

Dynamic Neutralization of the Lumbar Spine After Microsurgical Decompression in Acquired Lumbar Spinal Stenosis and Segmental Instability

Carola C. Würigler-Hauri, MD, Andreas Kalbarczyk, MD, Markus Wiesli, MD,
Hans Landolt, MD, and Javier Fandino, MD

Study Design. Prospective clinical study.

Objective. To report the outcome, radiologic findings, and complications in patients undergoing microsurgical radicular decompression and implantation of Dynesys (Zimmer Spine, Münsingen, Switzerland).

Summary of Background Data. The currently available peer-reviewed English-language medical literature addressing the use of the dynamic stabilization systems is limited. Indications, clinical results, and implant failure of Dynesys after microsurgical decompression are still controversial.

Methods and Results. This study included a total of 37 consecutive patients (mean age 58 years) presenting with acquired lumbar stenosis, signs of segmental instability, and degenerative disc disease underwent lumbar microsurgical decompression and implantation of Dynesys in 1 ($n = 11$), 2 ($n = 17$), 3 ($n = 9$), and 4 segments ($n = 1$). One patient was lost to follow-up. Lumbar and radicular pain was present in 33 patients (92%). Clinical evaluation included visual analogue scale (leg and back), distribution and severity of pain (%), Prolo Functional and Economic Status, Stauffer Coventry Scale, patient's self evaluation, and radiologic assessment preoperative and postoperative at 3 and 12 months. Leg and back pain (visual analogue scale) improved at 12 months from 8.4 ± 2.1 to 3.1 ± 1.4 and from 6.7 ± 2.8 to 4 ± 2.8 , respectively. Overall pain severity improved due to reduction of radicular pain from 59.2% to 27.3% after microsurgical decompression. Meanwhile, lumbar pain deteriorated from 40.8% to 47.8%. Twenty-seven percent (patient's self-evaluation) and 29.7% (Stauffer Coventry Scale) of the patients described a fair or poor outcome. Moreover, 51% and 54% of the patients had a Prolo Economic Status and Prolo Functional of 4 or 5, respectively. Complications included 4 broken and 2 misplaced screws from a total of 224 screws implanted, 2 loosen systems, and 1 cerebrospinal fistula. At 1-year, a total of 7 patients (19%) required surgical revision.

Conclusion. The reported biomechanical principles of Dynesys do not reflect advantages in outcome compared with none or others stabilization systems after microsurgical radicular decompression reported in the literature.

Key words: Dynesys, dynamic neutralization, lumbar stenosis, radiculopathy, dysfunctional segmental motion.
Spine 2008;33:E66–E72

Dysfunctional segmental motion (DSM) and degenerative lumbar spondylolisthesis are frequent causes of spinal stenosis and still subject to controversial discussion.^{1–3} These conditions are characterized by hypertrophied arthritis of the facet joint, resulting in segmental instability predominately in the sagittal plane.⁴ Degenerative disc disease (DDD) is associated with degenerative spondylolisthesis to a varying degree causing or accentuating radiculopathy. The nonsurgical management of lumbar spondylolisthesis should be considered, specially, in patients without radicular compression signs⁵ because fusion techniques contain major risks of adjacent segment degeneration.³ Outcome after fusion appears to be quite inconsistent. Turner *et al*⁶ evaluated systematically the outcome after lumbar spinal fusions and demonstrated satisfactory outcomes ranged from 16% to 95% with an average of 68%. Decompression alone might not change the course of segmental degeneration process, but significantly improve the quality of life in terms of amelioration of radicular pain.^{7–10}

Because the biomechanical background of stability concept is based on the spinal motion segment, new alternatives toward a dynamic stabilization device were recently proposed.¹¹ Dynesys was introduced in 1998 and stands for dynamic neutralization system for the spine.¹² The basic idea of this technique consists in improved movement and a load transfer of the spinal segment without the intention of fusion. This system was introduced in clinical practice in Europe in 2000 and is in approval in the United States for an adjunct device for fusion.

This study reports the outcome, radiologic findings, and complications in a series of patients undergoing instrumentation of the lumbar spine with Dynesys after microsurgical decompression of the epidural compartment.

■ Materials and Methods

This study included a consecutive series of 38 patients treated in our institution with the same assessment and surgical protocol during a 1-year period. Surgery and implantation of Dynesys (Zimmer Spine, Münsingen, Switzerland) was indicated if DSM was present and considered the cause of the clinical symptoms.

From the Department of Neurosurgery, Kantonsspital Aarau, Aarau, Switzerland.

Acknowledgment date: June 19, 2007. Revision date: August 27, 2007. Acceptance date: September 7, 2007.

The device(s)/drug(s) that is/are the subject of this manuscript is/are not FDA-approved for this indication and is/are not commercially available in the United States.

No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

Address correspondence and reprint requests to Javier Fandino, MD, Department of Neurosurgery, Kantonsspital Aarau, 5001 Aarau, Switzerland; E-mail: javier.fandino@ksa.ch

DSM was defined as a type of instability related to disc interspace or vertebral body degenerative changes that result in the potential for pain of spinal origin.^{1,13} The clinical criteria of DSM in this study included the description of a pain pattern which was defined as deep and agonizing, usually worsened by activity (loading) and improved by inactivity (unloading).

