Proposed Reclassification of Cervical Lateral Mass and Pedicle Screw Systems

Orthopedic Surgical Manufacturers Association (OSMA)
Agenda

FDA Regulation of Pedicle Screw Systems
   Susan Krasny, Ph.D.
   OSMA Board of Directors, Past President
   Vice President of Regulatory Affairs, Stryker Corp

Review of History and Surgical Techniques for Cervical Pedicle and Lateral Mass Screws
   John G. Heller, M.D.
   Baur Professor of Orthopaedic Surgery
   Spine Fellowship Director
   The Emory Spine Center
   Emory University School of Medicine

Published Literature Regarding Safety and Effectiveness of Cervical Pedicle and Lateral Mass Screws; Clinical Rationale for Reclassification
   Alexander J. Ghanayem, M.D.
   Professor, Department of Orthopaedic Surgery
   Director, Division of Spine Surgery
   Loyola University of Chicago

Proposed Regulatory Controls; Conclusion
   Sharon Starowicz
   OSMA President
   Director of Regulatory Strategy, DePuy Synthes Spine
FDA Regulation of Pedicle Screws

Susan Krasny, Ph.D.
OSMA Board of Directors, Past President
Regulatory History

- Pedicle screw systems for various spinal indications were first marketed in the U.S. before the 1976 Medical Devices Amendment.
- "Pre-amendment" devices require classification by FDA.
- July 27, 1998: FDA classified pedicle screws intended for treatment of various indications as Class II or Class III.
- Some indications remain unclassified, including the cervical indications that are the subject of the petition.
- Outside the United States, these systems have been CE marked since the mid 1990s.
FDA Classification of Medical Devices

• Classifications assigned by the device risk and the level of regulatory control needed for reasonable assurance of safety and effectiveness

• As the risk increases, the classification level and FDA regulatory control increase
  – Class I – General Controls
  – Class II – Special Controls
  – Class III - Premarket Approval (PMA)

• When a product is unclassified, by default, it is assigned to Class III until it is classified
Objective of Reclassification Petition

- Reclassify pedicle and lateral mass screws for use in the cervical spine, currently unclassified, to Class II (Special Controls)
Lateral mass and pedicle screw systems are intended to provide immobilization and stabilization of spinal segments as an adjunct to fusion during bone graft healing and fusion mass development and/or to restore the integrity of the spinal column even in the absence of fusion for a prolonged period.

Indicated for the following acute and chronic instabilities of the cervical spine (C1 to T3 inclusive):

- trauma, including spinal fractures and/or dislocations
- instability or deformity
- pseudarthrosis or failed previous fusions
- degenerative disease, including intractable radiculopathy and/or myelopathy, neck and/or arm pain of discogenic origin as confirmed by radiographic studies
- degenerative disease of the facets with instability
- tumors
Components of OCT Systems

<table>
<thead>
<tr>
<th>Component</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screws</td>
<td>• E.g., variable-angle, self-tapping, and self-drilling screws, double-thread, top-loading, pre-assembled</td>
</tr>
<tr>
<td></td>
<td>• Minimally invasive, percutaneous, open</td>
</tr>
<tr>
<td>Rods</td>
<td>• Fixed or varying lengths and diameters</td>
</tr>
<tr>
<td></td>
<td>• Straight, pre-contoured, and flat</td>
</tr>
<tr>
<td></td>
<td>• Various degrees of stiffness</td>
</tr>
<tr>
<td>Plates</td>
<td>• Variety of lengths and widths</td>
</tr>
<tr>
<td></td>
<td>• Round holes or elongated slots for the posterior cervical screws</td>
</tr>
<tr>
<td>Transverse</td>
<td>• Fixed or adjustable configurations to increase rotational stability</td>
</tr>
<tr>
<td>connectors</td>
<td></td>
</tr>
</tbody>
</table>

• Also may include other components such as hooks
• Range of materials
Recent FDA Clearances

