Expandable Interbody Implants

Mr M J H McCarthy
Consultant Spinal Surgeon

Disclosure

- Ad Hoc Educational Contract Globus Medical
- Nothing else

Indications for Surgery - DRS

- Decompression
  - Spinal cord / nerve roots
- Realignment
  - Correct deformity
- Stabilisation
  - Prevent / Treat
    - Neurological deficit / deformity / pain
      - (Non fusion technology form of "stabilisation")

All may require fusion

Require Instrumentation

Instrumentation increases fusion

Indications for Surgery

- **What are you trying to achieve?**
  - **Non-maleficence - "first, do no harm" (primum non nocere)**
- **DO THE APPROPRIATE OPERATION FOR THE PATIENT AND THEIR PATHOLOGY AND YOUR SKILL / ABILITY**

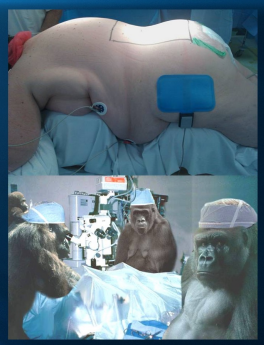
The 6Ps

- Proper
- Planning and
- Preparation
- Prevents
- Poor
- Performance



The Other 3 Ps

- Personality - Patient
- Personality - Pathology
- Personality - Practitioner



Copyright

Fusion

- Is an interbody fusion required:
  - Restore foraminal height (up / down)
  - Improve fusion
  - Revision of failed posterolateral fusion
  - Restore lordosis / correct deformity
  - Biomechanics – shear / large disc height / entire facet removed / long construct involving L5/S1

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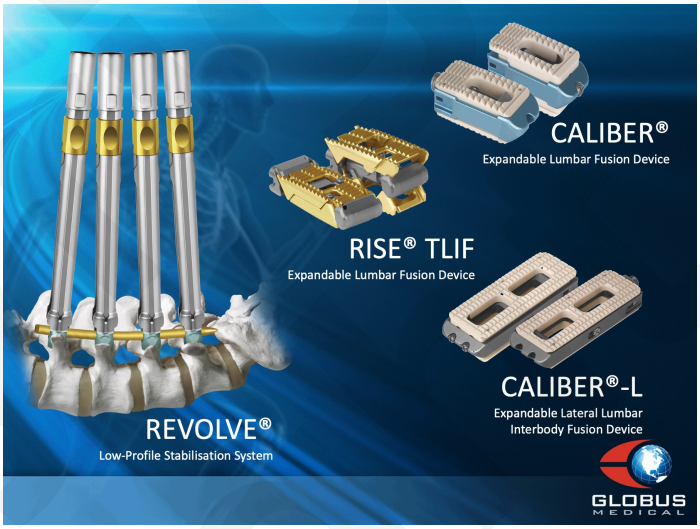
Fusion

- **Fusion – think:**
  - **α contact surface area (1/α subsidence)**
  - **↑ compression ↓ tension**
  - **autograft > allograft > synthetic**
  - **vascular > avascular**
  - **structural graft > non structural**
  - **BMP…**
  - **And unfortunately fusion may not be α clinical outcome**

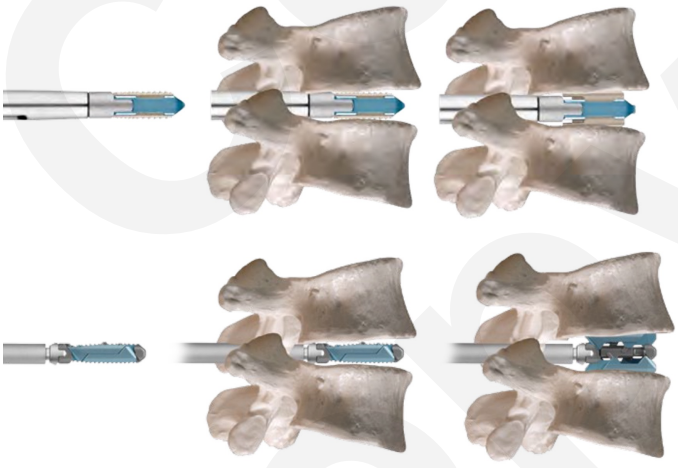
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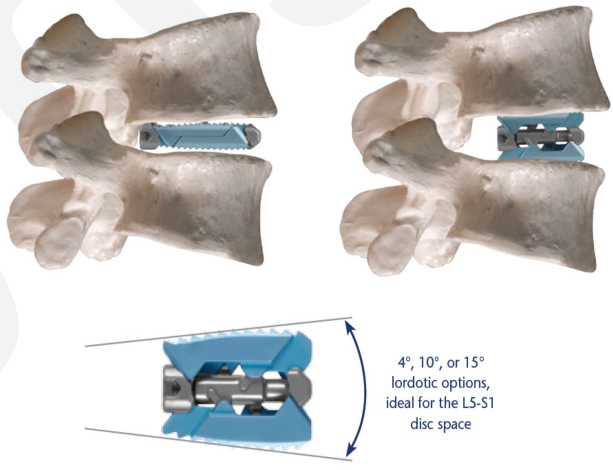
	Advantages	Disadvantages
PLIF	Bilateral access to canal, restores lordosis	Painful, infection, neural / dural injury scarring, limited higher up
Mini Open and MIS PLIF	Less painful, low infection, less blood loss, faster recovery	Fusion?, neural / dural injury scarring, limited higher up
Open TLIF	Access, fusion	Painful, infection, neural / dural injury scarring, endplate damage / subsidence
Mini Open TLIF	Less painful, low infection, fusion, less blood loss	Neural / dural injury scarring, disc preparation, endplate damage / subsidence
MIS TLIF	Even less pain, low infection, avoids paraspinal muscle damage, less blood loss, faster recovery	Fusion?, neural / dural injury scarring, disc preparation, endplate damage / subsidence
LLIF + Perc Post	Good fusion, less painful, low infection, T5-L5, avoids canal, less visceral vessel injury then ALIF, avoids paraspinal muscle damage, less blood loss, faster recovery	L4/5??, L5/S1 – No, endplate damage / subsidence, plexus injury, diaphragm injury, pneumothorax
ALIF + Perc Post	Best fusion, best restoration lordosis, less painful, low infection, avoids canal, avoids paraspinal muscle damage, mostly less blood loss than a TLIF	Access Surgeon, iliolumbar vein, visceral vessel injury, ileus, not above L3

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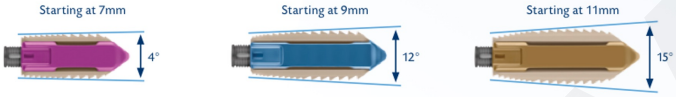
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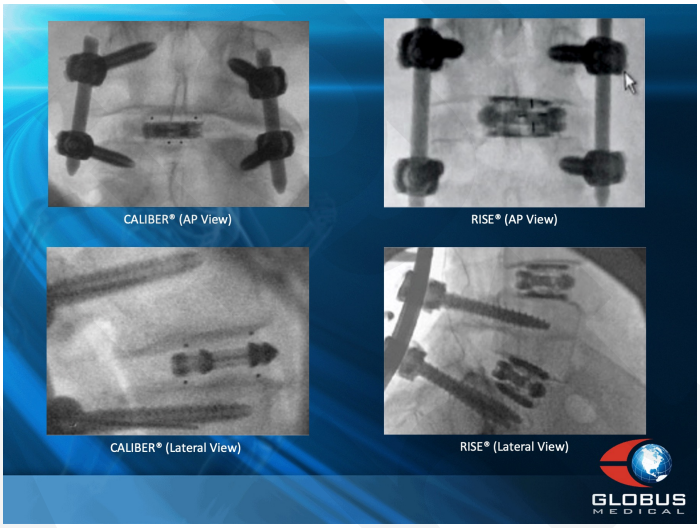
Multiple Sagittal Profiles

Lordotic Expansion

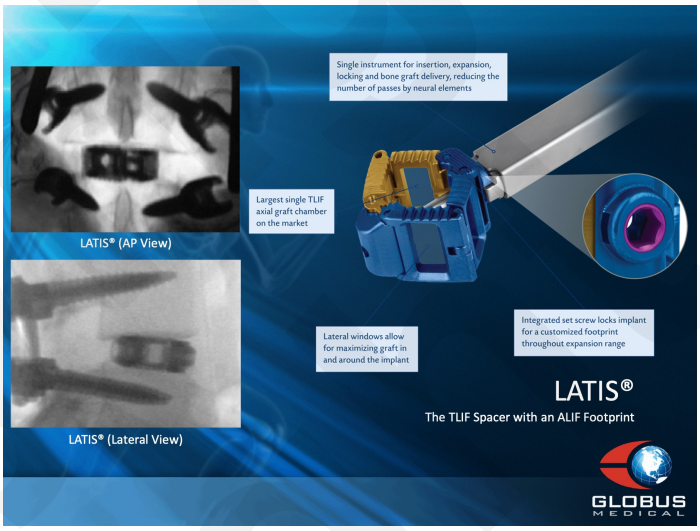


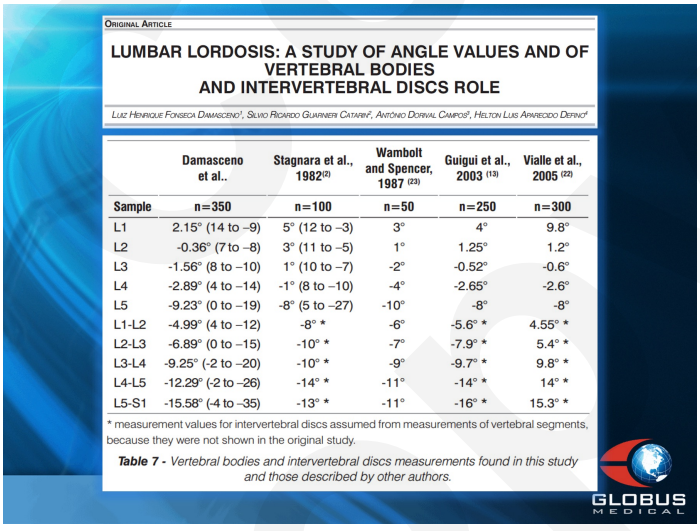
Parallel Expansion











ORIGINAL ARTICLE

LUMBAR LORDOSIS: A STUDY OF ANGLE VALUES AND OF VERTEBRAL BODIES AND INTERVERTEBRAL DISCS ROLE

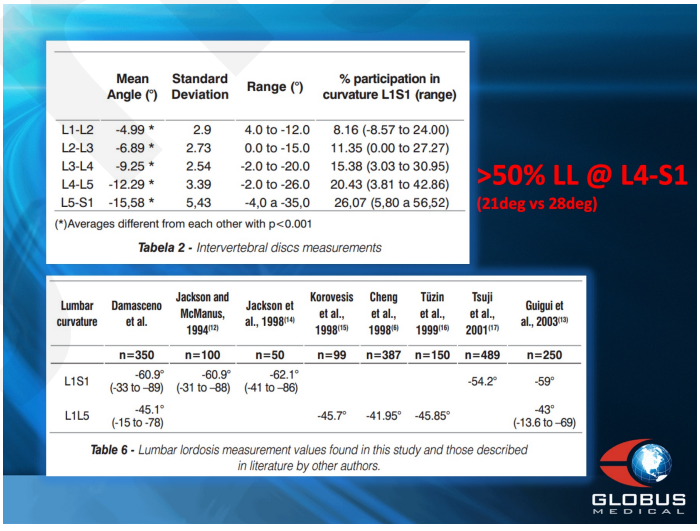
LUIZ HENRIQUE FONSECA DAMASCENO[1], SILVIO RICARDO GUARNIERI CATARIN[2], ANTÔNIO DORVAL CAMPOS[3], HELTON LUIS APARECIDO DEFINO[4]

	Damasceno et al..	Stagnara et al., 1982[2]	Wambolt and Spencer, 1987 [23]	Guigui et al., 2003 [13]	Vialle et al., 2005 [22]
Sample	n=350	n=100	n=50	n=250	n=300
L1	2.15° (14 to –9)	5° (12 to –3)	3°	4°	9.8°
L2	-0.36° (7 to –8)	3° (11 to –5)	1°	1.25°	1.2°
L3	-1.56° (8 to –10)	1° (10 to –7)	-2°	-0.52°	-0.6°
L4	-2.89° (4 to –14)	-1° (8 to –10)	-4°	-2.65°	-2.6°
L5	-9.23° (0 to –19)	-8° (5 to –27)	-10°	-8°	-8°
L1-L2	-4.99° (4 to –12)	-8° *	-6°	-5.6° *	4.55° *
L2-L3	-6.89° (0 to –15)	-10° *	-7°	-7.9° *	5.4° *
L3-L4	-9.25° (-2 to –20)	-10° *	-9°	-9.7° *	9.8° *
L4-L5	-12.29° (-2 to –26)	-14° *	-11°	-14° *	14° *
L5-S1	-15.58° (-4 to –35)	-13° *	-11°	-16° *	15.3° *

* measurement values for intervertebral discs assumed from measurements of vertebral segments, because they were not shown in the original study.

