Isolated electrode at the distal tip
Problemss with Lateral Lumbar Approach

- Insulated Dilators
- Minimizes current shunting
- Isolated stimulator at the distal tip

![Insulation](image_url)

stimulation source
Problems with Lateral Lumbar Approach

- Anatomic considerations
  - The other 5% of the population that has an anterior lumbar plexus (13)
  - Can lead to postoperative deficits at L4–5 (5)
Anatomic considerations

- Other nerves that are not directly monitored
- The iliohypogastric nerve
- The ilioinguinal nerve
- Lateral Femoral Cutaneous nerve
- Femoral nerve
Problemss with Lateral Lumbar Approach

Positioning Considerations
- Inexperienced staff/surgeons may position incorrectly
- SSEP changes may be seen
- Altering patient position may be difficult
- Heavy Patients
Problems with Lateral Lumbar Approach

- Positioning Considerations
  - Aggressive breaking of the bed may be used especially to access L4–5
  - This combined with retraction on the lumbar plexus can lead to post operative deficits (5)
Case Studies

Lateral Lumbar Fusions with Automated Monitoring
IOM for Lateral Interbody Fusion

- Monitoring SSEP
  - Median/ulnar SSEP positioning changes case #1
IOM for Lateral Interbody Fusion

Case #1
- 53 y/o female
- 100+ kilos
- L4–5 Lateral fusion
- Right side up
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion
15:03:58 reviewed all responses with dr
15:09:14 pt is being prepped
15:11:42 pt is prepped
15:14:58 time out
15:18:52 incision 3:10 pm OR time
15:31:04 neurovision in use
16:13:15 bp 92/51, map 66, hr 57, temp 35.8C, sevo 1.8%, propofol 100mcg/kg/min
16:34:59 reviewed responses with dr, informed of loss of ssep responses to the pt left arm
16:41:04 dr. order to try to reposition pt left arm
16:50:14 bp 84/47, map 61, hr 55, temp 35.8C, sevo 2%, propofol 100mcg/kg/min
16:51:46 reviewed responses with dr.
17:03:59 pt is in supine position, dr. will wait until responses are back on the left arm
17:19:10 flipping pt to prone position
IOM for Lateral Interbody Fusion

- Monitoring SSEP
  - Posterior Tibial SSEP changes case #2
IOM for Lateral Interbody Fusion

Case #2
- 69 y/o female
- L4–5 Lateral fusion
- L4–5 Spondylolisthesis
- Right side up
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion
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<td>SSEP must be paused/other system monitoring in use</td>
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<td>14:31:38 PM</td>
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<td>EMG - Stored EMG (Insert K wire)</td>
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<td>EMG - Stored EMG (x-ray guidance)</td>
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<td>Reported diminished right leg SSEP responses to the surgeon</td>
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<td>Surgeon chooses not to unbreak the bed or alter positioning</td>
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<td>15:03:22 PM</td>
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<td>x-ray</td>
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<td>15:04:15 PM</td>
<td>Medium</td>
<td>Reviewed SSEP signals with surgeon, reported lost right leg signals</td>
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<td>15:04:55 PM</td>
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<td>EMG - Stored EMG</td>
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IOM for Lateral Interbody Fusion

- Working with automated lateral systems
  - Large gaps between data acquisition
  - **Inexperience** among reps/tech/surgeon can lead to missed changes
Case #3
IOM for Lateral Interbody Fusion

- Monitoring SSEP
  - Posterior Tibial SSEP changes case #3
Case #3
- 54 y/o female
- L4–5 Lateral fusion
- Discogenic back pain, lumbar back pain
- Left side up
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion
IOM for Lateral Interbody Fusion

- Working with automated lateral systems
  - Tech had excellent communication with the sales rep
  - Tech had excellent communication with the surgeon
Other Fusion Systems

X–STOP (TM Medtronic, Inc.)
ILIF (TM NuVasive, Inc.)
Axialif (TM Transl Inc.)
Facet Fusions
X-Stop (TM Medtronic, Inc.)

