Direct Look LLIF

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Disclosures

- Consultant in last 2 years: Relivant, Globus, Nuvasive, Stryker
- Royalties: Globus, Nuvasive
- Stock Ownership: Spinicity

Background

- LLIF used to treat a variety of pathologies
  - Spondylolisthesis
  - Stenosis
  - Scoliosis
  - Tumors
  - Fractures

Interbody fusion devices are FDA cleared for use in treating degenerative disc diseases.
Background

- Initially described in the early 1990s by Mayer\(^1\) and McAfee\(^2\).
- Refined and popularized by Louis Pimenta\(^3\).
- Current principles include the following:
  - A transpsoas approach neuromonitoring, thorough discectomy from ipsilateral to contralateral annulus fibrosus, and a ring apophyseal fit of trans-laterally placed cage.

3. Pimenta, L. Lateral endoscopic transpsoas retroperitoneal approach for lumbar spine surgery. in VIII Brazilian Spine Society Meeting (Belo Horizonte, Minas Gerais, Brazil, 2001).

Compare to TLIF

***** Not in the LAB ~ Real life

- 600 Lateral cases (741 levels)
  - 6.2% complication rate from OR to 6 wks
  - 1 quad weakness, 1 TA weakness
  - Both resolved by 3 months post op
  - 11 reoperations

- Routine Lumbar Surgery\(^2\) Swedish Lumbar Spine Group (222 patients prospective)
  - 3.9% for PLIF
  - 9.7% for 360° (ALIF or PLIF with PLF)

Rogers, et al. Spine 2010

Barrier to Adoption: L4-5

- Nerve Palsies\(^1\)
  - Rocuronium?
  - Succinylcholine?

- “There is no safe zone for the lumbar nerve roots during direct lateral transpsoas approach”\(^2\)

- Deformity Makes it worse\(^3\)

3. Regev Spine 2009
On average, the nerve moves anteriorly by approx. 1.5 mm at the L5 superior endplate, with 40° table break.

Static safe zones are not a reality

Commonly done in TLIF, Microdisc, PSO

Is there a difference once nerves are in the psoas?
- PSO with 3% palsy rate

Utilize skills as surgeon
- Never abort L4-5

DISPELLING THE MYTH
1. Anesthesia
2. Cutaneous nerves
3. Psoas Fascia
4. Minor Arborization of Plexus
Reports of Quadriceps palsy after LLIF
- No indication of what induction agent was used.1,2
- Significant variability in neuromuscular recovery between depolarizing (succinylcholine) and non-depolarizing neuromuscular agents.3

40% of patients having residual paralysis on emergence from anesthesia after using rocuronium as an induction agent.1

Central muscles recover faster than peripheral muscles located at the extremities.1,2

The Anesthesia

is crucial

40% of patients having residual paralysis on emergence from anesthesia after using rocuronium as an induction agent.1

Central muscles recover faster than peripheral muscles located at the extremities.1,2

The facial muscles and core muscles, often monitored by the TOF device, may demonstrate more function compared to the quadriceps and tibialis anterior, where the lumbar plexus is monitored.1,2


Glutamatergic and GABAergic Pathways

Standardization of Plexopathy
Most Reports are inconsistent with wide variation in sensory and motor injury
Need for standardization in reporting
A call to action exists

Lumbar Plexus Arborization
- 1-3 major branches from Femoral Nerve (3,4 Nerve roots) to Psoas
- Minor Redundant Branches
- Confluent with Psoas Fascia

MR Neurogram
1. Neural Retraction is OK
2. Anesthesia is important
3. Skin incision can cause leg symptoms
4. Release of Psoas fascia
5. Create Potential Space

**Key Concepts**

**Modifications**

**ANATOMY**

**MODIFICATIONS**
Standardize Reporting

- LID
  - Lateral disability index
- ODI
Lordosis Correction Techniques for MIS LLIF
Choll W. Kim MD PhD
Spine Institute of San Diego

CONSULTANT/SPEAKER/INSTRUCTOR
• Globus*
• Pioneer
• Synthes
• Joimax
• Stryker
• K2M
• Spineview

* Royalties for Intercontinental

DISCLOSURES

MIS Reconstruction
TYPICAL PT
• 72y male
• Neurogen Claudic
• Back Pain
• Diff standing upright
MIS Reconstruction

