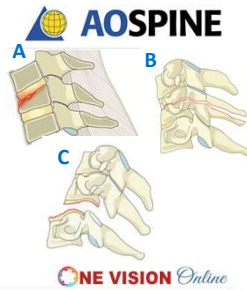


A word on classification systems...

- AO Classification
 - Morphologic classification system
 - Highly reproducible. Simple in its basic form.
 - In it's comprehensive form , much too cumbersome for daily use (research)
- **Type A – Compression injuries**
- **Type B – Tension band injuries**
- **Type C – Translational injuries**



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Cervical : SLIC

- Spine Trauma Study Group
- Sub-axial Injury Classification system
- Takes into account
 - Injury Morphology
 - Disco-ligamentous Complex
 - Neurological status of the patient
- Score
 - < 4 non-op
 - >4 operative
 - 4?

The Surgical Approach to Subaxial Cervical Spine Injuries
An Evidence-Based Algorithm Based on the SLIC Classification System
Marcel F. Dvorak, MD, FRCS, Charles E. Fisher, MD, MHS, FRCS, Michael G. Fehlings, MD, PhD, Y. Raja Rampersaud, MD, FRCS, F. C. Oner, MD, PhD, Bishan Arora, MD, and Alexander R. Vaccaro, MD

Characteristics	Points
Injury morphology	
No abnormality	0
Compression	1
Burst	2
Distraction	3
Translation	4
Integrity of the disco-ligamentous complex	
Intact	0
Indeterminate	1
Disrupted	2
Neurological status	
Intact	0
Nerve root injury	1
Complete	2
Incomplete	3
Persistent cord compression	+1

SLIC: Subaxial Injury Classification

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SLIC : Case Example

- 72 y/o M s/p MVC, transferred from OH
- RUE : 1/5 D, B, WE, T, FF, FA
- LUE : 3/5 D, B, WE, T, FF, 1/5 FA
- BLE : 3/5 IP, 4/5 Q, TA, GSC. 3/5 EHL.
- +Voluntary rectal tone. +Perianal sensation. +BC reflex intact.



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SLIC : Case Example

- 72 y/o M s/p MVC, transferred from OH
- RUE : 1/5 D, B, WE, T, FF, FA
- LUE : 3/5 D, B, WE, T, FF, 1/5 FA
- BLE : 3/5 IP, 4/5 Q, TA, GSC. 3/5 EHL.
- +Voluntary rectal tone. +Perianal sensation. +BC reflex intact.

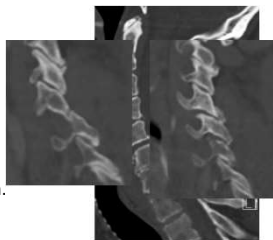


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SLIC : Case Example

- 72 y/o M s/p MVC, transferred from OH
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SLIC : Case Example

- 72 y/o M s/p MVC, transferred from OH
- RUE : 1/5 D, B, WE, T, FF, FA
- LUE : 3/5 D, B, WE, T, FF, 1/5 FA
- BLE : 3/5 IP, 4/5 Q, TA, GSC. 3/5 EHL.
- +Voluntary rectal tone. +Perianal sensation. +BC reflex intact.
- SLIC Score : 3 points for Distraction, 2 points for DLC disruption, 3 points for incomplete injury (8, surgical)

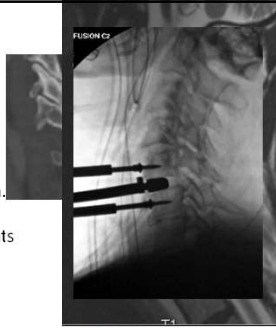


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SLIC : Case Example

- 72 y/o M s/p MVC, transferred from OH
- RUE : 1/5 D, B, WE, T, FF, FA
- LUE : 3/5 D, B, WE, T, FF, 1/5 FA
- BLE : 3/5 IP, 4/5 Q, TA, GSC. 3/5 EHL.
- +Voluntary rectal tone. +Perianal sensation. +BC reflex intact
- SLIC Score : 3 points for Distraction, 2 points for DLC disruption, 3 points for incomplete injury (8, surgical)



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SLIC : Case Example

- 72 y/o M s/p MVC, transferred from OH
- RUE : 1/5 D, B, WE, T, FF, FA
- LUE : 3/5 D, B, WE, T, FF, 1/5 FA
- BLE : 3/5 IP, 4/5 Q, TA, GSC. 3/5 EHL.
- +Voluntary rectal tone. +Perianal sensation. +BC reflex intact.
- SLIC Score : 3 points for Distraction, 2 points for DLC disruption, 3 points for incomplete injury (8, surgical)



