

# LUMBAR FACET ARTHROPLASTY; TECHNIQUES, BIOMECHANICS, AND CLINICAL EXPERIENCES

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American Hospital, Istanbul

Phoenix, March 2011

## Talk about

- Degenerative disc disease
- Chronic low-back pain
- Limited daily activity
- No obvious segmental instability

# Role of the lumbar facet articulation

- Enhance movement
- Provide stabilization
- Protect neural tissue
- Act as load transmitter

“Dynamic articular stabilization of the posterior column”

# Biomechanical Evaluation of Lumbar Spinal Stability After Graded Facetectomies

KUNIYOSHI ABUMI, MD,\* MANOHAR M. PANJABI, PhD, DTech,† KENNETH M. KRAMER, MD,†  
JOANNE DURANCEAU, MS,† THOMAS OXLAND, MSc,† and JOSEPH J. CRISCO, PhD†

Spine; 15 (11), 1990

- Unilateral medial facetectomy (50%)
  - increases flexion
- Unilateral total facetectomy
  - increases flexion and axial rotation

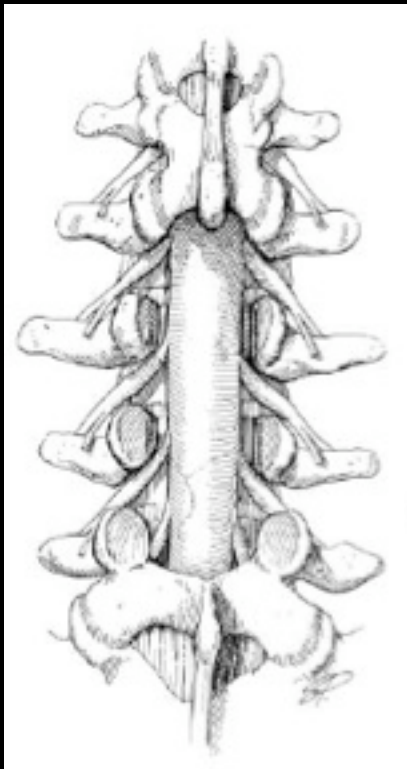
Medial Facetectomy = STABLE,  
Total Facetectomy = UNSTABLE

# Biomechanical comparison of facet-sparing laminectomy and Christmas tree laminectomy

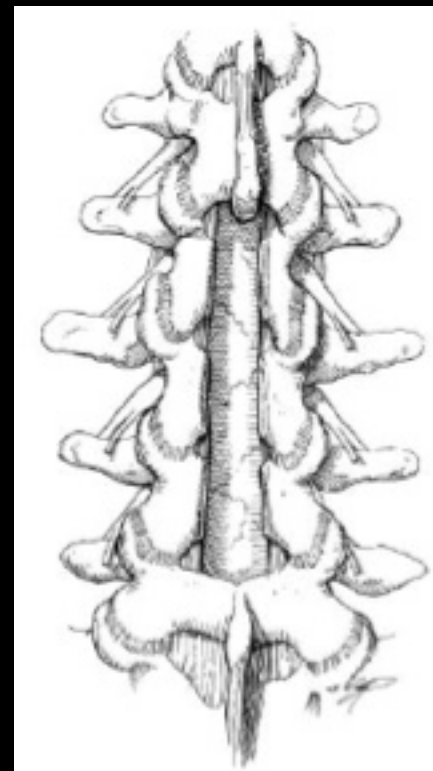
PAUL W. DETWILER, M.S., M.D., CHRISTINA B. SPETZLER, B.A., SARA B. TAYLOR, B.A.,  
NEIL R. CRAWFORD, PH.D., RANDALL W. PORTER, M.D., AND VOLKER K. H. SONNTAG, M.D.

J Neurosurg; 99 (2 Suppl), 2003

- FSL induces less instability than CTL



CTL



FSL

## How to achieve the posterior motion

- Dynamic pedicle screws
- Dynamic rods
- Hybrid systems (dynamic screw + dynamic rod)
- Facet arthroplasty

# What is the expectation with posterior dynamic stabilizations ?

- Provide normal ROM with adequate stabilization
- Prevent adjacent segment disease
- Forget pseudoarthrosis (without fusion)
- Promote fusion (with intervertebral fusion)

INTERNAL BRACE OF THE SPINE ?

# Why we fix SPINE !

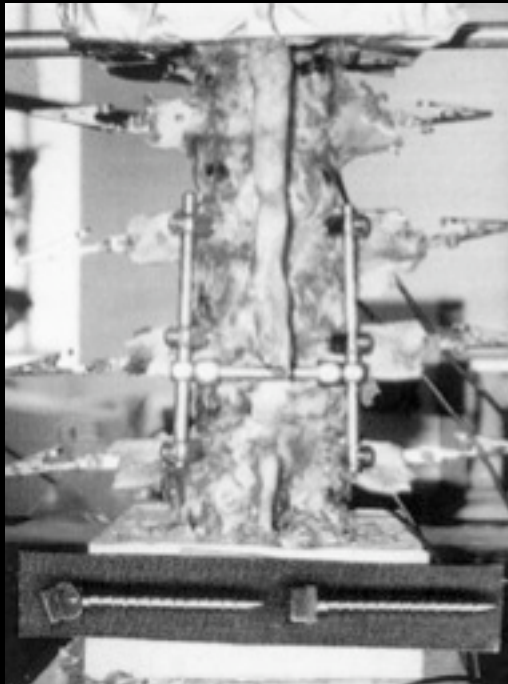


# What we know about dynamic pedicle screws

- Mimics facet articulation by different hinge design
- Applicable more than one level
- Decreased of mobility if applied more than two levels
- Combine with rigid pedicle screws

## Stability Analysis of an Enhanced Load Sharing Posterior Fixation Device and Its Equivalent Conventional Device in a Calf Spine Model

Jeffrey L. Scifert, BSE,\* Koichi Sairyo, MD,\* Vijay K. Goel, PhD,\* Leon J. Grobler, MD,\*  
Nicole M. Grosland, PhD,\* Kevin F. Spratt, PhD,\*† and Kathleen D. Chesmel, PhD‡



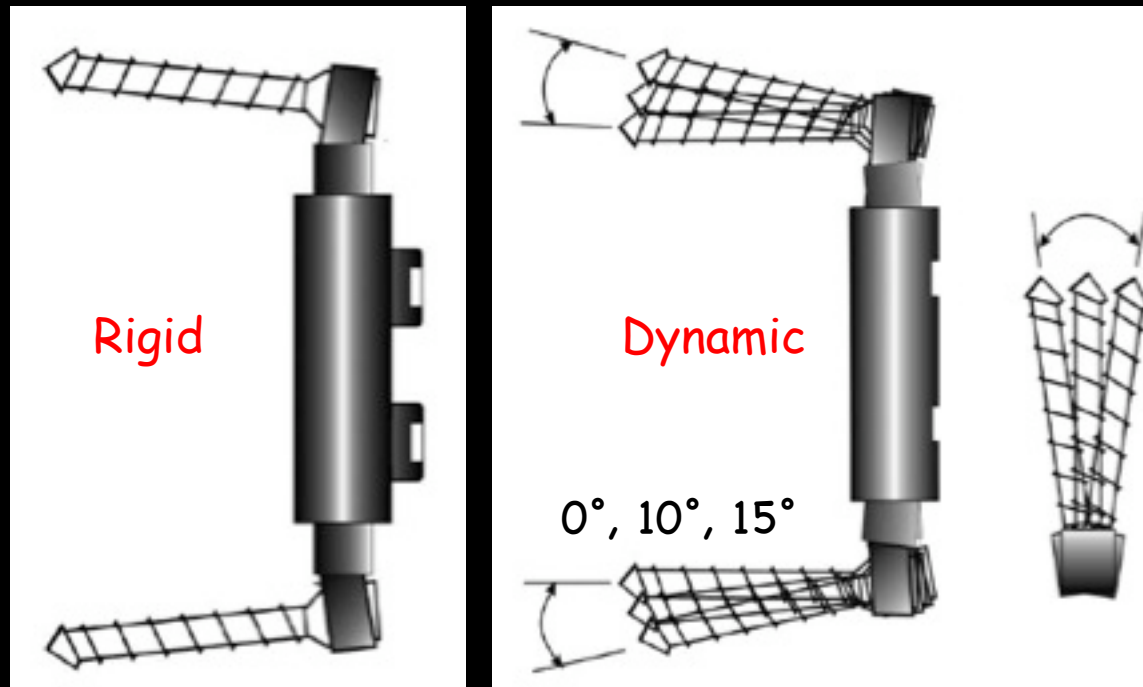
Motion at  $\pm 15^\circ$

Adequate stabilization, limited restriction during axial rotation

## Biomechanical evaluation of a dynamic pedicle screw fixation device

Hua-Zi Xu <sup>a,\*</sup>, Xiang-Yang Wang <sup>b</sup>, Yong-Long Chi <sup>a</sup>, Qing-An Zhu <sup>c</sup>, Yan Lin <sup>a</sup>,  
Qi-Shan Huang <sup>a</sup>, Li-Yang Dai <sup>b</sup>