**GOALS**
- Decompression
- Stabilization
- Realignment
  - Coronal
  - Sagittal
  - LORDOSIS

**MIS LLIF**
- Minimally invasive ALIF
- High fusion
- Large edge-edge graft
- Excellent disc space correction

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What are the radiographic results of MIS Reconstruction?
CORONAL CORRECTION

Reduction in Focal Cobb Angle (per fusion level)

<table>
<thead>
<tr>
<th>Degrees of Correction</th>
<th>Pre-op</th>
<th>Post-op</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2F</td>
<td>0°</td>
<td>10°</td>
<td>10°</td>
</tr>
<tr>
<td>C7F</td>
<td>5°</td>
<td>15°</td>
<td>10°</td>
</tr>
<tr>
<td>C7L</td>
<td>9°</td>
<td>14°</td>
<td>5°</td>
</tr>
</tbody>
</table>

SAGITTAL CORRECTION

Reduction in Focal Cobb Angle (per fusion level)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-op</th>
<th>Post-op</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior height (mm)</td>
<td>6.9</td>
<td>11.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Posterior height (mm)</td>
<td>4.6</td>
<td>6.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Focal Lordosis</td>
<td>3.8°</td>
<td>7.8°</td>
<td>4.0°</td>
</tr>
</tbody>
</table>
How can we do better?

**LLIF Lordosis Correction**

**ANTERIORLY**
- Thorough, careful disk release
- Anterior placement of spacer
- Lordotic spacers (eg. 10 degrees)

**POSTERIORLY**
- Thorough facet release (Ponte-type)
- Lordotic rod reduction
- Gentle compression
Subsidence
Endplate
Oversizing

10° Lordotic
Endplate
Preservation
Anterior
placement

Facet
resection
(Ponte-type)

Rod
contouring

**SAGITTAL CORRECTION**

Limited by
Anterior Longitudinal
Ligament *(ALL)*?
Can ALL resection improve lordosis correction?

CASE EXAMPLE

LLIF + ALL Resection

Spacer is unstable!
Integrated Plate-Spacer

CADAVERIC STUDY

Surgical Constructs

INTACT  LLIF  LLIF (X) ALL  LLIF (X) ALL

Larger Spacer  Larger Spacer

Screws

Biomechanics  Radiographic

n=6 specimens
L4-5
**RADIOGRAPHIC RESULTS**

- **INTACT**
- **LLIF**
- **RESECT ALL**
- **Larger Spacer**
- **Fix Screws**

- **ALL restricts lordosis correction**
- **ALL resection allows for greater implant size**
- **Overall greater lordosis correction**

**BIOMECHANICAL RESULTS**

- **ALL provides significant stability to LLIF**
- **Especially in AXIAL ROTATION**
- **Larger spacers improve Flex-Ext & Lateral Bending**
- **Larger spacer does not improve rotational instability**
- **Addition of screws improves stability back to intact**
CONCLUSIONS

MIS Lumbar Reconstruction

• KEY GOAL: Lordosis
• Key Strategies
  • Thorough discectomy, release
  • Anterior placement of spacer
  • Hyperlordotic spacers
  • Posterior facet resection
  • Rod contouring
  • Gentle compression

CONCLUSIONS

MIS Lumbar Reconstruction

• KEY GOAL: Lordosis
• Emerging Strategies
  • ALL resection/release
  • Spacers with integrated fixation needed for stability
  • Further develop surgical technique, instruments
  • Better assess safety profile

Minimally Invasive Spine Center of Excellence
Lateral Transpsoas Fusion and Lordosis Restoration

Chad Prusmack MD
Neurosurgery
Rocky Mountain Spine Clinic

Disclosures
• Globus Medical – Consultant, SAB, Shareholder

Introduction
• Adult Spinal Deformity (ASD)
• DDD, Osteoporosis, VB compression fractures

• Treatment ASD
• SVA < 5cm improves outcomes (Schuab et al., Glassman et al.)