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AOD

- Rare, highly unstable, and frequently fatal.
- Can be difficult to diagnose, often missed, with devastating consequences.
 - Careful scrutiny of Sagittal and Coronal recon views is critical
 - Any asymmetry is cause for concern
- Traynelis classification (not useful)
 - I – Anterior; II – Longitudinal; III – Posterior
- This is a LIFE-THREATENING INJURY
 - Swift action can save the patient's life
 - Collars are DISTRACTIVE and DANGEROUS (remove collar, apply temporizing halo with gentle compression)
 - Limit moving the patient

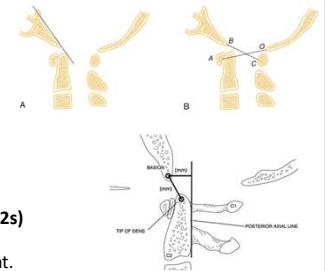


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AOD

- **A – Wackenheim's line**
- **B – Power's Ratio**
 - $B-C / O-A$
 - $>1 = AOD$
 - $NI < 0.77$
- **C – Harris' Measurements (Rule of 12s)**
 - BDI – basion-dens interval
 - BAI – basion-posterior axial line int.
 - Both should be < 12 mm

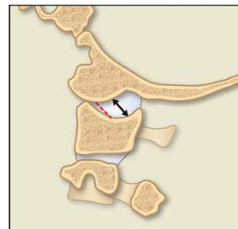


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AOD

- Revised Condylar-C1 Interval (CCI)
 - Simple, most reliable
 - Dislocation defined as >2.5 mm distance from bottom of occipital condyle to nadir of the C1 articular surface.



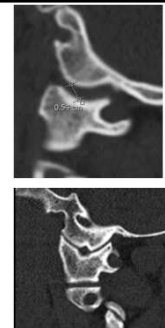
Global Spine | 2016;6:529-534.
The Application of the Revised Condyle-C1 Interval Method to Diagnose Traumatic Atlanto-occipital Dissociation in Adults

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AOD – Case Example

- 17 yo M s/p MVC with multiple injuries p/w asymmetric AO widening on left side. Will not fit in MRI scanner (allegedly)
- Bedside stretch test performed by NSR. No definitive injury identified.
- Long conversation had with family regarding treatment options. Given morbidity of OCF and questionable injury, family elected to go with immobilization



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AOD – Case Example

- 17 yo M s/p MVC with multiple injuries p/w asymmetric AO widening on left side. Will not fit in MRI scanner (allegedly)
- Bedside stretch test performed by NSR. No definitive injury identified.
- Long conversation had with family regarding treatment options. Given morbidity of OCF and questionable injury, family elected to go with immobilization



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AOD – Case Example

- Patient placed in collar. Cleared for other surgeries.
- Taken to OR by orthopaedic trauma for right sided SI screw
- Wakes from surgery with L>R quadraplegia.
- CT repeated:



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AOD – Case Example

- Taken by ortho spine to OR for ORIF / Occ-C3 PSIF w/ ICBG
- Quadraplegia gradually improves
- Ultimately completely resolved by 8 wks postop



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Thoracolumbar : TLICS

- Vacarro et al.
- First T/L scoring system to take into account the **neurologic status** of the patient (!!!)
- Very useful for residents
- Many fractures end up being a 4

Alexander R. Vaccaro, MD,*
A New Classification of Thoracolumbar Injuries
The Importance of Injury Morphology, the Integrity of the Posterior Ligamentous Complex, and Neurologic Status
SPINE Volume 30, Number 20, pp 2322-2333
©2005, Lippincott Williams & Wilkins, Inc.

TLICS 3 independent predictors		
1 Morphology immediate stability	<ul style="list-style-type: none"> • Compression 1 • Burst 2 • Translation/rotation 3 • Distraction 4 	<ul style="list-style-type: none"> • Radiographs 2 • CT 3
2 Integrity of PLC long-term stability	<ul style="list-style-type: none"> • Intact 0 • Suspected 2 • Injured 3 	<ul style="list-style-type: none"> • MRI 2
3 Neurological status	<ul style="list-style-type: none"> • Intact 0 • Nerve root 2 • Complete cord 3 • Incomplete cord 3 • Cauda equina 3 	<ul style="list-style-type: none"> • Physical examination 2
Predicts	<ul style="list-style-type: none"> • 0-3 0-3 • Need for surgery 4 • nonsurgical surgeon's choice • >4 surgical 	