Table 7 *- Vertebral bodies and intervertebral discs measurements found in this study and those described by other authors.*

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	Mean Angle (°)	Standard Deviation	Range (°)	% participation in curvature L1S1 (range)
L1-L2	-4.99 *	2.9	4.0 to -12.0	8.16 (-8.57 to 24.00)
L2-L3	-6.89 *	2.73	0.0 to -15.0	11.35 (0.00 to 27.27)
L3-L4	-9.25 *	2.54	-2.0 to -20.0	15.38 (3.03 to 30.95)
L4-L5	-12.29 *	3.39	-2.0 to -26.0	20.43 (3.81 to 42.86)
L5-S1	-15,58 *	5,43	-4,0 a -35,0	26,07 (5,80 a 56,52)

(*)Averages different from each other with p<0.001

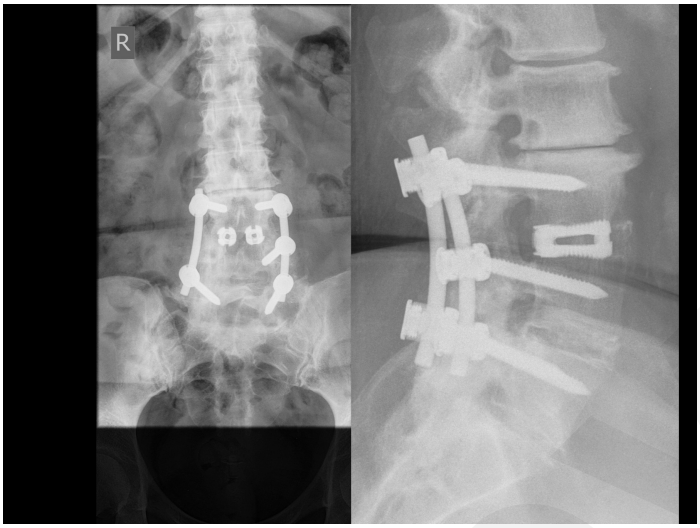
Tabela 2 *- Intervertebral discs measurements*

>50% LL @ L4-S1
(21deg vs 28deg)

Lumbar curvature	Damasceno et al.	Jackson and McManus, 1994[12]	Jackson et al., 1998[14]	Korovesis et al., 1998[15]	Cheng et al., 1998[6]	Tüzin et al., 1999[16]	Tsuji et al., 2001[17]	Guigui et al., 2003[13]
	n=350	n=100	n=50	n=99	n=387	n=150	n=489	n=250
L1S1	-60.9° (-33 to –89)	-60.9° (-31 to –88)	-62.1° (-41 to –86)				-54.2°	-59°
L1L5	-45.1° (-15 to -78)			-45.7°	-41.95°	-45.85°		-43° (-13.6 to –69)

Table 6 *- Lumbar lordosis measurement values found in this study and those described in literature by other authors.*

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J Korean Neurosurg Soc 42 : 251-257, 2007 10.3340/jkns.2007.42.4.251

A Multi-center Clinical Study of Posterior Lumbar Interbody Fusion with the Expandable Stand-alone Cage (Tyche® Cage) for Degenerative Lumbar Spinal Disorders



Table 2. Radiological change after surgery

	Pre-OP*	Post-OP	Final (24 months)	*p* value
Total number of exam	56		39	
Sagittal alignment (°)				
Segmental lordosis				
Flexion	1.02±3.81	–	4.77±3.96	<0.001
Neutral	3.54±3.70	–	6.37±3.97	<0.001
Extension	4.44±4.01	–	7.07±4.01	<0.001
Total lumbar lordosis	20.37±11.30	–	24.71±11.70	0.011
Intervertebral disc height (mm)	9.94±2.69	12.23±3.31	11.43±2.23	<0.001

*OP : operation

4 DEGREES

Original Article Clinics in Orthopedic Surgery 2009;1:207-213 • doi:10.4055/cios.2009.1.4.207

Radiographic Results of Single Level Transforaminal Lumbar Interbody Fusion in Degenerative Lumbar Spine Disease: Focusing on Changes of Segmental Lordosis in Fusion Segment

Sang-Bum Kim, MD, Taek-Soo Jeon, MD, Youn-Moo Heo, MD, Woo-Suk Lee, MD, Jin-Woong Yi, MD, Tae-Kyun Kim, MD, Cheol-Mog Hwang, MD*

*Department of Orthopaedic Surgery, *Radiology, Konyang University College of Medicine, Daejeon, Korea*

Table 2. Changes in the Radiographic Parameters Affecting the Sagittal Balance (Mean ± SD)

	SLL (°)	WLL (°)	DH (mm)
Preoperative	14.59 ± 9.81	39.10 ± 11.10	9.13 ± 2.92
Postoperative	18.21 ± 6.54	39.01 ± 8.48	11.64 ± 1.94
3 month follow-up	17.00 ± 7.21	42.05 ± 11.77	11.37 ± 1.92
Final follow-up	16.22 ± 7.39	42.55 ± 12.17	10.90 ± 2.02
Mean error	1.07 (0 - 3.86)	2.31 (0.03 - 5.76)	0.65 (0.03 - 1.85)
p-value*	0.069	0.000	0.002

SLL: Segmental lumbar lordosis, WLL: Whole lumbar lordosis, DH: Disc height. *The mean values for each parameter obtained before surgery and at the last follow-up were compared using a paired sample t-test.

NOT EXPANDABLE
N=26
3 DEGREES

Orthopaedic Surgery (2012), Volume 4, No. 1, 15–20

CLINICAL ARTICLE

Restoration of lordosis and disk height after single-level transforaminal lumbar interbody fusion

Christopher K Kepler MD, MBA, Jeffrey A Rihn MD, Kristen E Radcliff MD, Amar A Patel MD, D Greg Anderson MD, Alexander R Vaccaro MD, PhD, Alan S Hilibrand MD, Todd J Albert MD

Variable	Preoperative	Immediate postoperative	Final postoperative	*P* value*
Entire Cohort				
Lumbar lordosis	39.2°	43.9°	42.8°	$P < 0.001$
Disc height (mm)	5.3	10.3	9.8	$P < 0.001$
Spondylolisthesis subgroup				
Percent translation	20%	—	13.6%	$P < 0.001$

- **NOT EXPANDABLE**
- **N = 45**
- **3.6 DEGREES**

Improvement of sagittal balance and lumbar lordosis following less invasive adult spinal deformity surgery with expandable cages and percutaneous instrumentation

Clinical article

J Neurosurg Spine 18:4–12, 2013
©AANS, 2013

MICHAEL Y. WANG, M.D.

Department of Neurological Surgery, University of Miami Miller School of Medicine, Miami, Florida

- 25 pts with ASD
- MIS technique / facet osteotomies
- Expandable TLIF cages
- Mean Improvement of Lumbar lordosis (L1-S1)
  - 27.8 to 42 degrees
- Sagittal vertical axis improved
  - 7.4cm to 4.3cm
- **BUT DEFORMITY CORRECTION IS DIFFERENT**

ELSEVIER

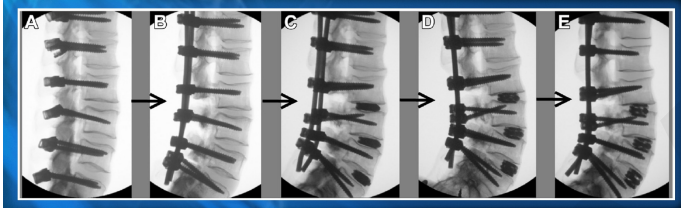
The Spine Journal ■ (2014) ■

THE SPINE JOURNAL

Basic Science

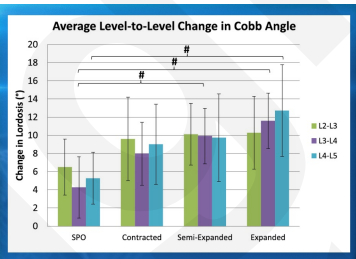
Additional sagittal correction can be obtained when using an expandable titanium interbody device in lumbar Smith-Peterson osteotomies: a biomechanical study

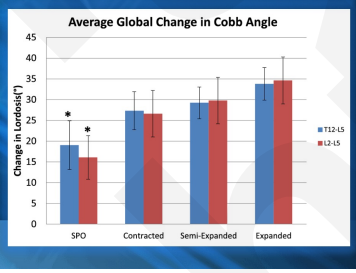
Nicholas A. Qandah, DO[a], Noelle F. Klocke, MS[b,*], Jordan J. Synkowski, DO[c], Suresh R. Chinthakunta, MS[b], Mir M. Hussain, BS[b], Kanaan G. Salloum, BS[b], Eric A. Marvin, DO[c], Brandon S. Bucklen, PhD[b]



N=7 Cadavers

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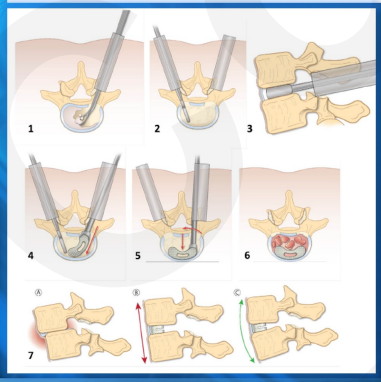




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Effect of steerable cage placement during minimally invasive transforaminal lumbar interbody fusion on lumbar lordosis

Timothy E. Lindley [a], Stephanus V. Viljoen [b], Nader S. Dahdaleh [c,*]



- **Bilateral facetectomies**
- **Improved lordosis**

Journal of Clinical Neuroscience 21 (2014) 441–444

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Why do I use Rise / Caliber?