- Minimally Invasive Posterior Fixation System
Facet Fusions
(TM Trans1 Inc., TM Trufuse, Inc., TM x-spine, Inc.)
AxiaLIF (TM Transl, Inc.)
What What? In the...
AxialIF (TM Trans1, Inc.)

- What is AxialIF
  - Trans 1 spine
  - MILF instrumentation company
  - Only L5–S1 fusions
  - Sacral approach to the spine
  - Also known as the Butt screw

http://Axialif

* Tosh.0, et al
AxialIF 360

- **Facet Screws**
  - lock adjacent facets into place
  - I personally have been asked to test these
  - Spinal nerve roots could still be impinged
  - Stabilization is the goal

- axialif–360 facet screws
AxiaLIF

- Monitoring concerns
  - Have not had any changes with these cases
  - Not even EMG activity
  - Only known complications have been perforated bowels
  - Revision is not likely or possible
Posterior Pedicle Screw Fixation Systems

Sextant (TM Medtronic, Inc.)
SpheRx (TM NuVasive, Inc.)
Denali (TM K2M, Inc.)
Viper 2 (TM Depuy, Inc.)
Matis (TM Stryker, Inc.)
Matrix (TM Synthes, Inc.)
Ballista (TM Biomet, Inc.)
Minimally Invasive Posterior Fixation System
SpheRx (TM NuVasive, Inc.)
Denali
(TM K2M, Inc.)
Viper 2 (TM Depuy, Inc.)
Matis
(TM Stryker, Inc.)
Ballista (TM Biomet, Inc.)
IOM in Posterior Pedicle Screw Fixation Systems

Minimally Invasive Posterior Fixation Systems
IOM in Posterior Pedicle Screw Fixation Systems

- **Getting Started**
  - Patient is positioned prone
  - SSEP and EMG baselines are acquired
  - Optimal X-ray is obtained
  - Pt is prepped and draped
Monitoring Tools
- Certified IOM technologist (CNIM)
- Neuromonitoring Machine
- Cannulated EMG Monitoring Pedicle Probe(s)
- Insulated dilator(s)
- Communication skills
IOM in Posterior Pedicle Screw Fixation Systems

- Getting Started
  - Navigation may or may not be used with tEMG
IOM in Posterior Pedicle Screw Fixation Systems

- Tapping Pedicles
  - Target angles are identified through X-ray
  - Surgeon begins to guide probe down the pedicle
IOM in Posterior Pedicle Screw Fixation Systems

- Live, real-time T-EMG feedback is given to the surgeon during tapping.
Tapping Pedicles
- Alarm/Alert Criteria is followed while going through the pedicle
- If necessary, probe re-direction is performed to obtain favorable monitoring signals

Summary of Alert and Alarm Criteria

<table>
<thead>
<tr>
<th>Alert Criteria (any of)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in T-EMG threshold by &gt;5 mA or to below 10 mA while establishing surgical corridor</td>
</tr>
<tr>
<td>S-EMG bursting or spike waveforms</td>
</tr>
<tr>
<td>30-50% amplitude reduction in SSEP amplitudes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alarm Criteria (any of)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approaching T-EMG 5 mA threshold while establishing surgical corridor</td>
</tr>
<tr>
<td>S-EMG train or neurotoxic discharges</td>
</tr>
</tbody>
</table>

Courtesy of Impulse Monitoring Inc.
IOM in Posterior Pedicle Screw Fixation Systems

- **Tapping Pedicles**
  - The T-Handle is removed
  - A Kwire is inserted
  - Some Surgeons choose to stimulate kwire (3)
IOM in Posterior Pedicle Screw Fixation Systems

- Tapping Pedicles
  - Dilators are inserted over the kwire
  - Insulated dilator must be used prior to tapping (12)
    - Important to be flush against the Transverse Process
Tapping Pedicles

- Stimulate the tap when it is all the way in the pedicle
- This value is thought to be the most correlative to standard open-pedicle screw EMG stimulation case data\(^{(2)}\)
IOM in Posterior Pedicle Screw Fixation Systems

- Screw/Tower Insertion
  - Screws inserted
  - EMG and SSEPs are continually monitored
    - Can NOT test Uninsulated Screw Towers
    - Current shunting can NOT be avoided
    - Thresholds are inaccurate (21)
IOM in Posterior Pedicle Screw Fixation Systems

