Posterior Dynamic Stabilization as an Alternative for Dorsoventral Fusion in the Treatment of Spinal Stenosis with Degenerative Lumbar Instability

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Abstract

Introduction

Degenerative spinal stenosis in aging people represents a significant degenerative spinal disorder with a reported occurrence between 1.7 and 10% [1,2]. In a demographically aging populace, patients with degenerative spinal infirmities form a constantly increasing part of the total population.

Numerous causes of a narrow spinal canal are known: acquired (post-traumatic, post-infectious), iatrogenic (post-operative peridural fibrosis) congenital (Klippel-Feil syndrome, Anquin syndrome) and constitutional (achondroplasia, Morquio syndrome) [3-6]. However in over 90% of the cases the stenosis has degenerative causes.

In the early 1950's the clinical picture of lumbar spinal stenosis took on increasingly differential-diagnostic significance and was first described in detail by Verbiest [6]. A better understanding of the pathoanatomy of spinal stenosis, especially the consequences of extensive osseous decompression with the possible instability in the segment under examination, gave rise to the development of various divisional principles (central, lateral and intraforaminal stenosis) [7] and their resulting therapeutic consequences. The total laminectomy was replaced among other things by more gentile procedures, which became standard methods, such as laminotomy [8,9], facetectomy [10], and lumbar laminoplasia.[11,12].

The degenerative instability or spondylolisthesis was first described as an entity in itself by Junghans [13] und distinguished from the iatrogenic instability caused by extensive osseous decompression. The morphological substrata of the degenerative instability with consecutive retro- or pseudolisthesis of the adjacent segments is comprised of the degeneration of the disk which is frequently associated with a spondylarthrosis giving rise to the predominately dorsal height reduction of the intervertebral disk space. These changes can also lead to subluxation depending on the orientation of the facet joints. The choice of therapy in cases of degenerative instability with accompanying spinal stenosis was controversial up to the beginning of the 1990's. Some authors [16,17] viewed decompression surgery alone as adequate on the basis of its good clinical results; others [18,19] however saw an indication for additional stabilization in the decompressed segment. On the basis of more modern literature [20] the question seems to have been answered in favour of additional stabilization. All stabilization procedures with or without dorsal instrumentation include in most cases an intercorporal fusion of the motion segment with the well-known problem of the protracted degeneration of the adjacent segment [21]. Depending on the stabilization technique, there are the additional risks of a second operation and an additional morbidity of the autologous iliac crest - or cancellous bone graft harvesting [22]. From these considerations it seems that a posterior dynamic stabilizing system without the necessity of an intercorporal fusion is a possible alternative therapy with significantly less morbidity in cases of spinal stenosis with degenerative instability.

The aim of this study is to evaluate the outcome of the dorsal dynamic stabilization in comparison with the dorsoventral spondylodesis on the basis of a group of patients selected according to clinical and radiological criteria.

Material and Methods

As of June 2001 24 patients who were diagnosed with a degenerative spinal stenosis accompanied by instability and who fulfilled the established clinical and radiological criteria (see inclusion criteria) underwent selective decompression surgery with dorsal dynamic stabilization (DYNESYS®, Centerpulse®, Switzerland) (Fig. 1). Ten patients whose post-operative examination interval was at least 12 months were admitted to the study. To form a test group for comparison purposes, the data was retrospectively acquired for the last ten patients who had the same diagnosis and the same clinical and radiological inclusion criteria and had undergone selective decompression surgery with dorsoventraler fusion prior to June 2001 (Krypton®, Ulrich Medizintechnik, Germany) (Fig. 2).

Clinical inclusion criteria

1. Claudicatio-spinalis symptoms with lumbar spinal pain with or without pseudoradicular radiation.

2. An unsuccessful, conservative treatment over a period of at least 6 months

3. Distinct improvement (>50%) on the basis of facet infiltration with a local anaesthetic in the segments intended for surgery

Inclusion criteria illustrated by imaging

1. In the lateral radiographs an ante- or retrolisthesis of 2-5 mm. (Fig. 3,4)

2. In the CT-examination evidence of spondylarthrosis (Fig. 5)

3. In the MR-examination osteoligamentous spinal stenosis with a maximum spinal canal diameter of 10 mm (Patients with solely disk-induced spinal stenosis were excluded).