- Minimize tissue trauma during insertion
- Minimize endplate trauma during insertion
- Minimize cage back out (wedged)
- Fill the front and the back of the disc space
  - ? Improve load sharing / fusion…
- Maintain lordosis with lordotic implant
- ? Improve lordosis…

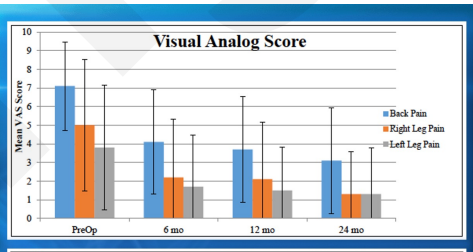
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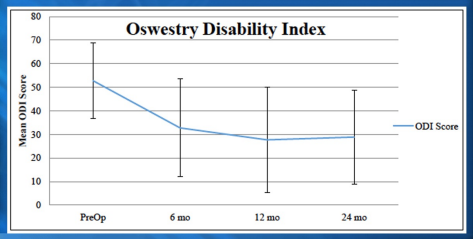
Eurospine 2015



- Multicenter retrospective
- Caliber – 202 patients – 2 year FU
- No device failures
- Asymptomatic migration subsidence = 12 (6%)
- Reoperations same level = 6 (3%)
  - screw failure pseudoarthrosis
- Significant and maintained restoration disc and foraminal height
- No change lordosis

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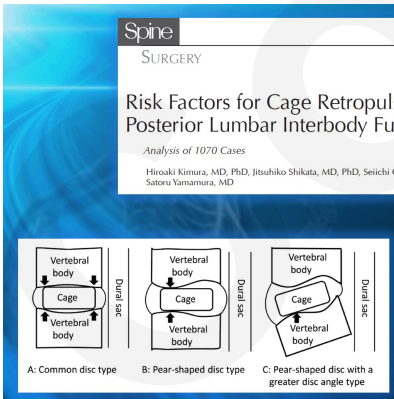
Do I have any evidence?

- Cardiff experience 2013-2015
- 5 Surgeons: 106 Patients
- 55 expandable cages (74 levels; 64 cages)
- 29 Caliber (PEEK) 26 Rise (Ti)
- 51 conventional cages (70 levels; 55 cages)
- 36 Oblique (22 Ti 14 PEEK) and 15 Banana (all Ti)
- FU ave. 8 and 10 months respectively

Cardiff Experience 2013-2015

Cage Type	Endplate Penetration at Operation	Post Operative Worsening Subsidence	Cage Back Out	Screw Loosening	Return to Theatre for Revision Surgery
Expandable	16 / 64 (25%)	3 / 64 (5%)	0	4 / 55 (7%)	3 / 55 (5%) (none cage related)
Conventional	20 / 55 (36%)	6 / 55 (11%)	5 / 55 (9%)	3 / 51 (6%)	5 / 51 (10%) (3 cage related)

- Segmental and global lordosis maintained
- Banana cages no significant improvement in lordosis

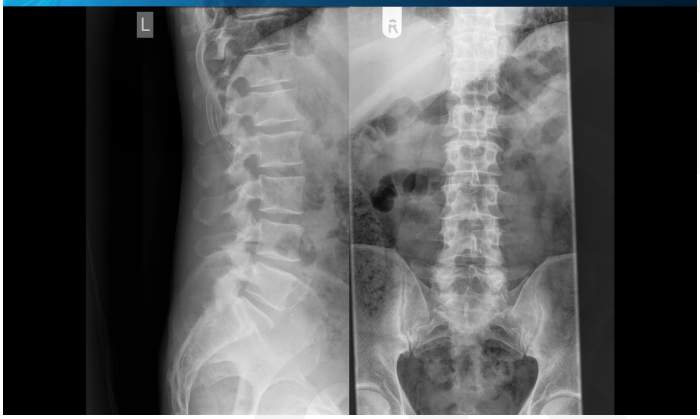


- L5/S1
- Wide disc with instability
- Multilevel
- Pear shaped disc space

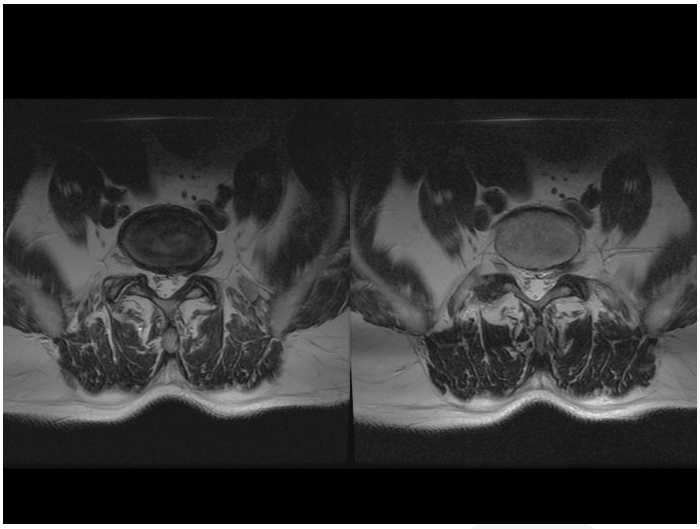
Pay Attention To The Details...