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Thoracolumbar : TLICS

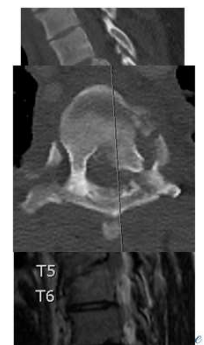
- 20 year old M s/p MVC with BLE weakness
 - RLE : 0/5 all motor groups, ½ SILT
 - LLE : 2/5 IP, 3/5 Q, 4/5 TA,EHL, GSC ½ SILT
 - Rectal : +VRT, +Perianal sens, BC intact
- TLICS : Burst (2), PLC indeterminate (2), Incomplete (3) = 7, operative



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Thoracolumbar : TLICS

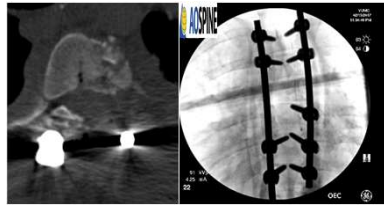
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 - Rectal : +VRT, +Perianal sens, BC intact
- TLICS : Burst (2), PLC indeterminate (2), Incomplete (3) = 7, operative



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Thoracolumbar : TLICS

- T/L fusion with transpedicular decompression
- ASIA E at 6 wks



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Thoracolumbar : TLICS

- T/L fusion with transpedicular decompression
- ASIA E at 6 wks



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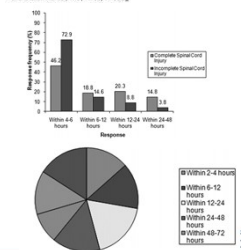
When to operate?

- Fehlings et al 2010 consensus study on timing of surgery for SCI
- **Major** discrepancy between acute SCI and traumatic CCS
 - 96% would decompress the acute SCI patient with jumped facets w/in 24 hours
 - 45% for CCS

SPINE Volume 35, Number 21S, pp S166-S173
©2010, Lippincott Williams & Wilkins

Current Practice in the Timing of Surgical Intervention in Spinal Cord Injury

Michael G. Fehlings, MD, PhD, FRCS, FACS,*† Doreen Rubin, MD, FRCS,*†
William Sears, MB, BS, FRACS,† David W. Cadotte, MSc, MD,*†
and Brian Aarabi, MD, FACS, FRCS*



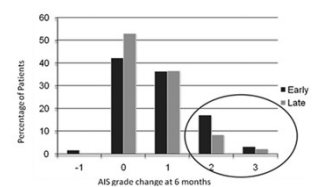
Online

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TIMING : STASCIS

- Prospective cohort study comparing neurologic recovery between patients receiving early (<24 hr) and late (>24 hr)
- The odds of AIS 2 grade improvement were **2.8 x** higher with early surgery ($p=0.03$)
- The odds of AIS 1 grade improvement showed no difference
- Complications lower in early surgery group (24% v. 30%, $p=0.21$)

Early versus Delayed Decompression for Traumatic Cervical Spinal Cord Injury: Results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS)



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If early is better, what about right away?

- 72 patients underwent MRI confirmed cervical decompression for acute SCI
- Ultra-early (<12 hours) did not confer a benefit in terms of neurologic AIS recovery at 6 months.
- The only variable predictive of postoperative recovery was **Intramedullary Lesion Length**

Journal of Neurotrauma

Efficacy of Ultra-Early (<12 hours), Early (12-24 hours), and Late (>24-138.5 hours) Surgery with MRI-Confirmed Decompression in AIS Grades A, B, and C Cervical Spinal Cord Injury

16 Jul 2019

Intramedullary Lesion Length (IMLL, mm, SD)	59.3 (20.7)	35.6 (9.6)	46.1 (19.4)	0.002
Admission grade A	54.2	31.9	40.6 (18.4)	0.003



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Central Cord Syndrome

- Schneider's classic 1954 JNS article
- "Recognition of the syndrome is important for the authors believe that it may imply a fairly good prognosis. Surgical decompression of the spinal cord is **contraindicated** because spontaneous improvement or complete recovery may occur. Furthermore, operation has actually been known to harm these patients rather than improve."