• Traditional Management
  • Anterior Lengthening (ALIF)
  • Posterior Shortening Osteotomies (SPO, PSO, VCR)
SpinoPelvic Harmony

- Ultimate goal in ASD:
- 3 Basic Radiographic Targets:
  - SVA < 5cm
  - Pelvic Tilt < 20°
  - LL = PI +/- 9 deg

Traditional Operations:
Anterior Lengthening
ALIF Vs TLIF

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Posterior Shortening Techniques:
Osteotomies

- SPO: 1 → 15°
- PSO: 30 → 40°
Traditional Deformity Surgery: complications

- Open Deformity Surgery
- High blood loss volume
- 30 day mortality (2.4%)
- High major complication rate (15 - 30%)
- Neurologic deficit (0 - 30%)
- Lumbosacral Junction Pseudo (7 - 24%)
- Revision Surgery for pseudo (32%)
- Junctional Collapse: fracture or fixation (25%)
- Spinal Epidural Hematoma (1 - 2%)

MIS

- Achieve Traditional Goals of surgery
- Decreasing Approach Related Morbidity
- Advantages
  - Less Major Complications
  - Less Blood Loss
  - Less Wound Infections
  - Faster Mobilization
  - Shorter Hospital Stays

Can MIS Correct Deformity?
Lateral Lumbar Interbody Fusion

- Lateral Retropertitoneal TransPsoas Approach
- Low Blood Loss
- Low Major Complication Rate
- Good Anterior Column Support
- Established good fusion rates
- Large Interbody Spanning Cortical Rim
- Sagittal balance most closely linked to:
  - Quality of life
  - Health status outcomes
  - Function

- Can LLIF Correct Deformity?

GOOD CORONAL CORRECTION

Kim, C. Spine Inst SD

What about sagittal?
The Effect of the Retropertitoneal Transpsoas Minimally Invasive Lateral Interbody Fusion on Segmental and Regional Lumbar Lordosis

Tian Y. Le, Andrew C. Vivas, Elias Dukerz, Ali A. Saleh, and Juan S. Uribe

- 50 patients (L2-L5)
- Avg levels/ case = 1.4
- 10° lordotic static PeeK
- 50 - 60mm Length
- 8 – 10 mm height
- 18 – 22 width
- Lateral Plate
- No post Fixation
MIS LLIF (+) PostFix:
improves segmental lordosis NOT regional lordosis

Does Posterior Fixation Matter??

Changes in coronal and sagittal plane alignment following minimally invasive direct lateral interbody fusion for the treatment of degenerative lumbar disease in adults: a radiographic study
Clinical article

- 36 patients (L1-L5)
- Avg # levels = 1.8
- LLIF + Post Fixation
- Peak 6° lordotic
- Length 50-55mm
- Height 10-12mm
LLIF + post fix increases **SEGMENTAL** lordosis
LLIF+ post fix **DOES NOT** increase **REGIONAL** lordosis
LLIF + Post Fix **DOES NOT** improve Global SVA

**LLIF: (+) FOCAL SAG CORRECTION**

**LLIF: (-)GLOBAL SAG CORRECTION**

Limited by Anterior Longitudinal Ligament (ALL)?
CADAVERIC STUDY

Surgical Constructs

<table>
<thead>
<tr>
<th>INTACT</th>
<th>LLIF</th>
<th>LLIF</th>
<th>LLIF</th>
<th>LLIF</th>
<th>LLIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>(X) ALL</td>
<td>(X) ALL</td>
<td>Larger</td>
<td>Spacer</td>
<td>Screws</td>
<td></td>
</tr>
</tbody>
</table>

n=6 specimens
L4-5

Biomechanics Radiographic

RADIOGRAPHIC RESULTS

<table>
<thead>
<tr>
<th>5.2°</th>
<th>6.6°</th>
<th>11.6°</th>
<th>16.0°</th>
<th>16.3°</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTACT</td>
<td>LLIF</td>
<td>RESECT</td>
<td>ALL</td>
<td>Larger</td>
</tr>
</tbody>
</table>

- ALL restricts lordosis correction
- ALL resection allows for greater implant size
- Overall greater lordosis correction
BIOMECHANICAL RESULTS

CASE EXAMPLE

CASE EXAMPLE

Early Outcomes of Minimally Invasive Anterior Longitudinal Ligament Release for Correction of Sagittal Imbalance in Patients with Adult Spinal Deformity

- 7 patients
- Avg ALR = 1.6
- Avg Lvl = 4
- + Post Fixation
- 30° hyperlordotic PEEK
LLIF + ALR + Post FIX:
INCREASES Global LL 24°
Improves SVA 5cm
Decrease Pelvic Tilt 7°
ALR INCREASES Segmental Lordosis 17°/level

LLIF + ALR in Clinical Practice?
• New Approach
• Learning Curve
• LS plexus issues
• Great Vessel Proximity
• Sympathetic Chain