The preoperative evaluation included standard plain anterior-posterior, lateral and lateral flexion-extension radiographic views of the lumbar spine, myelography, postmyelography computerized tomography (CT), and magnetic resonance imaging (MRI). In terms of radiographic criteria, an abnormal center of rotation was present in standard radiographic examinations. The main findings in MRI included secondary degenerative changes in the spinal segment. Patients presenting with moderate or high-grade isthmic spondylolisthesis (Meyerding grade II–V) were excluded as candidates for implantation of Dynesys. In this study, patients were distributed into 2 groups: DSM with or without stenosis. In addition, stenosis was defined as recessal and central according to the preoperative findings in the CT of the lumbar spine.

The surgical technique consisted in a standard midline dorsal approach. After laminotomy or laminectomy, a microsurgical decompression of the nerve root was performed. If necessary, the decompression was completed with a microsurgical discectomy. Under imaging control, the titanium alloy pedicle screws were positioned. The screws anchor the Dynesys in the pedicle and in the vertebral body. The rest of the Dynesys consists of polyester cords and polycarbonate urethane cylindrical spacers. The modular spacer fits in between pedicle screw heads. The stabilizing cord connects the pedicle screw heads via the hollow core of the spacer and holds the spacer in place (Figure 1).¹⁴ Facet joints were preserved during surgery. Patients were mobilized the day after surgery without bracing and no limitations of daily activities.



Figure 1. Photograph provided by the manufacturer illustrating Dynesys on a spine model.

The patients were assessed in the outpatient clinic of our department at 6 and 12 months after surgery. There was no independent data collection performed. Clinical evaluation was performed by 2 authors (CW and JF). The protocol consisted in a clinical examination, pain evaluation visual analogue scale (VAS) for leg and back, distribution and severity of pain in percentage, scoring according to Prolo Functional and economic status¹⁵ and Stauffer Coventry Scale.¹⁶ In addition, the interview included a patient's self evaluation. Radiologic follow-up was assessed at 6 and 12 months with standard plain anterior-posterior, lateral and lateral flexion-extension radiographic views of the lumbar spine.

■ Results

A total 38 consecutive patients were included in this study. Because 1 patient was lost to follow-up at 12 months and excluded from the data analysis, the results are based on the analysis of 37 patients (women: 22; men: 15). The mean age was 58 ± 13.7 years (range: 27–79). The mean body mass index was 26.8 ± 1.4 kg/m². Cigarette consume was documented in 19 (51%) patients. A summary of the preoperative symptoms and clinical findings are shown in Table 1.

Seventeen (41%) patients underwent previous surgery: discectomy in 11 patients (46%) and laminectomy for spinal stenosis in 6 patients. Preoperative radiologic evaluation showed DSM with signs of spinal stenosis in 34 (92%) patients and without stenosis in 3 (8%). Based on the preoperative CT findings, stenosis was present in 34 patients and was defined as central in 20 (54%) patients and lateral recessal in 13 (35%). Three (8%) patients presented with clinical and radiologic signs of DSM without signs of stenosis. Figure 2 illustrates a case presenting with DSM and spinal stenosis which underwent decompression and stabilization with Dynesys. One patient presented with stenosis due to acute disc herniation. DDD was present in a total of 13 patients distributed in both groups (12 patients with DSM and stenosis and 1 patient with DSM only). A total of 17 (46%) had previous lumbar spinal surgery for DDD or spinal stenosis. A total of 16 (43%) patients showed a monosegmental, 14 (38%) bisegmental, and 7 (19%) multisegmental affection. Signs of mild isthmic spondylolisthesis (Meyerding grade I) were documented in

Table 1. Clinical Signs and Symptoms Before Surgery and at 6 and 12 Months Postoperatively

Clinical Signs and Symptoms	Preoperative (%)*	6 Mo (%)*	12 Mo (%)*
Lumbar pain only	0 (0)	6 (16)	11 (30)
Radicular pain only	3 (8)	3 (8)	1 (3)
Lumbar and radicular pain	33 (92)	9 (24)	13 (35)
Neurogenic claudication	18 (49)	5 (14)	8 (22)
Diminished or absence reflexes	18 (49)	8 (22)	11 (30)
Straight leg raising sign	25 (68)	2 (5)	6 (16)
Weakness/motor disturbances	18 (49)	6 (16)	8 (22)
Urinary incontinence	1 (3)	0 (0)	1 (3)
Dermatomal sensory loss	23 (62)	12 (32)	10 (27)

*In relation to total of patients n = 37.

