DYNAMIC STABILIZATION SYSTEM OF THE SPINE

Fellow 林東儀
Concept

• Stabilize a spinal segment without rigid arthrodesis
• Mimicking natural spine movements
• To decrease incidence of adjacent-level degeneration
Posterior dynamic stabilization systems

• can be categorized into three types of devices:
  
  1) pedicle-based constructs
  2) posterior interspinous spacers
  3) total facet replacement systems
New classification

- Anterior dynamic stabilization
  - Disc replacement or alternatives
- Posterior dynamic stabilization
  - Transpedicular stabilization
    - Pedicle screw-based (dynamic rod; dynamic screw)
    - Total facet replacement
  - Interspinous stabilization
Nucleous pulposus alternatives

Figure 3: Nucleous Pulposus Alternatives: A) PDN, B) Nubac, C) Daskor, D) Neudisc.
New Technologies in Spine Surgery

- Potential indication:
  - grade I spondylolisthesis
  - spinal stenosis with instability
  - recurring disk herniation
  - DDD with mechanical back pain

- All should have had an unsuccessful course of nonsurgical treatment
OKU 10: Contraindications

- Poor bone stock
- Metabolic bone disease
- Active infection
- Scoliosis
- Severe spondylolisthesis
- Postlaminectomy destabilization
Graf ligament
(Sem Co., Montrouce, France)

- **Henry Graf** introduced in 1992 (*1st PDS*)
- in the treatment of low back pain
- a polyester braided bands to link pedicle screws
- Stabilize rotary motion
- Extension tension band
- Related to flexion instability

H. Graf, Rachis, 1992
Strauss PJ, Spine 1994
Grevitt et al:
50 chronic lower back pain patients

• Oswestry Disability Index (ODI) scores from 59 to 31
• postoperative radiculopathy was reported in 12 of 50 patients
• → prophylactic foraminal decompression prior to device placement

-----------------------------------------------

• Reasonably good result even at 5–10-year followup
• construct maintained segmental lordosis
• improved in spondylolisthesis or flexion instability

Grevitt MP. Eur Spine J 1995
High revision rate

• Hadlow et al:
  Graf ligament due to a higher revision rate after two years (73% for Graf ligament group versus 43% for the traditional fusion group)

• Patient with scoliosis or lateral listhesis (poor)

• Careful patient selection due to the potential for exacerbating facet disease and lateral recess/foraminal stenosis

Hadlow SV. Spine 1998
Hashimoto T, Spine J 2001
Graf Ligament

• As a result of the compression applied to the screws

• Secondary to either disc protrusion or foraminal narrowing ➔ radiculopathy

• A deleterious effect on the facet joint and may lead to back pain

Rothman 6th
Y. Choi et al. CORR, 2009
The **Dynesys**, Zimmer Spine

- Pedicle screws and cords (polyethylene terephthalate)
- A plastic spacer((sulene-polycarbonate urethane[PCU]) (unloading the facet joints)
- length spacer ➔ control the degree of distraction and compression

Rothman, 6th
Kaner et al. 2013, advance in orthopedics
Dynesys, Zimmer Spine

- performed first 1994
- Dynesys approved by FDA in 2004
- FDA: posterior stabilization system as an adjunct to fusion of the lumbar spine
  - neutralize abnormal forces
  - restored the spinal segments
  - while protecting adjacent degeneration

O. Schwarzenbach, et al
Orthopedic Clinics of North America, 2005
Biomechanical study: cadaveric spine

Schmoelz W et al. Eur Spine J, 2006

- Restricts flexion too much, equivalent to rigid fixation, but permits near-normal extension
- In flexion, Dynesys acts as a load-sharing device, which is ideal
- In extension, totally load bearing, no load transmission through the disc

- 83 patients: lumbar spinal stenosis, degenerative disc disease, disc herniation, and revision surgery.
- The mean F/U time was 38.1 months.
- Two screw displacement and screw loosening on X-ray.
- 9 complications unrelated to the implant.
- Seven patients had adjacent segment degeneration (8.4%).
- Mean Oswestry score was 55.4% to 22.9% post-OP (P < 0.01).

Dynesys was less invasive and theoretically produced less degeneration of adjacent segments.

Comparable to fusion.
Dynesys

- 2005, Grob: 69% (with decompression) → 39% (stand-alone) (Spine)
- 2007, Welch (FDA controlled clinical trial)
- Combines Dynesys with decompression
- Excluded activity-related mechanical back pain
- Avoid adjacent ?? (the primary clinical indication for dynamic) → an adjunct to fusion of the lumbar spine
26 patients: lumbar spinal stenosis and degenerative spondylolisthesis

- Decompression + Dynesys.
- Mean F/U: 52 months.
- Satisfaction high as 95%.
- Screw loosening in 3 patients in 2 years after operation.
- One patient instability related to a screw breakage.