Alternative : MIS Osteotomies
25 patients
- Bilateral MIS Facetecomies
- Preserve midline muscular envelope
- MIS TLIF using OptiMesh

MIS Osteotomies
- MIS Osteotomy
- Lumbar Lordosis \(15^\circ\)
- SVA Improved 3.1 cm
- Low Blood Loss
- Low Complication Rate

LLIF with Anterior Placed Cages +
MIS Posterior SPO
Concern of complications with ALL Release
DirectLook LLIF + MIS Tubular SPO

- MINI-Open Lateral "DirectLook" Retroperitoneal Approach
- Visualizing Neural Structures
- Dissect Psoas Under direct vision
- Place Retractor Under direct vision
- Place Interbody Lordotic Grafts Anterior
- Posterior Stage: Bilateral Tubular Osteotomies + Pedicle screw
Pelvic harmony correlates with improved outcomes

LLIF circumvents some of the major morbidities of traditional surgery making it an attractive tool.

LLIF can improve focal lordosis with and without post fixation

LLIF can not improve global LL, SVA or PT regardless of spacer height, lordosis or length

ALR + LLIF + PostFix CAN improve pelvic harmony

ALR however may lead back to major complications in less experience hands

MIS SPO may be affective and safer

DirectLook LLIF + MIS SPO may be a future consideration for minimizing risk while maintaining high fusion rates and restoring Pelvic Harmony.
Minimizing Thigh Symptoms and Avoiding Complications: Tips and tricks based on 2000+ LLIFs

William D Smith
Chief of Neurosurgery
UMC Las Vegas

CONFLICTS

• Nuvasive
• Pedigaurd
• Glyde
• Spineology
• Spinesmith
• S i Bone
• Ortho Bio Design
• AIMIS
• Ex - WIFE

LLIF: Best Practices

Pre-op planning

1. BMI not critical
**LLIF: Best Practices**

**Pre-op planning**

1. BMI not critical
2. Review paraspinal anatomy

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**L4-5 Vascular Anomaly**

Lateral Location of the Iliacs on the Right Side of the Patient

Potential vascular injury if any instrument was used to release through the contralateral annulus

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**LLIF: Best Practices**

Q. How Often is L₄₅ Aborted?
A. Never

**Pre-op planning**

1. BMI not critical
2. Review paraspinal anatomy
3. Cautions

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Iliopsoas at L5S1 Can Access L5 S1 laterally

Approach Considerations for L4-5

Psoas Cross Section Anatomy Avoids Lateral Xray Consideration For Access Planning

XLIF- Best Practices

Positioning (lumbar)

1. Tape technique

Wrap Anterior to Posterior
XLIF® Best Practices

Positioning (lumbar)

1. Tape technique
2. Location of break
3. Amount of break
4. Fluoroscopic imaging

Position C-arm perpendicular to floor
Adjust table "roll" and "trendelenberg"
Obtain "True" AP and lateral

Positioning (lumbar)

1. Tape technique
2. Location of break

Between trochanter and crest

Pull Femur Caudally more than Breaking Table
(Increasing Break Places Plexus Under More Tension)
XLIF® Best Practices

Pre-op planning

1. BMI not critical
2. Review paraspinal anatomy
3. Cautions
4. High Crest, Fused L5-S1

Order angled instruments

Slides
Guided Distraction and Delivery

Retroperitoneal access

1. 1 or 2 incisions

SAFE passage from skin (A) to psoas (B)
Retroperitoneal access

1. 1 or 2 incisions

2. Retroperitoneal dissection

- Reflect fat and peritoneum anterior
- Place dilator on psoas surface
- No interposed tissue
- Visual/Tactile

XLIF® Best Practices

Approach

- Reproducible
- Expanding Indications
  - Muscle dilation
  - Neural protection

Preserve superficial nerves
  - Gentle, blunt, bipolar

LLIF® Best Practices

Retroperitoneal access

1. 1 or 2 incisions

2. Superficial dissection

Preserve superficial nerves
  - Gentle, blunt, bipolar
Access retroperitoneal space

- Structures at risk:
  - Motor branches of abdominal wall muscles
  - Subcostal nerve (T12)
  - Ilioinguinal, Iliohypogastric (L1)

- Offender:
  - Skin knife
  - Monopolar

- Clinical significance:
  - Abdominal wall paresis
  - Sensory deficit

- Complication avoidance:
  - Splitting muscle fibers

LLIF· Best Practices

Transpsoas dissection

1. Twitch test
2. Dilators

Advance and rotate (360°) slowly
Locate nerves (not avoid)
Dissect over disc only
Avoid AP wandering

XLIF· Best Practices

Transpsoas dissection

1. Twitch test

No paralytic agents
NVJJB/M5 vs. Non-directional Monitoring

Discrete real-time directionality and relative proximity to nerve

Traditional neuromonitoring would provide the same reading for these two dilator positions.