• Although unclassified, there are a few examples of lateral mass/pedicile screw systems already cleared by FDA via the 510(k) process, for example:
  – K062254 – Included spinal screw fixation with posterior pedicle and lateral mass screws for various indications from C2-T3 (inclusive)

• FDA has also classified other products for similar uses in Class II and has cleared them via the 510(k) process
Consistency in Class II Designation

• Many other similar or related cervical devices are already classified in Class II
  – Posterior approach:
    • Laminoplasty plate
    • Hook and rod constructs
    • Wiring or cabling constructs
  – Anterior approach:
    • Anterior cervical plate
    • Interbody cervical cage with bone graft
Why is Reclassification Being Proposed?

• Current unclassified status leaves the vast majority of cervical pedicle and lateral mass screws neither cleared nor approved
• Standard of care for specific uses
• This regulatory status precludes manufacturers from addressing these uses
• Clarification of the regulatory status of these products will allow improved labeling, training, and manufacturer support
Review of Surgical Techniques for Cervical Pedicle and Lateral Mass Screws

John G. Heller, M.D.
Baur Professor of Orthopaedic Surgery
Spine Fellowship Director
The Emory Spine Center
Emory University School of Medicine
Introduction

• Evolution of posterior cervical fixation techniques:
  – Three decades
  – Global standard of practice

• Responsible surgical education:
  – Empower optimal surgical planning & execution
  – Patient safety

• A word about ‘equipoise’
Posterior Cervical Fixation
History: Through Late 1980s
Posterior Cervical Fixation
History: Through Late 1980s

Deficient Posterior Elements

Failure of fixation:

a) Wire Failure
b) Trauma
c) Laminectomy
d) Hypoplastic
Posterior Cervical Fixation
History: Through Late 1980s

1. Arthrodesis
2. Internal fixation
   a) Wire/Cable
      - Interspinous
      - Facet
      - Sublaminar
Posterior Cervical Wiring
The ‘Gold Standard’

- Long history of use
- Simple
- Effective
- Cheap
Why Plates & Screws?
We needed something better...
A Quantum Leap Forward
When a Halo-Vest is Contraindicated, etc.

Host Considerations:

a) Halo Contraindicated
   - Skull Fx
   - Chest Trauma
b) Neurologic Deficit/Rehab

b) Neurologic Deficit/Rehab

b) Neurologic Deficit/Rehab

c) Psychosocial

d) Terminal Prognosis
When a Halo-Vest is Contraindicated, etc.
Posterior Cervical Instrumentation

Good news for Surgeons

- **Anatomy:**
  - Quantitative

- **Biomechanics:**
  - Adaptive engineering

- **Levels to be purchased:**
  - Occiput
  - Atlas
  - Axis
  - Subaxial
  - C-T Junction
Quantitative Anatomy
Occipital Bone

Quantitative Morphometry

• Occipital bone
  – Olivier 1975
  – Heywood 1988
  – Grob 1991
  – Zupnick 1996
  – Ebraheem 1996
  – Roberts 1998
Quantitative Anatomy Atlas

Courtesy of Brad Currier
Quantitative Anatomy Atlas

- Articular mass
- Posterior arch  
  *(Noh, AP-CSRS 2011)*
Quantitative Anatomy Atlas
Quantitative Anatomy
Axis - Odontoid

- Heggeness (1993)
- Heller (1991)
- Jauregui (1993)
- Schaffler (1991)
- Tominaga (1995)
- Xu (1995)
Unique shape/function:

- Large canal (20mm)
- Transitional post arch:
  - No “lateral mass”
  - Large pedicles
  - Thick lamina
  - Vertebral artery location

Significant surgical adaptability

*(Takeuchi, AP-CSRS 2011)*
Quantitative Anatomy
Axial
Axis
Quantitative Anatomy
Axis

PA

JR
Occipito-Cervical Fusion
Occipito-Cervical Fusion

- Eliminate the halo?
- Rods/Loops
  - Wire fixation
  - Limited stability
    - Vertical
    - Torsional
    - # fixation points
Occipito-Cervical Fusion