Pre-operative data acquisition

The preoperative data acquisition involved medical history, physical examination, neurological examination, and an analysis of the imaging performed. For each patient pre-operative radiographs of the lumbar spine in lateral projection at maximal flexion and extension as well as CT- and MR-examinations were performed. All radiographs were standardized in the same department and produced at a film-focus-distance of 110 cm in a strictly lateral projection. All radiographs were digitalized and stored on a PC (DiagnostiX, Basis 2048; GEMED, Germany). The measurements of the translation pre- and post-operatively took place with a special software which automatically indicates the distances registered. Subsequently the measured values were transformed to the actual distance by the enlargement factor of 1:1,5. The spinal canal diameter in the transversal MR-images was determined with the help of computer analysis. The facet joints were analyzed in the CT-images. Every patient filled out the OQ and SF-36 questionnaire prospectively.

Intra- and post-operative Data

Duration of surgery, blood loss, number and height of the compressed and instrumented segments, intra-operative complications, and length of hospitalization were documented.

Surgical technique

The dorsal instrumentation took place in both groups by means of a median access to the lumbar spine. The positioning of the pedicle screw was performed according to the conventional method (according to Magerl). The decompression took place by excision of the hypertrophic ligamenta flava and by undercutting the hypertrophic facet joints.

The ventral intercorporal fusion was performed in "press fit technique" using an autologous tricortal iliac crest graft, which was taken from the left anterior part of the iliac crest in all patients. The extraperitoneal exposition of the anterior lumbar spine took place via a pararectal access.

Implants

The internal fixator (Krypton®, Ulrich Medizintechnik) was used for the dorsal rigid stabilization in Group I (Fig. 5), and the dynamic neutralizing system (DYNESYS®, Centerpulse®) was used for the dorsal dynamic stabilization in Group II (Fig. 6). The dynamic system is composed of screws (from the Ti-Al-Nb-forged alloy Protasul™ 100), polycarbonate urethane space holders (Sulene™-PCU), and a polyethylene terephthalate band (Sulene™-PET). Dynesys is anchored in the vertebrae by means of screws; the PET band limits flexion, while the space holders maintain the vertebra in the proper position and limit stretching.

Follow-up examination

At the time of the follow-up examination radiographs in two views and dynamic x-rays of the lumbar spine in lateral projection were produced and the OQ and SF-36 score filled out again.

Results

The average age in Group I (6 men, 4 women) was 66 years (53.8-72.9) and in Group II (4 men, 6 women) 64.6 years (51.8-77.8). The average follow-up examination interval was 14.4 months (Group I) and 15.2 months (Group II).

The pre-operative average translation was 2.6 mm (2-4mm) in Group I and 2.8 mm (1-5mm) in Group II. Post-operatively the translation could be reduced to an average of 0.3 mm (0-2mm) in Group I and 1.6 mm (0-3 mm) in Group II.

In Group I an average of 1.4 segments (1-2) were fused and 1.2 (1-2) segments decompressed. Level L4-L5 was treated in 4 patients, L4-L1 in 4 patients, and L5-L1 in 2 patients. In Group II 1.6 segments (1-3) were instrumented and 1.6 (1-3) segments decompressed. Level L3-L4 was treated in 2 patients, L3-L5 in 2 patients, L3-L1 in 2 patients and L4-L5 in 4 patients. A total of 42 pedicle screws were used in Group 1 and 54 in Group II.

The average hospitalization lasted 28.4 days (16-37) in Group I, 19.3 days (11-28) in Group II. The average total duration of surgery (dorsal and ventral) lasted 218.3 min. (140-325) in Group I and 163.3 min. (90-210) in Group II. The average total blood loss was 892 ml (375-1600) in Group I and 922 ml (300-3000) in Group II. In both groups a dural lesion occurred intra-operatively without permanent post-operative functional deficit symptoms and without a cerebrospinal-fluid loss syndrome. No superficial or deep infection occurred in either group. In one case in Group I the vena iliaca was injured, which was treated with a blood vessel suture.

