



Minimally Invasive Spine Surgery

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Minimally Invasive Spine Surgery

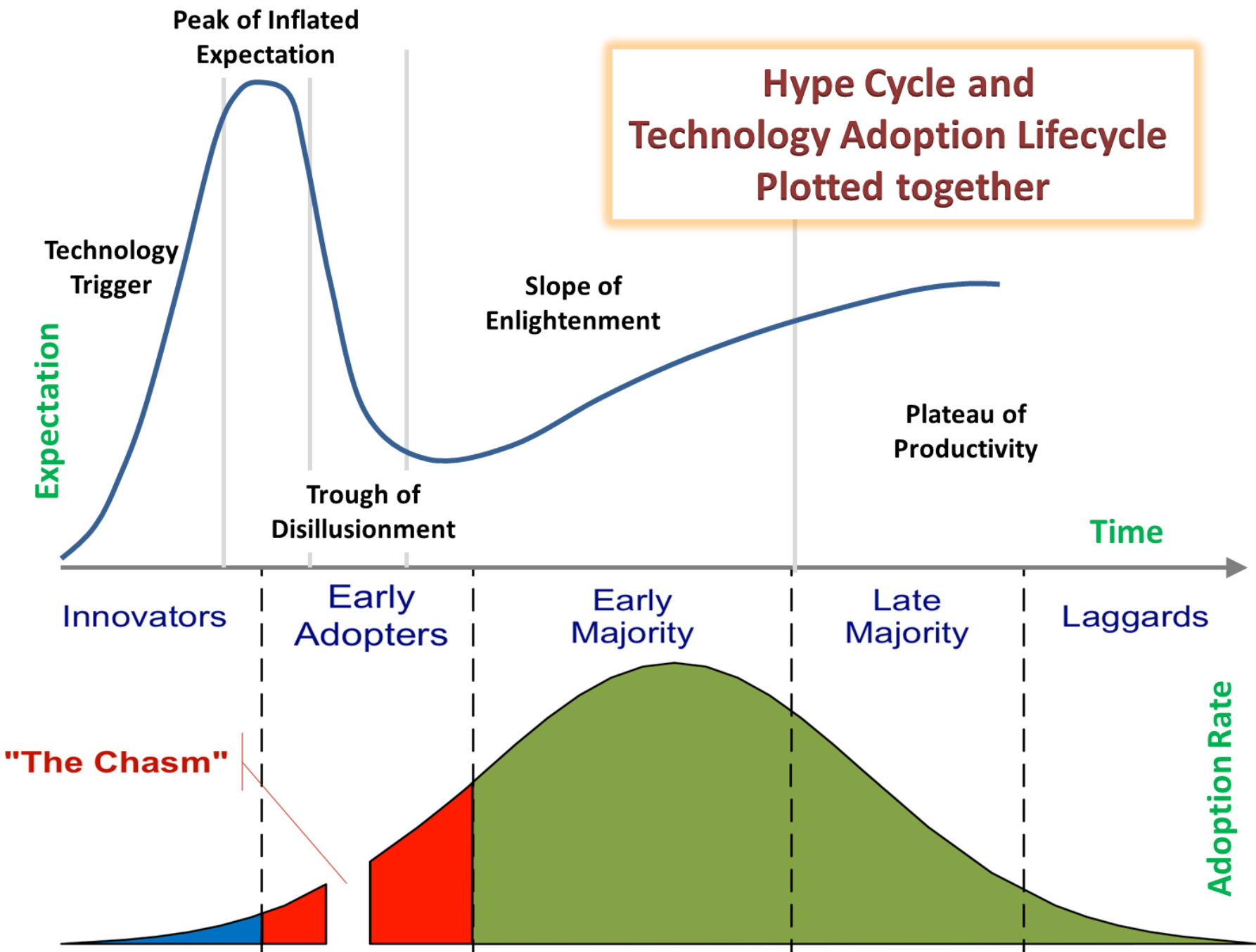
- What is minimally invasive spine surgery?
 - Term first coined by Dr. Parviz Kambin in 1990
 - International Society for Minimal Intervention in Spinal Surgery (ISMIS)
 - 930,000

Disclosures

- Consultant: Depuy, Stryker



Hype Cycle and Technology Adoption Lifecycle Plotted together



Minimally Invasive Spine Surgery

- What is minimally invasive spine surgery?



Minimally Invasive Spine Surgery

HYPOTHESIS

- Surgery → Tissue Damage
- Tissue Damage → Pain/Function
- MIS → Less Pain/Better Function

Key Concept of *Minimally Invasive Surgery*

- Avoid trauma to muscles
- Limit incision size
- Minimize retraction pressure
- Expose only what is needed