2005



DPS;

- Adequate stabilization
- Slightly increase flexion/extension ROM
- Less stiffness of flexion–compression
- Reduction in stress shielding



## Hinged-Dynamic Posterior Device Permits Greater Loads on the Graft and Similar Stability as Compared with Its Equivalent Rigid Device: A Three-Dimensional Finite Element Assessment

[JPO, 2001 Vol. 13, Num. 1](#), pp. 17-20

Vijay K. Goel, PhD

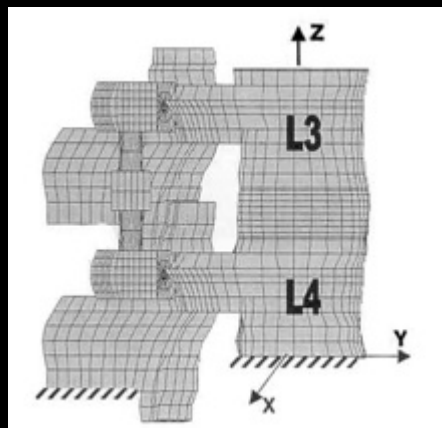
Regina J. Konz, MS

H. T. Chang, MS

Nicole M. Grosland, PhD

Leon J. Grobler, MD

K. D. Chessel



| Graft      | Rigid   |        | Hinged  |        |
|------------|---------|--------|---------|--------|
|            | Nucleus | Device | Nucleus | Device |
| Cancellous | 712.4   | 87.6   | 767.9   | 32.1   |
| Cortical   | 741.2   | 58.8   | 773.5   | 26.5   |
| Titanium   | 742.5   | 57.5   | 774.3   | 25.7   |

DPS produces more axial displacement than RPS (promote fusion)

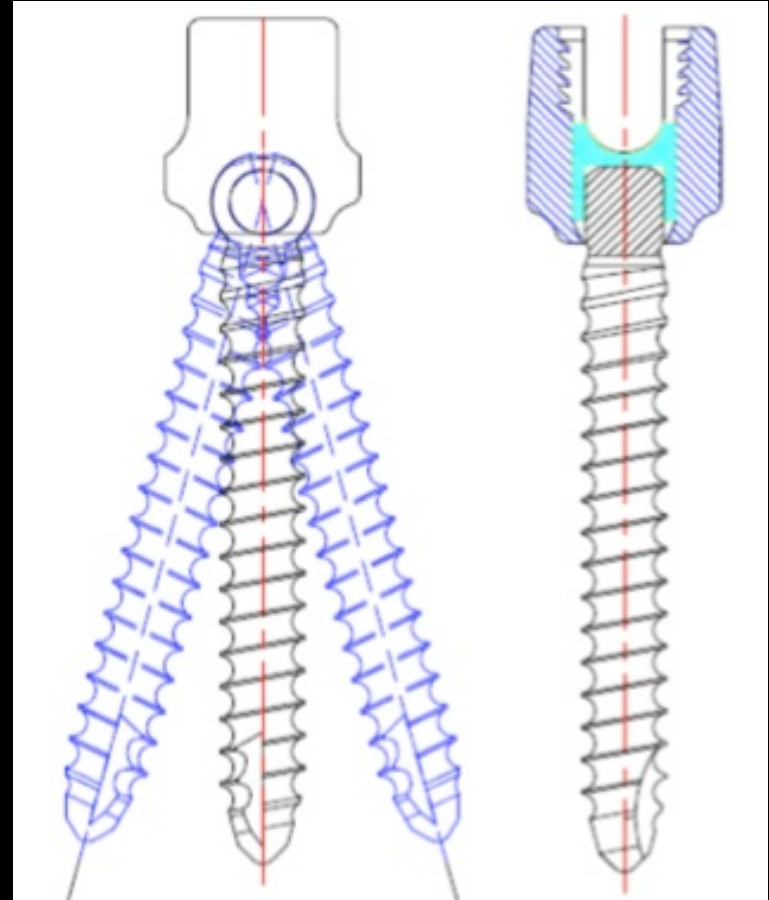
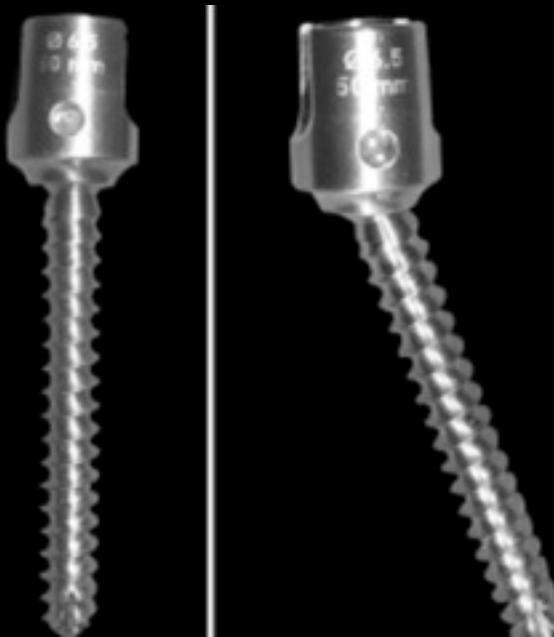
More load pass through RPS than DPS

# Dynamic pedicle screw

Flexion 10°

Extension 10°

Axial rotation 2°



Safinaz, Algoritma AS, Turkey

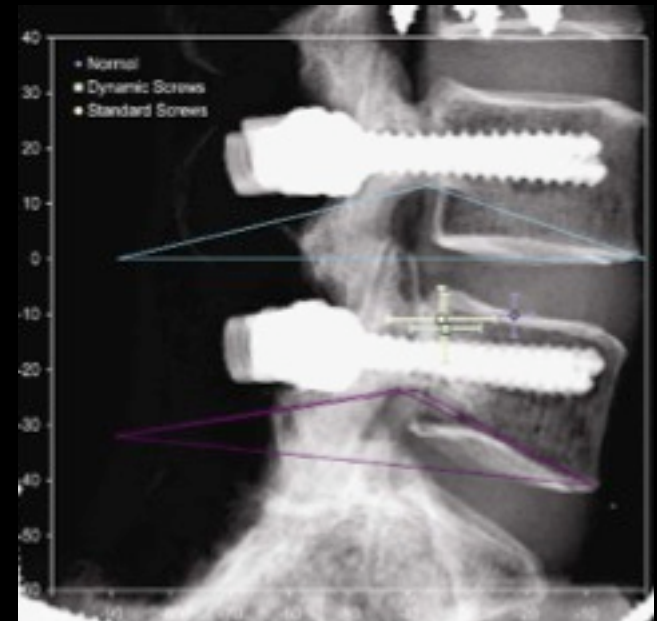
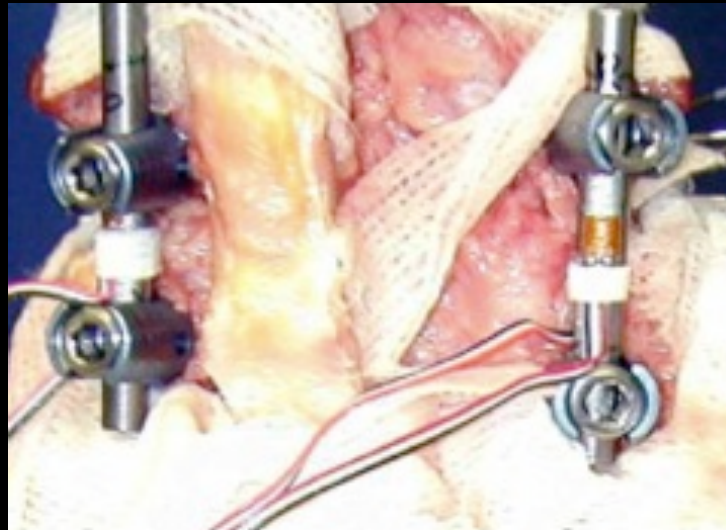
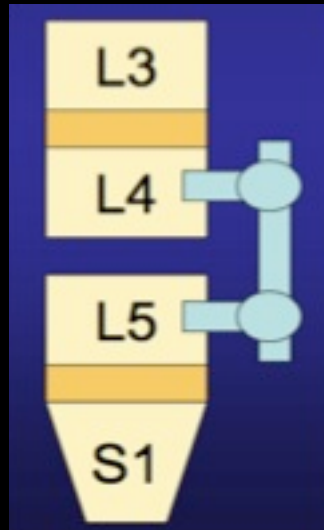
# Dynamic lumbar pedicle screw-rod stabilization: in vitro biomechanical comparison with standard rigid pedicle screw-rod stabilization

