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Combined Dynamic and Rigid Multilevel Posterolateral Lumbar Fixation Systems in Prevention of Adjacent Segment Disease

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Abstract

Introduction: The gold standard in the treatment of lumbar degenerative spinal diseases is the posterolateral fusion with rod and screws. Semi-rigid systems were first designed to stabilize the abnormal segment and to unload degenerated discs and facet joints. One commonly observed consequence of fusing spinal motion levels has been adjacent segment disease (ASD). Due to prevention of ASD is a complicated and controversial topic, the aim of this study was to assess the role of combined dynamic and rigid posterolateral fixation systems in prevention of ASD.

Patients and Methods: A total of 76 adult patients with various lumbar spine pathologies, treated with posterior fusion and pedicle screw fixation between T12 and sacrum were included in this study. The prevalence of radiological and clinical ASD was measured and the functional outcome of the patients was evaluated using the Oswestry questionnaire.

Results: Evidence of radiographic ASD was noted in 6 of the 76 patients (7.9%), of whom one patient was symptomatic (16.67%). The mean preoperative Oswestry score was 27.2 ± 20.7 and the mean postoperative Oswestry score was 15.4 ± 20.3. There was a significant difference between the 2 scores (p=0.027). The mean postoperative lumbar lordosis was -53° ± 2.08 and the pelvic incidence 61° ± 3.12. Related to the complications, 6 patients with superficial wound infections, one patient with deep venous thrombosis (DVT), and one patient with ASD were reported.

Discussion: In our study, the very low incidence of ASD is achieved by the mean of preservation of the top facet joint, correction and preservation of coronal and sagittal balance, preservation of motion in the lumbar spine with the use of semi-rigid devices, and early rehabilitation accompanying by the training of the patient regarding to the body balance. Semi-rigid fixation significantly reduces the risk of screw fracture by the absorption of the stress on the interpedicular damper and enhances the bone fusion by maintaining constraints on the cages which remain under a compressive load.

Keywords: Spinal fusion; Adjacent segment disease

Introduction

The gold standard in the treatment of lumbar degenerative spinal diseases is the posterolateral fusion with rod and screws. Biomechanically, the two main principles of pedicle-screw based systems can be divided into semi-rigid and rigid devices. Semi-rigid systems were first designed to stabilize the abnormal segment and to unload degenerated discs and facet joints, while maintaining the same level of normal motion [1].

It is known that spinal fusion results in the alteration of the normal biomechanics of the spine and the loss of motion at the fused segments. This motion restriction is compensated by increased motion at other unfused levels. As a result, a significant amount of additional force is placed on the facet joints at the unfused segments [2]. One commonly observed consequence of fusing spinal motion levels has been adjacent segment disease (ASD). The incidence of radiographic ASD following fusion has been reported to be as high as 70% in the lumbar spine at 10 years [3]. However, the incidence of clinically relevant symptomatic adjacent segment disease is quite lower, estimated at 36% in the lumbar spine at 10 years [4].

Due to prevention of ASD is a complicated and controversial topic, the aim of this study was to assess the role of combined dynamic and rigid posterolateral fixation systems in prevention of ASD.

Patients and Methods

A total of 76 adult patients with various lumbar spine pathologies, treated consecutively with posterior fusion and pedicle screw fixation between T12 and sacrum were included in this study. The operations were performed by the same surgeon. Patients with 2 to 8-level fusions up to T11 using pedicle screws were included in the study, whereas patients in whom hook or hybrid constructs were used were excluded. Radiographs were obtained before surgery, immediately following surgery, at six months and every year postoperatively. Lumbar lordosis (T12–S1) angle and pelvic incidence were measured. The radiographs were analyzed with particular attention paid to degeneration of adjacent levels. Degeneration of adjacent disc was graded using the Weiner classification [5]. Radiographic ASD was defined by the development of spondylolisthesis >4 mm, segmental kyphosis>10°, complete collapse of the disc space, or by deterioration in the Weiner classification of 2 or more grades [6]. Clinical ASD was defined as symptomatic spinal stenosis, mechanical back pain, and sagittal or coronal imbalance. The Oswestry questionnaire was used before surgery and at the ultimate follow-up in order to assess the functional outcome [2].

Surgical procedure

The surgical approach of the levels to be treated was performed via a median incision. The spinal muscles are decorticated to the bone in order to have full access to laminae, articular processes and

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the posterior side of the transverse processes. Release of the neural elements was achieved via laminectomies, discectomies, and removal of the hypertrophic medial facets. In the cases of spondylolisthesis, additional removal of the pars interarticularis was performed. After that, distracting PLIF was performed by using two intervertebral polymer cages (ADONIS, Scient'X, Guyancourt, France) for each level. 8 to 10° lordotic cages at the L5-I1 level and 4° lordotic cages in the other levels were used. The cages were filled up with cancellous bone grafts from the laminectomy. Posterior interpedicular fixation in compression was performed for immediate stabilization and restoration of lordosis. All patients received the same dynamic instrumentation (ISOLOCK$_{TM}$, Scient'X, Guyancourt, France), made of implantable titanium and titanium alloys, consisting of pedicular screws linked by semirigid rods provided with a damping element allowing an angular movement in all plans and with a stop device limiting the movement to the extent of physiological amplitude. The types of elements and the implant sizes allow for customized constructs depending on patient anatomy.