Minimally Invasive Spine Surgery

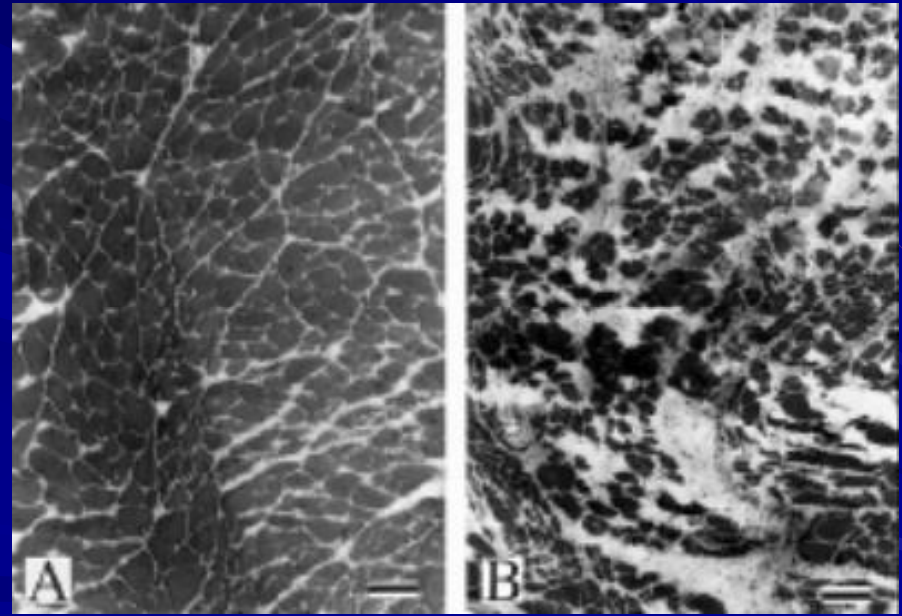
- What is minimally invasive spine surgery?
 - Minimize tissue disruption
 - Quicker recovery
 - Equivalent results to open surgery



Muscle Injury

Animal Models –

- Muscle necrosis
- Inflammation
- Swelling
- Atrophy



Normal

Surgery

Best Indications for MIS



Best Indications for MIS

- Medical Co-Morbidities
- Elderly
- Obese



Strategies for MIS

- Herniated disks
- Degenerated disks
- Stenosis
- Spondylolisthesis
- Scoliosis
- Infections, Tumors, Fractures

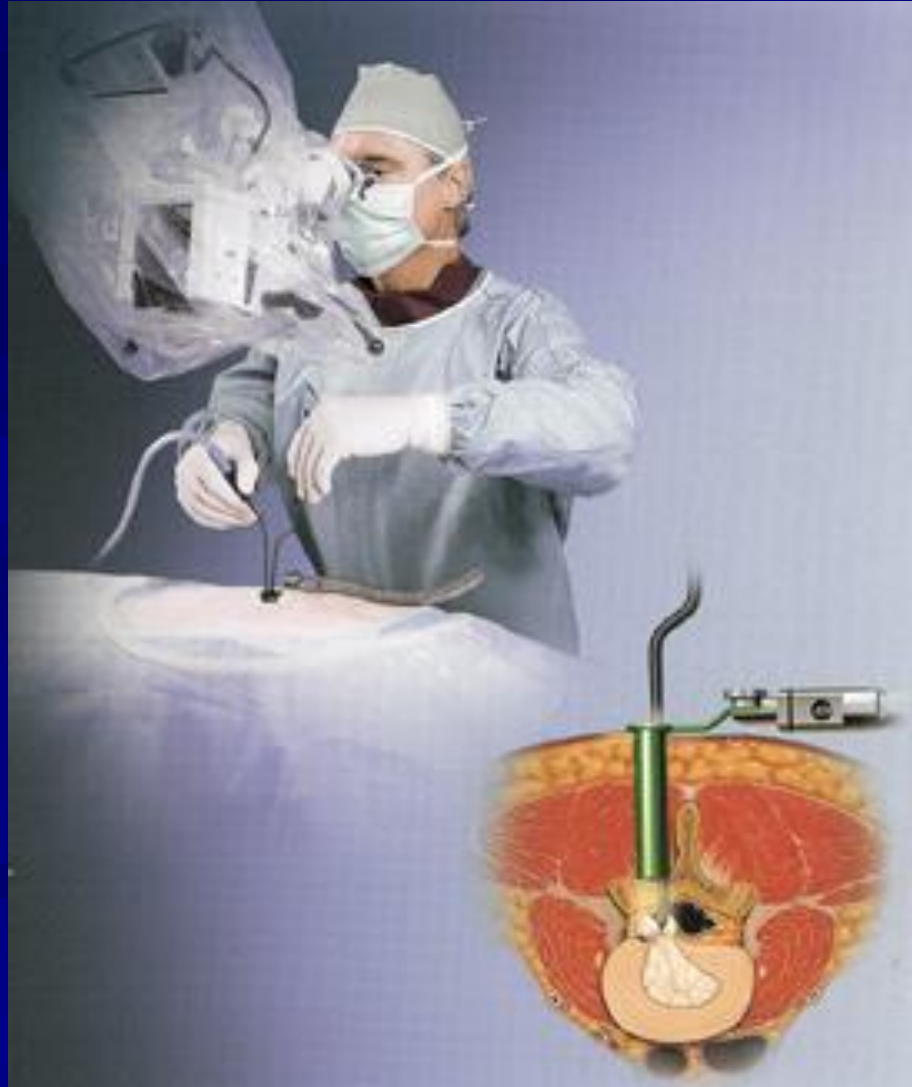
Strategies for MIS

COMPREHENSIVE

- Endoscopic Surgery
- Thoracoscopic Surgery
- MIS Decompression
- MIS Fusion
- MIS Reconstruction
- Vertebroplasty/Kyphoplasty
- ACDF
- Mini-Open ALIF