- Screw and Rod Insertion
  - EMG and SSEPs are continually monitored
  - Sextant (TM) Towers Mate
  - Rod inserted
  - Final Tightening
IOM for Percutaneous Pedicle Screw Testing

- EMG activity (Triggered)
  - When the surgeon is inserting screws, he can not visualize the medial portion pedicle with C-arm
    A. A/P x-ray
    B. Lateral x-ray
    C. Axial (O-arm only)
EMG activity (Triggered)

- There is a risk of nerve root or spinal cord impingement if the screw is placed too Medial.
- In open PSF cases, a threshold of greater than 20 mA of stimulation without a CMAP response to muscle corresponding to that specific level justifies the medial placement.
EMG activity (Triggered)
- A threshold of less than 10 mA warrants alert criteria (4)
- Under 5 mA warrants ground for screw removal (4)
IOM for Percutaneous Pedicle Screw Testing

- Triggered EMG (tEMG)
  - Minimally invasive surgeries do not have the benefit of open air to insulate the path of stimulation
  - Current shunting must be avoided
IOM for Percutaneous Pedicle Screw Testing

- Free Run or Spontaneous EMG (sEMG)
  - sEMG when tapping pedicles/screw insertion
  - Nuerotonic discharges could be missed otherwise
IOM for Percutaneous Pedicle Screw Testing

- Nerve root baseline
  - Nerve root baselines cannot be acquired through Percutaneous incisions
  - False positives from chronically compressed nerve roots cannot be accounted for

<table>
<thead>
<tr>
<th>Structure</th>
<th>Stimulus threshold, mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal nerve root</td>
<td>2.2 (0.2–5.7)*</td>
</tr>
<tr>
<td>Chronically compressed nerve root</td>
<td>6.3–20†</td>
</tr>
<tr>
<td>Normal hole</td>
<td>30.4 (16.5–44.3)*</td>
</tr>
<tr>
<td>Normal screw</td>
<td>24 (12.1–35.9)*</td>
</tr>
<tr>
<td>Misplaced hole</td>
<td>3.4 (1–6)*</td>
</tr>
<tr>
<td>Misplaced screw</td>
<td>3.5 (1–6)*</td>
</tr>
</tbody>
</table>

* From Maguire et al. (1995).
† From Holland et al. (1998).
Alarm Criteria

- Bindal et al. (2) suggested the following tEMG protocol
  - Greater than 7 mA for the jamshidi needle (A, B & C)
    - Needle redirection was recommended for lesser thresholds
  - Greater than 15 mA for the insulated threaded tap (D)
Alarm Criteria
- Bindal et al. (2) cont...
- There were no insulated threaded tap thresholds that tested under 15 mA
- In 20 of the 25 patients CT scans were performed
- 3 lateral breaches were found
- No medial breaches

<table>
<thead>
<tr>
<th>Case No.</th>
<th>No. of Screws Placed</th>
<th>Treated Levels</th>
<th>PAK Needle Trajectory Changed†</th>
<th>Pedicle Tap EMG Activation Threshold‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>L5–S1</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
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<td>4</td>
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<td>—</td>
</tr>
<tr>
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<td>4</td>
<td>L4–S1</td>
<td>4</td>
<td>—</td>
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<td>9</td>
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<td>4</td>
<td>L5–S1</td>
<td>4</td>
<td>1</td>
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<tr>
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<td>4</td>
<td>L4–5</td>
<td>2</td>
<td>—</td>
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<tr>
<td>12</td>
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<td>19</td>
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<td>6</td>
<td>L4–S1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>6</td>
<td>L4–S1</td>
<td>3</td>
<td>—</td>
</tr>
</tbody>
</table>

*PAK = pedicle access; — = not applicable.
† Changed because of EMG activation. The values represent the number of screws for which one or more alterations in the trajectory of the pedicle access needle was made as a direct result of intraoperative EMG activation.
‡ Indicates threshold at which EMG activation occurred with stimulation of the pedicle tap.
IOM for Percutaneous Pedicle Screw Testing