Adjacent segment degeneration in 47% after four years.
Cakir et al. Spine, 2009: monosegmental study

- 26 patients with low back pain and neurogenic claudication due to L4-L5 degenerative instability and spinal stenosis
- Decompression and Dynesys posterior stabilization (n = 11) or decompression and fusion (n = 15).
- Index level at L4-L5
- Adjacent segments which are L3-L4 and L5-S1
- Dynesys VS fusion + instrumentation
  no beneficial effect on adjacent segment mobility
Comparison of Dynesys posterior stabilization and posterior lumbar interbody fusion for spinal stenosis L4-L5

Shang-Won Yu, Shih-Chieh Yang, Ching-Hou Ma, Chin-Hsien Wu, Cheng-Yo Yen, Yuan-Kun Tu

<table>
<thead>
<tr>
<th></th>
<th>Dynesys group</th>
<th>PLIF group</th>
<th>p</th>
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<tbody>
<tr>
<td></td>
<td>(n = 27)</td>
<td>(n = 26)</td>
<td></td>
</tr>
<tr>
<td><strong>Radiological outcome</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Motion preservation (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operated level (L4-5)</td>
<td>65.06% ± 14.72*</td>
<td>15.99% ± 10.21*</td>
<td>&lt; 0.001**</td>
</tr>
<tr>
<td>Cranial level (L3-4)</td>
<td>111.95% ± 30.41</td>
<td>140.22% ± 47.12*</td>
<td>0.012**</td>
</tr>
<tr>
<td>Caudal level (L5-S1)</td>
<td>103.49% ± 25.42</td>
<td>119.12% ± 26.33*</td>
<td>0.032**</td>
</tr>
<tr>
<td><strong>Clinical outcome</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oswestry Disability Index</td>
<td>-32.74 ± 8.63*</td>
<td>-29.31 ± 12.72*</td>
<td>0.254</td>
</tr>
<tr>
<td>VAS leg pain</td>
<td>-5.37 ± 1.42*</td>
<td>-5.08 ± 1.55*</td>
<td>0.475</td>
</tr>
<tr>
<td>VAS back pain</td>
<td>-4.33 ± 2.37*</td>
<td>-4.15 ± 2.77*</td>
<td>0.801</td>
</tr>
</tbody>
</table>

Prospective study: f/u 3 years
Preserve motion at L4-5
Decrease hypermobility at adjacent level
HIVD ➔

Putzier et al. Spine, 2005

• compared nucleotomy procedure of the lumbar disc prolapse
  1. without Dynesys (49)
  2. with posterior dynamic stabilization with Dynesys (35)

• All patients: MODIC 1 disc degeneration in all patients
• The mean follow-up duration 34 months

➔ with Dynesys group:

meaningful less signs of progressive degeneration
Sequestrectomy With Additional Transpedicular Dynamic Stabilization for the Treatment of Lumbar Disc Herniation

*No Clinical Benefit After 10 Years Follow-up*

Eike Hoff, MD, Patrick Strube, MD, Christian Gross, MD, and Michael Putzier, MD
Patient and Methods

Group S
N: 49
Sequestrectomy
2 died
9 loss f/u

Group D
N: 35
Sequestrectomy + Dynesys
1 died
5 loss f/u

10 years f/u

Group S
N: 38 (78%)

Group D
N: 29 (83%)

3m post-op, mid-term: 2.8y (2.0-3.9), long term: 10.2y (8.3-12.2)
<table>
<thead>
<tr>
<th>Event</th>
<th>Group D (n = 29)</th>
<th>Group S (n = 38)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progression of degeneration at the index level, n (%)</td>
<td>3 (10)</td>
<td>11 (29)</td>
<td>0.08</td>
</tr>
<tr>
<td>Progression of degeneration at the adjacent level(s) (ASD), n (%)</td>
<td>6 (21)</td>
<td>1 (3)</td>
<td>0.04</td>
</tr>
<tr>
<td>Recurrent disc herniation, n (%)</td>
<td>0 (0)</td>
<td>2 (5)</td>
<td>0.50</td>
</tr>
<tr>
<td>Implant failure, n (%)</td>
<td>6 (21)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>ROM at index level (SD)</td>
<td>2.1° (± 1.7°)</td>
<td>7.8° (± 1.9°)</td>
<td>&lt;0.01*</td>
</tr>
</tbody>
</table>

For comparison between the groups, a 2-sided Fisher’s exact test was performed.

*A 2-sided Student’s t test was used; κ = 0.86 for all findings.