Background



Background

Schizas C. Neurosurgery. 2005 Oct;57(4 Suppl):357-60

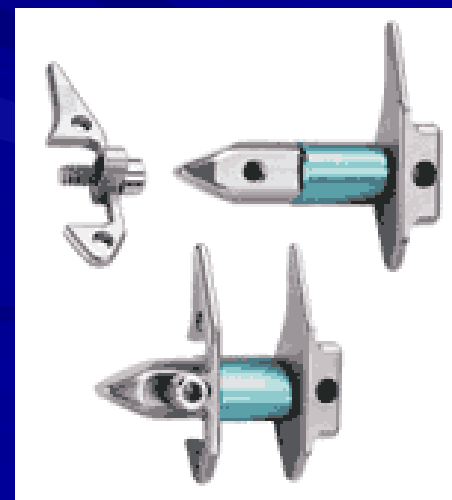
- ODI mean scores were 22.3% in the MED group and 15% in the MSD group
- Low back pain scores were 17.6 in the MED group and 11.4 in the MSD group
- Average length of stay was 1.83 days in the MED group versus 2 days in the MSD group
- One patient in the MED group had a dural tear

Background

■ X-stop

– Zucherman et al. Spine 2005

- 191 pts 2 yr f/u
- Symptom severity score improved 45%
- 73% of patients satisfied with treatment



Background



center for
LASER
SPINE
SURGERY

Background

Payer M. "Minimally invasive" lumbar spine surgery: a critical review. Acta Neurochir (Wien). 2011 May 1

-Only nine comparative studies could be retrieved


-No clear benefit could be found for minimally invasive procedures

Muscle Injury

Fan S, Hu Z, Zhao F, et al. Multifidus muscle changes and clinical effects of one-level posterior lumbar interbody fusion: minimally invasive procedure versus conventional open approach. Eur Spine J. 2010 Feb;19(2):316-24

- 59 patients (minimally invasive approach in 28 and conventional open approach in 31)
- MRI at 1 year follow up
- Multifidus atrophy was less in the minimally invasive group ($P < 0.001$)

Background

- 
- Peng CW, Yue WM, Poh SY, et al. Clinical and radiological outcomes of minimally invasive versus open transforaminal lumbar interbody fusion. *Spine (Phila Pa 1976)*. 2009 Jun 1;34(13):1385-9.
 - Prospective study
 - 29 MIS TLIF were matched paired with 29 Open TLIF
 - morphine used for MIS cases (17.4 mg) was less compared to Open (35.7 mg, $P < 0.05$)
 - MIS (4 days) patients have shorter hospitalization compared to Open (6.7 days, $P < 0.05$)
 - No difference in VAS and ODI at 6 months and 2 years

Infection rates

Parker SL, Adogwa O, Witham TF, et al. Post-Operative Infection after Minimally Invasive versus Open Transforaminal Lumbar Interbody Fusion (TLIF): Literature Review and Cost Analysis. Minim Invasive Neurosurg. 2011 Feb;54(1):33-7.

- SSI was significantly lower for MIS vs. open-TLIF (0.6% vs. 4.0%, $p=0.0005$)
- \$ 98 974 per 100 MIS-TLIF procedures performed.

Background

Rodgers WB, Gerber EJ, Patterson JR. Intraoperative and early postoperative complications in extreme lateral interbody fusion (XLIF): An analysis of 600 cases. Spine (Phila Pa 1976). 2011 Jan 1;36(1):26-32.

- Prospective study
- 600 patients

Background

- Hemoglobin change from pre- to postoperation averaged 1.38.
- Hospital stay averaged 1.21 days
- No wound infections, no vascular injuries, no intraoperative visceral injuries, and 4 (0.7%) transient postoperative neurologic deficits



Background

Rodgers WB, Gerber EJ, Rodgers JA.
Lumbar fusion in octogenarians: the promise of minimally invasive surgery. *Spine (Phila Pa 1976)*. 2010 Dec 15;35(26 Suppl):S355-60.

- Retrospective study
- 40 patients
- >80 years old
- Open PLIF versus XLIF

Background

Rodgers WB, Gerber EJ, Rodgers JA.

Lumbar fusion in octogenarians: the promise of minimally invasive surgery. *Spine (Phila Pa 1976)*. 2010 Dec 15;35(26 Suppl):S355-60.

- Complication rate, blood loss/transfusion rate, and hospital stay were significantly lower in the minimally invasive surgery (MIS) group ($P < 0.0001$)
- MIS patients left the hospital an average of 4 days earlier

Background

Rodgers WB, Gerber EJ, Rodgers JA.

Lumbar fusion in octogenarians: the promise of minimally invasive surgery. *Spine (Phila Pa 1976)*. 2010 Dec 15;35(26 Suppl):S355-60.

- Six deaths occurred in the PLIF follow-up, 3 within 3 months postoperatively; there was 1 death at 6 months postoperatively XLIF

Background


Isaacs RE, Hyde J, Goodrich JA, et al. A prospective, nonrandomized, multicenter evaluation of extreme lateral interbody fusion for the treatment of adult degenerative scoliosis: perioperative outcomes and complications. *Spine (Phila Pa 1976)*. 2010 Dec 15;35(26 Suppl):S322-30.

- Prospective study
- 107 patients
- Degenerative scoliosis

Background

- Mean 4.4 levels
- Mean age: 68
- Mean operative time and blood loss were 178 minutes (58 minutes/level) and 50 to 100 mL.
- Mean hospital stay was 3.8 days overall.
- Five patients (4.7%) received a transfusion
- 3 (2.8%) required intensive care unit admission






■ Adequate restoration of sagittal plane alignment is necessary to significantly improve clinical outcome and avoid subsequent pseudarthrosis

- Booth KC, Bridwell KH, Lenke LG, Baldus CR, Blanke KM: Complications and predictive factors for the successful treatment of flatback deformity (fixed sagittal imbalance). *Spine* 1999; 24:1712-1720.
- Bridwell KH, Lewis SJ, Lenke LG, Baldus C, Blanke K: Pedicle subtraction osteotomy for the treatment of fixed sagittal imbalance. *J Bone Joint Surg Am* 2003; 85:454-463.
- Kim YJ, Bridwell KH, Lenke LG, Rhim S, Cheh G: Pseudarthrosis in long adult spinal deformity instrumentation and fusion to the sacrum: Prevalence and risk factor analysis of 144 cases. *Spine* 2006; 31:2329-2336.
- Kim YJ, Bridwell KH, Lenke LG, Rinella AS, Edwards CII: Pseudarthrosis in primary fusions for adult idiopathic scoliosis: Incidence, risk factors, and outcome analysis. *Spine* 2005; 30:468-474.