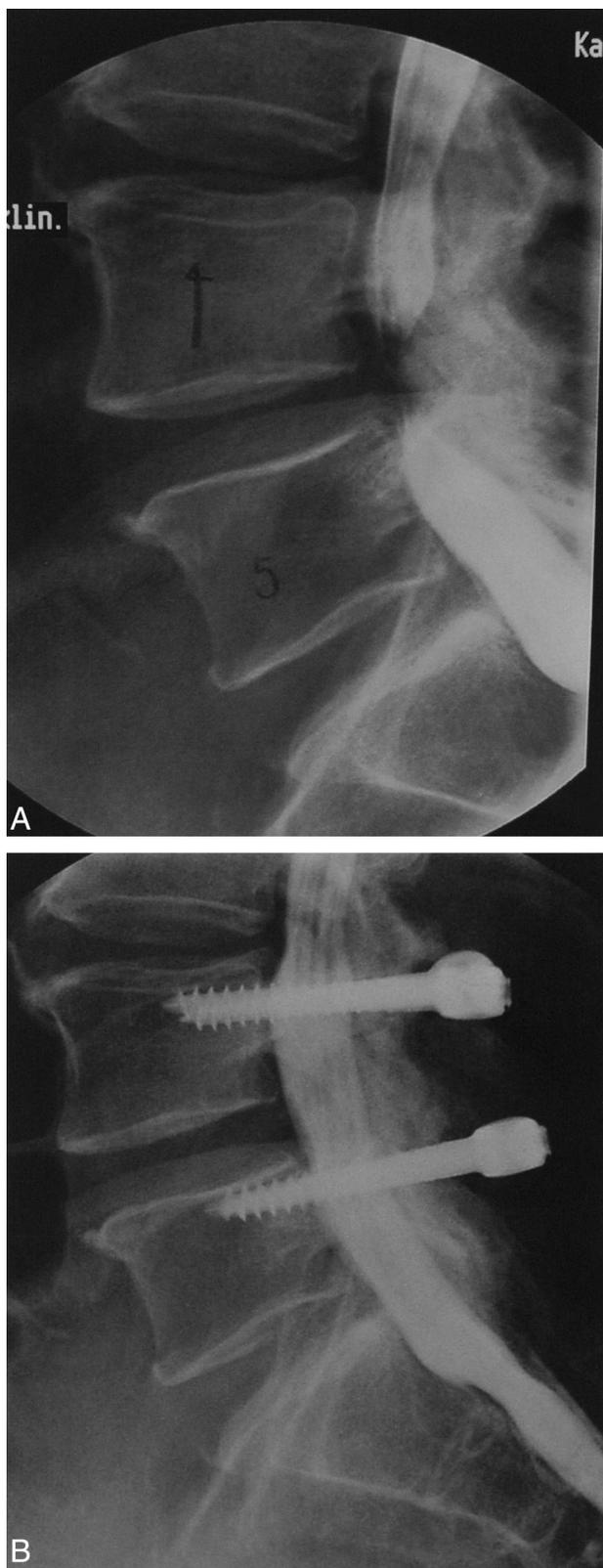


Figure 2. Myelography of the lumbar spine in a patient presenting with central absolute lumbar stenosis (A). After decompression and implantation of Dynesys, a normalization of the contrast dye passage could be demonstrated (B). In this case, an improvement of the radicular symptoms but not of lumbar pain could be documented.

lateral flexion-extension radiographic views of the lumbar spine in 32 (86%) of 37 patients. No patient presented with moderate or high-grade isthmic spondylolisthesis (Meyerding grade II–V), or signs of fatigue fractures in the form of spondylolysis on preoperative radiographic studies.

Dynesys was implanted in 1 level in 10 (27%) patients, in 2 levels in 17 (46%) patients, in 3 levels in 9 (24%) patients, and in 4 levels in 1 (3%) patient. Four (11%) patients underwent total laminectomy, 1 (3%) patient hemilaminectomy, 6 (16%) patients underwent discectomy, 2 (6%) patients medial facetectomy, 11 (30%) patients unilateral laminotomy, and 20 (54%) patients bilateral laminotomy. Nine (24%) patients required additional decompression or discectomy in adjacent segments to the level in which Dynesys was implanted. The duration of surgery was 177 ± 10 minutes. The intraoperative blood loss was 430 ± 141 mL.

Postoperative symptoms at 6 and 12 months are shown in Table 1. VAS for leg and back pain improved from 8.4 ± 2.1 to 3.1 ± 1.4 and from 6.7 ± 2.8 to 4 ± 2.8 at 12 months, respectively. Pain severity improved due to reduction of radicular pain after microsurgical decompression. Nevertheless, in term of percentage of patients suffering back and leg pain, more patients described to have more back pain (40.8%–47.8%) than leg pain (59.2%–27.3%) after surgery at 12 months.

A total of 32.4% and 29.7% of the patients described a fair or poor outcome based on the Stauffer Coventry Scale and patients' self evaluation at 12 months, respectively (Table 2). Moreover, only a total of 19 (51%) reached a Prolo economic status of 4 or 5 meaning working or being active at previous level with or without limitation at 12 months. In addition, 20 (54%) patients had a Prolo functional of 4 or 5 meaning occasional or no pain 12 months after surgery (Table 3).

A total of 7 patients (19%) required revision due to complications of the procedure or failure of the implanted material. Within the 1-year follow-up, 4 (1.8%) out of 224 implanted screws were broken (Figure 3). All broken screws were documented in 4-level fusions. Four patients (10.8%) underwent removal of the system and/or replacement with a rigid fusion system due to postoperative persistence painful instability. Two patients required surgical replacement of misplaced screws. Among the patients who were reoperated, 5 patients de-

Table 2. Stauffer Coventry Scale and Patient's Self-Evaluation Data

	Stauffer Coventry Scale		Patient's Self-Evaluation Data	
	6 Mo (%)	12 Mo (%)	6 Mo (%)	12 Mo (%)
Excellent	12 (32.4)	10 (27)	14 (37.8)	14 (37.8)
Good	14 (37.8)	15 (40.5)	13 (35.1)	13 (35.1)
Fair	4 (10.8)	3 (8.1)	4 (10.8)	2 (5.4)
Poor	7 (18.9)	9 (24.3)	6 (16.2)	8 (27)