Getting up and walking without any external contention was allowed two days after the surgical procedure. The patient was discharged after five days with direction to avoid excessive flexion and axial rotation. All patients received the same rehabilitation program in hospital's physiotherapy department.

SPSS software (Scientific Package for Social Sciences 11.5.0, SPSS Inc. Chicago, Illinois) and specifically the Mann-Whitney U test were used for the comparisons between groups. A p value of less than 0.05 was considered significant.

Results

From the 76 patients included in the study, 48% suffered from degenerative lumbar spine, 24% from disc herniation, 21% from flat back syndrome, and 7% from spondylolisthesis. 15 from 76 patients (19.7%) underwent a revision surgery. 13 of 15 suffered from failed back syndrome and 2 from ASD (Figures 1 and 2). There were 27 men and 49 women with a mean age of 59.4 years (range 20 to 84). The operations were performed between 2002 and 2006 and the mean follow up was 7.2 years (range 2 to 10). A total of 5 patients underwent a 2-level fusion, 8 patients underwent a 3-level fusion, 23 patients underwent a 4-level fusion, 18 patients underwent a 5-level fusion, and 22 patients underwent a 6-level fusion (Table 1).

Evidence of radiographic ASD was noted in 6 of the 76 patients (7.9%), of whom one patient was symptomatic (16.67%). That patient had also a radiographic evidence of ASD with a spondylolisthesis of 5 mm, did not have a prior fusion, and was underwent a 4-level fusion. In all cases, degeneration of the adjacent level was noted radiographically proximal to the prior fusion. The mean preoperative Oswestry score was 27.2 ± 20.7 and the mean postoperative Oswestry score was 15.4 ± 20.3. There was a significant difference between the 2 scores (p=0.027). The mean postoperative lumbar lordosis was -53° ± 2.08 and the pelvic incidence 61° ± 3.12 (Table 2).

In an attempt to assess the risk factors of ASD, we have compared the patients with radiological and clinical ASD with the patients without ASD regarding the sex, age, the body mass index, the number of fused levels, the cranial extension of the fusion, and the primary diagnosis. None of those comparisons revealed any significant difference (p>0.05 in all risk factors).

Related to the complications, 6 patients with superficial wound infections, one patient with deep venous thrombosis (DVT), and one patient with ASD were reported (Table 3). Wound infections were treated with per os administration of antibiotics (second generation cephalosporin). The patient with DVT was treated with low molecular heparin, and the patient with ASD was recovered with rest and a 10 days treatment with nonsteroid anti-inflammatory drugs.

Discussion

The relation between the incidence of adjacent segment disease and the number of levels included in a lumbar fusion remains controversial. Wiltse et al. found that the length of fusion was not significant in the development of ASD in his study of patients with a maximum 3-level fusion [7]. In another study by Ghiselli et al., patients who had a single-level fusion were more likely to have clinical ASD than those who had a multilevel fusion [4]. On the other hand, Gillet et al. found that, when examining up to 4-level fusions, an increased incidence and severity of ASD were reported as more levels were included in a fusion [8].

The location of the proximal instrumented vertebra influences the development of ASD in the lumbar spine. Cheh et al. reported that fusions ending at L1, L2, or L3 increased the occurrence of clinical ASD as opposed to the fusions ending at L4 or L5 [6]. Gillet found that, when 5 or more levels were included, there was no increased risk of ASD [8]. He attributed this observation to the bracing effect of the rib cage in the thoracic spine; therefore, based on this observation, he recommended extension of a fusion up to the thoracic area when treating adjacent segment degeneration proximal to a prior fusion.

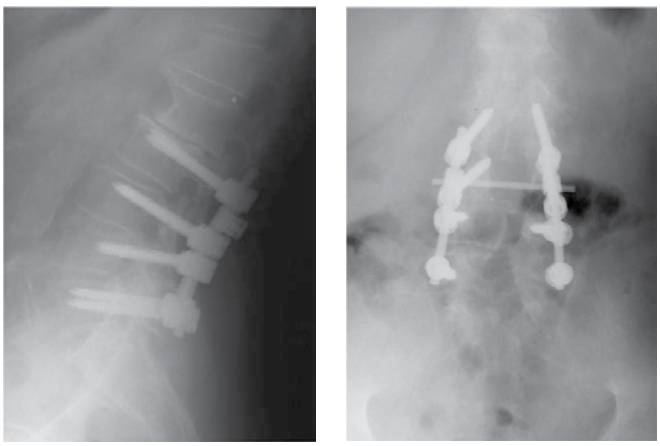

Figure 1. Preoperative Lateral (a) and A/P (b) x-rays of a 77 years old patient who suffered from low back pain and underwent a L3, L4, L5 laminectomy and a L2, L3, L4, L5 posterior fixation with screws, rigid rods, and cross-link. After 2 months free of symptoms, severe low back pain, L1 right radiculopathy, and partial cauda equina syndrome were presence.