Background

- 
- Kim MK, Lee SH, Kim ES, et al. The impact of sagittal balance on clinical results after posterior interbody fusion for patients with degenerative spondylolisthesis: a pilot study. *BMC Musculoskelet Disord.* 2011 Apr 5;12:69.
 - Retrospective review
 - VAS improvements in Group A were significantly related to postoperative lumbar lordosis
 - ODI improvements were also associated with postoperative lumbar lordosis

Background

- Dakwar E, Cardona RF, Smith DA, Uribe JS. Early outcomes and safety of the minimally invasive, lateral retroperitoneal transpsoas approach for adult degenerative scoliosis. *Neurosurg Focus*. 2010 Mar;28(3):E8.
 - Retrospective review
 - 25 patients
 - mean improvement of 5.7 points on visual analog scale scores and 23.7%
 - Three patients (12%) experienced transient postoperative anterior thigh numbness
 - did not correct the sagittal balance in approximately one-third of the patients

Radiation



Background

Phan K, Rao PJ, Kam AC et al. Minimally invasive versus open transforaminal lumbar interbody fusion for treatment of degenerative lumbar disease: systematic review and meta-analysis. *Eur Spine J.* 2015 Mar 27

- intraoperative blood loss
- Infection rates
- VAS and ODI better in MIS cases
- higher radiation exposure for the surgical team.

Estimation of Patient Dose and Associated Radiogenic Risks From Fluoroscopically Guided Pedicle Screw Insertion

Perisinakis et al. (2004) Spine, Vol. 29, No. 14, pp. 1555-1560

Time and Estimated Number of Fluoro Shots

View	Time (s)	Approx. Fluoro Shots (At 0.8 s per shot)
A-P	15	19
Lateral	26	32
Total	41	51



Estimation of Patient Dose and Associated Radiogenic Risks From Fluoroscopically Guided Pedicle Screw Insertion

Perisinakis et al. (2004) Spine, Vol. 29, No. 14, pp. 1555-1560

Estimated Procedural Radiation Dose and Radiogenic Risk

Sex	Effective Dose (mSv)	Gonadal Dose (mGy)	Radiogenic Risk for Fatal Cancer (Per million)
Male	1.40	0.12	4
Female	1.52	0.67	15



Radiation exposure

- Rampersaud YR, Foley KT, Shen AC, Williams S, Solomito M. Radiation exposure to the spine surgeon during fluoroscopically assisted pedicle screw insertion. *Spine*. 2000 Oct 15;25(20):2637-45.
 - Cadaveric study
 - Fluoroscopically assisted thoracolumbar pedicle screw placement exposes the spine surgeon to significantly greater radiation levels
 - Dose rate to the torso was greatest when the surgeon was positioned ipsilateral to the beam source (53.3 mrem/min, compared with 2.2 mrem/min on the contralateral side)

Radiation exposure

- For occupational exposure, the limit is 50 mSv in a single year with a maximum of 100 mSv in a consecutive five-year period
- 68 mSv: estimated maximum dose to evacuees who lived closest to the Fukushima I nuclear accidents

Radiation exposure

- 2.2 mrem/min
- 100 rem = 1 Sv
- 100 cases = 220 mrem = 2.2 mSv
- Max = 50 mSv



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Radiation exposure

- Tabaraee E, Gibson AG, Karahalios DG, et al. Intraoperative cone beam-computed tomography with navigation (O-ARM) versus conventional fluoroscopy (C-ARM): a cadaveric study comparing accuracy, efficiency, and safety for spinal instrumentation *Spine (Phila Pa 1976)*. 2013 Oct 15;38(22):1953-8
 - Cadaveric study
 - O-ARM use results in similar breach rates as C-ARM for the placement of pedicle screws
 - Time for instrumentation is shorter with the O-ARM, but requires a longer setup time
 - O-ARM exposes less radiation to the surgeon, but higher doses to the cadaver

Radiation exposure

- Van de Kelft E, Costa F, Van der Planken D, et al. A prospective multicenter registry on the accuracy of pedicle screw placement in the thoracic, lumbar, and sacral levels with the use of the O-arm imaging system and StealthStation Navigation. *Spine (Phila Pa 1976)*. 2012 Dec 1;37(25):E1580-7
 - Multi-center prospective study
 - 1922 screws in 353 patients
 - 97.5% accuracy rate
 - mean radiation dose was comparable with half the dose of a 64 multi-slice CT scan