The pre-operative OQ showed improvement in Group I at the follow-up examination, coming down from an average of 46 points to 32 points, in Group II from an average of 54 points to 33 points (Fig. 9). The physical health summary measures in SF-36 improved in Group I from 36 to 43 points and in Group II from 36 to 46 points (Fig. 8). It was possible to register an improvement of the values in all subcategories of the SF-36 scores with the exception of the score for "General health" in Group II (Fig. 7). Three of ten patients in Group I complained of considerable pain in the area where the bone graft was harvested, and one patient developed a symptomatic incisional hernia in the area of the ventral access.

The radiographic follow-up exams could not detect any breakage or dislodgment of screws in either group. A certain osseous fusion was detected in all patients in Group I.

Discussion

After decades of discussing the choice of therapy in cases of degenerative spinal stenosis accompanied by instability, the Mata analysis of Mardjetko [20] seems to have led to a choice in favour of additional stabilization after decompression. Arguments for the stabilization are, first of all, the possible postoperative instability after considerable decompression, sacrificing the supportive dorsal structures of the motion segment, and secondly, the simultaneous therapy of the symptomatic spondylarthrosis in most cases. The possible operative techniques for producing a stability in the motion segment extend from instrumented, non-instrumented, dorsal, anterolateral, posterolateral up to intertransversal spondylodesis. Even though the rates of success among the various spondylodesis techniques vary considerably, they all have in common the additional morbidity of the intercorporal fusion and the problem of the protracted degeneration of the adjacent segment [21,22]. Lee [21] reports on 22 operations in 18 patients after an average of 8.5 years because of an adjacent segment problem following fusion operations: In 16 cases because of symptomatic spondylarthrosis, in 8 cases because of spinal stenosis, and in 5 cases because of advanced disk degeneration. Mayer [22] reported in a retrospective analysis of 134 patients about a complication rate of 5.2% with ventral accesses and about 37 fusion-specific complications, of which the morbidity of the iliac crest graft harvesting formed the greatest portion with 11 cases. On the grounds of this and similar results in literature and the results of the present study, showing a distinctly high rate of complications after fusion operations, it appears that a dorsal dynamic stabilization without the additional morbidity of the intercorporal fusion represents a justifiable alternative therapy.

Dubois [23] reports good results in 57 patients with lumbar instability after instrumentation with DYNESYS®. In the study of Dubois as well as in the study of Stoll [24] with 83 patients, the DYNESYS® was implemented in patients with various indications. In these studies, however, the concept of instability was not precisely defined, so that the comparison of the post-operative outcome is made more difficult. In the present study detailed clinically and radiologically defined patient material with a well-established instability (translation in two motion segments 2-5 mm) was used and a direct comparison made with a fusion operation. In this way it was possible to examine the value of the dorsal dynamic stabilization with relationship to a defined indication area. No further diagnostic clarification of the patient's condition was undertaken in the form of a disk graph to exclude "discogenic" pain. After evaluating the present patient material, it can be established that a distinct reduction in pain was achieved in both patient groups. For this reason it "seems" that a possible discogenic pain does not represent any major contra-indication against the implementation of DYNESYS®. Nevertheless it appears that the evaluation of possible discogenic pain is prospectively appropriate in order to discuss the relationship between "discogenic" pain and the clinical results after dorsal dynamic stabilization.

The results of the present study tend to the conclusion that a for the most part anatomic reposition with spondylolistthesis does not have any significant influence on the clinical outcome. The distinctly improved post-operative repositions results in Group I were not linked with distinctly improved clinical follow-up results. The outcome of similar studies [25,26] confirm this result. Despite a standardized procedure for taking X-rays, inexact measurements arsing from projection problems cannot be excluded [27]. In view of the fact that no alternative method for measurements is available to the present date and that the published studies to the present utilize this measuring device with the associated questions and problems, it appears that the measurements performed for this study are appropriate [25,26]. The mechanism achieving a possible reposition with the dorsal dynamic stabilization is still not adequately clarified up to the present. Theoretically it appears that a certain distraction in the area of the facet joints with the associated capsule-disk-apparatus and dorsal ligament structures, behind which the rotation axis of the motion segments lie, gives rise to a possible reduction effect in the motion segment. This reduction effect could be additionally supported by the tension of the space holder between the screw heads. These remarks should be viewed as "theoretical" in nature. We anticipate new scientific findings on these questions from continuing studies in this field, especially from biomechanical studies.