THE SYNDROME OF ACUTE CENTRAL CERVICAL SPINAL CORD INJURY
WITH SPECIAL REFERENCE TO THE MECHANISMS INVOLVED IN HYPEREXTENSION INJURIES OF CERVICAL SPINE*
RICHARD C. SCHNEIDER, M.D., GLENN CHERRY, M.D.,† and HENRY PASTER, M.S.E. (SE)
University of Michigan Hospital and Medical School, Ann Arbor, Michigan
(Received for publication July 9th, 1954)

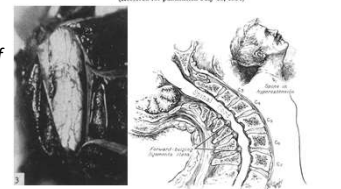


Fig. 1. Case 2. Showing the hyperextension of the upper cervical spine as the primary cause of the spinal cord injury. The hyperextension is caused by the hyperflexion of the neck.

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Central Cord Syndrome – Timing of Surgery

- Lenehan et al. analyzed a subset of the STASCIS patients with CCS without instability.
- Early surgery again defined as within 24 hours.
- **Early Surgery** resulted in a **6.31** point greater improvement in AIS motor scores vs. late surgery ($p = 0.038$) at 12 months.
- **Early Surgery** also had a increased chance of **ASIA motor grade** improvement at 6 and 12 months (OR 3.39 and 2.81).

The Urgency of Surgical Decompression in Acute Central Cord Injuries With Spondylosis and Without Instability

Brian Lenehan, MD, MCh, FRCS,* Charles G. Fisher, MD, MHS, FRCS,* Alex Vaccaro, MD, PhD,† Michael Fehlings, MD, PhD,‡ Brian Aarabi, MD,§ and Marcel F. Dvorak, MD, FRCS*

SPINE Volume 35, Number 21S, pp S180–S186
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Central Cord Syndrome – Timing of Surgery

- Our recommendations were: “We suggest that early surgery be considered as a treatment option in adult patients with traumatic central cord syndrome” and “We suggest that early surgery be offered as an option for adult acute SCI patients regardless of level.”
- Quality of evidence for both recommendations was considered **low**

A Clinical Practice Guideline for the Management of Patients With Acute Spinal Cord Injury and Central Cord Syndrome: Recommendations on the Timing (≤24 Hours Versus >24 Hours) of Decompressive Surgery

AOSPINE

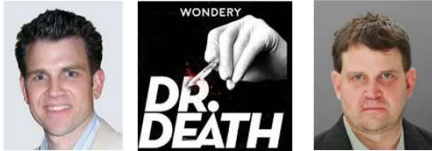
Global Spine Journal
2017, Vol. 7(3S) 195S-202S

Michael G. Fehlings, MD, PhD,

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Surgical Strategies and Goals of Surgery



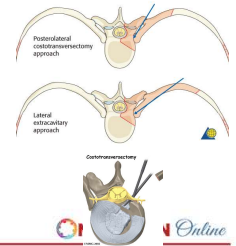
- 1) Stabilize
- 2) Decompress neural elements
- 3) Correct deformity / Maintain alignment

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Approaches : T/L

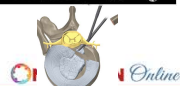
- All Posterior
 - Workhorse for all thoracolumbar trauma
 - Excellent ability to stabilize with modern pedicle screw technology
 - Can achieve decompression via :
 - Laminectomy
 - Transpedicular Approach*
 - Costo-transversectomy*
 - Lateral extra-cavitary*



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Approaches : T/L

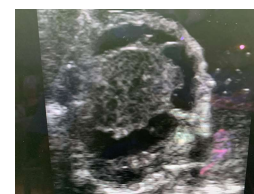
- All Posterior
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 - Excellent ability to stabilize with modern pedicle screw technology
 - Can achieve decompression via :
 - Laminectomy
 - Transpedicular Approach*
 - Costo-transversectomy*
 - Lateral extra-cavitary*



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All-Posterior Approach : Intraop Ultrasound



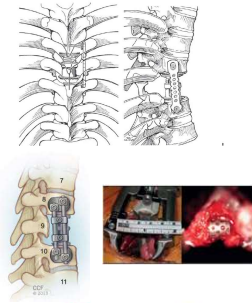
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Approaches : T/L

• Anterior

- Anterior decompression (via either posterior, anterior, or combined approach) is necessary with SCI from retropulsed bone fragments (burst fracture)
- Isolated anterior approach described, but currently rarely performed
- Access surgeon issues, traditionally
- Modern techniques allow for less invasive approaches; however they are rarely used in isolation for thoracolumbar trauma



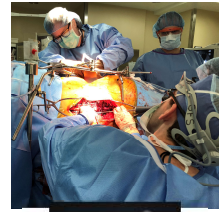
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Approaches : T/L

• Combined A-P

- Due to utility of costo-transversectomy, **rarely** required in trauma



LATERAL VIEW
L2-L3 SPECIMEN X-RAY, O.R.-16

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Approaches : Anterior Cervical

• Anterior

- Advantages

- Fast, reproducible
- Great outcomes
- Easy recovery

- Disadvantages

- Dysphagia
- Adjacent Segment Disease
- Not an ideal surgery for congenital stenosis
- Enough fixation?