Retractor Management

1. Posterior docking
   - 0-30 yard line: acceptable
   - Maximizes disc exposure
   - Reduces risk of ALL rupture
   - Avoids Genitofemoral nerve
Customizable Access with Minimum Disruption

MaXcess® 4
• Dock posterior and retract away from lumbar plexus
• Reduced psoas trauma
• Optimal Exposure
• Conforms to anatomical needs

Other Lateral Access
• Aggressively large dilation
• One size fits all approach

Slow Gradual Opening of Retractor...Reduces Psoas Trauma

Retractor Management
1. Posterior docking
2. Orientation
   - Centered over and parallel with disc

LLIF® Best Practices

Retractor Management
1. Posterior docking
2. Orientation
3. Intradiscal shim
   - Direct vision
   - Centers Retractor over Disc Space
   - Secures position
   - Stabilizes Retractor
   - Protects Lumbar Plexus

LLIF® Best Practices
Anatomic considerations

Regev et al, Spine 2009
- Retrospective review 100 human MRIs
- Measured average % distance from posterior border of disc space to motor nerve
  - L1-2: 10.5%, 89.5% “safe zone”
  - L2-3: 15.5%, 84.5% “safe zone”
  - L3-4: 16.4%, 83.6% “safe zone”
  - L4-5: 25.9%, 74.1% “safe zone”
- 74.1% of disc space at L4-5 free of motor nerves—similar to Benglis et al.

Ant-Post L Disc Dimension
28-34 mm

Shifting Retractor Posterior 3-5 mm
(10% of Total AP Dimension
Easier Operation!

Disc/Endplate preparation (steps)
1. Annulotomy (templating)
2. Cobb elevator & contralateral release
3. Pituitary (moving tip faces anterior)
4. Box cutter (ensure parallel with endplates)
5. Pituitary
6. Endplate preparation (templating improves endplate preparation)
Relevant anatomy

Ligament sparing for ligamentotaxis

ALL Sparing And Endplate Preservation Key to Success

LLIF® Best Practices

Sizing

1. ↑ Area = ↓ Stress

2. Length (ring apophysis) = ↓ Strength

Better long than short Flush if plating

Caution at L45 especially if Plexus retracted
**LLIF: Best Practices**

**Sizing**

1. $\text{Area} = \downarrow \text{Stress}$
2. $\text{Length (ring apophysis)} = \downarrow \text{Strength}$
3. $\text{Wider (AP) implants} = \downarrow \text{Stress/subsidence}$

**BioMechanics**

Composite ROM

($\text{Weighted by In vivo ROM; proportions 7.2x FE, 2.7x LB, 1x AIR}$)

- Composite stability of “XL W + 4H Decade” is greater than “XL + Bilateral PS”
- Other single position fixation options (Decade + ipsilateral PS, or Affix II) provide further stability

**LLIF: Best Practices**

**Retractor Management**

1. Posterior docking
2. Orientation
3. Intradiscal shim
4. Aperture size/shape
5. Retractor time

Monitor retractor time <30 mins/level
If not, close retractor
53 yo female 3 years hx leg and back pain
Pain worsens with Flexion, Areflexic
Failed ESI  PT
Unable to participate in Hiking due to claudication
Does Ant Post Position of Cage Matter?
Always Direct Vision to Reduce Post Op Hematoma

10 Years of LLIF Experience

XLIF at L4-5 (facts)

1. Most common XLIF level
2. Over 3500 XLIF cases in literature (70-75% are at L4-5)
3. NV identification of nerves common at L4-5 (>50%)
4. Complications rates similar between L4-5 and other levels
5. Neural injury rate of 2.9%, transient <6 mo
6. L4-5 level is NOT a contraindication to XLIF
10 Years of XLIF- Experience

Summary
1. Technology- validated
2. Technique- safe and reproducible
3. Indications- fusion T5-L5
4. Outcomes- meet or exceed traditional technique
5. All of above- continue to evolve

Single Position Surgery

-11 degrees LL
48 degrees LL

THANK YOU!