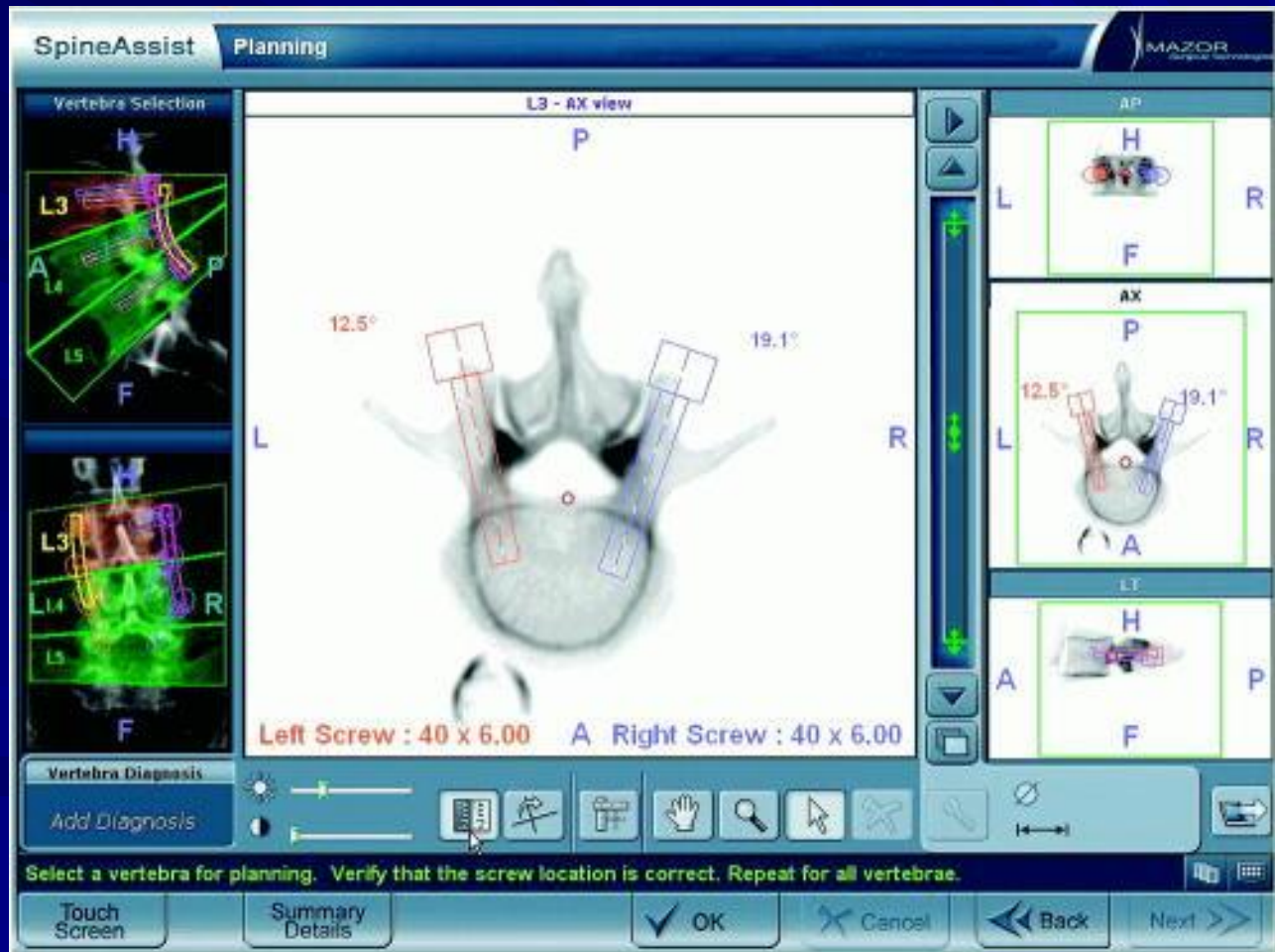
Robotic Assistance

- Lieberman IH, Hardenbrook MA, Wang JC, et al. Assessment of Pedicle Screw Placement Accuracy, Procedure Time, and Radiation Exposure Using a Miniature Robotic Guidance System. *J Spinal Disord Tech.* 2011 May 19
 - 234 pedicle screws in 12 cadavers
 - fewer screw placement deviations (average, 2.6 ± 0.7 mm vs. 1.1 ± 0.4 mm; $P < 0.0001$)
 - fewer pedicle wall breaches of 4 mm or greater (average, 5.4% vs. 1.5%)
 - lower surgeon radiation exposure (average, 136 mrem vs. 4.2 mrem)
 - lower fluoroscopy time per screw (average, 33.0 s vs. 0.9 s)

Robotic Assistance

- Pechlivanis I, Kiriyanthan G, Engelhardt M. et al. Percutaneous placement of pedicle screws in the lumbar spine using a bone mounted miniature robotic system: first experiences and accuracy of screw placement. Spine (Phila Pa 1976). 2009 Feb 15;34(4):392-8.
 - A deviation <2 mm to the surgeon 's plan in 91.0% to 98.5%

Robotic Assistance



Robotic Assistance



Sacroiliac Joint

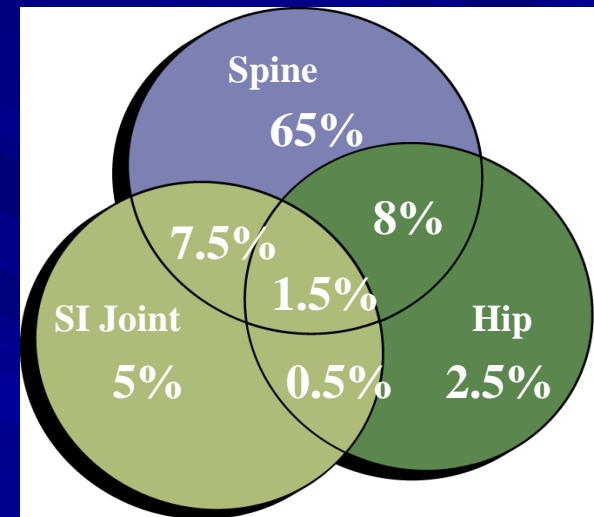


Background

- Up to 25% of LBP patients have significant pain coming from their hip and/or SI Joint
- SIJ is a significant pain generator in 14.5% of LBP patients

Sembrano and Polly,

Spine 2008



Pathomechanics

Chou LH, Slipman CW, Bhagia SM, et al. Inciting events initiating injection-proven sacroiliac joint syndrome. *Pain Med.* 2004; 5:26-32.