- Personal experience with tEMG Alarm Criteria
  - The area of the jamshidi or PAK needle (medronic inc) is only a few mm
  - The charge density gives very local information about the integrity of the pedicle wall
Personal experience with tEMG Alarm Criteria

- The Lowest CMAP thresholds bottom out when the jamshidi needle is at the junction between the pedicle and the vertebral body

4 mA*  7 mA*  15 mA*

*Fictional values
IOM for Percutaneous Pedicle Screw Testing

- Thresholds between 4–7 mA typically correlate to threaded insulated tap values between 15–20 mA
- Further research needs to be conducted between systems
- Stimulation Duration (pulse width)
Recent Journal Articles

Impact On IOM for Percutaneous Pedicle Screw Testing
Recent Journal Articles

  - Featuring Nuvasive’s new Navigation system
Recent Journal Articles

- **NeuroVision M5** (NuVasive, Inc.)
  - Five of 326 screws penetrated the pedicle cortex*
  - 3 medial and 2 lateral
  - pedicle breach rate of 1.53%
    - Medial 0.92% lateral 0.61%
  - overall accuracy of 98.47%
  - No mention or correlation of tEMG thresholds for the jamshidi or threaded insulated tap

*Idler et al. 2010
Next Article

Not good news for IOMers

- A clinical study of 409 screws in 93 patients
- Presented at the 2009 Joint Spine Section Meeting
Results Not Good

- Out of 5 pedicle breaches, **ALL were false negatives**
- There were **35 false positives** as well

**TABLE 2: Results of testing using CT scanning as the gold standard for detection of breaches and less than 12 mA as the test threshold**

<table>
<thead>
<tr>
<th>Stimulation Threshold (mA)</th>
<th>CT Evidence of Breach</th>
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<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>≥12</td>
<td>369</td>
</tr>
<tr>
<td>&lt;12</td>
<td>35</td>
</tr>
<tr>
<td>total</td>
<td>404</td>
</tr>
</tbody>
</table>
Results Not Good

- 5 medial breaches (2 with neurologic complication) that tested at **MORE** than 12 mA!
- No true positives

**TABLE 2: Results of testing using CT scanning as the gold standard for detection of breaches and less than 12 mA as the test threshold**

<table>
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<td>374</td>
</tr>
<tr>
<td>&lt;12</td>
<td>35</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>total</td>
<td>404</td>
<td>5</td>
<td>409</td>
</tr>
</tbody>
</table>
MIS Triggered EMG

- Results Not Good
  - 35 false positives out of 409 screws (8.6%)
  - All screws that tested below 12 mA showed NO radiographic evidence of a medial breach

[Table 2: Results of testing using CT scanning as the gold standard for detection of breaches and less than 12 mA as the test threshold]

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</table>
According to this article, MIS EMG is a MISS.
Discussion

◦ How can this be?
◦ Anyone have personal experience with this
  • False Positives?
  • False Negatives?
◦ Anyone have a surgeon/others mention this article to you?
MIS Triggered EMG

- Possible Explanations
  - For the false positives
    - May be lateral breaches
    - Lateral are asymptomatic
    - Lateral breaches can give low thresholds

What does that mean?
Other Explanations

- Source of error would be the differences or variability in metallic conductivity.
- A 1.2% rate of pedicle violations would be considered substantially lower than other reports.
  - This finding may likely be related to our dependence on the intensive use of intraoperative fluoroscopy to place percutaneous screws.
- Computed tomography scanning can also be a source of error.

Conclusions

Stimulus-evoked EMG is less reliable for testing minimally invasive percutaneous pedicle screws when compared with testing in open surgery. While this modality may still prove useful for preventing complications, high false-positive and false-negative rates were identified. Increased reliance on intraoperative imaging techniques and careful interpretation of evoked EMG testing are recommended if low-grade pedicle violations are to be avoided.
Automated Neuromonitoring Systems (ANS)

FAIL

FAIL
Automated Neuromonitoring Systems (ANS)

- There is IOM being performed without technologists
- Most of these cases are also monitored without Professional oversight interpretation
- Examples
  - Surgical Instrumentation Companies
    - NuVasive (Neurovision tm)
    - Medtronic (NIM tm)
Automated Neuromonitoring Systems (ANS)

