Expandable Cage Technology

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Calusa Spine meeting
Spine surgery has evolved over time

- Progression towards MIS style surgeries
- Goals to decrease Morbidities and Improve Outcomes
- MIS challenges in Inter body cage insertion
- Maximizing Lumbar Lordosis
- Controlling Sagittal and Coronal Alignment
Inter-body fusion

Static inter-body cages have progressed by means of two main areas:

- **Insertion Style**
  - Different shapes and sizes

- **Fusion Potential**
  - Material components
  - Manufacturing Techniques
    - 3D Printing

- **Shift from Static technology to Expandible Technology**
Expandable Cages

- A viable alternative to potential undersize to smaller PLIF/TLIF cages
- Allow a larger footprint
- Minimally invasive to local tissues
- Allow for improved sagittal alignment
- Better Fill of Interbody space
Types of Expandable Cages

- Medial-Lateral Cages
- Expandable height
- Expandable footprint
- Translating footprint
- Lateral, Anterior, and Posterior cages
So many which one should I use
Early Expandable Cages

- Staxx
- PEEK wafers inserted sequentially to expand device in a cephalo-caudal manner
- No areas for placement of bone graft
- Cannot be retracted, once deployed, it's "bought"
- I still use this cage
InFix Anterior Lumbar System

In-situ Assembly • Seven Lordotic Options • Modular

• One of the FIRST
• 84 Unique Configurations
  • 3 footprints
  • 4 heights (8mm-14mm posterior)
  • 7 lordotic angles (0° - 18° in 3° incr.)
• In-Situ expansion reduces endplate trauma
• Restores lordosis & sagittal balance
• Titanium construction
• Endplate spikes for migration Resistance
• Load Sharing & Strain Limiting Design side strut design
• Large graft cavity with fenestrated endplates
The InFix System is an anterior lumbar system that:

- Restores lordosis & sagittal balance
- Serves as a revision tool for lumbar non-union repair

Lordotic Angles

- End plates are available in 0°, 3°, 6°, and 9° lordosis
- Enables a construct range of 0° - 18°
- Restores sagittal balance

Migration Resistance

- Spikes resist migration and rotation
- Allows for initial stability of device
Fenestrated Endplates
- Designed to allow a generous cross-section of bridging bone to grow and strengthen fusion
- 56-72% of endplate is open space for fusion

The InFix System:
Implant Built within Anterior Column

InFix endplates inserted into collapsed disc space
Endplates are distracted to achieve desired anterior and posterior height

Strut Heights
- Color-coded, titanium alloy struts are available in 8, 10, 12 and 14mm
Load Sharing and Strain Limiting Design*

Strut design that permits load sharing between the implant and the graft:

- Allows the device to compress and apply load on the graft to promote bone growth
- Stiffness of the device is between cancellous and cortical bone
- Shock absorber protects graft against damage
- Offers the strength of metal with the modulus of elasticity more similar to cancellous bone and PEEK, rather than solid Ti6Al4V

![Diagram of strut design under load](Image)

<table>
<thead>
<tr>
<th>Material</th>
<th>Effective Elastic Moduli (MPa)</th>
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<tbody>
<tr>
<td>Cancellous Bone</td>
<td>220 MPa</td>
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<tr>
<td>InFix</td>
<td>1,089 MPa</td>
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<tr>
<td>PEEK</td>
<td>3,600 MPa</td>
</tr>
<tr>
<td>Cortical Bone</td>
<td>12,000 MPa</td>
</tr>
<tr>
<td>Ti</td>
<td>113,800 MPa</td>
</tr>
<tr>
<td>CoCr</td>
<td>234,000 MPa</td>
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*Data on file, Zimmer Spine.
In-Situ Assembly

1. Boney endplates of collapsed disc space are prepared for fusion. Implant endplates are atraumatically inserted into the collapsed disc space to remove the need for distraction.

2. Struts are inserted into the lordotic endplates to achieve desired anterior and posterior height.

3. Open implant cavity is available for the packing of graft material.
Keypoints of ΩLIF™ Expandable Interbody

Features and Benefits:

- All Titanium construction for superior strength and structural integrity
- Infinitely adjustable expansion from 0 to 3 mm
- One-step expansion with no need for an additional locking step
- Bullet-nose design for ease of insertion
- Cannulated for over-the-wire guidance for Amendia’s KLIF approach

Sizing:

- **Widths:** 9mm and 11mm
- **Lengths:** 28mm and 34mm
- **Collapsed Heights:** 8-13mm (each expanding up to 3mm)
- **Lordosis:** Parallel, 4° PLIF, 11° PLIF, 4° KLIF, and 11° KLIF
Globus Expandibles

CALIBER®
Jan. ‘11

RISE®
Sept. ‘12

ALTERA™
Oct. ‘14
Indications

Spacers are interbody fusion devices intended for use in patients with degenerative disc disease (DDD) at one or two contiguous levels of the lumbosacral spine (L2-S1).