- 44% of cases, 35% were idiopathic, and 21% were due to repeated stress



Background

Ha K, Lee S, Kim K. Degeneration of sacroiliac joint after instrumented lumbar or lumbosacral fusion. *Spine*. 2008; 33(11):1192-1198.

- rate of SI joint degeneration was nearly double in patients that had undergone posterior spinal fusion compared to age-matched controls followed over a five year period

Background

- In patients with gluteal pain after lumbar fusion
 - 34% were very likely and 29% were probably SIJ related

Katz, Spine Disorders 2003



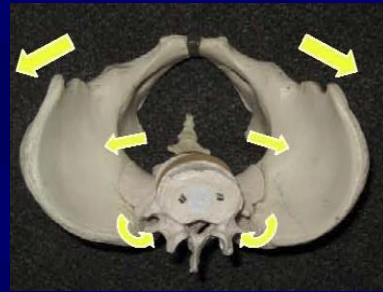
Work-up

- Pain Descriptions
 - Point to pain, Fortin test
 - Draw location of pain

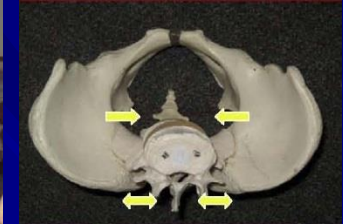


Provocative Testing

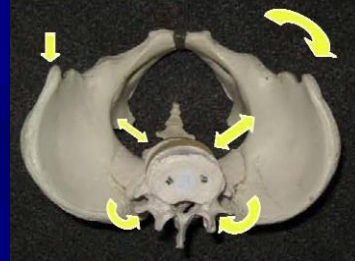
Distraction (Gapping)



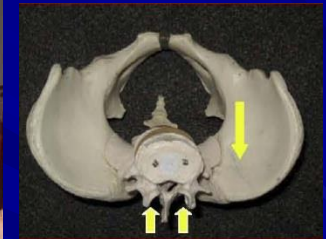
Compression Test



Patrick's (Faber) Test



Thigh Thrust Test



Gaenslen's Test



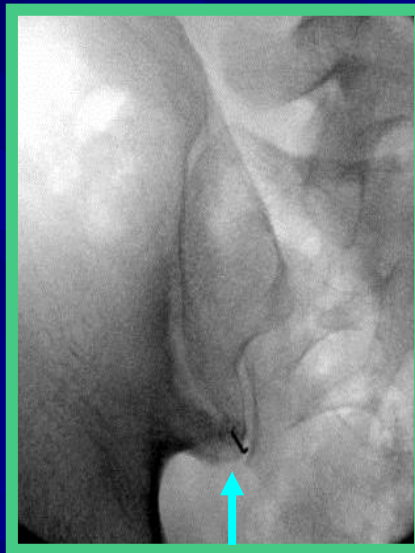
Sacral Thrust Test



Gold Standard for Diagnosis

- Perform 1-2 Fluoroscopic guided anesthetic SIJ injections with only 1-2 cc's
 - If pain reduced by >75%, then likely cause is SIJ
 - If pain reduced 50 – 75 %, then perform another injection
 - What the patient experiences here is what the patient will experience after the iFuse procedure