## Laboratory investigation

**HAKAN BOZKUŞ, M.D.,<sup>1</sup> MEHMET ŞENOĞLU, M.D.,<sup>2</sup> SEUNGWON BAEK, M.S.,<sup>2</sup>  
ANNA G. U. SAWA, M.S.,<sup>2</sup> ALI FAHİR ÖZER, M.D.,<sup>1</sup> VOLKER K. H. SONNTAG, M.D.,<sup>2</sup>  
AND NEIL R. CRAWFORD, Ph.D.<sup>2</sup>**

*<sup>1</sup>Department of Neurosurgery, VKV Amerikan Hastanesi, Istanbul, Turkey; and <sup>2</sup>Barrow Neurological Institute, Spinal Biomechanics Research Laboratory, Phoenix, Arizona*

J Neurosurg Spine;  
12, 2010



Dynamic screws allowed a motion closer to normal condition, and allowed less stress shielding than rigid screws

## Dynamic Lumbar Pedicle Screw-Rod Stabilization: Two-Year Follow-Up and Comparison with Fusion

Ali Fahir Ozer<sup>\*1</sup>, Neil R. Crawford<sup>2</sup>, Mehdi Sasani<sup>1</sup>, Tunc Oktenoglu<sup>1</sup>, Hakan Bozkus<sup>1</sup>, Tuncay Kaner<sup>3</sup> and Sabri Aydin<sup>1</sup>

<sup>1</sup>American Hospital, Department of Neurosurgery, Istanbul, Turkey

<sup>2</sup>Barrow Neurological Institute, Spine Biomechanics Research Laboratory, 350 W. Thomas Road, Phoenix, AZ, USA

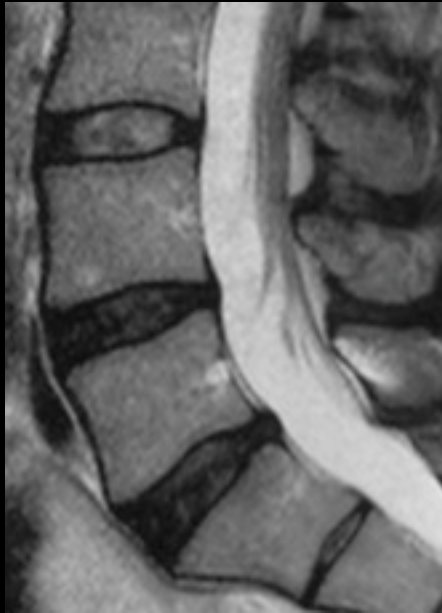
<sup>3</sup>Pendik State Hospital, Neurosurgery Department, Istanbul, Turkey

41 DDD patients (19 DPS, 22 RPS)

- Intervertebral disc height, segmental and global lumbar lordosis
- ODI, VAS

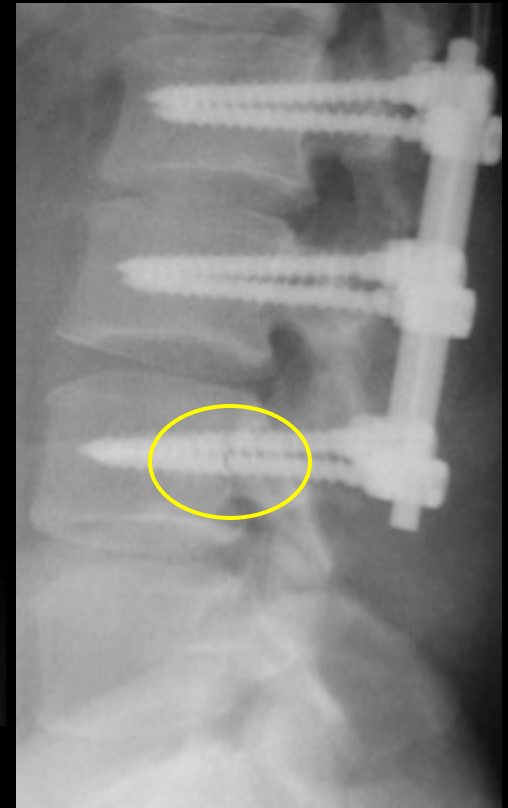
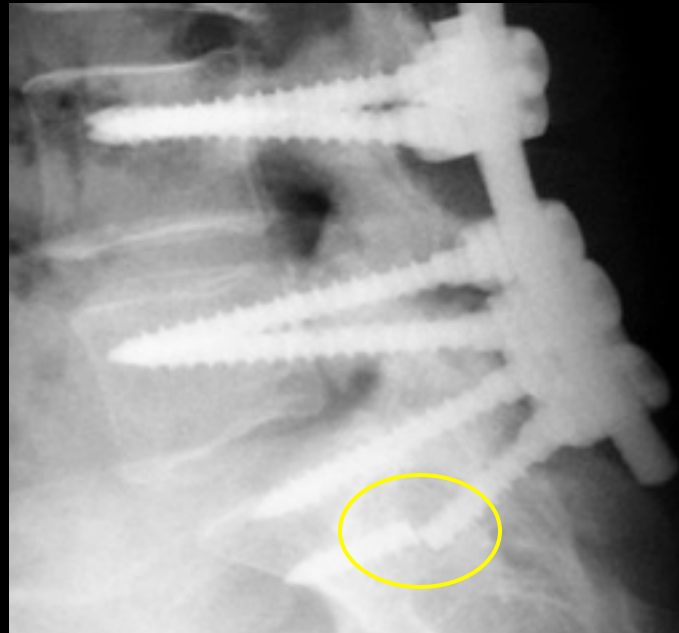
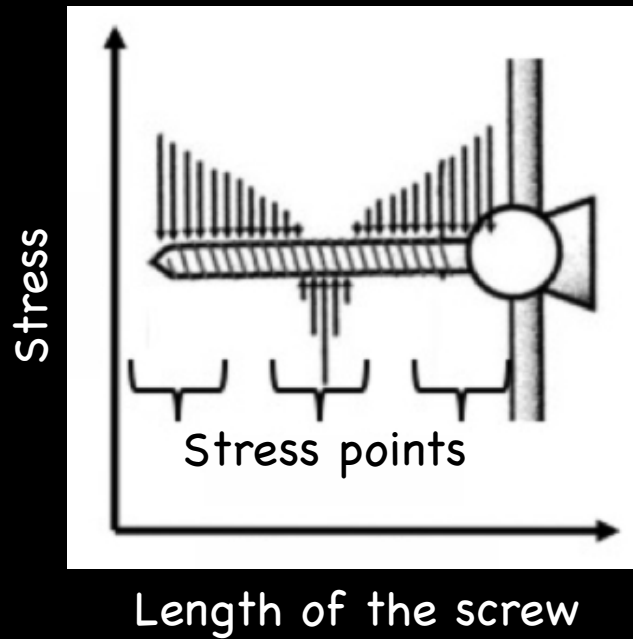
DPS had equivalent relief of pain and maintenance of sagittal balance as RPS

## Broken dynamic screw



Broken screw at 2 years follow up  
No clinical sign at 4 years follow up

# Why the dynamic screws had broken



Accumulation stress in the middle of screw's axis

## What we know about dynamic rods

- Act as posterior tension band
- Applicable to multi-levels
- Combine with rigid rods

# Technology



Cosmic



TFAS



Dynesys



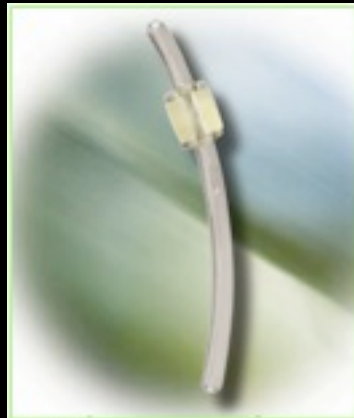
Bioflex

Modulus C



TOPS

Agile



# Graf Ligaman



Dacrilene

- Disc pressure profile shifts to the posterior anulus
- Foraminal narrowing/  
nerve root compression  
25%