- Eliminate the halo?
- Rods/Loops
  - Wire fixation
  - Limited stability
    - Vertical
    - Torsional
    - # fixation points
Subaxial Purchase
Lateral Mass Technique Options

- Starting Point
- Trajectory
  - axial
  - sagittal
ROY-CAMILLE VS. MAGERL

Accuracy
- Gross dissection
- Radiographic

Heller, Spine 1991
Heller, Spine 1991
Complications of Lateral Mass Plating
Cadaveric Study

Predicted Complications

Nerve Root Injury <3.6%
Facet Violation <3.6%
Vertebral Artery Injury 0%
Spinal Cord Injury 0%

Learning curve demonstrates benefit of training

Heller, Spine 1991
# Complications of Lateral Mass Plating

## Directly to Screw Insertions

<table>
<thead>
<tr>
<th>Type</th>
<th>Observed Cases (%)</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve Root Injury</td>
<td>4 (0.6)</td>
<td>(≤3.6)</td>
</tr>
<tr>
<td>Facet Violation</td>
<td>1 (0.2)</td>
<td>(≤3.6)</td>
</tr>
<tr>
<td>Vertebral Artery Injury</td>
<td>0 (0)</td>
<td>(0)</td>
</tr>
<tr>
<td>Spinal Cord Injury</td>
<td>0 (0)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

## Neurological Deficit

<table>
<thead>
<tr>
<th>Complication</th>
<th>Per Patient</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal Cord Injury Unrelated to Implant</td>
<td>2.6%</td>
<td>0%</td>
</tr>
<tr>
<td>Iatrogenic Stenosis</td>
<td>2.6%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Mean Pull-Out Force for all Screws at Each Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>278</td>
</tr>
<tr>
<td>C3</td>
<td>355</td>
</tr>
<tr>
<td>C4</td>
<td>391</td>
</tr>
<tr>
<td>C5</td>
<td>313</td>
</tr>
<tr>
<td>C6</td>
<td>262</td>
</tr>
<tr>
<td>C7</td>
<td>266</td>
</tr>
</tbody>
</table>

Heller et al, JBJS 1996
Mean Pull-Out Force Values

Unicortical v. Bicortical

Bicortical $18\% >$ Unicortical
Cervical Pedicle Screw Biomechanics

- **↑ Stability with 3-column injury**

- **Pull out: Pedicle > Lateral Mass**
**Sub-Axial Fixation**

**Mean Load to Failure**

<table>
<thead>
<tr>
<th></th>
<th>Pedicle</th>
<th>Lateral Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>671 N</td>
<td>355 N</td>
</tr>
</tbody>
</table>

Cervical Pedicle Anatomy
C2-C7

Panjabi, *Spine* 1991:
- Width: 5.1 – 6.6mm
- Height: 6.7 – 7.6mm
- Pedicle screw fixation feasible
Cervical Pedicle Screws
Abumi v. Frameless Stereotactic Guidance

1. Abumi and frameless stereotactic guidance methods have a similar accuracy
2. Accuracy varies according to level
3. The vertebral artery is the most frequently injured structure
4. Pedicle diameters < 4.5mm have unacceptable rate of screw malposition
Trans-Facet Screw Salvage Option

C-7 is Transitional
- Elongated
- Narrow in AP plane
- Larger pedicle
Cervicothoracic Fixation
Anatomic Feasibility

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>FIXATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3-6</td>
<td>Lateral Mass, Pedicle</td>
</tr>
<tr>
<td>C7</td>
<td>Pedicle</td>
</tr>
<tr>
<td>Thoracic</td>
<td>Pedicle</td>
</tr>
</tbody>
</table>