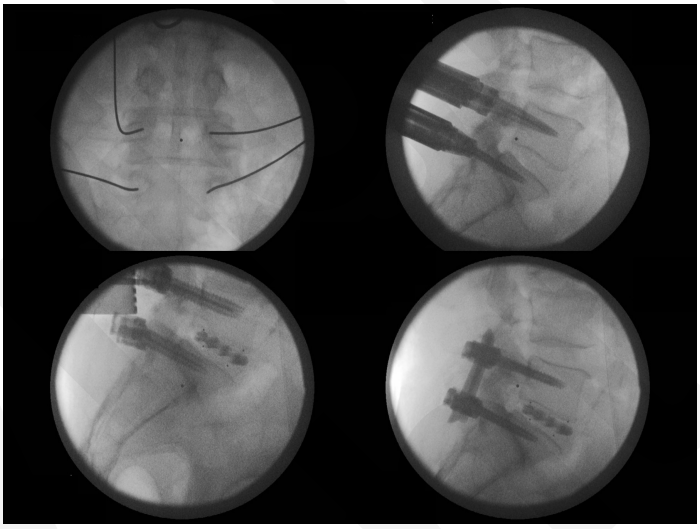


Foraminal Stenosis

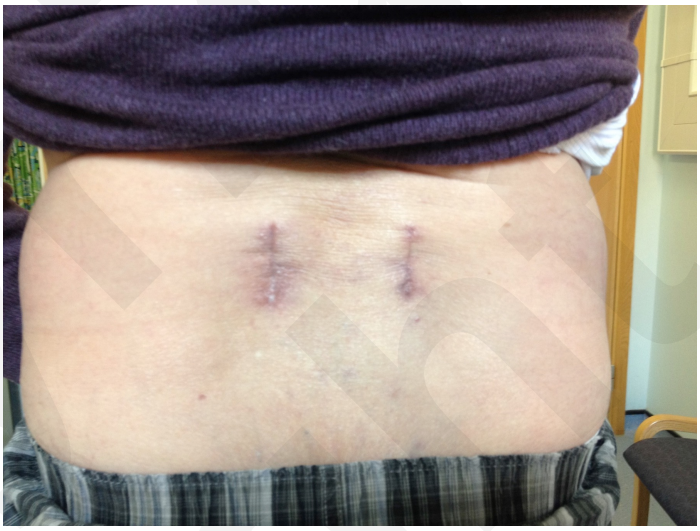


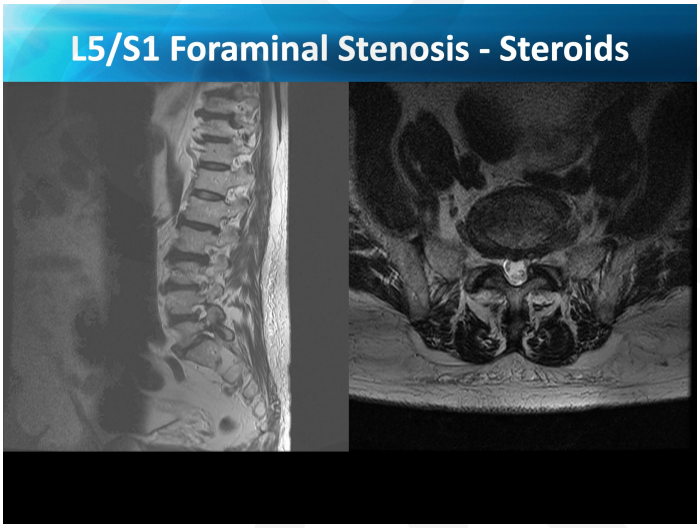


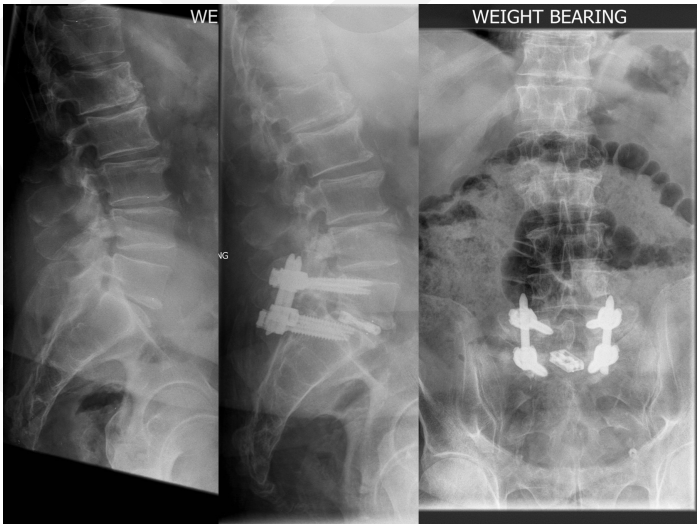




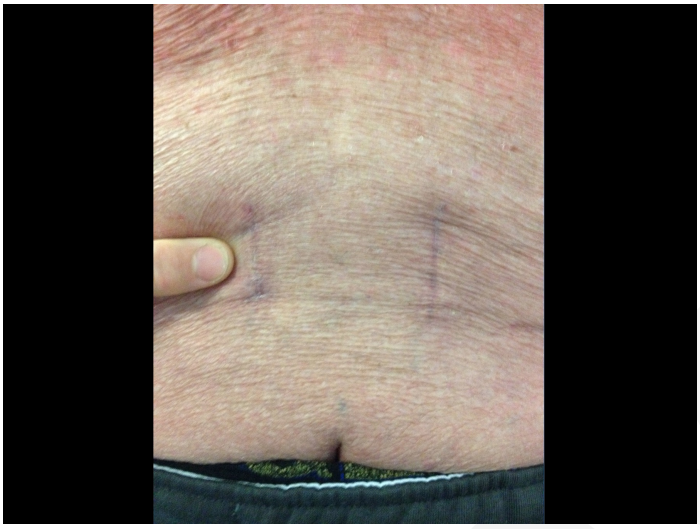


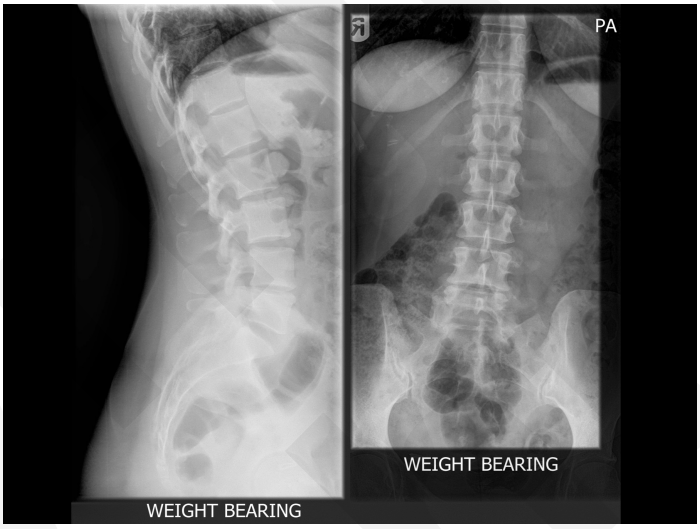


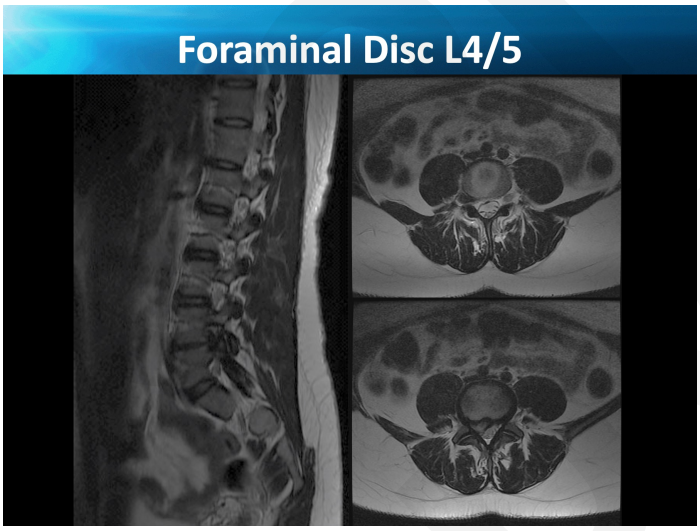


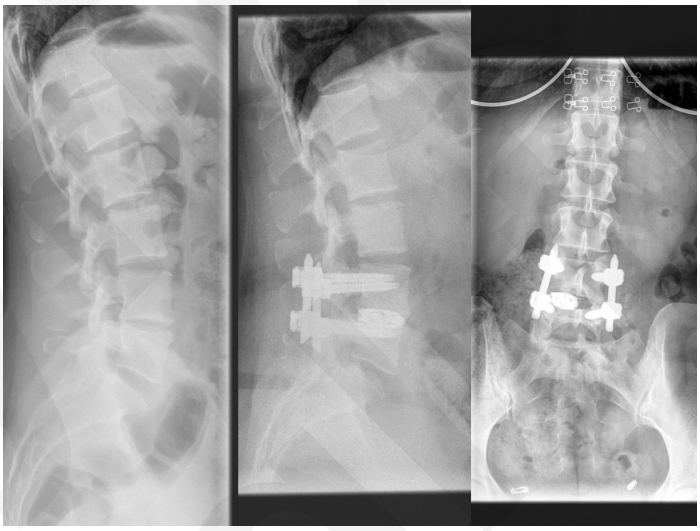


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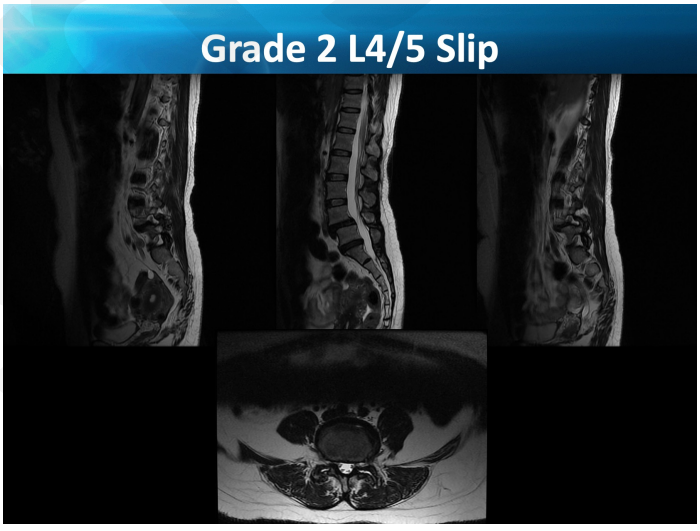