SI Joint



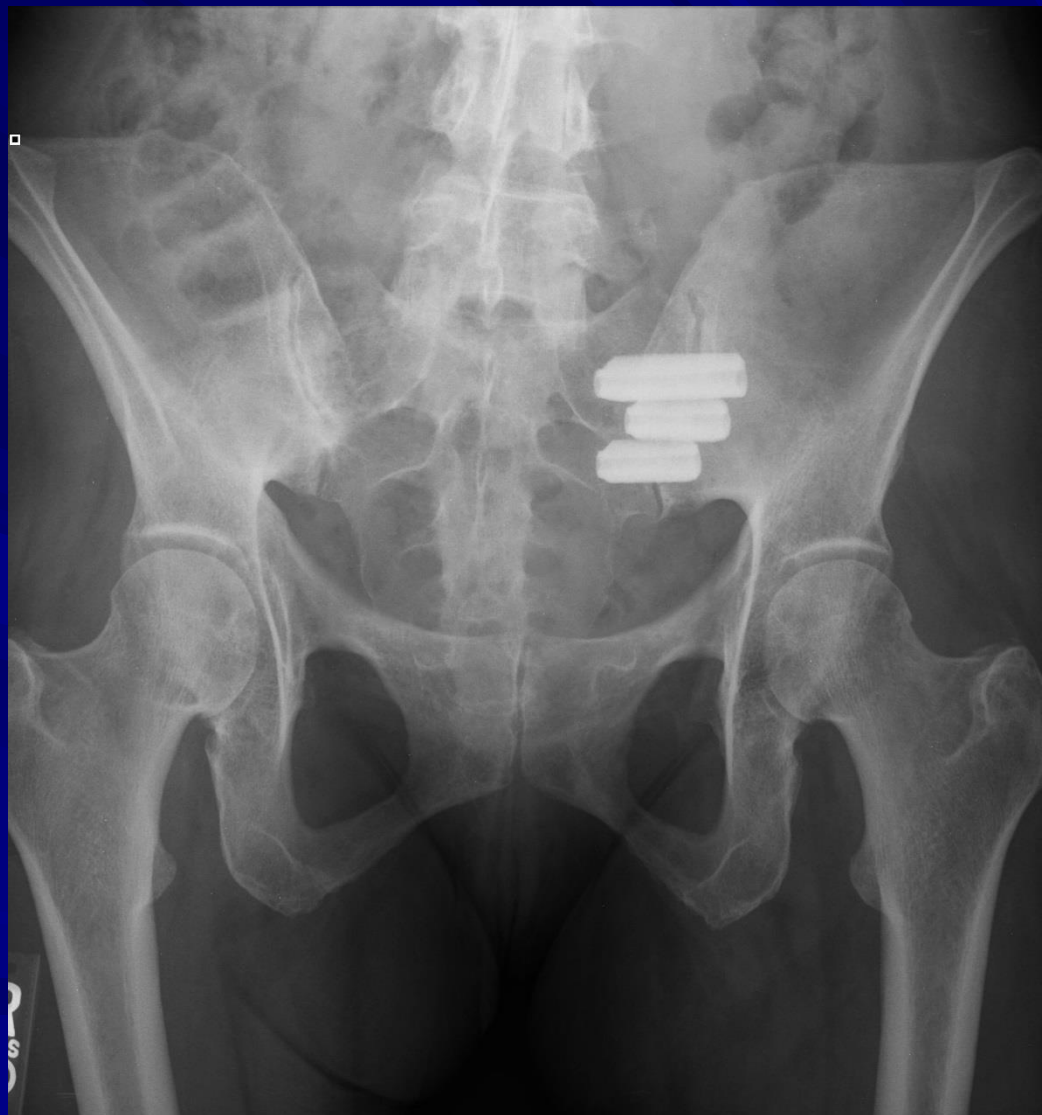
Needle at SI Joint
No more than 1.5 cc of
anesthetic block



Contrast Media
Injection Confirming
Needle Position







What's New

- **Whang P, Cher D, Polly D, et al. Sacroiliac Joint Fusion Using Triangular Titanium Implants vs. Non-Surgical Management: Six-Month Outcomes from a Prospective Randomized Controlled Trial. Int J Spine Surg. 2015 Mar 5;9:6**
 - Prospective, randomized study
 - 148 patients
 - Six-month follow-up from this level 1 study showed that minimally invasive SI joint fusion using triangular titanium implants was more effective than non-surgical management in relieving pain, improving function and improving quality of life



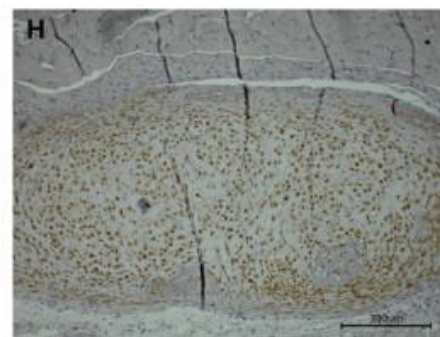
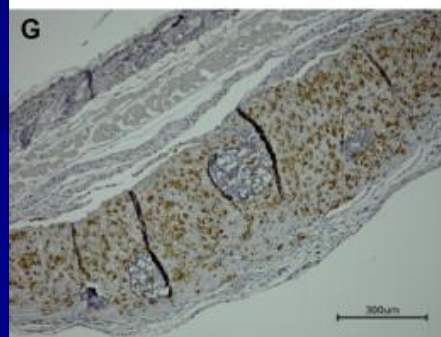
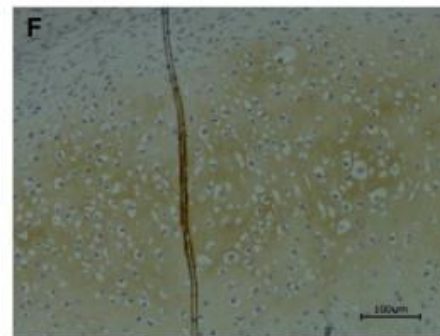
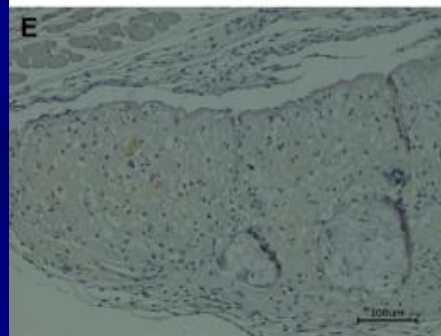
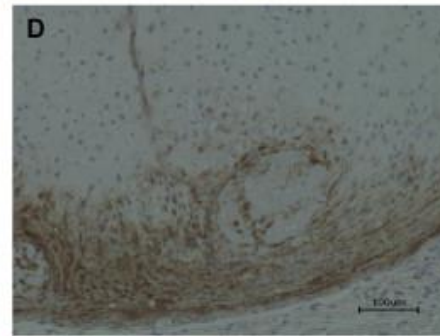
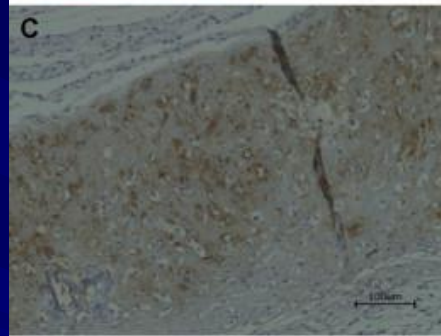
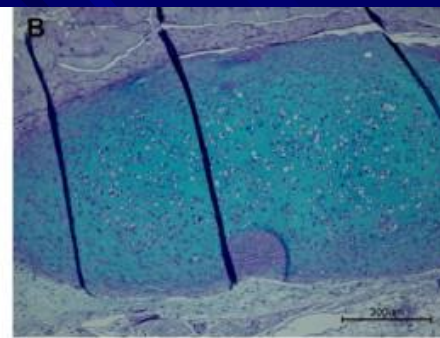
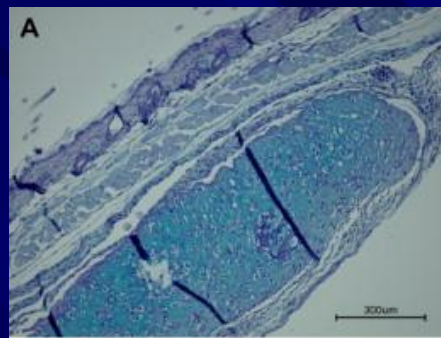
What's New