Basilar Invagination
Reducible v. Irreducible
Basilar Invagination
Reducible

Preop

Postop
Posterior Cervical Instr.
Summary Recommendations

<table>
<thead>
<tr>
<th>Anatomical Level</th>
<th>Purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occiput</td>
<td>“Midline” below EOP</td>
</tr>
<tr>
<td>C-1</td>
<td>Art. Mass or Post. Arch</td>
</tr>
<tr>
<td>C-2</td>
<td>Pars or Pedicle</td>
</tr>
<tr>
<td>C3-6</td>
<td>Lat. Mass; for specific conditions pedicle screw fall back</td>
</tr>
<tr>
<td>C-7</td>
<td>Lat. Mass or Ped</td>
</tr>
<tr>
<td>Thoracic</td>
<td>Pedicle</td>
</tr>
</tbody>
</table>
Where do we go from here?

• We cannot go back!
  – These posterior fixation techniques have become the clinical standard worldwide

• Equipoise no longer exists between screw fixation & wiring techniques:
  – RCT is neither ethical nor practical

• We must be able to teach these techniques properly:
  – Optimize patient safety & clinical outcomes
Published Literature:
Safety and Effectiveness of Cervical Pedicle and Lateral Mass Screws

Alexander J. Ghanayem MD
Professor, Department of Orthopaedic Surgery
Director, Division of Spine Surgery
Loyola University of Chicago
OBJECTIVES

• Summarize the published clinical literature regarding cervical lateral mass and pedicle screws

• Review the evidence of how these screws are effective with an acceptable risk profile
LITERATURE SEARCH METHODS

• Comprehensive and systematic search
• National Library of Medicine PubMed
  • Period: 1999 to July 23, 2012
• Review of bibliographies of selected articles
• Include articles
  – > 15 subjects with reports of safety and/or effectiveness results
  – Construct included lateral mass and/or pedicle screws
• Also searched: cables, hooks and/or wiring
## SEARCH STATISTICS

<table>
<thead>
<tr>
<th>Search</th>
<th>Titles</th>
<th>Articles: Reviewed</th>
<th>Articles: Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral mass and pedicle screws</td>
<td>545</td>
<td>87</td>
<td>51</td>
</tr>
<tr>
<td>Cables, hooks, and wiring</td>
<td>71</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>
STUDY CHARACTERISTICS: Lateral Mass and/or Pedicle Screws

• Anchor:
  – Lateral mass only: 14
  – Pedicle screw only: 25
  – Lateral mass/pedicle screws: 12

• Study Design:
  – Single cohort: 45
  – Comparative: 6 (various placement and imaging methods, other screw constructs)

• 2,967 patients
STUDY CHARACTERISTICS: Cables, Hooks and/or Wiring

• Study Design:
  – Comparative: 2 studies
    • Wiring/rod vs. wiring/graft onlay vs. screw/plate vs. screw/rod (Winegar 2010)
    • Non-rigid (rod/cable, wire/cable alone (3) and no instrumentation) vs. rigid (screws with plates or rods) (Garrido 2011)
  – Single cohort: 5 studies (total 156 patients)
VARIETY OF INDICATIONS:
Lateral Mass and Pedicle Screws

- Trauma: 35%
- Instability/Deformity: 31%
- Degenerative: 22%
- Tumor: 7%
- Pseudarthrosis/Failed Fusion: 3%
- Other: 2%
- Others: 59%
ANCHORS USED BY INDICATION

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Trauma</th>
<th>Instability/ Deformity</th>
<th>Degenerative</th>
<th>Tumor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma</td>
<td>1,027</td>
<td>658</td>
<td>931</td>
<td>218</td>
</tr>
</tbody>
</table>

Diagram showing the percentage of lateral mass, pedicle screws, and lateral mass and pedicle screws used across different indications: Trauma Instability/Deformity, Degenerative, and Tumor.
INDICATION BY ANCHORS USED

<table>
<thead>
<tr>
<th>N</th>
<th>Lateral Mass</th>
<th>Pedicle Screw</th>
<th>Pedicle Screw + Lateral Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studies</td>
<td>14</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>Subjects</td>
<td>1046</td>
<td>1233</td>
<td>688</td>
</tr>
</tbody>
</table>
EFFECTIVENESS RESULTS: High Fusion Rates