Spacers are to be filled with autogenous bone graft material. These devices are intended to be used with supplemental fixation systems.
<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Minimized insertion height</td>
<td>• Help reduce nerve root retraction&lt;br&gt;• Minimizes impaction force</td>
</tr>
<tr>
<td>Controlled continuous expansion</td>
<td>• Allows an optimized endplate-to-endplate fit&lt;br&gt;• May help reduce the risk of over-distraction once in the disc space</td>
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<tr>
<td>In situ distraction</td>
<td>Allows disc height restoration and an optimized fit</td>
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<td>PEEK/Metal endplates</td>
<td>Allows radiographic assessment of fusion</td>
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<tr>
<td>Automatic locking</td>
<td>Height stability without an extra locking step</td>
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<td>Easily identifiable radiographic markers</td>
<td>Facilitates implant positioning</td>
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<tr>
<td>Convex profile</td>
<td>Optimal fit within vertebral endplates</td>
</tr>
<tr>
<td>Adjustable trial</td>
<td>Reduces trialing steps &amp; accurately determines disc height</td>
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<tr>
<td>One instrument for both insertion and expansion</td>
<td>Ease of use</td>
</tr>
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</table>
CALIBER® Implant Options

- Five footprints
  - 10x22mm, 10x26 mm, 10x30mm, 12x26mm, 12x30mm

- Six Height Expansion ranges
  - Two sagittal profiles (4°, 12°, 15°)
  - Four easily identifiable radiographic markers to facilitate positioning

22, 26, or 30mm overall length
X-ray Images

Anterior / Posterior

Lateral
Description
RISE® TLIF Implant Features

- One instrument for insertion and expansion
- Convex profile fits anatomy
- Axial graft opening to help promote fusion
- Automatic locking for simple operation
- Titanium endplates allow for integration of bone to implant
- Expandable design allows for up to 7mm of travel
- Slim design is ideal for Minimally Invasive Surgery (MIS) applications
- Convex profile fits anatomy
- One instrument for insertion and expansion
- Expandable design allows for up to 7mm of travel
**Description**

RISE® TLIF Implant Overview

**Widths:** 8, 10, 12mm

**Lengths:** 22, 26, 30mm

**Heights:** 7-17mm

**Lordosis:** 4°, 10°, 15°

*Implant information is available in the Technique Guide*
X-ray Images

Anterior / Posterior  Lateral
What is ALTERA™?

- Titanium Endplates
- Integrated Articulation
- Secure Threaded Connection
- Generous Graft Chamber
- Autograft Delivery Window
- 4mm of Expansion

Generous Graft Chamber
Secure Threaded Connection
Integrated Articulation
Titanium Endplates
4mm of Expansion
Autograft Delivery Window
What is ALTERA™?

ALTERA™ is a revolutionary MIS lumbar fusion device designed to maximize lordosis correction, minimize insertion challenges and optimize graft delivery.

- **STEERABILITY**
- **EXPANDABILITY**
- **PACKABILITY**
Traditional static implants may experience difficulty crossing the lower posterior margin and achieving far anterior placement. Lordosis is limited by the height of the spacer that can be inserted past the lower posterior margin.

ALTERA™ is designed to be easily inserted and articulated into far anterior placement, and once expanded, optimizes lordosis more than a traditional static implant.
Features

- Minimized insertion height allows easier insertion and articulation
- Articulation mechanism allows for steerable anterior placement
- Robust threaded connection between inserter and implant
- 4mm expansion range at all articulation angles, providing all the benefits of an expandable spacer:
  - Minimized impaction
  - Controlled distraction
  - Optimized fit
- Post-expansion access for bone graft
- Two sagittal profiles: 8° and 15°
- Three lengths: 26, 31 and 36mm
- Four expansion ranges: 8–12mm, 9–13mm, 10–14mm and 12–16mm
ALTERA™’s ABILITIES

FEATURES

STEERABILITY
Controlled Articulation

EXPANDABILITY
Minimized Insertion Height
Easier Articulation

PACKABILITY
Post Expansion Graft Packing

BENEFITS

SAGITTAL BALANCE

EASE OF PLACEMENT

OPTIMIZED FUSION AREA
Final Construct
Lateral Expandable Cages

- Sequential trialing not needed
- Decreasing procedure time
- Lessening retractor time
- More preservation of the endplate

Improved coronal deformity correction
- Can attack the concave side
- Can access smaller disc space

- Safer to place a smaller cage
Advantages

- Ease of Cage insertion
  - Placement of cage with minimal exposure needed
    - Using MIS Tubes or mini-open incisions
    - Maneuvering around scar tissue

- More precise restoration of disc height

- Precise placement enhances sagittal correction

- Improved clinical outcomes
  - Secondary to decreased retraction, less dissection of nerve root, faster surgical times, etc
Pimenta et al – demonstrated a higher biomechanical advantage to larger footprint cages

M-L Cages are able to provide ALIF sized footprints

Equivalent to TILF with PS fixation in flex-ex and lateral bending

Kim CW\textsuperscript{1}, Doerr TM\textsuperscript{2}, Luna IY\textsuperscript{3}, Joshua G\textsuperscript{3}, Shen SR\textsuperscript{4}, Fu X\textsuperscript{5}, Wu AM\textsuperscript{4}.