Table 3. Prolo Economic (Activity) and Prolo Functional (Pain) Status

Score*	Prolo Economic (Activity) Status		Prolo Functional (Pain) Status	
	6 Mo (%)	12 Mo (n) (%)	6 Mo (n) (%)	12 Mo (n) (%)
1	1 (2.7)	1 (2.7)	1 (2.7)	2 (5.4)
2	5 (13.5)	7 (18.9)	7 (18.9)	12 (32.4)
3	11 (29.7)	10 (27)	12 (32.4)	3 (8.1)
4	16 (43.2)	11 (29.7)	12 (32.4)	16 (43.2)
5	4 (10.8)	8 (21.6)	5 (13.5)	4 (10.8)

*Prolo economic (activity) status: (1) complete invalid (worse); (2) no gainful occupation (housework, retirement activities); (3) working/active but not at premorbid level; (4) working/active at previous level with limitation; working/active at previous level without restriction; Prolo functional (pain) status: (1) total incapacity (worse); (2) moderate-to-severe daily pain (no change); (3) low level of daily pain (improve); (4) occasional or episodic pain; (5) no pain.

scribed persistence of both, lumbar and radicular pain at 12 months after revision. Two patients describe an improvement of lumbar pain after replacement of Dynesys

with a rigid fusion system. The median postoperative VAS at 12 months for the revised patients was for leg pain 4 and for back pain 4.9. Discectomy and facetectomy was not associated to implant failure. None of the 4 patients who underwent reintervention underwent discectomy or medial facetectomy. Finally, 1 patient required revision due to persistent cerebrospinal fluid fistula.

■ Discussion

This study demonstrated limited advantages after treatment with Dynesys in terms of clinical outcome compared with series reported previously in which radicular decompression was performed with or without fusion.¹⁷⁻²⁰ In our series, patients with a good outcome experienced an improvement of radicular pain and neurologic signs (from 59% to 27%). Nevertheless, most of the patients with a fair or poor outcome in terms of patients' self evaluation and Coventry Scale (27% and 29.7%, respectively) had persistence of lumbar pain. In fact, lumbar pain was the

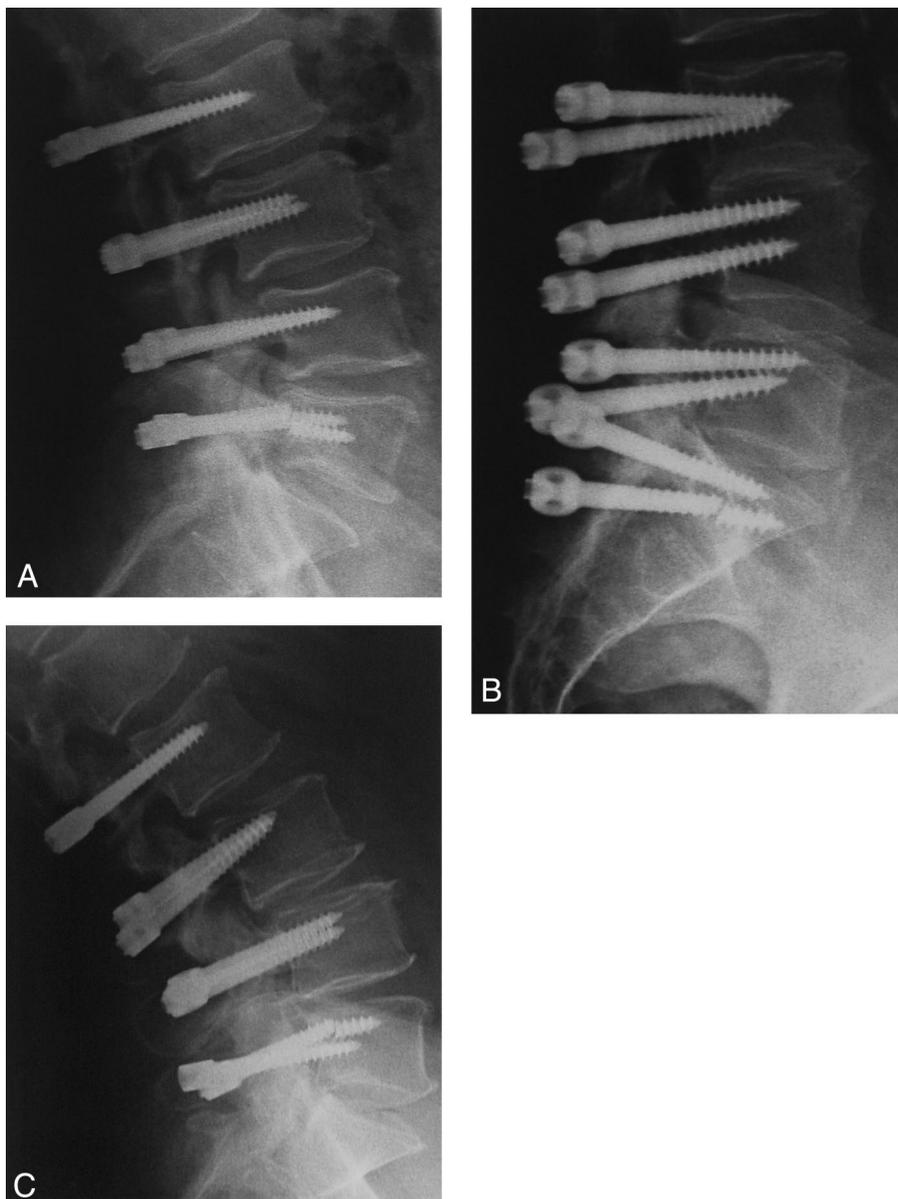


Figure 3. Broken screws observed in 3 patients during the 1-year follow-up period. All 4 cases presenting with broken screws in this series underwent more than 2-level instrumentation.