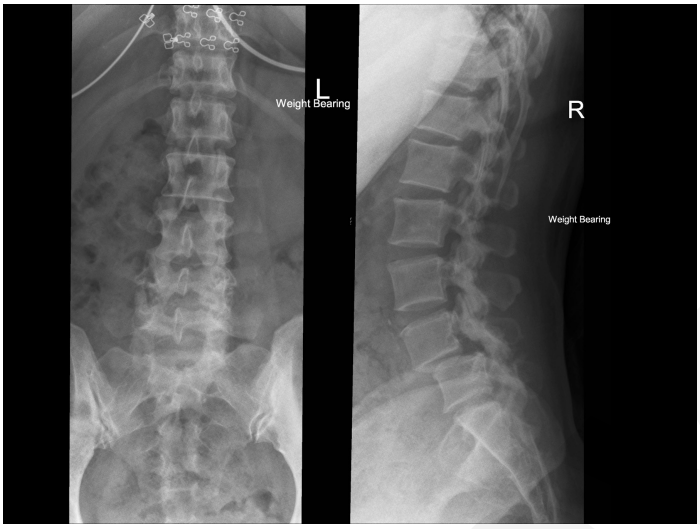

PA
WEIGHT BEARING
WEIGHT BEARING

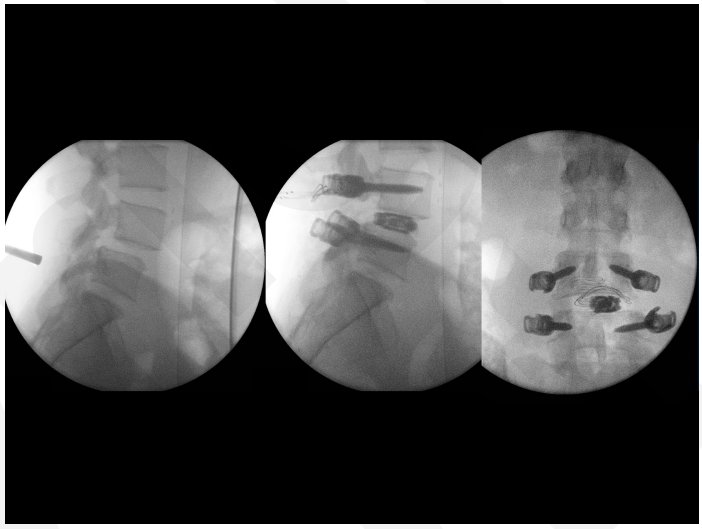

Foraminal Disc L4/5

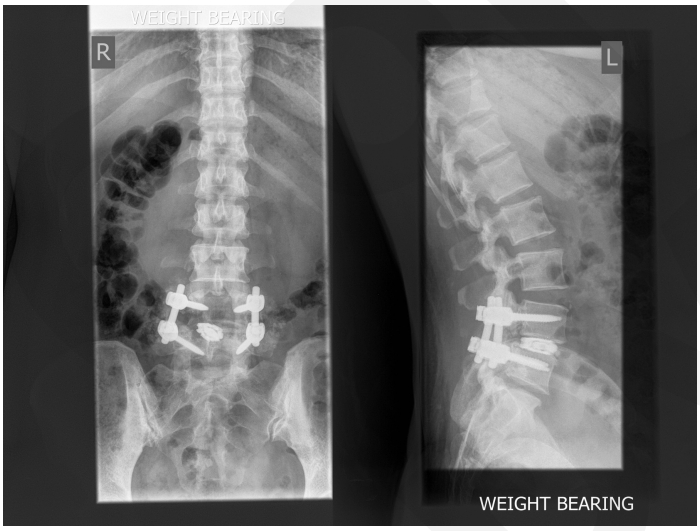


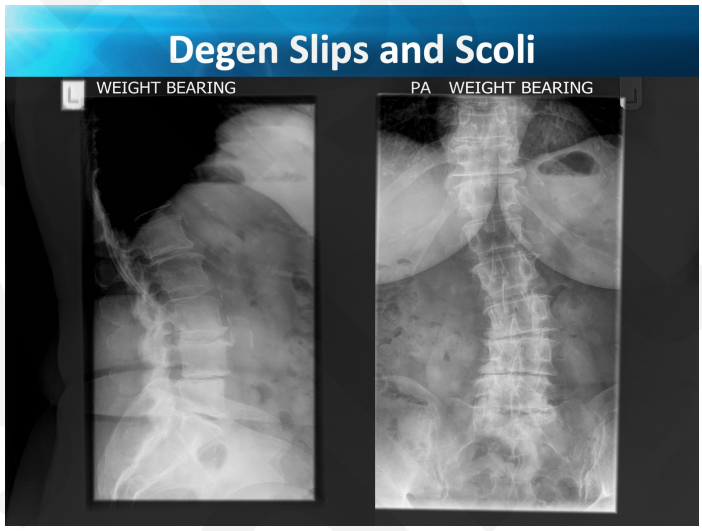


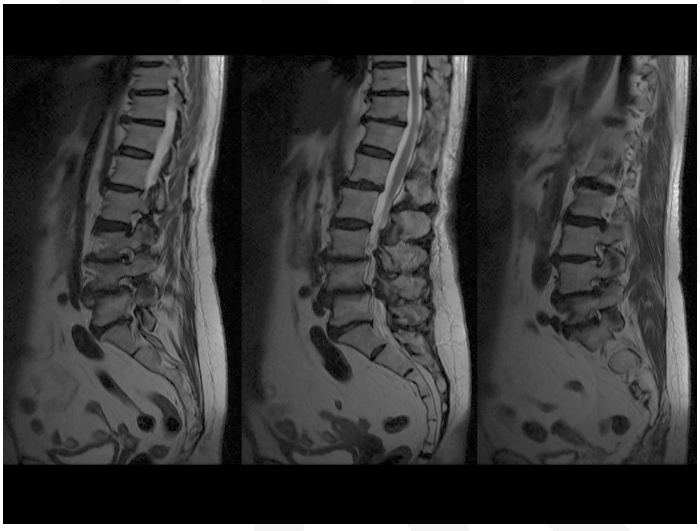

Grade 2 L4/5 Slip

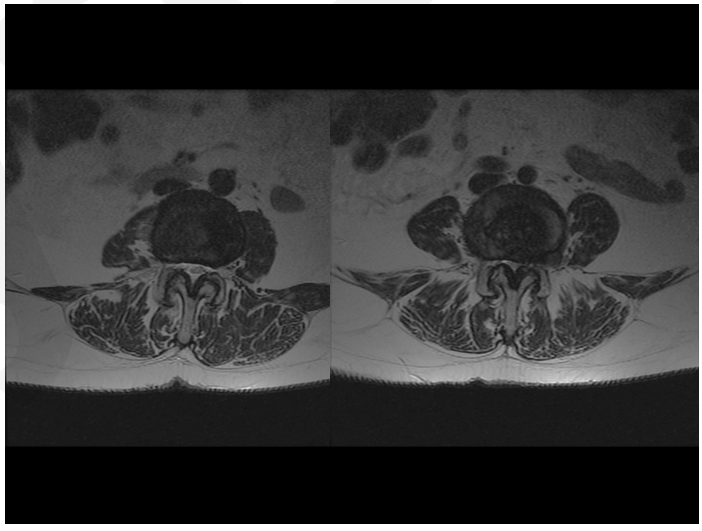

L
Weight Bearing
R
Weight Bearing

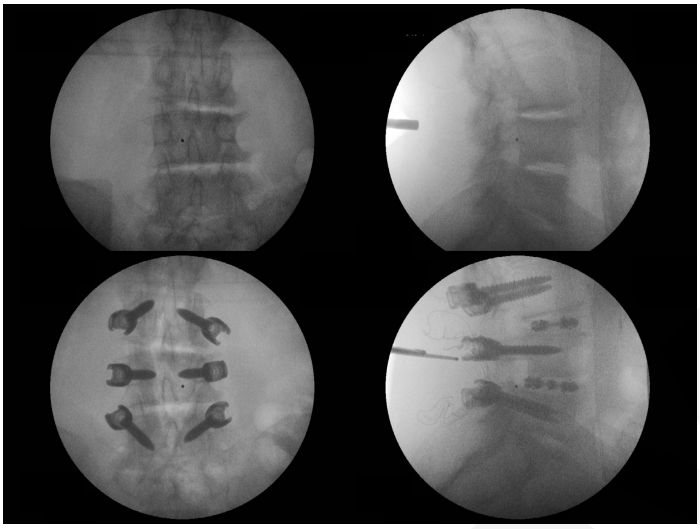


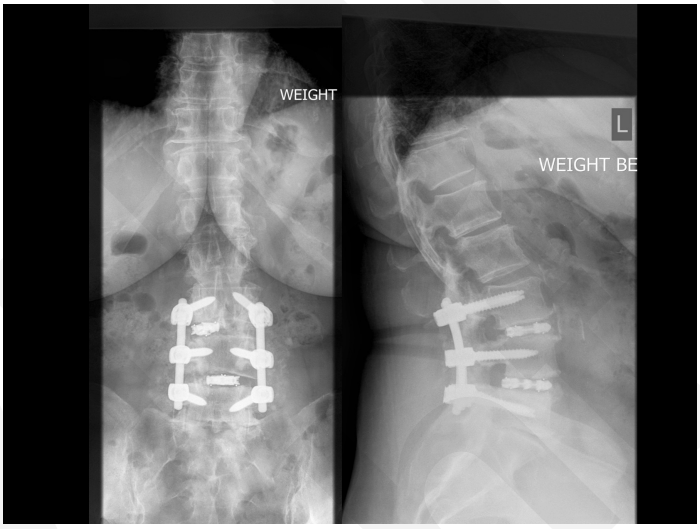

WEIGHT BEARING
R
L
WEIGHT BEARING

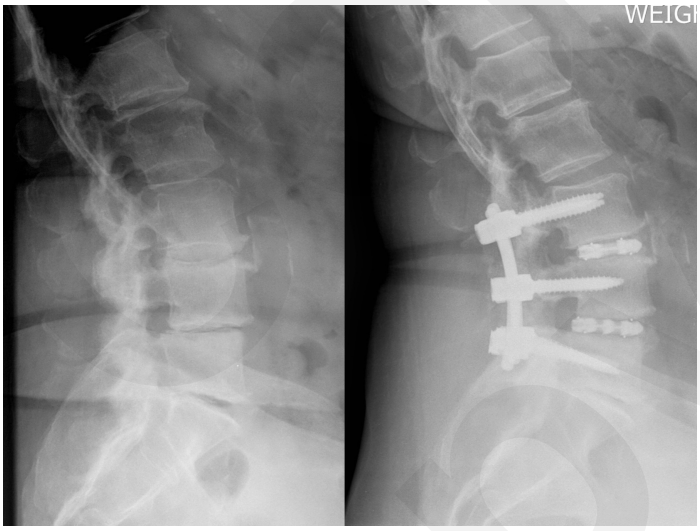

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WEIGHT BEARING
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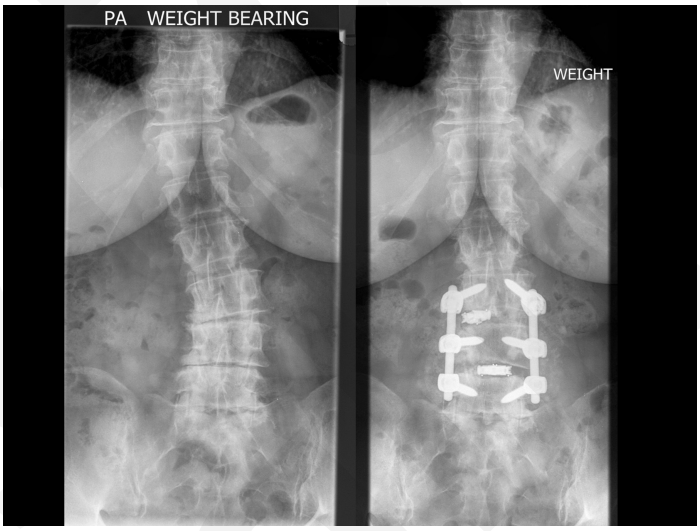