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Approaches : Posterior Cervical

- Indications

- Multi-level stenosis (≥ 3)
- Lami alone \rightarrow 47% develop post laminectomy kyphosis

- Advantages

- Easily achieve wide decompression
- Powerful surgery
- Deformity correction

- Disadvantages

- Pain
- Slightly increased infection rate (vanc powder)
- Longer hospital stay



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Approaches : Anterior-Posterior Cervical

- Indications

- Retro-corporal stenosis
- Cervical Burst Fractures
- High-Energy Jumped Facets

- Advantages

- Solid Fixation
- Excellent decompression

- Disadvantages

- More extensive surgery
- Time
- ? Necessity



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Cervical Laminoplasty

- Indications

- Multi-level stenosis (≥ 3)
- **Central Cord Syndrome**

- Advantages

- Non-fusion technique
- FAST
- Powerful surgery

- Disadvantages

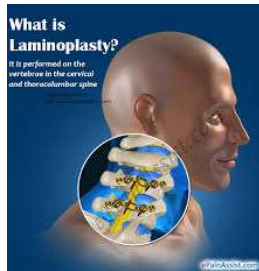
- Increased immediate pain
- Increased infection rate
- Requires neutral-to-lordotic sagittal alignment



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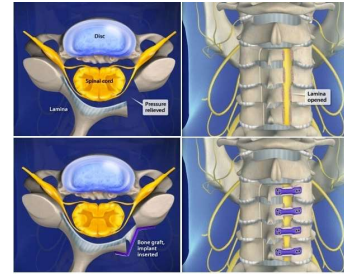
Cervical Laminoplasty



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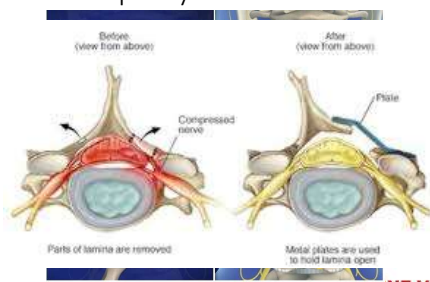
Cervical Laminoplasty



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Cervical Laminoplasty



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Cervical Laminoplasty

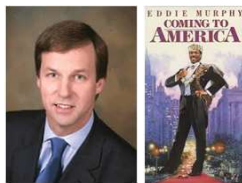


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Laminoplasty – the perfect surgery?

- Popularized in Japan
- 'Brought to America' by John Heller et al (Emory)
- **Better** surgery
 - Motion preserving
 - Faster surgical time
 - Faster recovery
 - Equivalent neurological outcomes to fusion
 - No need to heal a fusion
 - Negates the ASD phenomenon (non-fusion surgery)



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Laminoplasty – the perfect surgery?

Laminoplasty Does not Lead to Worsening Axial Neck Pain in the Properly Selected Patient With Cervical Myelopathy

SPINE Volume 42, Number 24, pp 1844-1850
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A Comparison With Laminectomy and Fusion

Byron F. Stephens, MD,* John M. Rhee, MD,[†] Thomas M. Neustein, MD,[‡] and Rafael Arceo, BS[§]

TABLE 2. Perioperative Data			
	LP	LF	P
Operative levels	4.45 ± 0.748	5.73 ± 1.63	<0.001
Operative time (minutes)	122.3 ± 25.31	200.0 ± 71.3	<0.001
EBL (mL)	97.5 ± 73.8	177.0 ± 134.8	<0.001
Hospital stay (days)	2.62 ± 1.50	3.90 ± 2.03	<0.001
Delirium Palsy	3	5	0.13

EBL = estimated blood loss.

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Laminoplasty – the perfect surgery?