• Comparative Study (systematic review, Winegar 2010)

<table>
<thead>
<tr>
<th>Group</th>
<th>Screw/Rod</th>
<th>Screw/Plate</th>
<th>Wiring Rod</th>
<th>Wire/Graft Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusion</td>
<td>93.0%</td>
<td>94.7%</td>
<td>95.9%</td>
<td>88.3%</td>
</tr>
</tbody>
</table>

• Single cohort studies:
  • Lateral mass and/or pedicle screw studies
    • 90%-100% (24 studies)
    • 89% (1 study) and “stable” (one study)
  • Cable, wire and/or hook studies (4 studies)
    • 71%, 93%, 95% and 100%
EFFECTIVENESS RESULTS: Improved/Maintained Neurologic Function

- Comparative Study (Systematic review, Winegar 2010)

<table>
<thead>
<tr>
<th>Group</th>
<th>Screw/Rod</th>
<th>Screw/Plate</th>
<th>Wiring Rod</th>
<th>Wire/Graft Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic Improvement</td>
<td>81.6%*</td>
<td>72.4%</td>
<td>51.8%</td>
<td>72.9%</td>
</tr>
</tbody>
</table>

*p<0.05

- Single cohort studies
  - 16 reported neurological outcomes with lateral mass and/or pedicle screws
  - All reported improved/maintained neurologic function
EFFECTIVENESS RESULTS: Improved Pain and Disability

• Single cohort studies
  – 10 reported pain and disability outcomes with lateral mass and/or pedicle screws
  – Improved pain and/or disability
RISKS TO HEALTH: Screw Placement Accuracy

- 35 studies included assessment of screw placement
  - 32 studies immediate post-op via CT
    - 2,138 subjects and 8,151 screws
  - 2 studies compared results for various operative visualization methods
  - 1 meta-analysis of the published literature
RISKS TO HEALTH: Screw Placement Accuracy

• Of 32 studies
  – Satisfactory placement:
    • 27 reported >90%
    • 5 reported 74.7%-87.5%

<table>
<thead>
<tr>
<th></th>
<th>Subjects</th>
<th>Screws</th>
<th>Satisfactory</th>
<th>% Satisfactory</th>
<th>Events</th>
<th>% events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedicle screw</td>
<td>1604</td>
<td>5136</td>
<td>4813</td>
<td>93.7%</td>
<td>20</td>
<td>1.2%</td>
</tr>
<tr>
<td>Lateral mass</td>
<td>432</td>
<td>2381</td>
<td>2248</td>
<td>94.4%</td>
<td>4</td>
<td>0.9%</td>
</tr>
<tr>
<td>PS+LM</td>
<td>102</td>
<td>634</td>
<td>614</td>
<td>96.8%</td>
<td>1</td>
<td>1.0%</td>
</tr>
<tr>
<td>ALL</td>
<td>2138</td>
<td>8151</td>
<td>7675</td>
<td>94.2%</td>
<td>25</td>
<td>1.2%</td>
</tr>
</tbody>
</table>
RISKS TO HEALTH: Screw Misplacement

• 25 adverse events
  – 16 (0.75%) vertebral artery injuries all resolved intra-op with application of bone wax or screw insertion
  – 9 (0.42%) neurologic events; 3 transient and 6 resolved with screw revision or removal
RISKS TO HEALTH: Screw Placement Accuracy

• Meta-analysis (Kosmopoulos 2007)
  – 12,299 pedicle screws (32 studies) compared cervical, thoracic, lumbar
  – mean and median accuracy of placement
    • 92.4% and 95.2% with navigation
    • 82.2% and 90.3% without navigation
  – For studies focusing on specific spine levels
    • Overall placement rate accuracy was high with and without navigation for all levels of the spine
    • Highest rates for the cervical spine
RISKS TO HEALTH: Comparative Studies