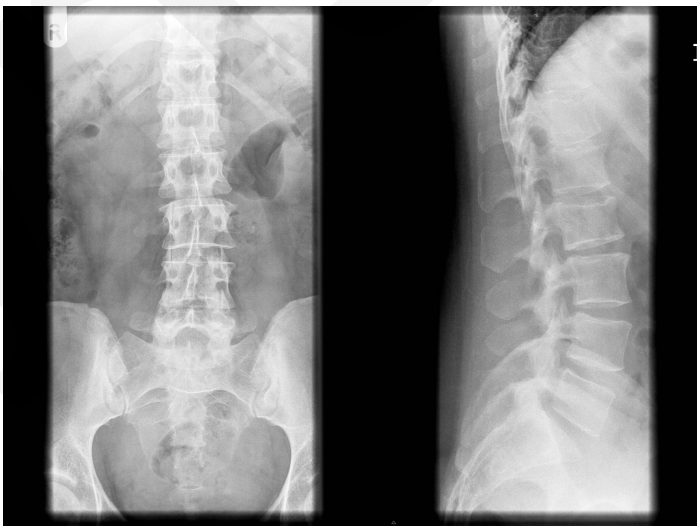








- 50 year old female
- Previous “kyphosis procedure” for stenosis







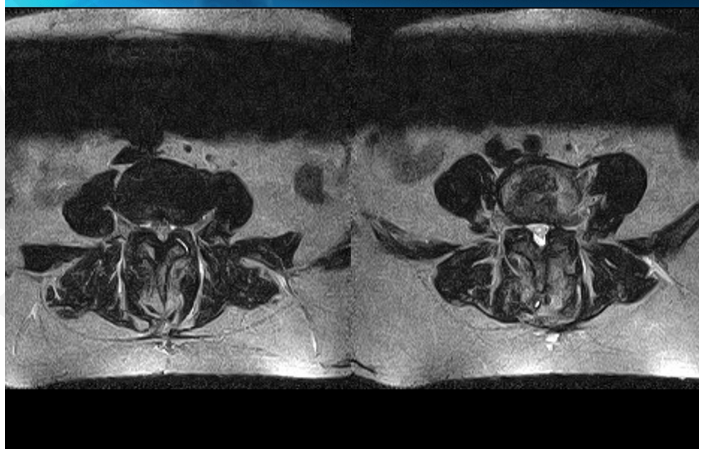


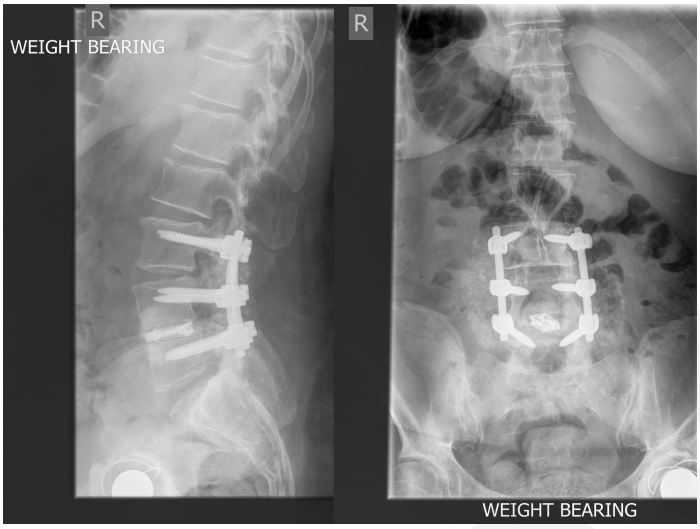


Now LBP and bilateral leg pain

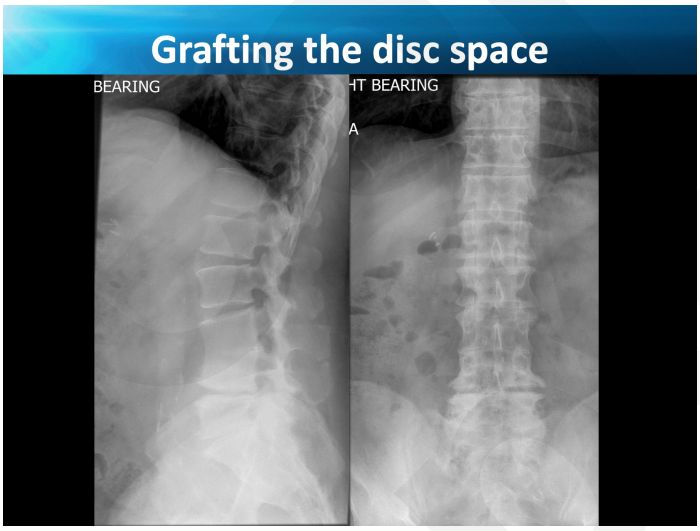


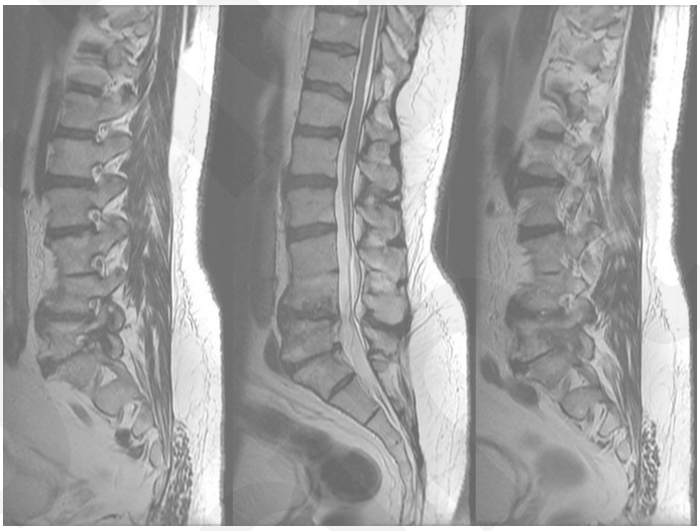
Stenosis 3/4/5, Facet Arthrosis, DDD

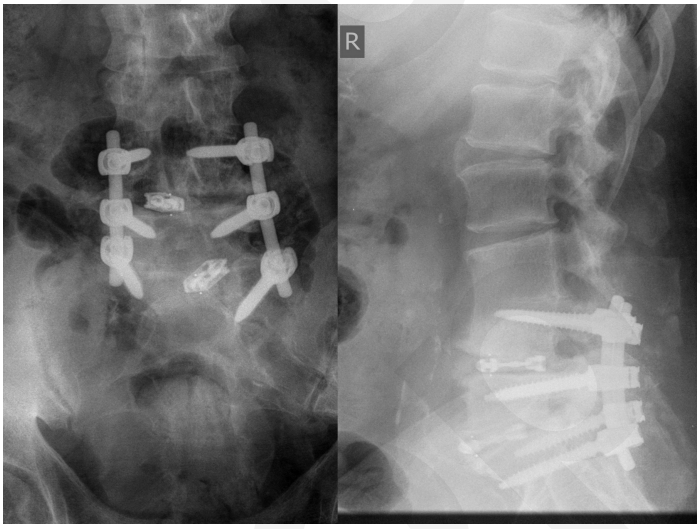


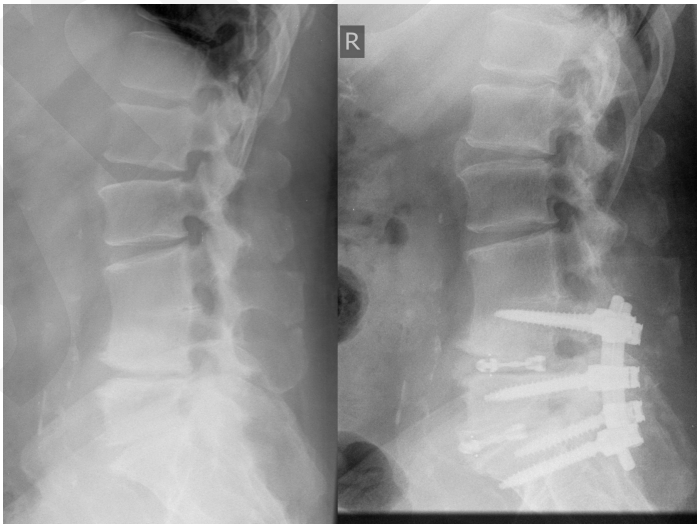

R
WEIGHT BEARING
R
WEIGHT BEARING

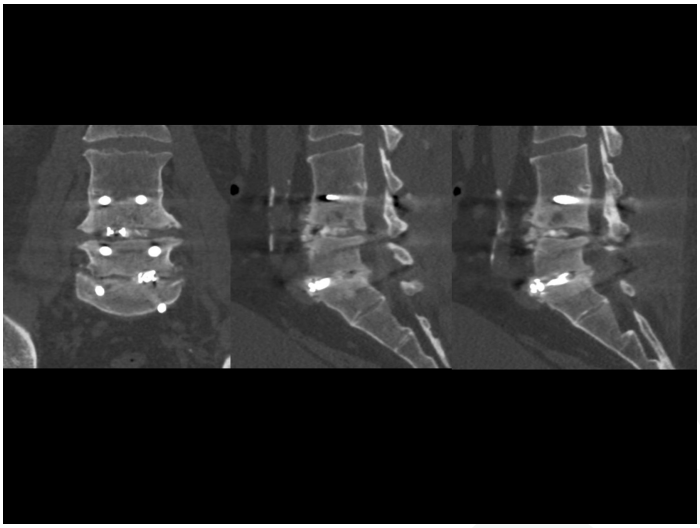

WEIGHT BEARING


Grafting the disc space
BEARING




R


R

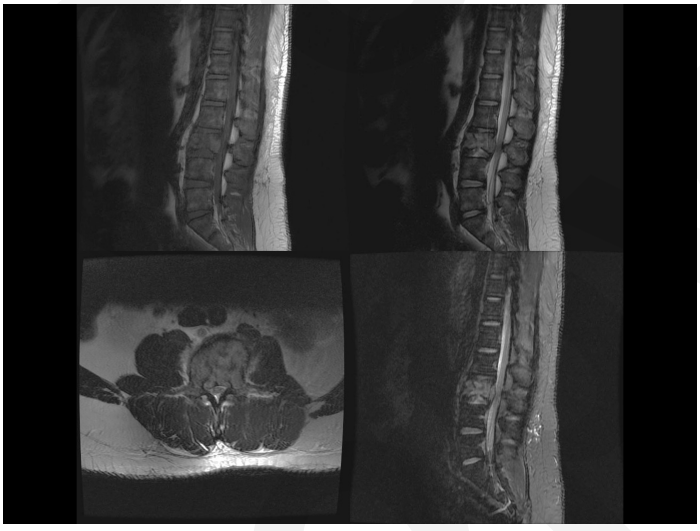


Grafting the disc space

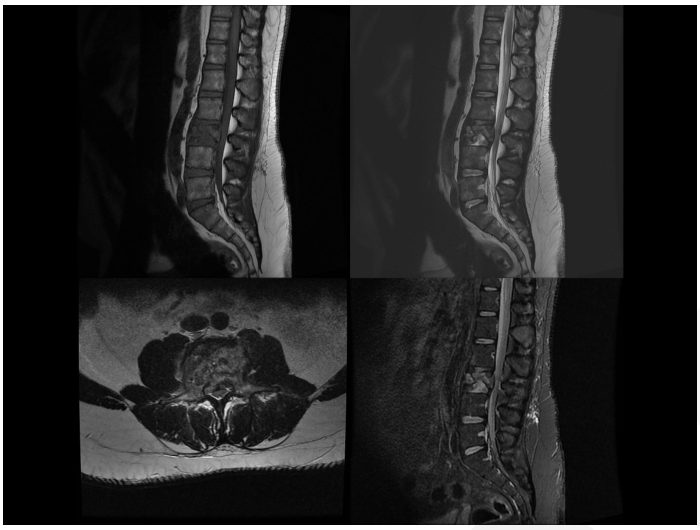


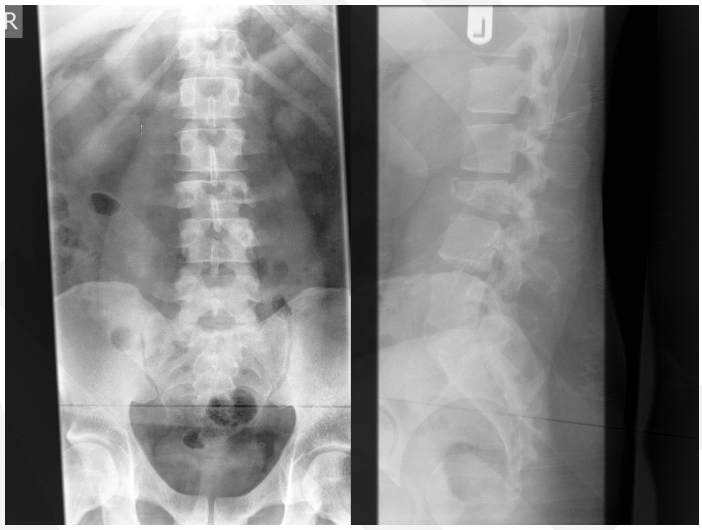
- 30 year old man
- Insidious onset low back pain
- Gradually worsening
- Unable to stand up



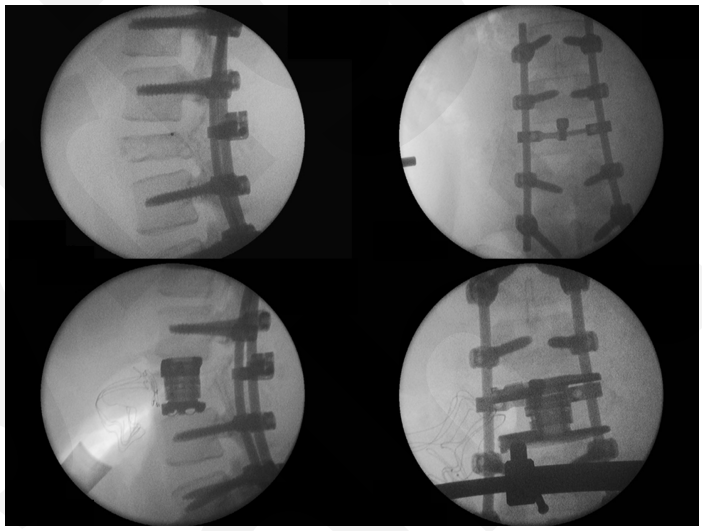


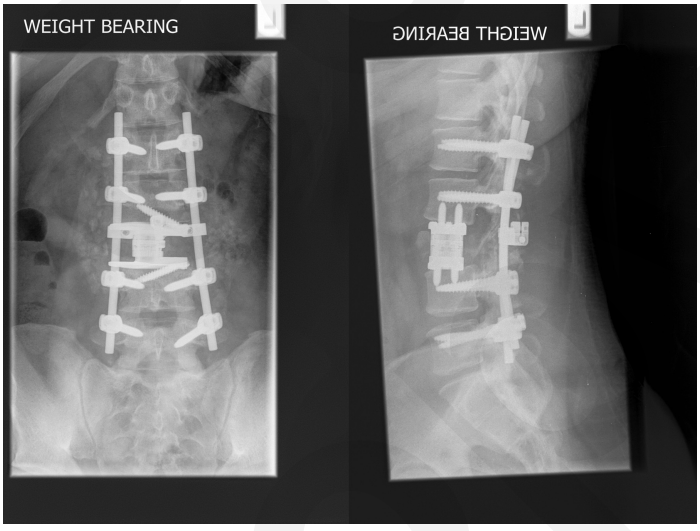
- 6 weeks later
- Pain getting worse
- Biopsy x2 negative
- Rpt MRI