main complain in 30% of the patients after surgery at 12 months. In contrast, an improvement of radicular pain after surgery resulted in a good outcome. Lumbar and radicular pain (as single category) decreased from 92% to 35% postoperative whereas only 1 patient had persistent radicular pain only at follow-up (Table 1). The fact that at 12 months a greater percentage of patients described to have more back pain (40.8%–47.8%) than leg pain (59.2%–27.3%) in comparison with initial complains, allow us to think that nerve root decompression only, rather than implantation of Dynesys, might explain the improvement of radicular symptoms. Moreover, the assessment using the VAS demonstrated a trend of improvement in leg pain more than back pain. These observations should be interpreted as additional insufficiency of Dynesys to stabilize the lumbar spine in cases of significant DSM leading therefore to persistence or worsening of back pain. The cost of Dynesys constitutes a major concern if advantages to rigid fusion are discussed. In our series, the costs in USD of screws, cords, and spacers per case was 9300 (1 level), 11,800 (2 levels), and 14,300 (3 levels). In Switzerland, the costs of Dynesys are higher compared with other fusion systems in the market. Understanding this fact, it will be difficult to justify dynamic stabilization over pedicle screws without a randomized study.

In terms of natural history explaining these findings, Fischgrund *et al*,¹⁷ reported a randomized study comparing decompressive laminectomy and arthrodesis with and without spinal instrumentation. After a 2-year follow-up period the authors concluded that successful fusion did not influence the patients' outcome. In terms, natural history of spondylolysis and spondylolisthesis, Beutler *et al*²¹ demonstrated in a 42-year follow-up study that a marked slowing of slip progression occurred with each decade and that no subject in this series reached a 40% slip.

DSM may be implied by the observation of excessive degenerative changes at a given segmental level. For this degeneration to have occurred, excessive stresses or motion must have been predisposing factors in the disc interspace changes. Nevertheless, it cannot be overemphasized that the lack of objectivity makes the diagnosis of DSM often controversial. The main purpose of Dynesys is the preservation of the motion segment, restoration of the discal height by posterior distraction on pedicular screws and spacer which might prevent further degeneration of the spine.^{12,22} Dynamic fixation techniques are designed to prevent the major disadvantages of rigid fixation, such as adjacent segment degeneration or pseudarthrosis.

Initial experimental studies measuring intradiscal pressure in cadavers to assess load bearing by dynamic fixation with Dynesys showed similar results for intradiscal pressure as in internal fixation.²³ Moreover, increased stiffness and greater change in orientation of the helical axis orientation with shorter spacer was shown in a study from Niosi *et al*.²⁴

Biomechanical principles of posterior dynamic stabilization techniques have been described recently. Sengupta²⁵ discussed carefully the different dynamic stabilization techniques in the treatment of low back pain. A biomechanical related method consists in the fulcrum assisted soft stabilization system which lowers the pressure in the disc space and maintains the lordosis. This technique was additionally tested biomechanically in cadaver spine specimens by the same group.²⁶ The soft stabilization methods are intended to load share with the disc and the facet joints only partially and unloads the motion segment. Recently, Beall *et al*²⁷ reported positional MRI findings in an *in vivo* study including 34 patients with dominant low back pain, with or without leg pain, treated with the Dynesys. The authors demonstrated that Dynesys allows movement at the instrumented level, albeit reduced, with no significant increased mobility at the adjacent segments. Moreover, a reduction of the anterior disc height without a significant increase of the posterior disc height was observed.

The currently available peer-reviewed English-language medical literature addressing the use of the dynamic stabilization systems is limited. Recently, Schnake *et al*²⁸ reported a study in elderly patients comparing Dynesys with pedicular screws fusion after decompression. The authors found similar results in both groups in terms of progression of spondylolisthesis or instability.

The largest series reporting a consecutive series of patients undergoing treatment with Dynesys in 94 patients and was published by Bordes-Monmeneu *et al*.²⁹ This study included patients presenting with DDD and lumbar spinal stenosis classified according to the Kirkaldy-Willis instability criteria.³⁰ The authors demonstrated an improvement of radiculopathy in 96% and improvement of low back pain 70% of the patients within 1 and 2 years follow-up period. As in our study, these results might be explained primary due to a sufficient radicular decompression in most of the patients before the implantation of Dynesys. In terms of complications, this Spanish group reported in their study 1 case with screw misplacement, 1 broken screw, and 2 patients presenting with a late infection. In our series, we could demonstrate a higher rate of material failure in terms of broken screws (1.8%) and loose systems which needed to be replaced. In a multicenter study including a consecutive series of 83 patients, Stoll *et al*¹⁴ reported 9 complications unrelated to the implant, and 1 due to screw misplacement. Based on our observations, it seems that incidence of broken screws is higher if Dynesys is implanted in more than 2 levels.