• Systematic literature review (Winegar 2010)
  – OC construct failure statistically significantly lower for screw/rod constructs versus wire-based fixation constructs, although small number of patients evaluated
  
<table>
<thead>
<tr>
<th>Group</th>
<th>Screw/ Rod</th>
<th>Wiring Rod</th>
<th>Wire/ Graft Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct Failure and Rates</td>
<td>7.9% (3/38)</td>
<td>13.5% (13/96)</td>
<td>100% (14/14)</td>
</tr>
</tbody>
</table>

• Retrospective study (Garrido 2011)
  – Non-rigid (rod/cable or wire/cable) compared to rigid (screws with plates or rods)
  – Complication rate of patients statistically significantly higher in the non-rigid compared to the rigid group
  • 48% (12/25) vs 4% (2/46)
# RISKS TO HEALTH: Device Adverse Events by Anchor Type

<table>
<thead>
<tr>
<th>Anchor Type</th>
<th>ALL</th>
<th>LM</th>
<th>PS</th>
<th>LM + PS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Number of Patients: Device Events</strong></td>
<td>2080</td>
<td>744</td>
<td>1017</td>
<td>319</td>
</tr>
<tr>
<td><strong>Adverse Events</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Device:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral mass fracture</td>
<td>1.6%</td>
<td>4.3%*</td>
<td>0.6%</td>
<td></td>
</tr>
<tr>
<td>Pedicle fracture</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Malposition Screws</td>
<td>0.7%</td>
<td>0.1%</td>
<td>1.0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Loss of Correction</td>
<td>0.6%</td>
<td>0.3%</td>
<td>0.8%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Screw loosening/pull out</td>
<td>1.4%</td>
<td>2.6%</td>
<td>0.8%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Strut/graft displacement</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Screw breakage/dislodgment</td>
<td>1.1%</td>
<td>1.1%</td>
<td>1.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Rod dislodged</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Plate breakage</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Progressive degenerative change</td>
<td>0.3%</td>
<td>0.1%</td>
<td>0.4%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Heterotopic ossification</td>
<td></td>
<td></td>
<td></td>
<td>0.3%</td>
</tr>
<tr>
<td>Pseudoarthrosis</td>
<td>0.5%</td>
<td>0.9%</td>
<td>0.3%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

* The bone fracture rate is a conservative estimate, as 27 of the 35 events were reported “per screw” not “per patient”.

70
RISKS TO HEALTH:  
Other Adverse Events by Anchor Type

<table>
<thead>
<tr>
<th>Anchor Type</th>
<th>All</th>
<th>LM</th>
<th>PS</th>
<th>LM+PS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Number of Patients: Other Events</strong></td>
<td>2216</td>
<td>848</td>
<td>1049</td>
<td>319</td>
</tr>
<tr>
<td><strong>Neurological:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper extremity numbness/pain</td>
<td>0.3%</td>
<td>0.2%</td>
<td>0.4%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Neuropathic pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nerve root palsy</td>
<td>1.0%</td>
<td>0.9%</td>
<td>1.3%</td>
<td></td>
</tr>
<tr>
<td>Residual paresthesias, shoulder</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Transient paresis</td>
<td>0.3%</td>
<td>0.2%</td>
<td>1.3%</td>
<td></td>
</tr>
<tr>
<td>Muscle weakness</td>
<td>0.4%</td>
<td>0.6%</td>
<td>0.2%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Dural lesion/violation</td>
<td>0.4%</td>
<td>0.8%</td>
<td></td>
<td>0.6%</td>
</tr>
<tr>
<td>Radiculopathy</td>
<td>0.6%</td>
<td>0.6%</td>
<td>0.7%</td>
<td>0.3%</td>
</tr>
<tr>
<td><strong>Wound:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dehiscence/debridement</td>
<td>0.2%</td>
<td>0.5%</td>
<td></td>
<td>0.3%</td>
</tr>
<tr>
<td>Delayed wound healing</td>
<td></td>
<td></td>
<td></td>
<td>0.1%</td>
</tr>
<tr>
<td>Wound hematoma/seroma</td>
<td>0.3%</td>
<td>0.5%</td>
<td>0.2%</td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>0.9%</td>
<td>1.5%</td>
<td>0.3%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Deep wound infection</td>
<td>0.7%</td>
<td>0.4%</td>
<td>1.0%</td>
<td>0.6%</td>
</tr>
<tr>
<td>CSF leak</td>
<td>0.7%</td>
<td></td>
<td>1.4%</td>
<td></td>
</tr>
</tbody>
</table>
## RISKS TO HEALTH: Other Adverse Events by Anchor Type