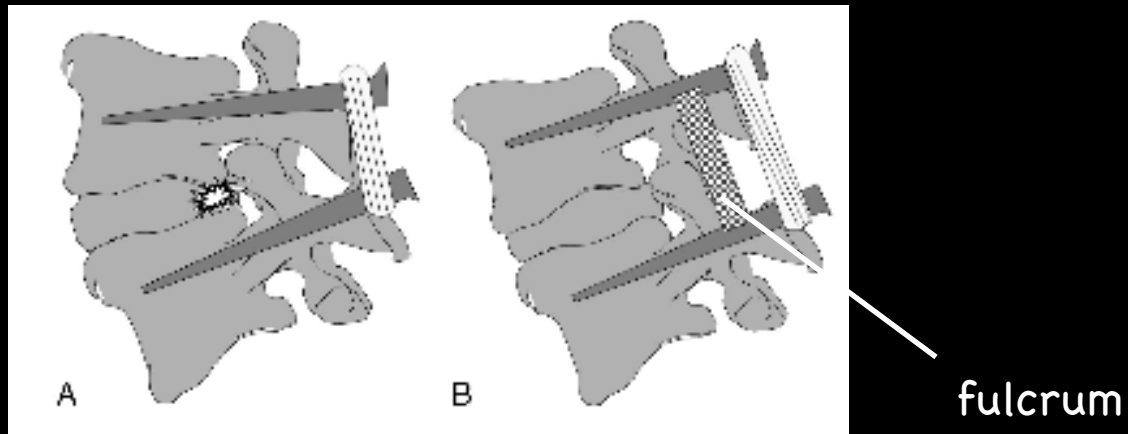
Neoligaments, Leeds, UK

Henry Graf, 1989

## **Fulcrum Assisted Soft Stabilization System**

A New Concept in the Surgical Treatment of Degenerative Low Back Pain

Dilip K. Sengupta, MCh\* and Robert C. Mulholland, FRCS†



- Unload disc
- Maintain lordosis

# Dynesis



(Zimmer Inc, IN,US)

- Introduced by Dobois 1994, without bone fusion
- Stabilization of segmental motion
- No increase adjacent segment motion
- Lordosis ?

Thomas M. Stoll  
Gilles Dubois  
Othmar Schwarzenbach

## The dynamic neutralization system for the spine: a multi-center study of a novel non-fusion system

- 83 patients, mean follow up 38.1 months

**Table 5** Complications related to implant

|                                        |                     |
|----------------------------------------|---------------------|
| Pedicle fracture (intraop.)            | 1                   |
| Screw loosening                        | 1 <sup>a</sup>      |
| Signs of screw loosening on radiograph | 7                   |
| Screw malplacement                     | 2 (1 <sup>a</sup> ) |

<sup>a</sup>Reoperated

**Table 6** Later, additional surgery

|                                                            |   |
|------------------------------------------------------------|---|
| Complete implant removal                                   | 8 |
| Dynesys extension (adjacent stenosis)                      | 2 |
| Decompression of adjacent segment (1 patient, later fused) | 2 |
| Laminectomy of index segment                               | 1 |



- Hardware failure similar or less than RPS

## Clinical outcomes of the Dynesys dynamic neutralization system: 1-year preliminary results

**WILLIAM C. WELCH, M.D.,<sup>1</sup> BOYLE C. CHENG, Ph.D.,<sup>1</sup> TARIQ E. AWAD, M.D.,<sup>1,2</sup>  
REGINALD DAVIS, M.D.,<sup>3</sup> JAMES H. MAXWELL, M.D.,<sup>4</sup> RICK DELAMARTER, M.D.,<sup>5</sup>  
JEFFREY K. WINGATE, M.D.,<sup>6</sup> JOHN SHERMAN, M.D.,<sup>7</sup> AND M. MASON MACENSKI, Ph.D.<sup>8</sup>**

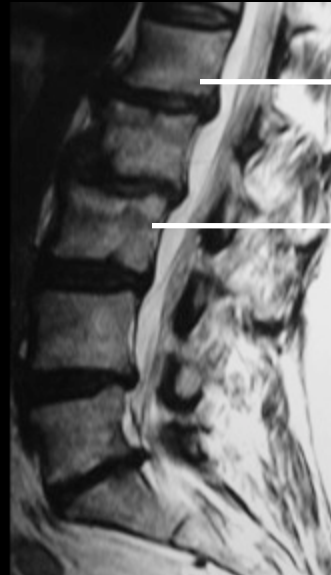
*<sup>1</sup>University of Pittsburgh Medical Center–Health System, Presbyterian University Hospital, Pittsburgh, Pennsylvania; <sup>2</sup>Suez Canal University, Ismailia, Egypt; <sup>3</sup>Greater Baltimore Medical Center, Baltimore, Maryland; <sup>4</sup>Scottsdale Spine Care, Scottsdale, Arizona; <sup>5</sup>The Spine Institute, Santa Monica, California; <sup>6</sup>Michigan Spine Institute, Waterford, Michigan; <sup>7</sup>Twin Cities Orthopaedic, Minneapolis, Minnesota; and <sup>8</sup>Zimmer Spine, Minneapolis, Minnesota*

- 101 patients, 6 FDA IDE sites
- 1 year follow up
- leg pain improved 80.3 to 25.5
- back pain improved 54 to 29.4
- ODI improved 55.6 to 26.3
- 10 patients need revision surgery

# Bioflex (nitinol spring memory rod)



BioSpine Co Ltd., Korea



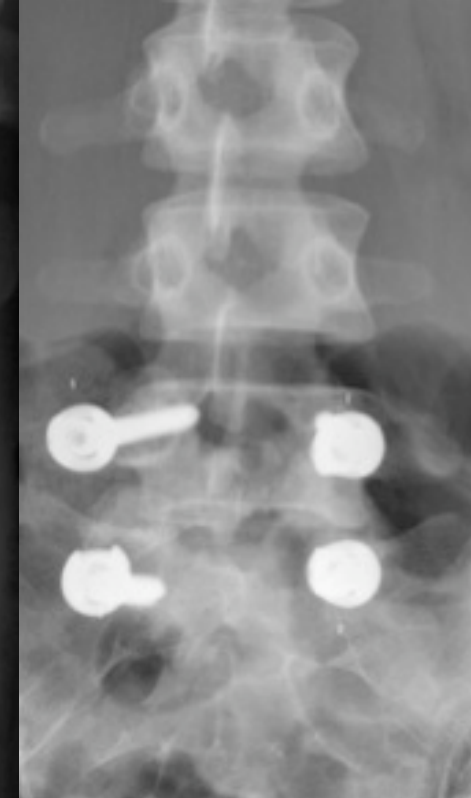
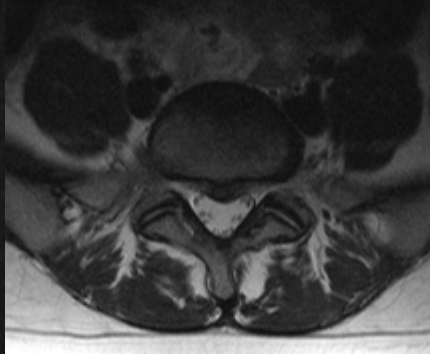
Degenerative listesis



- Stiff ?
- Lordosis ?



# Carbon Rod



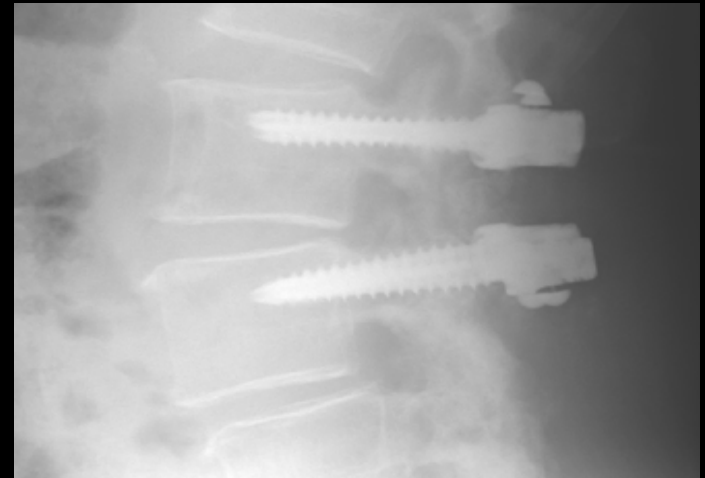
- No visualization of rods
- Stiff ?
- Pre-bended rod