Schwarzenbach *et al*²² considered the main goal of Dynesys to address dynamic instability in early stages of degeneration. The authors consider this implant appropriate in younger patients without osteoporosis or macroinstability. In this study, no adverse effects treated with Dynesys were reported.

In a retrospective study, Grob *et al*³¹ studied 50 patients undergoing Dynesys. In this series 42% of the pa-

tients underwent additional decompression. Within the follow-up period 19% had required or were scheduled for a further surgical intervention. Two patients required fusion with a rigid system. After 2 years, back symptoms improved in 67% and were the same in 30%, leg symptoms improved in 64% and remained the same in 21%. Physical activity was reported as improved in 40% and even worse in 27% of the patients. Only 35% of the patients expressed that this technique did not help them. The authors reported that their results regarding back and leg pain were moderately high. Moreover, they concluded that the results were poorer than historical controls undergoing fusion.

Putzier *et al*³² applied Dynesys in 35 patients after minimal invasive nucleotomy and compared with patients with nucleotomy only. Duration of symptoms was 6 weeks, age at time of surgery ranged from 23 to 58 years. During the follow-up time of 3 months no surgery related or implants associated complications, nor novel neurologic symptoms were observed. Complete remission of preoperative neurologic symptoms occurred in 74.3%. Oswestry score improved significantly up to 3 month postoperative. VAS showed significant pain reduction. The authors discussed the ability of this system to prevent a progression of degeneration of the spine, although it is to be mentioned that the follow-up time of 3 months might not adequately reflect this process.

The importance of the sagittal balance in the spine after Dynesys was studied by Legaye.³³ The author reported the clinical and radiologic results of 26 patients with a mean follow-up of 9.5 ± 3.3 months. In this study, posterior inappropriate distraction led to loss of lordosis and excessive mechanical stress, which might cause pelvic compensation achieving better dynamic balance. It was concluded that Dynesys might stabilize DDD and protect the adjacent levels. Moreover, Beastall *et al*²⁷ recently reported an *in vivo* study using positional MRI in a series of 24 patients. The authors observed that Dynesys allows movement at the instrumented level without significant mobility at adjacent segments.

Plev *et al*³⁴ published a retrospective study of 79 patients with Dynesys with a follow-up of 12 month. The authors reported complications in 15 patients, which were device-related. These complication included screw loosening, recurrent herniated disc, adjacent level degeneration, local muscle irritation, ossification, and postoperative scoliosis.

Korovessis *et al*³⁵ reported recently the short-term radiologic and clinical results of a correlative study comparing rigid, semirigid *versus* dynamic instrumentation. The authors used as dynamic instrumentation the system called Twinflex and analyzed 3 groups each 1 with 45 adult patients and a mean follow-up of 47 ± 14 months. In this study, the results showed that all 3 instrumentation systems applied over a short area improved similarly both self-assessment and pain scores. Hardware failure occurred, however, at a low rate after dynamic instrumentation. The authors were not able to make any rec-

ommendation in favor of any instrumentation. In comparison with our results, the authors demonstrated less material failures such as broken screws. Implant failure in our series might be explained due to failure of the device to sustain the multilevel loading in cases of postoperative deterioration of destabilization signs. Cases presenting with multilevel degenerative signs that underwent the construct in more than 1 level might be at risk of implant failure.

The first study in patients undergoing Dynesys in North America was published in abstract form. This prospective multicentric study reported by Davis and Maxwell³⁶ studied 45 patients throughout a 1-year follow-up period. The authors described a decrease of Oswestry score from 56.5 before surgery to 35.4 at 1 year after surgery. The mean patient satisfaction was 74.8% and likelihood of recommendation was 79.4%. As conclusion it was stated that rigid fusion might reflect greater improvements in outcomes over time. In a recent publication, Welch *et al*³⁷ reported a noncomparative prospective clinical investigation including 101 patients treated with Dynesys in 6 investigational device exemption sites in North America from March 2003 to May 2006. The indications included spondylolisthesis (20 patients), central stenosis (26 patients), lateral stenosis (40), and others (7 patients). A total of 8 (7.9%) patients were excluded from the analysis due to incomplete records. The authors reported a significant improvement of mean pain and function scores compared with baseline at 12 months (leg pain improved from 80.3 to 25.5, back pain from 54 to 29.4, and ODI score from 55.6% to 26.3%). Nevertheless, the results of this study have to be interpreted with caution because a high rate of complications was reported. A total of 15 (15%) patients required reinterventions by the time of the 1-year follow-up evaluation. The authors reported that 10 of the 18 reinterventions were revision surgery performed at the same spinal level due to radiculopathy, increased back pain, or increased instability. Moreover, in 3 of these 10 reinterventions removal of Dynesys was required. Based on these findings, it is hard to understand how the authors concluded that the results of Dynesys are promising. Considering the fact that the authors of this study acted simultaneously as consultants for the company might add bias in the interpretation of the results.

Dynesys is in approval in the United States for an adjunct device for fusion. Our results and the studies reported until now have to be considered for the introduction of this instrumentation system for spinal surgery in the near future. Long-term and controlled studies are needed to support the recommendation of Dynesys in degenerative spine disease.