<table>
<thead>
<tr>
<th>Event</th>
<th>ALL</th>
<th>LM</th>
<th>PS</th>
<th>LM + PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Patients: Other Events</td>
<td>2216</td>
<td>848</td>
<td>1049</td>
<td>319</td>
</tr>
<tr>
<td>Neck pain</td>
<td>0.3%</td>
<td>0.2%</td>
<td></td>
<td>1.6%</td>
</tr>
<tr>
<td>Swallowing disturbance</td>
<td>0.1%</td>
<td></td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>Blurred vision</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Blood loss</td>
<td>0.5%</td>
<td>1.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venous plexus bleeding</td>
<td>0.3%</td>
<td></td>
<td></td>
<td>1.9%</td>
</tr>
<tr>
<td>Vertebral artery bleeding</td>
<td>0.2%</td>
<td>0.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertebral artery injury</td>
<td>0.8%</td>
<td></td>
<td>1.3%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Respiratory Issue</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.2%</td>
<td></td>
</tr>
<tr>
<td>Skin Irritation</td>
<td>0.1%</td>
<td></td>
<td>0.2%</td>
<td></td>
</tr>
<tr>
<td>Iliac crest pain</td>
<td></td>
<td></td>
<td></td>
<td>0.3%</td>
</tr>
<tr>
<td>Other General Medical</td>
<td>0.6%</td>
<td>0.5%</td>
<td>0.9%</td>
<td></td>
</tr>
<tr>
<td>Death related to procedure and/or device</td>
<td></td>
<td></td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Re-operations</td>
<td>2.1%</td>
<td>2.8%</td>
<td>1.8%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>
RISKS TO HEALTH: Vertebral Artery Injuries

• Results include 4 additional vertebral artery injuries
  – 2 no further detail
  – 1 stopped with tamponade via packing
  – 1 no consequence

• 1 death
  – C2 medial breach in the transverse foramen
  – VA stenosis and thrombosis of the basilar artery (angiography)
  – Extubated with neurologic deterioration
  – 6 hours later, the patient was comatose
  – Endovascular thrombolysis was unsuccessful
  – Patient expired post-op day 7

No other deaths related to pedicle or lateral screws were identified in the published literature.
RISKS TO HEALTH: Posterior Wiring, Cabling or Hooks

- Compared to the literature cohort of pedicle and lateral mass screw studies, rates higher in wiring/cable studies

<table>
<thead>
<tr>
<th></th>
<th>Wiring/Cable Studies</th>
<th>Pedicle and Lateral Mass Screw Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic Events</td>
<td>5.8%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Re-operation</td>
<td>10.3%</td>
<td>2.1%</td>
</tr>
</tbody>
</table>
RISKS TO HEALTH: FDA’s MAUDE Database

- No reported events for two devices cleared for lateral mass and/or pedicle screw use
- For comparison of cervical devices that are Class II, “worse case” rates based on MAUDE and PearlDiver 2006-2011
  - Anterior: 0.17% (2,431/1,413,244)
  - Posterior: 3.01% (2,962/98,361)
- Event rates for cervical pedicle/lateral mass within range of these events
CONCLUSIONS

• Studies demonstrate that the use of pedicle and lateral mass screws in cervical spine constructs is effective
  – High fusion rates
  – Improved/preserved neurologic function
  – Improvement in pain and function also noted
  – Compared to hooks, cables and wiring, which are Class II devices, lateral mass and pedicle screws resulted in comparable or higher fusion rates and higher rates of neurologic improvement
CONCLUSIONS