RESULTS: Mean patient age was 58.1 years (56.2\% female). In all, 76\% (38/50) underwent 1-level fusion, and 24\% (12/50) 2-level fusion. Average operative time was 239.9 ± 86.9 minutes for 1-level and 350.3 ± 74.9 minutes for 2-level procedures; average hospital stay overall was 2.5 ± 1.7 days, with no intraoperative complications reported. Mean visual analogue scale and Oswestry Disability Index scores decreased significantly from preoperative to all postoperative assessment times (6, 12, and 24 months) (P < 0.05). Intervertebral disc height (8.3 ± 2.7 vs. 11.3 ± 1.9 mm) increased significantly, with increases sustained over 24 months (P < 0.05). Postoperative radiographs showed no evidence of cage migration, subsidence, or collapse and suggested fusion at all operative levels by 12 months and 24 months (93\%, 54/58; 97\%, 28/29), respectively.

CONCLUSIONS: An expandable interbody cage led to significant improvement in clinical and radiographic outcomes after MIS TLIF, including intervertebral disc height restoration and high fusion rates, with no evidence of device-related complications.
Comparison of Expandable and Fixed Interbody Cages in a Human Cadaver Corpectomy Model: Fatigue Characteristics.

Pekmezci M, Tang JA, Cheng L, Modak A, McClellan RT, Buckley JM, Ames CP.

RESULTS: Three fixed and 2 expandable cages withstood the cyclic loading despite perfect sagittal and coronal plane fitting of the endcaps. The majority of the constructs settled in after initial subsidence. The catastrophic failures that were observed in clinical practice could not be reproduced with hyperlordotic cages. However, all cages in this group subsided, and 60% resulted in endplate fractures during deployment of the cage.

CONCLUSIONS: Despite greater surface contact area, expandable cages have a trend for higher subsidence rates when compared with fixed cages. When there is edge loading as in the hyperlordotic cage scenario, there is a higher risk of subsidence and intraoperative fracture during deployment of expandable cages.
Sagittal Alignment

Expandable cages allow for increased sagittal alignment correction


Additional sagittal correction can be obtained when using an expandable titanium interbody device in lumbar Smith-Peterson osteotomies: a biomechanical study.

RESULTS: Change in Cobb angle from L2 to L5 was significantly greater with the interbody spacer compared with SPO alone. Despite an obvious increase in lordosis with expansion height, there were no significant differences between implant expansion states for the L2-L5 Cobb angle. All instrumented constructs were statistically equivalent in every mode of motion once rigid instrumentation was implemented, regardless of expansion state.

CONCLUSIONS: The expandable interbody did have a slight effect on lordotic correction; each additional millimeter in height expansion yielded approximately 1° in correction across the three SPO levels. Even without significant differences between the states, an expandable device may allow the surgeon more control of lordotic correction within the operating room than a static spacer alone.
Contact areas were found to be higher in expandable cages at the endplate.
No correlation with the expansion torque and final endplate forces.
Caution must be observed with expanding these cages.
Clinical Evidence in Single Level Fusion Patients


Materials and methods: Forty-five patients who had single-level TLIF were included in this study. Pelvic and spinal radiological parameters of sagittal balance were measured preoperatively, postoperatively and at latest follow-up.

Conclusion: Single-level circumferential fusion helps patients reducing their pelvic compensation, but the amount of correction does not allow for complete correction of sagittal imbalance.
Disadvantages

- Expanding the cage can unload the bone graft
- Endplate Damage is possible
- Cost differential
Bone Grafting

- Evolving subject
- Cage design
  - Open cages with bone graft windows
  - Back-loading graft cages
- Graft Packing Techniques
55 year old female with sagittal coronal deformity
Failed conservative care
Surgery including osteotomies and expandible cages
NOT MIS
Conclusions

In a patient without clinically significant flat back syndrome, how important is it that we focus on maintaining or improving lordosis for SINGLE LEVEL surgery?

- Probably not important for single level problems
- Loss of lordosis is a natural event
- Most of the surgeries we perform do not improve sagittal alignment
- Most patients can compensate for a few degrees of lost lordosis at a single level
Conclusion

- Expandable Cages Provide a unique solution to many intraoperative issues that may arise
  - Scar tissue
  - Aberrant Nerve root
- Allow for a more MIS style of surgery
  - Decreased morbidity
- Correction of Sagittal and Coronal Deformities
- Do have some drawbacks that the surgeon needs to be aware of
  - Bone Grafting
  - Endplate damage
Thank You