Ostapek, Coligne AG, Zurich

## Flexible rods and the case for dynamic stabilization

**JASON M. HIGHSMITH, M.D., LUIS M. TUMIALÁN, M.D., AND GERALD E. RODTS JR., M.D.**

*Department of Neurosurgery, Emory University School of Medicine, Atlanta, Georgia*



PEEK rods can reduce stress on hardware, increase fusion rate, reduce adjacent segment disease

# Peek Rod (polyether ether ketone)



Medtronic Sofamor Danek, US

## Biomechanics of polyaryletherketone rod composites and titanium rods for posterior lumbosacral instrumentation

Presented at the 2010 Joint Spine Section Meeting

Laboratory investigation

HARLAN J. BRUNER, M.D.,<sup>1</sup> YABO GUAN, PH.D.,<sup>1</sup> NARAYAN YOGANANDAN, PH.D.,<sup>1</sup>  
FRANK A. PINTAR, PH.D.,<sup>1</sup> DENNIS J. MAIMAN, M.D., PH.D.,<sup>1</sup> AND MICHAEL A. SLIVKA, M.S.<sup>2</sup>

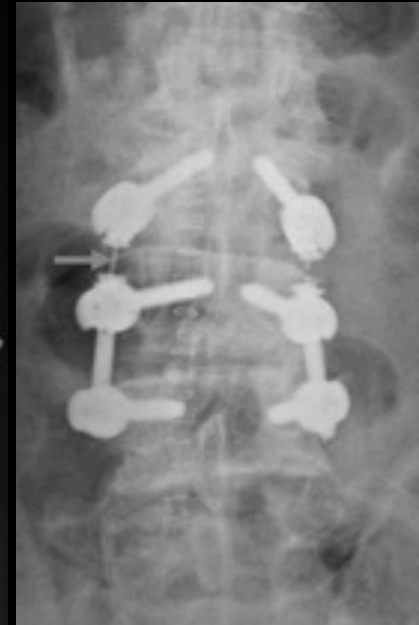
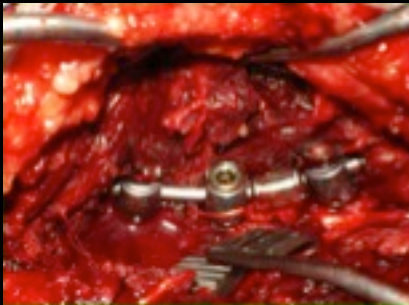
<sup>1</sup>Department of Neurosurgery, Medical College of Wisconsin, Milwaukee, Wisconsin; and <sup>2</sup>DePuy Spine, Raynham, Massachusetts

- PEEK, CFRP (carbon fiber reinforced-PEEK) and titanium rod
- All have equal stiffness and resistance to motion
- CFRP reduces strain than PEEK
- CFRP has radiolucency advantage

# Hybrid Rod

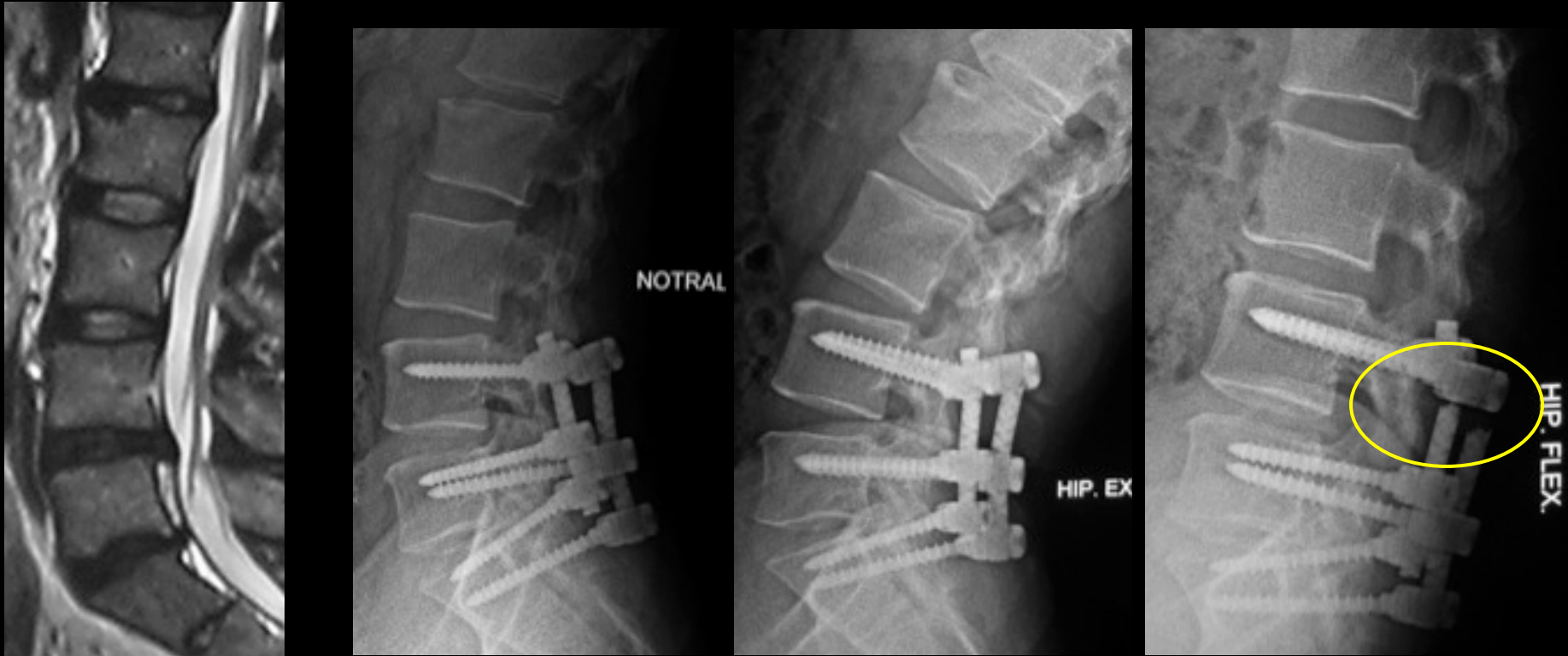


Medtronic  
Sofamor Danek, US



- Prone to failure, shearing and cable breaks
- No more in the market

# Dynamic rod complication



- 1 year follow up

# Aim of the lumbar facet arthroplasty

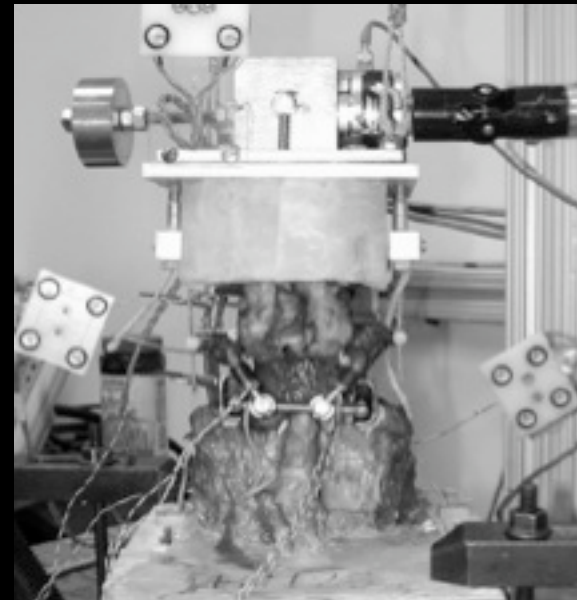
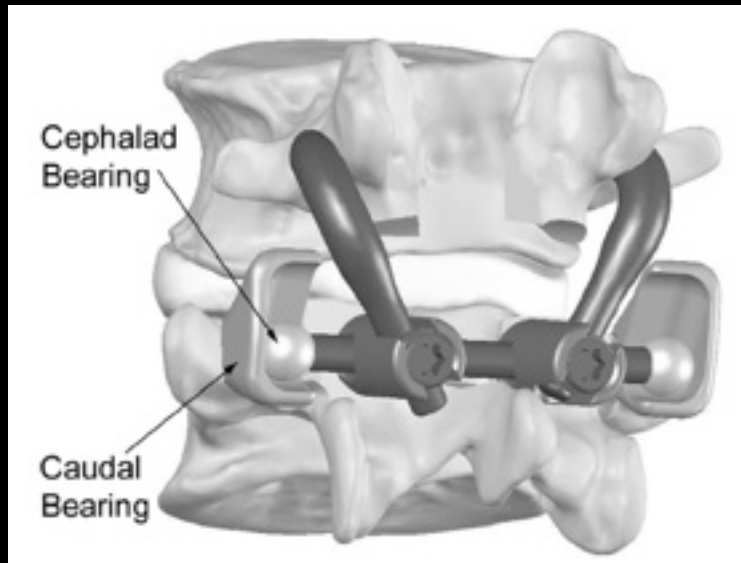
- Simulate normal facet joint role
- 