- Placement accuracy rates of lateral mass and pedicle screws in the cervical spine
  - High, and the results were comparable to screw placement accuracy in the thoracic and lumbar spine
  - Rate of vertebral artery and neurologic injury was low
  - One event out of 2,216 surgeries resulted in death (due to vertebral artery injury)

- Rates of device specific events were low

- Rate of neurologic, instrument failure and re-operation events for lateral mass and pedicle screws was lower than the cited studies for posterior wiring/cabling
Clinical Rationale for Reclassification
Standard of Clinical Care

• Indications are well defined
• Will not realize an increase in the number of posterior cervical cases
• Anterior cervical procedures will not be converted to posterior procedures
• Reclassification makes classification clinically relevant with respect to posterior cervical fixation techniques
Enhance Patient Safety

• Maximize appropriate opportunities for physician education
• Optimize the learning curve
• Decrease the reliance on antiquated wiring techniques and associated halo-vest immobilization
Proposed Regulatory Controls

Sharon Starowicz
OSMA President
General Controls

- Manufacturing establishment registration
- Quality System regulation
- Adulteration and misbranding provisions (labeling requirements)
- Record keeping provisions
- Reporting of adverse events, recalls
Special Controls

• Performance standards
  – Materials
  – Biocompatibility
  – Mechanical testing
• Training
• Labeling information
# Material Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM F-67</td>
<td>Standard Specification for Unalloyed Titanium, for Surgical Implant Applications</td>
</tr>
<tr>
<td>ASTM F-136</td>
<td>Standard Specification for Wrought Titanium-6 Aluminum-4 Vanadium ELI (Extra Low Interstitial) Alloy for Surgical Implant Applications</td>
</tr>
<tr>
<td>ASTM F-1295</td>
<td>Standard Specification for Wrought Titanium-6 Aluminum-7 Niobium Alloy for Surgical Implant Applications</td>
</tr>
</tbody>
</table>
Biocompatibility

- Biocompatibility can be assured through testing in accordance with ISO 10993, *Biological Evaluation of Medical Devices*
- Adherence to existing material standards
- Materials used have a well-established safety profile in orthopedic implants, including use in the cervical spine
Mechanical Testing

- Well-established methods exist to evaluate the mechanical performance of pedicle and lateral mass screws.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM F-1717</td>
<td>Standard Test Methods for Spinal Implant Constructs in a Vertebrectomy Model</td>
</tr>
<tr>
<td>ASTM F-1798</td>
<td>Standard Guide Evaluating the Static and Fatigue Properties of Interconnection Mechanisms and Subassemblies Used in Spinal Arthrodesis Implants</td>
</tr>
<tr>
<td>ASTM F-2706</td>
<td>Standard Test Methods for Occipital-Cervical and Occipital-Cervical-Thoracic Implant Constructs in a Vertebrectomy Model</td>
</tr>
</tbody>
</table>
Training Requirements

• Medical training and education on posterior cervical spine surgery are currently offered by the major orthopedic and spinal societies

• Manufacturers may also sponsor product-specific training regarding cervical pedicle and lateral mass screw systems
Labeling Requirements

- Use by experienced spinal surgeons with appropriate training
- Preoperative planning using CT and/or MRI, in addition to radiographs
- Revise labeling currently required for thoracolumbar pedicle screws to include cervical use
Summary

• Clinical evidence demonstrates general and special controls are appropriate to ensure safe use of cervical pedicle and lateral mass screws
• Classification as Class II would be consistent with current Class II status of other cervical spinal implants and similar thoracolumbar pedicle screw systems
• Classification will allow labeling and training for use of the screws that is consistent with current standard of clinical care
Conclusion

• OSMA believes that the information presented provides reasonable assurance of safety and effectiveness of pedicle and lateral mass screws for cervical use.

• Class II is the appropriate classification.