Laminoplasty Does not Lead to Worsening Axial Neck Pain in the Properly Selected Patient With

SPINE Volume 42, Number 24, pp 1844-1850
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M. Neustein, MD,¹ and Rafael Arceo, BS¹

LF	P
5.73 ± 1.63	<0.001
200.0 ± 71.3	<0.001
177.9 ± 134.8	<0.001
3.90 ± 2.03	<0.001
5	0.13

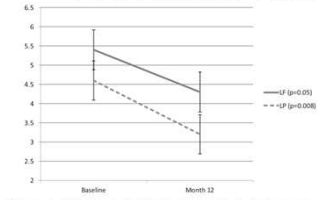


Figure 3. VAS total significantly improved in both groups (LP -1.4 ± 0.51 , $P=0.008$; LF -1.04 ± 0.52 , $P=0.05$). VAS indicates visual analogue score; LF, laminectomy and fusion; LP, laminoplasty.

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Laminoplasty – the perfect surgery?

Laminoplasty Does not Lead to Worsening Axial Neck Pain in the Properly Se

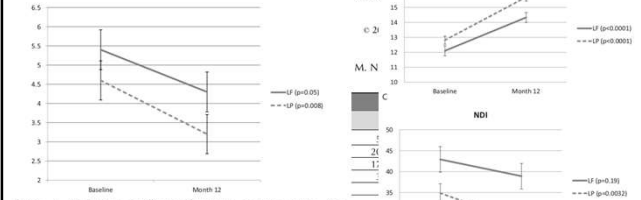
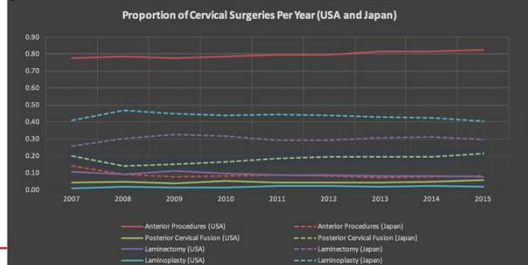


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Laminoplasty – the perfect surgery?

- Despite its efficacy, laminoplasty is under-utilized in the US vs. Japan



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So why isn't laminoplasty more popular?

- Training issue
 - Technically demanding surgery
 - If surgeons didn't learn the technique in fellowship, unlikely to use it in practice
- Misconception about neck pain
- And ...



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So why isn't laminoplasty more popular?



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So why isn't laminoplasty more popular?

- C3-7 ACDF
 - 74 wRVUs
- C3-7 PCF with laminectomy
 - 57 wRVUs
- C3-7 laminoplasty
 - 25 wRVUs



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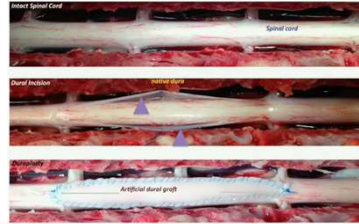
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Future efforts

- Duraplasty
- Interesting preliminary basic science data
- No human trials ... yet

Expansion Duroplasty Improves Intraspinal Pressure, Spinal Cord Perfusion Pressure, and Vascular Pressure Reactivity Index in Patients with Traumatic Spinal Cord Injury: Injured Spinal Cord Pressure Evaluation Study

Israr Phang¹, Melissa C. Weirich², Samira Saadoun³, Georgios Varoux², Munkh C. Zorinhu², Angelo Zampieri², and Marinos C. Papadopoulos²



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Future efforts – Cell Therapy ?

Review

Spinal cord injuries: how could cell therapy help?

Anna Badner, Ahad M. Siddiqui & Michael G. Fehlings

Pages 529-541 | Received 08 Nov 2016, Accepted 15 Mar 2017, Accepted author version posted online: 17 Mar 2017, Published online: 27 Mar 2017

Expert opinion: Most preclinical studies, and an increasing number of clinical trials, are finding that single cell therapies have only modest benefits after SCI. These considerations, alongside issues of therapy cost-effectiveness, need to be addressed at the bench. In addition to exploring combinatorial strategies, researchers should consider cell reproducibility and storage parameters when designing animal experiments. Equally important, clinical trials must follow strict regulatory guidelines that will enable transparency of results.

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Future efforts – Scaffolding?

Neuro-Spinal Scaffold™ IN VIVO THERAPEUTICS

The *Neuro-Spinal Scaffold™* is an investigational bioresorbable polymer scaffold that is designed for implantation at the site of injury within a spinal cord contusion. The *Neuro-Spinal Scaffold* provides structural support to the spared spinal tissue and a supportive matrix to facilitate endogenous repair processes. It degrades over several weeks.



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THANK YOU



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