- Discussed at MDTM
- What now…
- Young man…
- Something nasty going on…







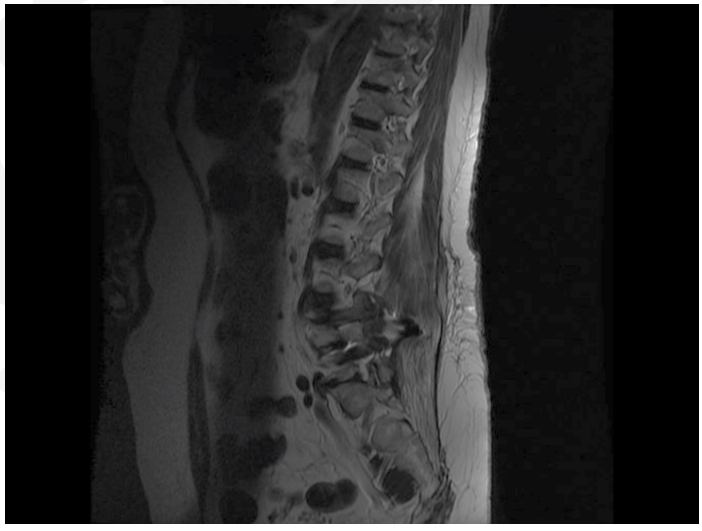






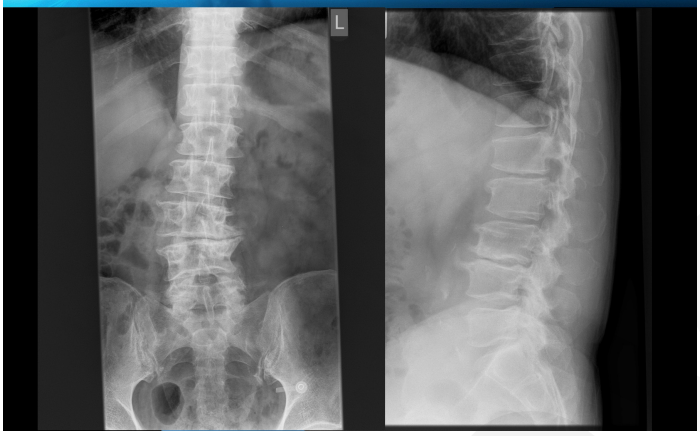




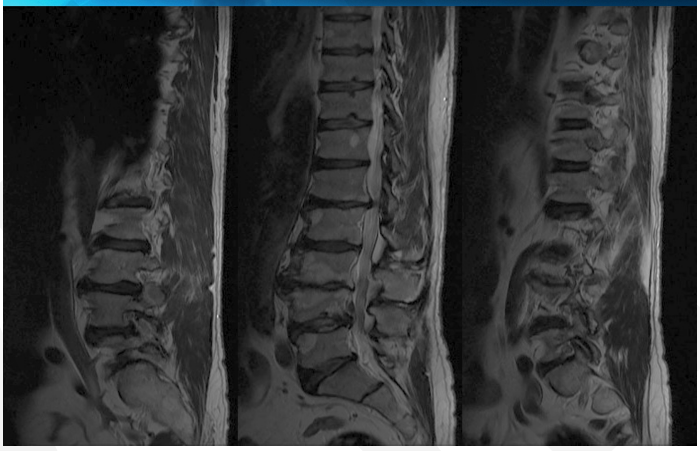


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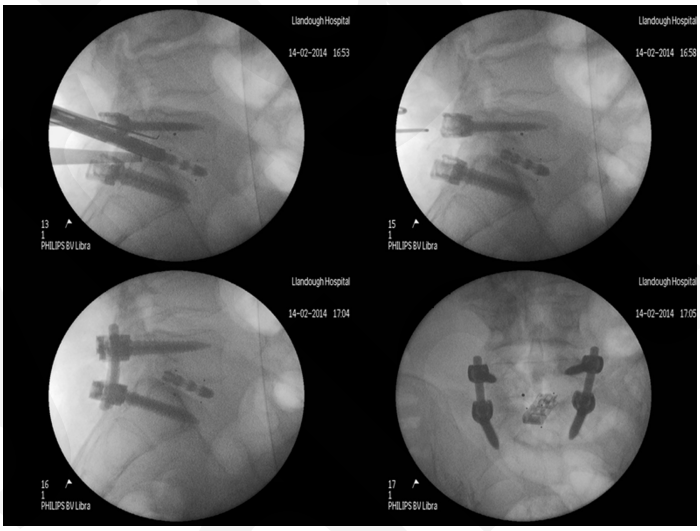
Endplate Breech at Op

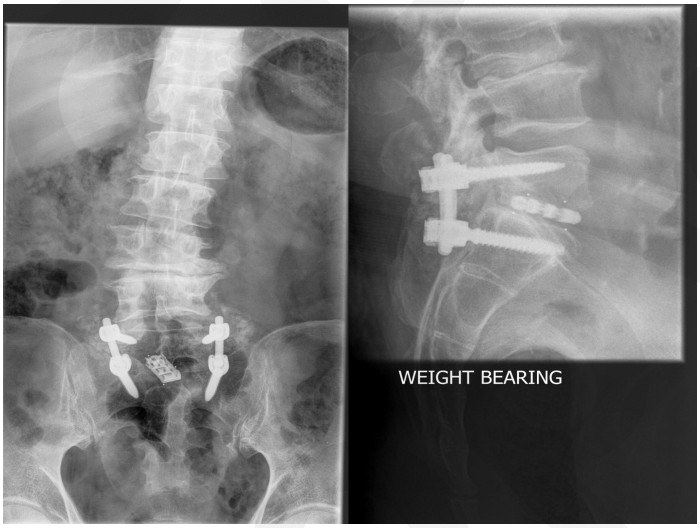


L5 / S1 Foraminal Stenosis

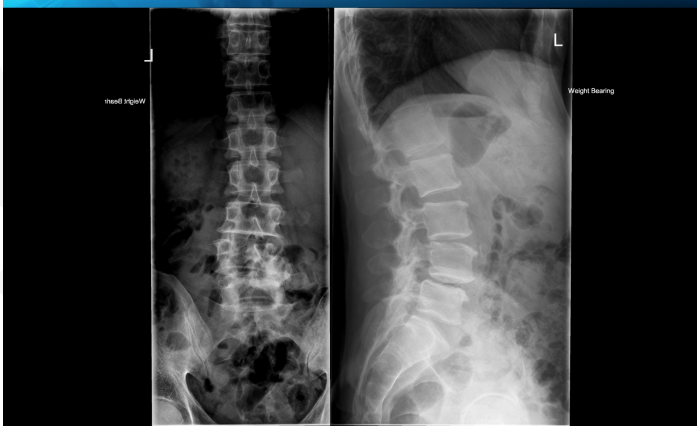


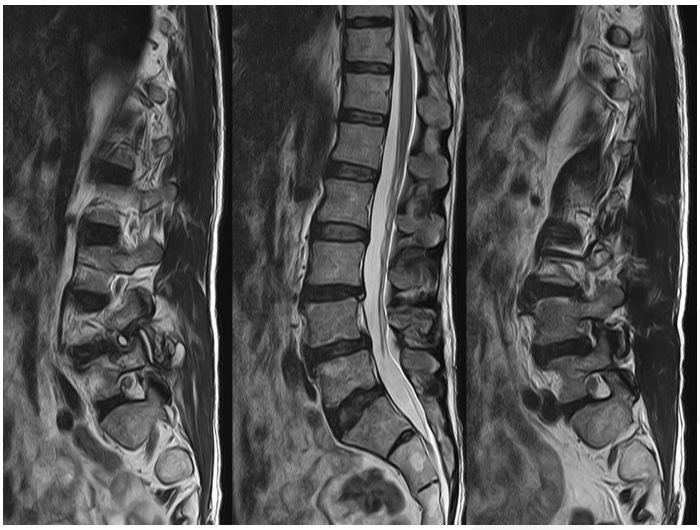


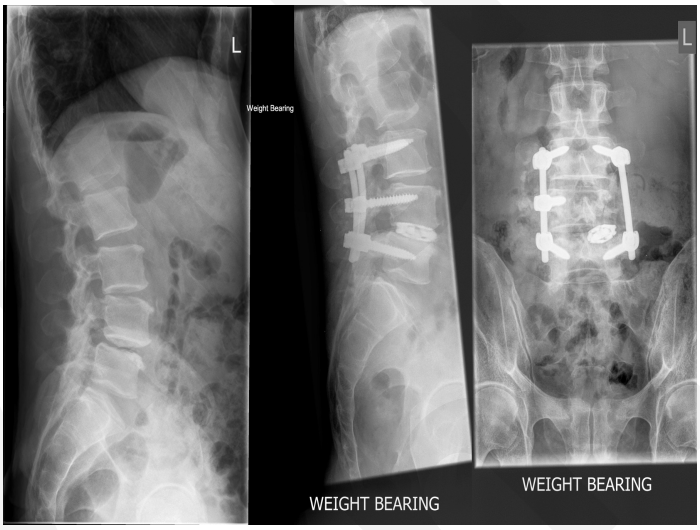




Pedicle Screw Problem



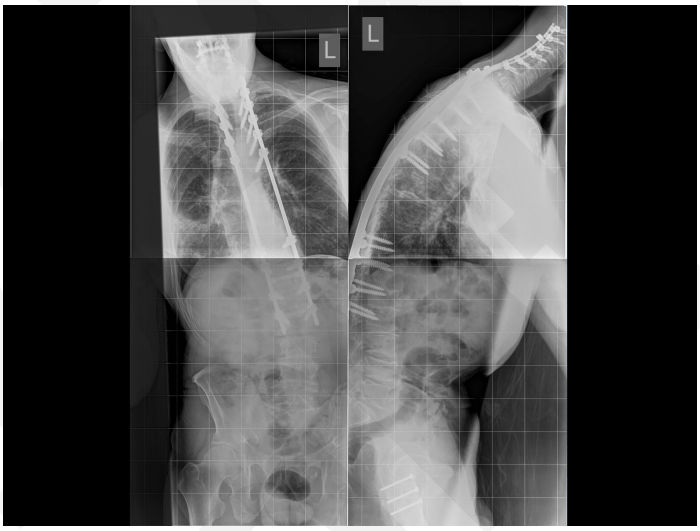


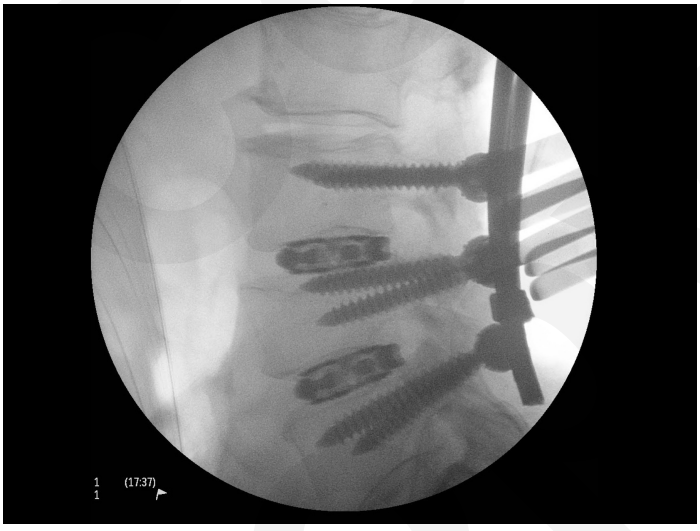


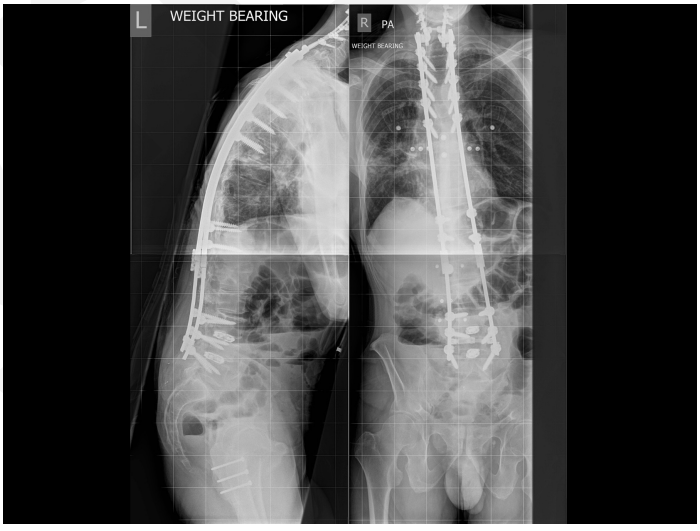
Failures do occur

- Sagittal balance lever arm case
- Parallel cage pedicle fixation failure case

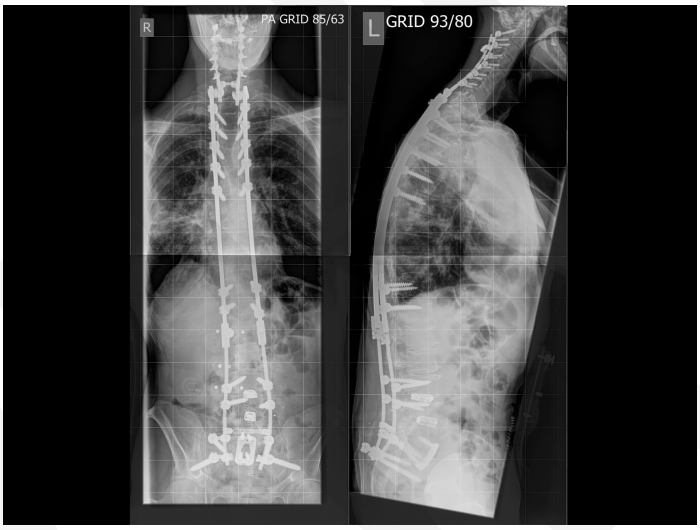
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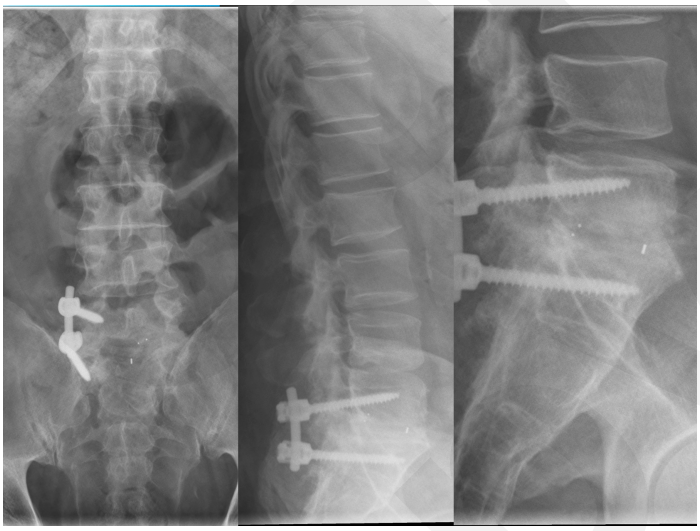