In view of a possible reduction of the instability in the adjacent segment after dorsal dynamic stabilization in comparison with fusing procedures, it seems that an evaluation of the segmental and total lumbar lordosis angle is of significance. Von Lackum [28] postulated an increase of shearing forces at the lumbosacral junction with too strong lordosis, resulting in poor posture. Splithoff and Jackson [29] came to the conclusion after comparing patients with and without backpain that a hypolordosis is more frequently associated with back pain. Magora [30] describes a hypolordosis as a good indicator of back pain. Till the present day, neither the relationship between non-physiological lumbar lordosis and possible instability in the adjacent segment, nor the effect of dynamic stabilization of the lumbar spine and the resulting changes of segmental and total lumbar lordosis have been adequately explained. Personal tests [31] conducted on 24 patients after endoprosthetic replacement of the lumbar spine showed a statistically significant increase of the segmental lordosis angle in the instrumented segment with statistically unchanged total lumbar lordosis. Further studies will have to answer how this statistical relationship will develop with the use of the dorsal dynamic stabilization with DYNESYS® and what long-term relationship exists between the segmental and the total lordosis angle and the reduction of instability in the adjacent segment.

When dynamic stabilization is performed, there is no application for the ventral intercorporal fusion. This is reflected both in the duration of the operation as well as in the duration of hospitalization, which are distinctly lower or shorter. Similar blood losses in both groups despite one particular operation in Group II can be explained by the number of pedicle screws used, which were 25% more in Group II with 54 screws than in Group I with 42 screws.

From a critical standpoint, it should be noted on the one hand that the dynamic stabilization compared to the fusion operation was not, despite its advantages, was not accompanied by a distinctly improved quality of life (SF-36 score). In both groups a marked improvement in pain (OQ) was achieved. Overall the results of the dynamic stability were better. On the other hand no statement about possible long-term complications can be made on the basis of the short-term follow-up interval. It remains to be seen whether a significantly lower complication rate can be achieved by means of an exactly specified indication, compared to the patient population examined by Stoll et al [24], in which significant complications were registered after an average observation period of 38.1 months.

The overall positive results after dorsal dynamic stabilization are to be interpreted as short-term results with a relatively small patient population. Long-term observations will analyse more closely the value of this procedure, especially by means of an expected reduction of instability in the adjacent segment compared with fusion procedures.

Figure 1
Dorsal (left) and lateral (right) view of the posterior dynamic stabilization system (DYNESIS®) at level L3 – L5 in a ‘sawbone model’. (1) grub screw for polyethylene terephthalate band fixation (2) cylindric space holder made of polycarbonate urethane (3).

Figure 2
Dorsal (left) and lateral (right) view of a rigid instrumentation with the internal fixator (Krypton®) at level L4 – S1 in a ‘sawbone model’.

Figure 3
Clear correction of pre-operative translation (left) coming down from 3 mm in both segments to < 1mm in segment L3/4 and 2mm in segment L4/5 post-operatively (right) with posterior dynamic stabilization.

Figure 4
Complete correction of pre-operative translation of 3 mm (left) and good post-operative (right) consolidation of ventral intervertebral spondylodesis after rigid stabilization with the internal fixator.

Figure 5
CT level L3-4: irregularly contoured joint surface (1) and clear facet hypertrophy with impression of dural sac (2) as a sign for advanced spondylarthrosis.

Figure 6
MRI level L4-5: spinal canal stenosis (1) on level L4/5 (max. diameter 7 mm), hypertrophy of flaval ligament (2) and subluxation of left facet joint.

Figure 7
SF 36 results by subgroup pre- and post-operatively

- Mental health
- Role-emotional
- Social functioning
- Vitality
- General health
- Bodily pain
- Role-physical
- Physical functioning

- Group I pre-op
- Group I post-op
- Grpou II pre-op
- Group II post-op