- Single design (custom made ?)
- No unilateral design
- Not applicable more than one segment

## Biomechanical Evaluation of the Total Facet Arthroplasty System™

### 3-Dimensional Kinematics

Qingan Zhu, PhD,\* Chad R. Larson, MSc,\* Simon G. Sjøvold, BSc,\*† David M. Rosler, MS,‡  
Ory Keynan, MD,\* David R. Wilson, PhD,\*† Peter A. Cripton, PhD,\*†  
and Thomas R. Oxland, PhD\*†

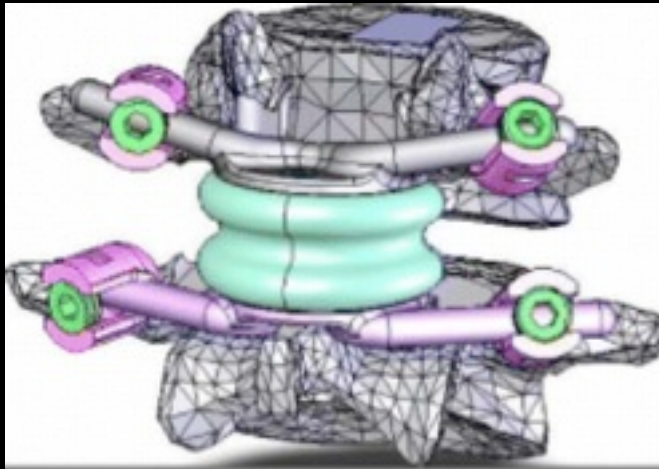


Arcus Orthopedics, Inc.

ROM is less than the intact in flexion and lateral bending, greater than the intact in axial rotation.  
HAR shifted anteriorly in axial rotation

## Treatment of lumbar spinal stenosis with a total posterior arthroplasty prosthesis: implant description, surgical technique, and a prospective report on 29 patients

Paul McAfee, M.D.<sup>1</sup>, Larry T. Khoo, M.D.<sup>2</sup>, Luiz Pimenta, M.D.<sup>3</sup>, Andy Capuccino, M.D.<sup>4</sup>, Domagoj Coric, M.D.<sup>5</sup>, Robert Hes, M.D.<sup>6</sup>, Bart Conix, M.D.<sup>6</sup>, Farbod Asgarzadie, M.D.<sup>2</sup>, Azmi Hamzaoglu, M.D.<sup>7</sup>, Yigal Mirofsky, M.D.<sup>8</sup>, and Yoram Anekstein, M.D.<sup>8</sup>



Implant Inc.

- TOPS provides multi-axial stability in all motions.
- (1 year follow up)
- No more in the market

# Acadia™, Facet Solution Inc, MA, US



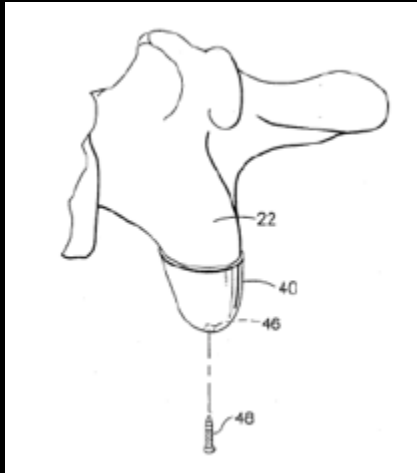
For Release: 7:00 am EST on November 9th, 2009

## Facet Solutions Enrolls 100th Patient in US Pivotal IDE Study

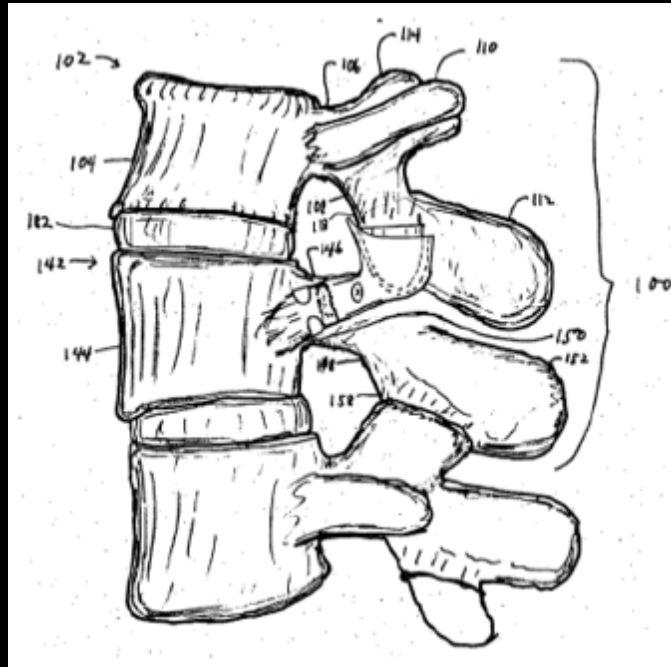
**Hopkinton, MA**(November 9, 2009) – Facet Solutions, Inc. today announced that it has enrolled the 100th patient in its randomized, controlled ACADIATM IDE study for lumbar spinal stenosis. "We are well ahead of our projections for 2009," stated President and CEO, Geoff Pardo, "It is indicative of the market need, the clinical outcomes that surgeons are seeing, and the ease with which they can implant ACADIATM." Over 1.5 million people are diagnosed with lumbar spinal stenosis each year in the United States. Current treatment alternatives include fusion, which eliminates motion and can result in long recovery for patients.

- Bilateral facetectomy needed
- Single level application
- Segmental lordosis ?