Based on our experience, the reported biomechanical principles of Dynesys do not reflect advantages in out-

come compared with none or others stabilization systems after microsurgical radicular decompression.

■ Key Points

- This study reports the results of implantation of Dynesys after microsurgical lumbar decompression.
- Better outcome after Dynesys was due mainly to improvement of radicular signs.
- High incidence of implant failure was observed.

References

1. Benzel E. Stability and instability of the spine. In: Benzel E, ed. *Biomechanics of Spine Stabilization*. Rolling Meadows, IL: American Association of Neurological Surgeons; 2001:29–43.
2. Cauchoix J, Benoist M, Chassaing V. Degenerative spondylolisthesis. *Clin Orthop Relat Res* 1976;115:122–9.
3. Jane JA Sr, Jane JA Jr, Helm GA, et al. Acquired lumbar spinal stenosis. *Clin Neurosurg* 1996;43:275–99.
4. Newman P. Stenosis of the lumbar spine in spondylolisthesis. *Clin Orthop* 1976;115:116–21.
5. Matsunaga S, Ijiri K, Hayashi K. Nonsurgically managed patients with degenerative spondylolisthesis: a 10- to 18-year follow-up study. *J Neurosurg* 2000;93:194–8.
6. Turner JA, Ersek M, Herron L, et al. Surgery for lumbar spinal stenosis. Attempted meta-analysis of the literature. *Spine* 1992;17:1–8.
7. Maroon JC. Current concepts in minimally invasive discectomy. *Neurosurgery* 2002;51:S137–S145.
8. Yorimitsu E, Chiba K, Toyama Y, et al. Long-term outcomes of standard discectomy for lumbar disc herniation: a follow-up study of more than 10 years. *Spine* 2001;26:652–7.
9. Kotilainen E, Valtonen S. Clinical instability of the lumbar spine after microdiscectomy. *Acta Neurochir (Wien)* 1993;125:120–6.
10. Rahm M, Hall B. Adjacent-segment degeneration after lumbar fusion with instrumentation: a retrospective study. *J Spinal Disord* 1996;9:392–400.
11. Schaeren N, Dubois G, Braunschweiler R. Static and Dynamic Biomechanical Test of a Dynamic Neutralization System for the Spine. Innsbruck: ESS; 1998.
12. Dubois G, Germy B, Schaerer N, et al. Dynamic neutralization: a new concept for restabilization of the spine. In: Szpalski M, Gunzburg R, Pope M, eds. *Lumbar Segmental Instability*. Philadelphia: Lippincott Williams & Wilkins; 1999:233–40.
13. Dimmet J, Fischer L, Gonon G, et al. Radiographic studies of lateral flexion in the human spine. *J Biomech* 1978;11:143–50.
14. Stoll TM, Dubois G, Schwarzenbach O. The dynamic neutralization system for the spine: a multi-center study of a novel non-fusion system. *Eur Spine J* 2002;11(suppl 2):S170–S178.
15. Prolo DJ, Oklund SA, Butcher M. Toward uniformity in evaluating results of lumbar spine operations. A paradigm applied to posterior lumbar interbody fusions. *Spine* 1986;11:601–6.
16. Stauffer RN, Coventry MB. A rational approach to failures of lumbar disc surgery: the orthopedist's approach. *Orthop Clin North Am* 1971;2:533–42.
17. Fischgrund J, Mackay M, Herkowitz H, et al. Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective, randomized study comparing decompressive laminectomy and arthrodesis with and without spinal instrumentation. *Spine* 1997;15:2807–12.
18. Grob D, Humke T, Dvorak J. Degenerative lumbar spinal stenosis. Decompression with or without arthrodesis. *J Bone Joint Surg Am* 1995;77:1036–41.
19. DiPierro CG, Helm GA, Shaffrey CI, et al. Treatment of lumbar spine stenosis by extensive unilateral decompression and contralateral autologous bone fusion: operative technique and results. *J Neurosurg* 1996;84:166–73.
20. Deyo RA, Ciol MA, Cherkin DC, et al. Lumbar spinal fusion. Cohort study of complications, reoperations, and resource use in the Medica population. *Spine* 1993;18:1463–70.
21. Beutler W, Fredrickson W, Murtland A, et al. The natural history of spondylolysis and spondylolisthesis: 45-year follow-up evaluation. *Spine* 2003;28:1027–35.
22. Schwarzenbach O, Berlemann U, Stoll TM, et al. Posterior dynamic stabilization systems: DYNESYS. *Orthop Clin North Am* 2005;36:363–72.
23. Schmoelz W, Huber JF, Nydegger T, et al. Dynamic stabilization of the lumbar spine and its effects on adjacent segments: an in vitro experiment. *J Spinal Disord Tech* 2003;16:418–23.
24. Niosi CA, Zhu QA, Wilson DC, et al. Biomechanical characterization of the three-dimensional kinematic behaviour of the Dynesys dynamic stabilization system: an in vitro study. *Eur Spine J* 2006;15:913–22.
25. Sengupta DK. Dynamic stabilization devices in the treatment of low back pain. *Orthop Clin North Am* 2004;35:43–56.
26. Sengupta DK, Herkowitz HN. Degenerative spondylolisthesis: review of current trends and controversies. *Spine* 2005;30:S71–S81.
27. Beastall J, Karadimas E, Siddiqui M, et al. The Dynesys lumbar spinal stabilization system: a preliminary report on positional magnetic resonance imaging findings. *Spine* 2007;32:685–90.
28. Schnake KJ, Schaeren S, Jeanneret B. Dynamic stabilization in addition to decompression for lumbar spinal stenosis with degenerative spondylolisthesis. *Spine* 2006;31:442–9.
29. Bordes-Monmeneu M, Bordes-Garcia V, Rodrigo-Baeza F, et al. [System of dynamic neutralization in the lumbar spine: experience on 94 cases.]. *Neurocirugia (Astur)* 2005;16:499–506.
30. Kikarldy-Willis W, Farfan H. Instability of the lumbar spine. *Clin Orthop* 1982;165:110–23.
31. Grob D, Benini A, Junge A, et al. Clinical experience with the Dynesys semirigid fixation system for the lumbar spine: surgical and patient-oriented outcome in 50 cases after an average of 2 years. *Spine* 2005;30:324–31.
32. Putzier M, Schneider SV, Funk JF, et al. The surgical treatment of the lumbar disc prolapse: nucleotomy with additional transpedicular dynamic stabilization versus nucleotomy alone. *Spine* 2005;30:E109–E114.
33. Legaye J. [Unfavorable influence of the dynamic neutralization system on sagittal balance of the spine]. *Rev Chir Orthop Reparatrice Appar Mot* 2005;91:542–50.
34. Plev D, Sutcliffe J. Outcome and complications using a dynamic neutralization and stabilization pedicle screw system (Dynesys): is this a soft fusion? *Spine J* 2005;5:141S–142S.
35. Korovessis P, Papazisis Z, Koueras G, et al. Rigid, semirigid versus dynamic instrumentation for degenerative lumbar spinal stenosis: a correlative radiological and clinical analysis of short term results. *Spine* 2004;29:735–42.
36. Davis R, Maxwell J. Dynamic stabilization with a flexible screw system: a preliminary outcome's report with 1-yr follow-up from two surgical centers. *Spine J* 2005;5:146S–147S.
37. Welch WC, Cheng BC, Awad TE, et al. Clinical outcomes of the Dynesys dynamic neutralization system: 1-year preliminary results. *Neurosurg Focus* 2007;22:E8.