ANS is ‘Surgeon Controlled’

- ANS do not ‘perform’ IOM or interpret it
- Without Professional oversight interpretation...
  - The surgeon is liable for any monitoring complications
  - The hospital also may be liable for any monitoring complications
  - The instrumentation company is usually exempt
ANS is not usually ‘Surgeon Controlled’

- Sales representatives participate in most aspects of IOM

- IOM duties performed by the Sales Reps include
  - Providing the IOM machine
  - Providing the IOM electrodes and supplies
  - Often applying the electrodes
  - Checking the validity/reliability of the data
  - Relaying IOM changes to the surgeon
Automated Neuromonitoring Systems (ANS)

Other ANS Pitfalls

- The machines are being run by unqualified, under-educated personnel
- Technical errors often go misidentified or unnoticed
- ANS are limited in performance (EMG and MEP only)
- ANS are designed as an adjunct to concurrent instrumentation
- ANS is notoriously expensive (2 to 3 times the cost of conventional IOM)
Conventional Technologist Based IOM
Conventional Technologist Based IOM

Why Conventional IOM?

- Superior certified personnel and equipment
- Cost effectiveness
- Multimodality capabilities
- Position statements from credentialing bodies:
  - ASET  [http://aset.org](http://aset.org)
Neurophysiologists have specific training to obtain optimal recordings.

They are available to troubleshoot hardware/software problems.

Specific training for optimal needle electrode placement is important to obtain accurate recordings.

IOM is the only focus, we do NOT sell or market any other type of services or product, especially DURING THE CASE
Technologists have comprehensive IOM experience.
Technical errors such as EMG artifacts are a common occurrence and must be identified and eliminated immediately.
Lumbar Spine Surgeries

- EMG artifacts
  - Familiarity with anesthesia and the requirements for effective monitoring.
  - The experience to know if the patient is light and/or about to start bucking.
Lumbar Spine Surgeries

- EMG artifacts
  - Is this real or artifact?
Lumbar Spine Surgeries

- EMG artifacts
  - Is this real or artifact?
    - Not possible to tell out of context
WHY Technologist?

- SSEP and other types of monitoring is available and concurrently monitored.
- Vascular and positional changes are monitored.
WHY Technologist?

- Clear, Cogent and Consistent documentation
WHY Technologist?

- Similar features are inherent in current monitoring software
- Live data feed can be presented at surgeon’s request
‘REAL TIME MONITORING’ is a false concept
Red light/Green Light threshold based monitoring is an oversimplification
Clear demarcation of artifact/response is imperative
WHY Technologist?

- Experienced in Dlif/Xlif monitoring

![Image of medical equipment and data output with the text 'Detecting Threshold Left L3 21.6 mA Click to Stop']
Experience in minimally invasive percutaneous screw insertion monitoring techniques

Common pitfalls such as current shunting and charge density false positives can be resolved
The END
MIS Glossary

- ACDF = anterior cervical discectomy and fusion;
- AD = aggressive discectomy
- ADR = artificial disc replacement
- ALIF = anterior lumbar interbody fusion
- APLD = automated percutaneous lumbar discectomy
- BMP = bone morphogenetic protein
- CAVHS = Central Arkansas Veterans Healthcare System
- DLIF = direct lateral interbody fusion
- IDET = intradiscal electrothermy
- LD = limited discectomy
- LPD = laser-assisted percutaneous discectomy
- MAST = minimal access spinal technique
- MED = microendoscopic discectomy
- MIS = minimally invasive surgery
- PEEK = polyetheretherketone
- PLIF = posterior lumbar interbody fusion
- rhBMP-2 = recombinant human BMP-2
- TLIF = transforaminal interbody fusion
- XLIF = extreme lateral interbody fusion.
References

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- K2M, Inc.
- Medtronic, Inc.
- NuVasive, Inc.
- NuWave Monitoring, LLC.
- Stryker, Inc.
- Synthes, Inc.
- Tosh.0
- Trans1, Inc.
- Trufuse, Inc.
- x-spine, Inc.