ROM indicates range of motion; SD, single standard deviation; ASD, adjacent segment degeneration.
After a long-term follow-up

- Additional dynamic stabilization does not lead to a clinical benefit
- The high rate of necessary reoperations
- **do not recommend** this surgical strategy for this indication
New Dynesys system: hybrid

- the Dynesys DTO device
- This device is intended to combine the features of dynamic stabilization at one spinal segment with rigid rod stabilization at an adjacent level
- Further long-term evaluation is necessary
IsoBar (Scient’x, Maitland, FL)

- FDA clearance for use as an **adjunct to spinal fusion** in 1999
- A mobile joint within the rod
- Titanium alloy o-rings, the Isobar TTL allows a small amount of both axial and angular motion to the rigid rod
Design of Isobar

- design-allowable 0.75 mm of maximum axial compression or distraction
- $4^\circ$ of angular motion (in flexion-extension and lateral bending). $15^\circ$ lordosis built into the rod
22 patients with lumbar spondylolisthesis

- Two level Isobar + PEEK cage interbody fusion
- All fusion at the rigidly fixed level
- ➡️ no device failure or revision surgery required
- A mean follow-up of 8.27 years
- Long-term clinical outcomes were excellent with
  - 68.2% of patients reporting mild leg pain
  - 72% no or mild back pain
  - 91% of patients very satisfied with the procedure
  - Adjacent level also appeared to be protected
Clinical experiences

- **a long-term (average 10.2 years) clinical outcomes of 18 patients (loss 4 patients)**

- **Adjacent levels presented mild degenerative changes in 8 patients (a normal aging process??)**

- significant and stable symptoms relief, absence of implant-related complications, no revision surgery, and few adjacent segment degenerative changes
Dynamic stabilization

Hybrid dynamic stabilization with posterior spinal fusion in the lumbar spine

William R. S. Hudson, MD, John Eric Gee, MD, James B. Billys, MD, Antonio E. Castellvi, MD *

Center for Spinal Disorders, Florida Orthopaedic Institute, Tampa, FL

• 28pts, 17F, 11M, mean: 43y/o
• 22 pts with complete 2-year f/u
• Lumbar DDD for greater than 3 months
Clinical result

- Functional improvement
- No increase in the motion at above level
- 1 patient Adjacent-level degeneration
- 1 herniated disc at the index level ➔ OP
- 3 post-op infection
- 3 pts underwent revision to a rigid fusion
• 2007 and 2011 on 38 patients (multiple Dx)
• 4 cases of grade I spondylolisthesis, 11 cases of lumbar instability and lumbar disc protrusion, 21 cases SSS + HIVD, and 2 cases of recurrence disc
• The mean F/U was 27.8 months
• reliable fixation
• no loosening, breakage, and adjacent segment degeneration
• ➔ Isobar TLL had good short-term effectiveness
Stabilimax NZ

- received FDA approval in January 2007
- composed of a rod with dual concentric springs
- maintain the spinal segment in a neutral position during spinal motion
- RCT began: compare to traditional spinal fusion for patients with lumbar spinal stenosis with or without grade I spondylolisthesis
Cosmic Posterior Dynamic System

- The Cosmic system (1999) (Ulrich GmbH & Co. KG, Ulm, Germany)
  ➔ hinged pedicle heads to allow for segmental motion

A 2-year- follow-up study for lumbar degenerative disorders
- with the Cosmic system had comparable clinical outcomes to the fusion group.
- alternative to traditional fusion therapy
- adjacent level degeneration ??

von Strempel A, World Spine J 2006
Bozkus, et al.
Journal of Neurosurgery: Spine 2010

- in vitro biomechanical study
- provides a stability similar to rigid systems
- the hinged-dynamic screws allow less stress shielding
T. Kaner, et al.
Orthopedics, 2010

totaly 46 patients.

- cosmic posterior dynamic stabilization (26)
- fusion group (20) with rigid screw
- similar result of VAS, Oswestry, the measurements of lumbar lordosis and segmental lordosis angle after two years of follow-up.
- intervertebral space ratios in the cosmic statistically meaningful higher
- ==> disc degeneration is slowed down
Dynamic Stabilization System (DSS)

• With flexible elliptical metal coil connected to the screws

• two developmental cycles ➔ DSS II

• This device is not approved in USA

• but has been used in other parts of the world for preliminary evaluation
DDS-II system

• 16 patient study
• treated with the DSS for single level mechanical back pain with DDD
• a two-year followup period
• The mean ODI 65% to 27%
• VAS scores decreased from 7.3 to 3.7.
• NO instrumentation failure or screw loosening

Sengupta D. Spinal Arthroplasty Society. 2005
Summary
Adjacent problem following spinal fusion

• Long-term results (10 year F/U) show the incidence of X-ray: adjacent segment degeneration: 20% to as high as 70%

• Symptomatic disease as high as 36%

• Biomechanical studies: stabilizing a motion segment transfers stresses to the adjacent level

Ishihara H, J Spinal Disord 2001
Okuda S, Spine 2004
Lee CK, Spine 1988
Advantage than rigid implants

- restoring some native motion
- increased load sharing
- while providing stability

- decreasing adjacent segment degeneration
- has not been yet proved clearly
Short-term result promising

- Problem: loosening failures (revision)

- **not options** to treat osteoporotic patients

- Survival against fatigue failure is the biggest challenge
Future prospect

- Suitable patients selection
- Long-term follow up; comparison study
Thank you