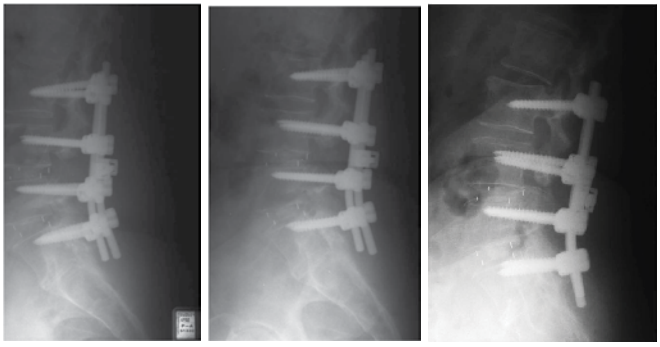

Figure 2. Lateral x-rays immediately after the operation (a), after 1 month (b), and after 6 months (c). The patient underwent a revision surgery which include removal of rods and cross-link, diskectomy at L1-L2 level, PLIF, polyaxial U-screws in L1, rigid rods, and cross-link.

Type of lumbar pathology (Nr of patients 76)	Prevalence (%)
Degenerative lumbar spine	48
Disc herniation	24
Flat back syndrome	21
Spondylolisthesis	7
Nr of patients underwent revision surgery	15 (19.7%)
Men/Women (Nr of patients)	27/49
Mean follow up	4.2 years (range 2 to 6)
Levels of fusion	**Nr of patients**
2-level fusion	5
3-level fusion	8
4-level fusion	23
5-level fusion	18
6-level fusion	22

Table 1: Summary of results (part 1).

Prevalence of ASD		Nr of patients (%)	
Radiographic ASD		6 (7.9)	
Clinical ASD		1 (1.32)	
	Preoperative	**Postoperative**	**P value**
Oswestry score	27.2 ± 20.7	15.4 ± 20.3	0.027
Postoperative lumbar lordosis		-53° ± 2.08	
Postoperative pelvic incidence		61° ± 3.12	

Table 2: Summary of results (part 2).

Complication	Nr of patients
Superficial wound infections	6
Deep venous thrombosis	1
Adjacent segment disease	1

Table 3: Complications

Posterior surgery has also been blamed for ASD. Wiltse et al., Ghiselli et al., and Kumar et al. found an increased incidence of ASD with the use of pedicle screws [4,7,9]. More specifically, Kumar et al found that patients were symptom free before the onset of ASD for 13.1 years when an uninstrumented fusion was performed but only 5.2 years when a circumferential fusion was performed [9].

The fact that in our study only one patient developed clinical ASD makes the determination of the risk factors which influences ASD impossible. The radiographic deterioration of the adjacent segment did not correlate with symptoms, since evidence of radiographic ASD was noted in 6 of the 76 patients (7.9%), of whom one patient was symptomatic (16.67%). These results are in agreement with previous studies [10]. The patient with the clinical ASD was fully recovered after a 10 days treatment including rest and nonsteroid anti-inflammatory drugs.

In our study, the very low incidence of ASD is achieved by the mean of preservation of the top facet joint, correction and preservation of coronal and sagittal balance, preservation of motion in the lumbar spine with the use of semi-rigid devices, and early rehabilitation accompanying by the training of the patient regarding to the body balance. Semi-rigid fixation significantly reduces the risk of screw fracture by the absorption of the stress on the interpedicular damper and enhances the bone fusion by maintaining constraints on the cages which remain under a compressive load (Wolffs law). This semi-rigid fixation system prevents the stress-shielding phenomenon. Fusion with polymer cages and semi-rigid fixation, collectively meet all the requirements not only for pain relief but also for definitive stabilisation without iatrogenic spinal complication or further destabilisation of spine at the adjacent level to the arthrodesis. Semi-rigid fixation which allows controlled intervertebral motion for this adjacent level seems to create the mechanical conditions for a transitional intervertebral zone between the rigid fused segment and the "free" adjacent level above the spinal instrumentation. This biomechanical intermediate zone seems to be very important before the restoration of physiological lordosis achieved by recovery of efficient posterior muscles. Such semi-rigid fixation seems to be an efficient measure to prevent adjacent level degeneration and recurrence of symptoms.

The main limitation of this study is that there is not a control group treated with with rigid fixation, so the results have been estimated on the basis of bibliographical data. Another disadvantage of this study is the relatively short duration of follow-up. Further long term studies are necessary to confirm the benefits of combined dynamic and rigid multilevel posterolateral lumbar fixation systems in prevention of adjacent segment disease.

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