Letters

To the Editor:

Re: Malinin T, Mark D. Brown. *Changes in vertebral bodies adjacent to acutely narrowed intervertebral discs—observations in baboons. Spine 2007;32:E603–E607.*

In this article, they used nonhuman primates to investigate changes in the vertebral bodies adjacent to acutely narrowed intervertebral discs. On inducing acute disc degeneration, they caused adjacent bone marrow changes. The trabecular bone response to physical stress was manifested by microfractures and bone marrow depletion.

The authors stated that the most important factor on maintaining the endplate functional was its discal support. I would suggest that it would be interesting the development of a method to evaluate patterns of endplate vasculature. This would allow the screening of patients with Pfirrmann¹ Grade 1 disc in the “very early phase of degeneration”. This could slow the progression of DDD and would eventually create the optimal place for arthroplasty. Knowledge and techniques in spine surgery are in constant evolution. As the old Latin words: *natura non facit saltus* (life/nature is not made of jumps). Maybe this would be an interesting point to study.

Another aspect I would comment was about the adjacent endplate changes they described progressing with time. The vascular, edematous reaction corresponds to the MRI described Modic type 1 changes. Our group

studied recently the predictive value of MRI vertebral endplate (Modic) changes on clinical outcome of surgically treated symptomatic one-level lumbar DDD.² We concluded that combination of low back pain of discal origin and severe DDD with Modic type 1 lesions on MRI may lead to excellent results after fusion in a large proportion of patients. Conversely, arthrodesis for patients harboring Modic type II changes implicates smaller benefit of doubtful clinical significance.

Maybe the benefit of the patient with Modic I changes comes from a reorganization of the vasculature of the endplate, independent from its complete integrity. The worst results found with Modic type 2 changes may derive from the impossibility of this vascular reorganization due to fatty bone marrow replacement.

Dr. João Luiz Pinheiro-Franco
Samaritano Hospital
Department of Neurosurgery
São Paulo
Brazil

References

1. Pfirrmann CW, Metzdorf A, Zanetti M, et al. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine* 2001;26:1873–8.
2. Esposito P, Pinheiro-Franco JL, Froelich S, et al. Predictive value of MRI vertebral end-plate signal changes (Modic) on outcome of surgically treated degenerative disc disease. *Neurochirurgie* 2006;52:315–22.
3. Vital JM, Gille O, Pointillart V, et al. Course of modic 1 six months after lumbar posterior osteosynthesis. *Spine* 2003;1;28:715–20.

Errata

Würgler-Hauri CC, Kalbarczyk A, Wiesli M, et al. Dynamic neutralization of the lumbar spine after microsurgical decompression in acquired lumbar spinal stenosis and segmental instability: clinical case series. *Spine* 2008;33:E66–E72.

In the above-mentioned article, the first author's name was spelled incorrectly. It should appear as: Carola C. Würgler-Hauri.

Weisskopf M, Ohnsorge JA, Niethard FU. Intravertebral pressure during vertebroplasty and balloon kyphoplasty: an in vitro study. *Spine* 2008;33:178–82.

In the above-mentioned article, the first author's name was spelled incorrectly. His name should appear as: Markus Weisskopf.