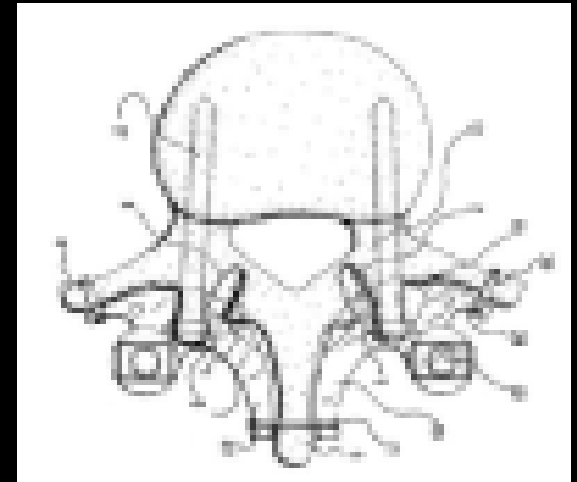
# Facet replacement systems



Fitz, 1996



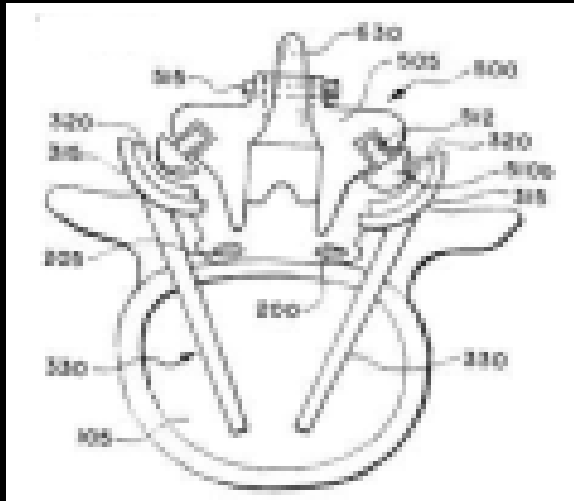
Lee,



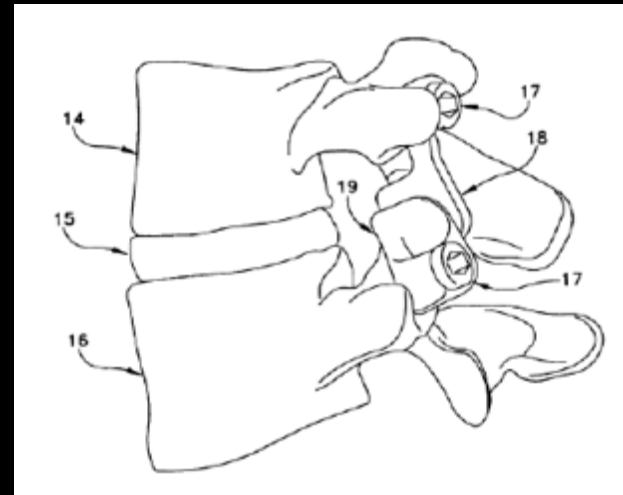
Martin, 2000

U.S. Pat. No. 6132464

# Facet replacement systems

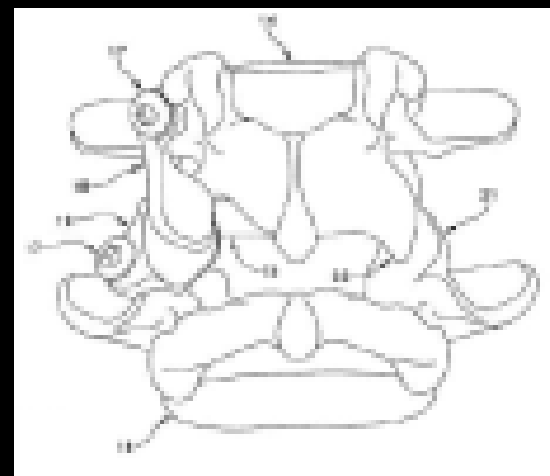
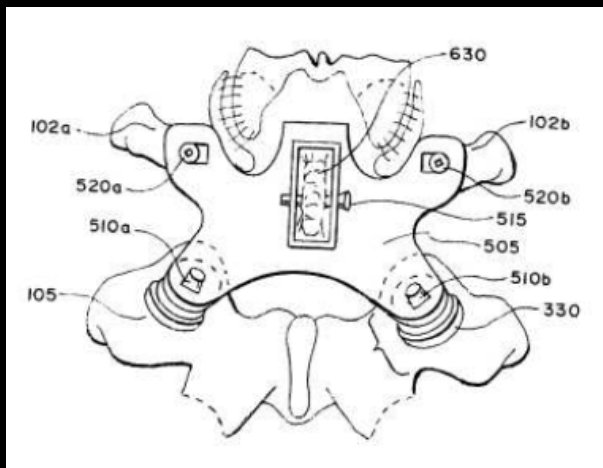