What's New

- Berjano P, Cecchinato R, Sinigaglia A, et al. Anterior column realignment from a lateral approach for the treatment of severe sagittal imbalance: a retrospective radiographic study. *Eur Spine J.* 2015 Apr 17
 - Retrospective review 12 patients
 - mean value of 27° of lordosis were restored at a single ACR level.
 - Two major complications occurred, a bowel perforation and a postoperative early infection of the posterior wound that required surgical debridement.

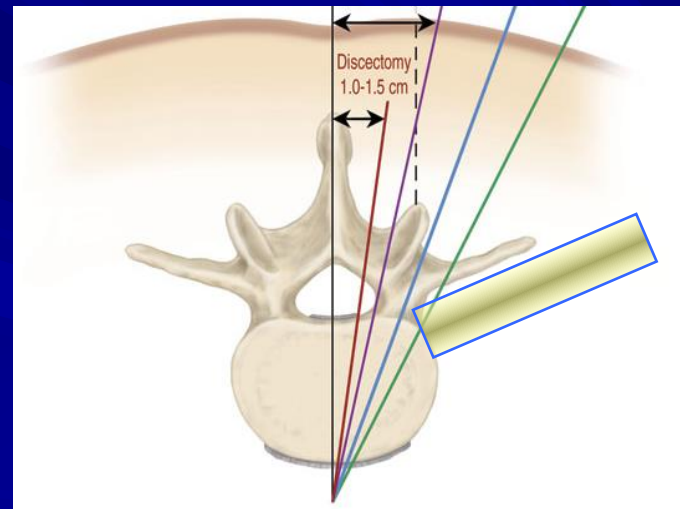
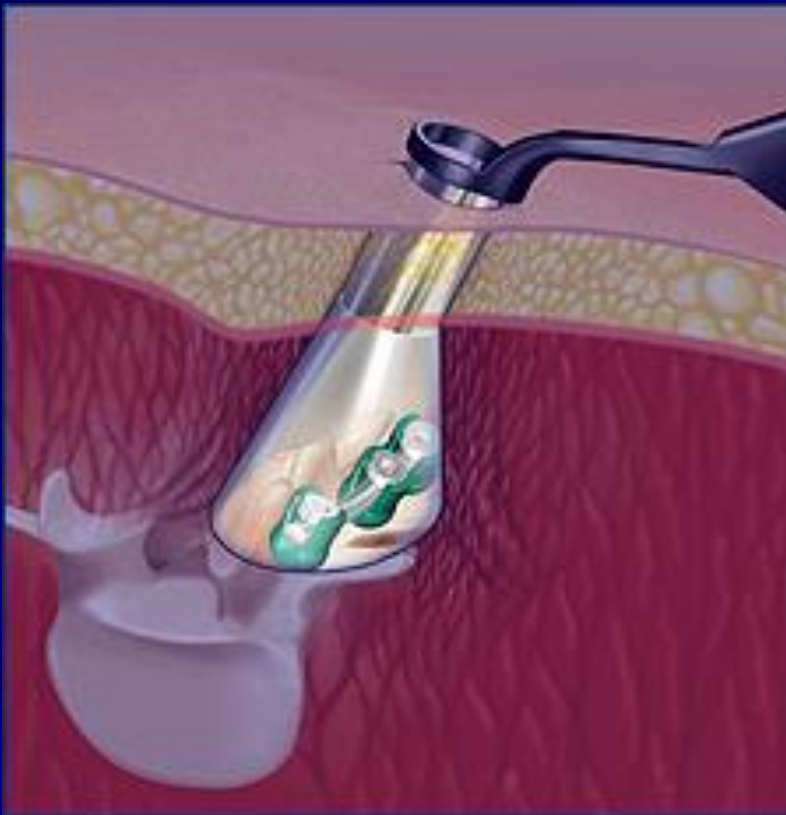
What's New

- Tsaryk R, Gloria A, Russo T, et al. Collagen-low molecular weight hyaluronic acid semi-interpenetrating network loaded with gelatin microspheres for cell and growth factor delivery for nucleus pulposus regeneration. *Acta Biomater.* 2015 Apr 8
 - hydrogel were successfully combined with TGF- β 3 delivery by gelatin microspheres, which promoted the chondrogenic phenotype.



What's New

■ Endoscopic TLIF



Thank You