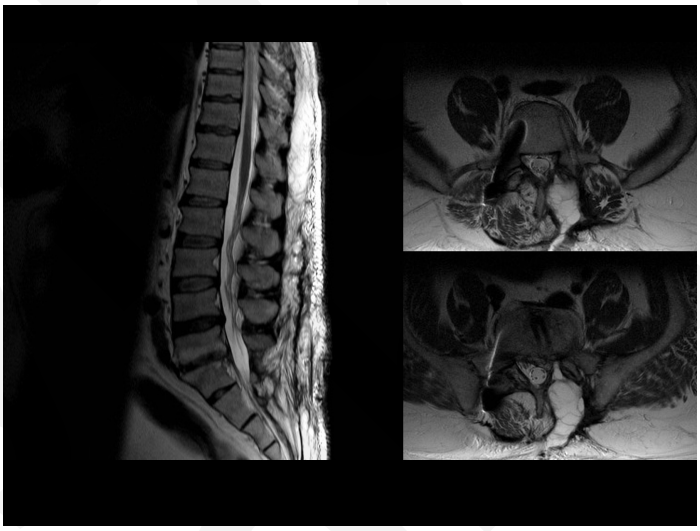




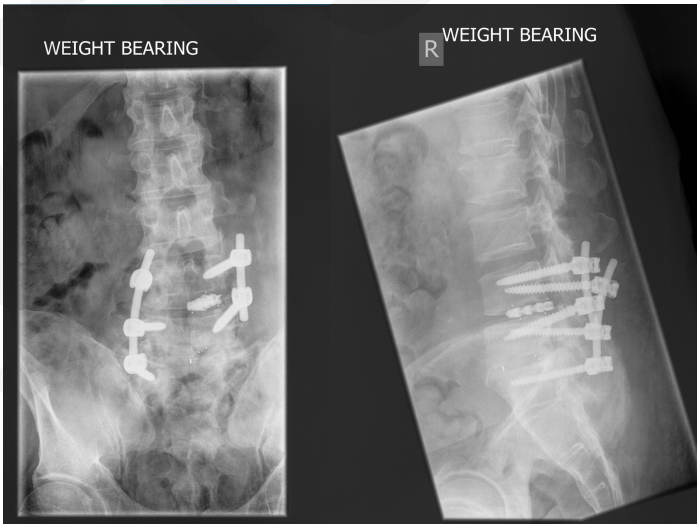




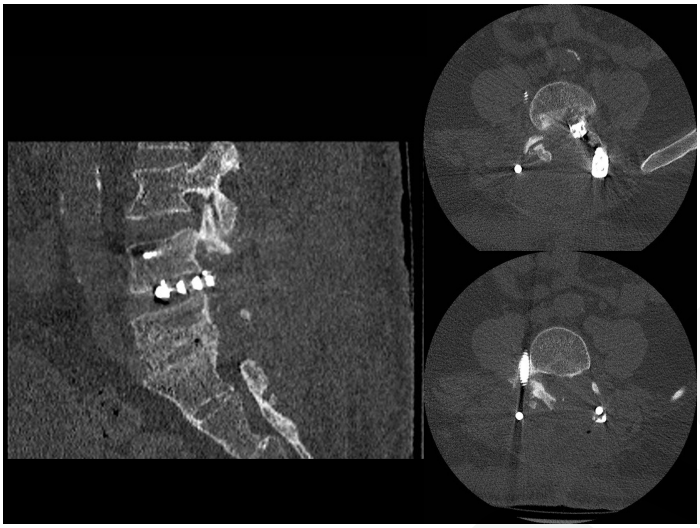


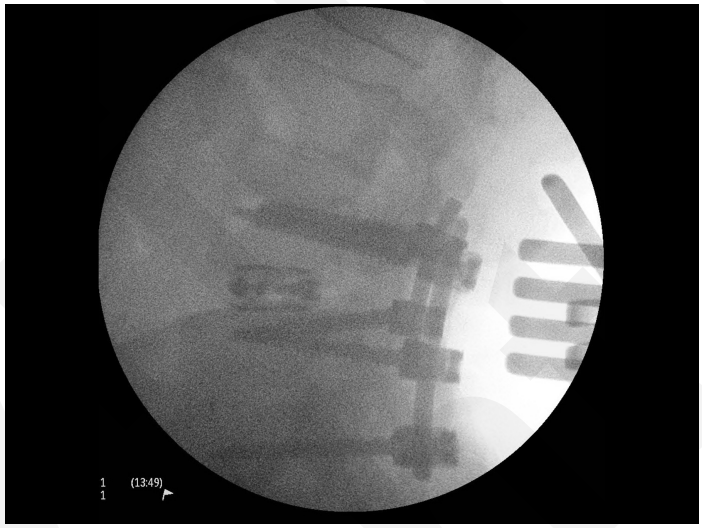


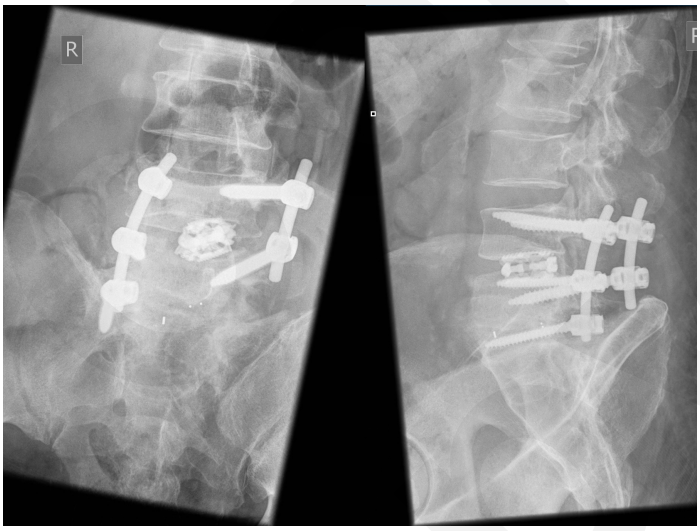




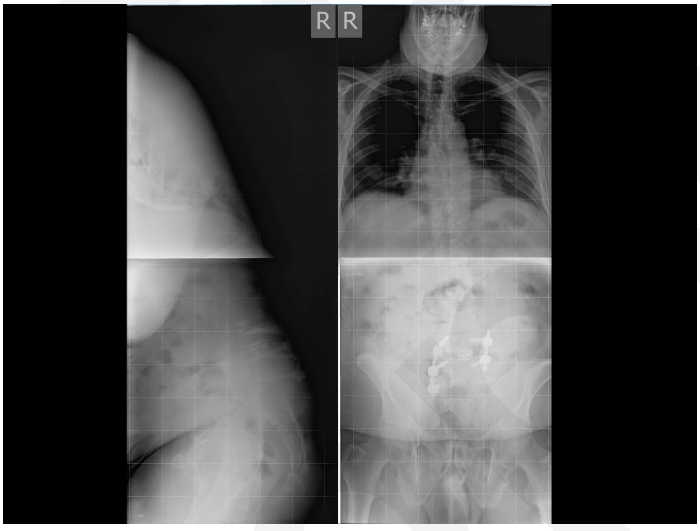
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SPINE Volume 41, Number 8S, pp S44–S49
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BIOMECHANICS

MIS Expandable Interbody Spacers

A Literature Review and Biomechanical Comparison of an Expandable MIS TLIF With Conventional TLIF and ALIF

Andrew F. Cannestra, MD, PhD,* Mark D. Peterson, MD,† Stephen R. Parker, MD,‡ Thomas F. Roush, MD,§ Justin V. Bundy, MD,¶ and Alexander W. Turner, PhD‖

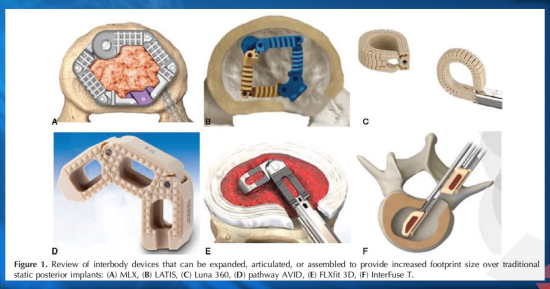
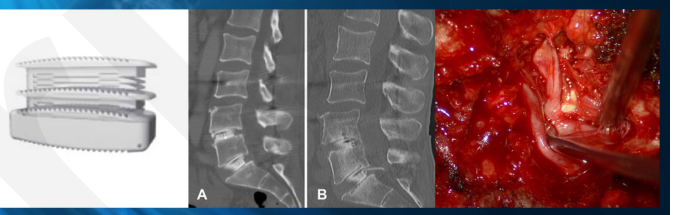


Figure 1. Review of interbody devices that can be expanded, articulated, or assembled to provide increased footprint size over traditional static posterior implants: (**A**) MLX, (**B**) LATIS, (**C**) Luna 360, (**D**) pathway AVID, (**E**) FLXfit 3D, (**F**) InterFuse T.

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Cage Failure and Extrusion



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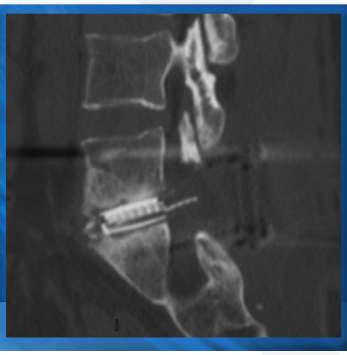
SPINE Volume 37, Number 18, pp E1155–E1158
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CASE REPORT

Extrusion of Expandable Stacked Interbody Device for Lumbar Fusion

Case Report of a Complication

Paul D. Kim, MD,* Eli M. Baron, MD,† and Michel Levesque, MD, FRCSC, FACS‡



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My Main Indications for TLIF

- Spondylolisthesis
  - Restore foraminal height
  - Improve fixation stability vs the sheer forces in “dynamic / mobile” slips
- Foraminal stenosis
- Improve fusion “270” / “360”

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My Main Indications ALIF

- 5/1 SPL
- Foraminal stenosis
- 5/1 DDD
- Restore lordosis

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My Main Indications LLIF

- (Mainly L2/3/4)
- Foraminal Stenosis
- Laterolisthesis

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My Main Indications Corpectomy Cage
• Tumour
• Trauma
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