Reiley, 2003

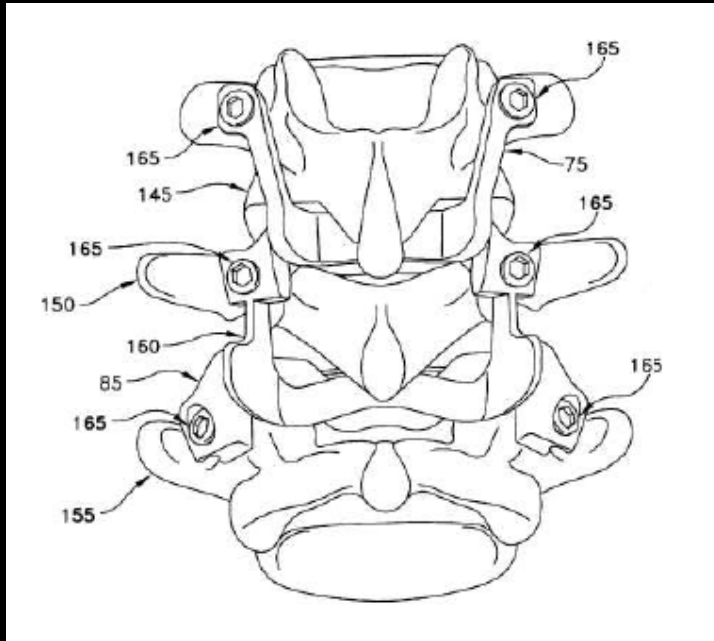


Goble, 2002

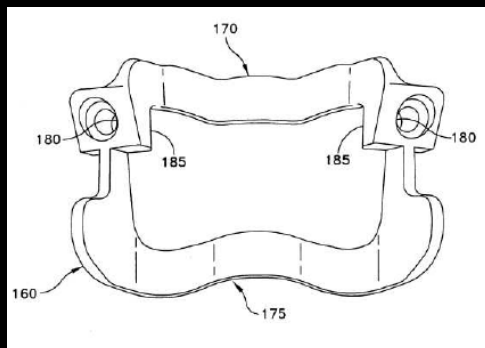
U.S. Pat. No. 6579319



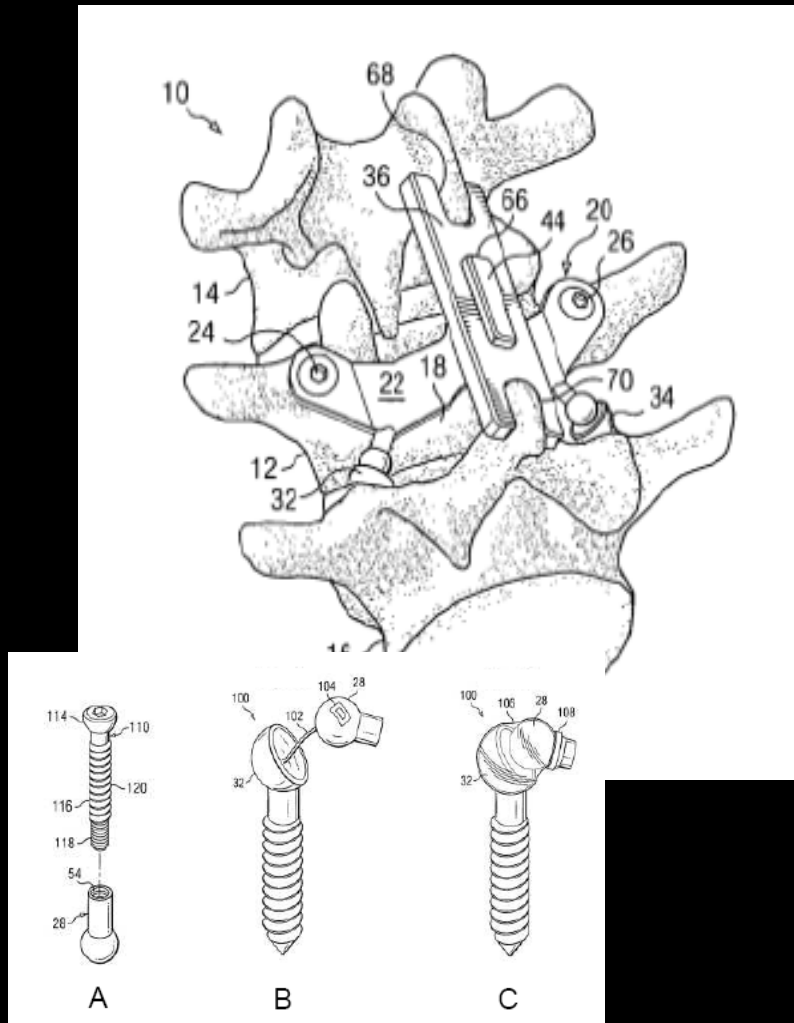
# Facet replacement systems



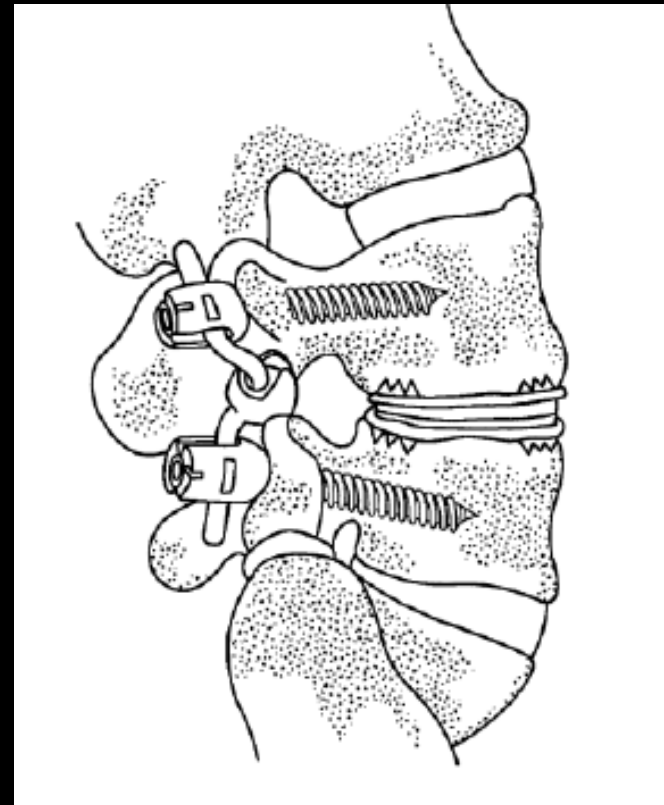
Fallin,



# Facet replacement systems



Berry, 2005



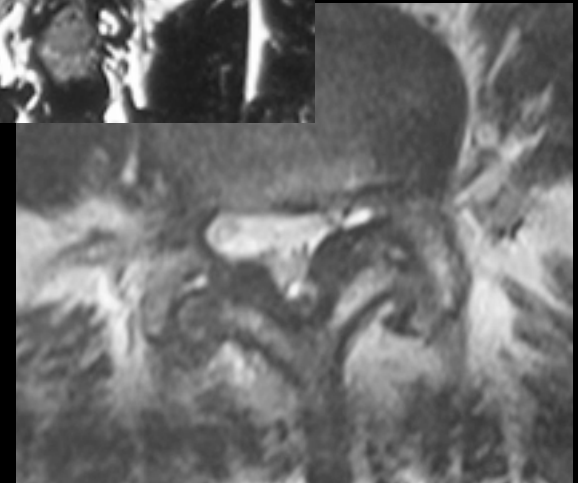
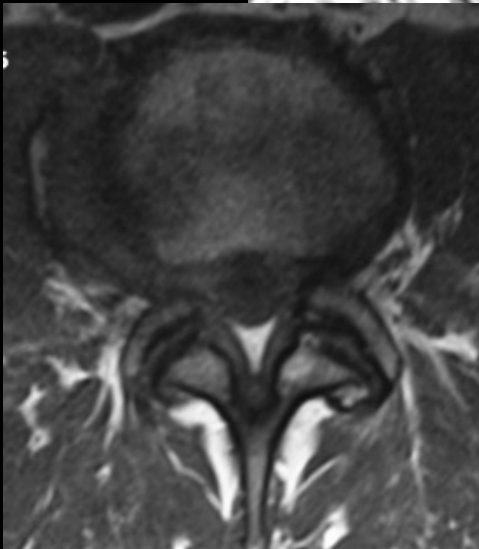
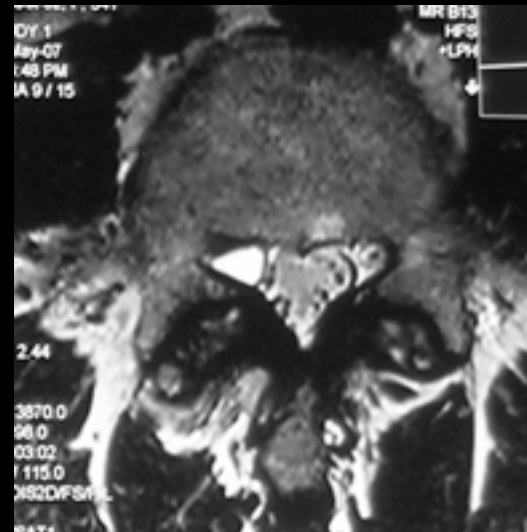
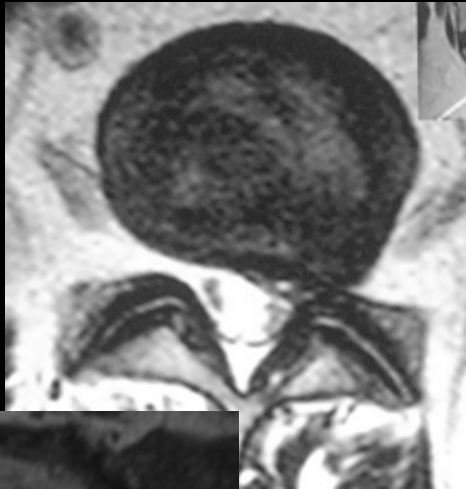
Serhan, 2005

# What we need to know

- Optimization of the tools
- Hardware failure
- Long term follow-up

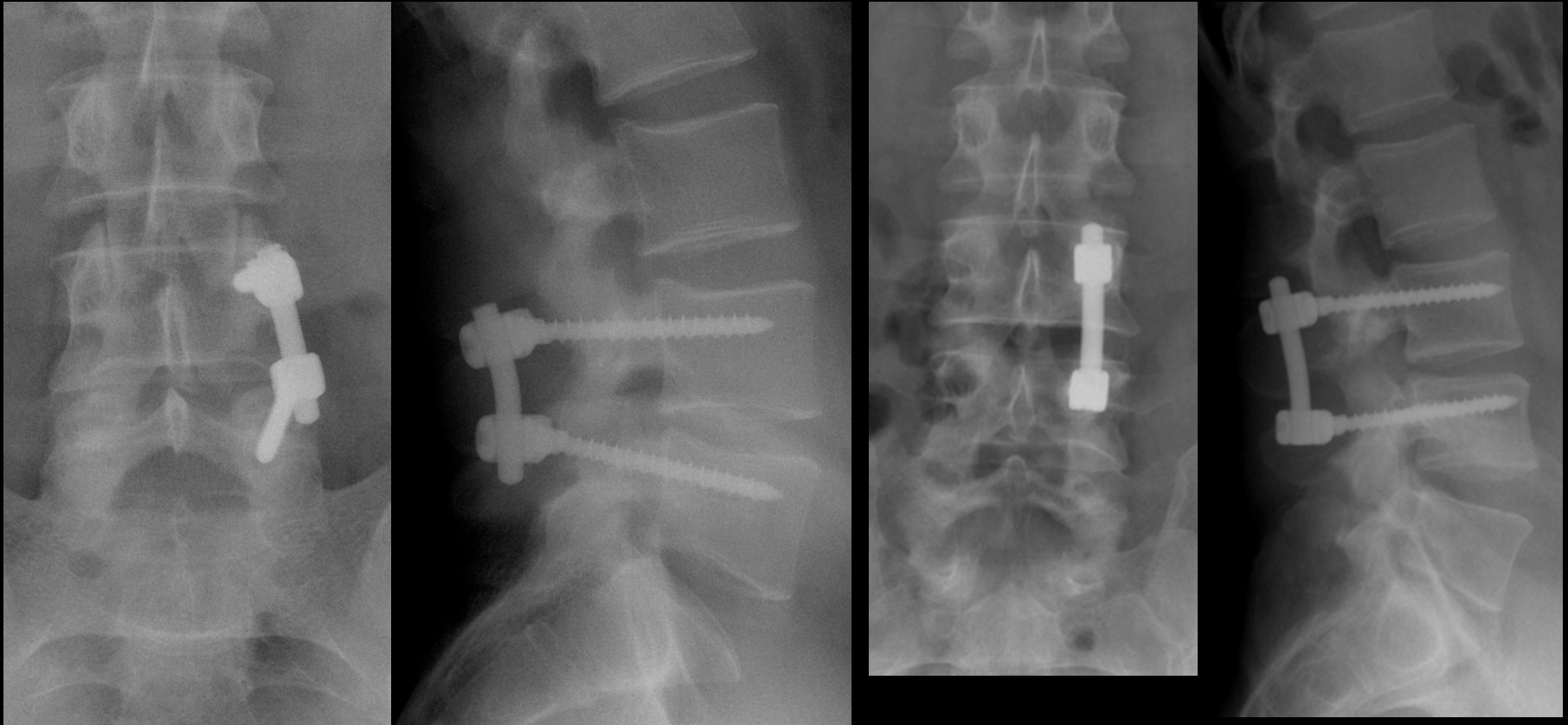
# Do we need complicated tools ?

## What if we need to do unilateral facetectomy



Synovial cysts  
Foraminal discs  
Extra-foraminal discs

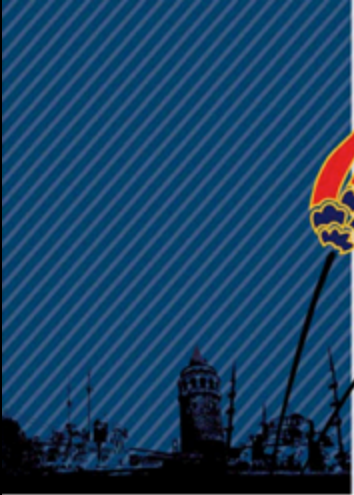
# Why we operate the other side



Dynamic pedicle screws

## Conclusion

- There is no single solution yet
- Ideal posterior dynamic design should have easy applicable design
- Hybrid models seems work better
- Unilateral model design is necessarily



Candidate City

# XVI. World Congress of Neurosurgery 2017

Destination Istanbul



[www.wfns2017.info](http://www.wfns2017.info)

Istanbul, the European Capital of Culture 2010,  
is ready to host the XVI. World Congress of  
Neurosurgery on behalf of the WFNS.

Thank you