Good Functional Outcome and Adjacent Segment Disc Quality 10 Years after Single-Level Anterior Lumbar Interbody Fusion with Posterior Fixation

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Abstract

We reviewed the records of a prospective consecutive cohort to evaluate the clinical performance of anterior lumbar interbody fusion with a titanium box cage and posterior fixation, with emphasis on long-term functional outcome. Thirty-two patients with chronic low back pain underwent anterior lumbar interbody fusion and posterior fixation. Radiological and functional results (visual analogue scale [VAS] and Oswestry score) were evaluated. Adjacent segment degeneration (ASD) was evaluated radiologically and by magnetic resonance imaging (MRI). Twenty-five patients (78%) were available for follow-up. Functional scores showed significant improvement in pain and function up to the 2-year follow-up observation. At 4 years, there was some deterioration of the clinical results. At 10-year follow-up, results remained stable compared with 4-year results. MRI showed ASD in 3/25 (12%) above and 2/10 (20%) below index level (compared with absent preoperatively). ASD could not be related to clinical outcome in this study. Anterior lumbar interbody fusion and posterior fixation is safe and effective. Initial improvement in VAS and Oswestry scores is partly lost at the 4-year follow-up. Good clinical results are maintained at 10-year follow-up and are not related to adjacent segment degeneration.

Keywords
- functional outcome
- long-term follow-up
- anterior lumbar fusion
- adjacent segment disease

Since the first description of anterior lumbar interbody fusion (ALIF) by Burns, the technique has been used not only for spondylolisthesis but for the management of degenerative disc disease (DDD) of the lumbar spine.[1,2] The main clinical goals in performing lumbosacral fusion are to achieve pain relief and functional restoration including working capacity. Surgical goals are correction of spinal alignment and provision of mechanical stability. An ideal environment for spinal fusion is to be provided with as limited morbidity as possible.[3] Autografts or allografts as stand-alone interbody grafts fail to achieve these ideals.[4] An overview of the advantages of cages was given by Steffen et al.[5] These issues have been addressed in our first report.[6] Despite the significant increase in lumbosacral fusion for low back pain (LBP) in the past 10 years, only limited data are available on long-term follow-up.[7–10] To date, there is no conclusive evidence favoring either anterior, posterolateral, or circumferential fusion. The study by Fritzell and colleagues showed no difference in functional outcome at 2-year follow-up with three different fusion techniques (posterior uninstrumented, posterior instrumented, and posterior instrumented with additional anterior column support, either from posterior or anterior).[11] The report by Pavlov et al showed favorable outcome, surgical as well as functional, on 52 patients at 4-year follow-up.[6] The

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randomized controlled trail by Brox et al showed that chronic low back pain after previous disc surgery is treated equally effectively with posterolateral fusion and a cognitive intervention and exercises program, but only at 1-year follow-up.[12] Over the last years, there has been much debate regarding the adjacent segment. No conclusive evidence has been presented regarding the cause of disc degeneration adjacent to a fused segment. Reports regarding experimental fusion in rabbits by Phillips indicated a mechanical component in the degenerative cascade.[13] The report by Stokes and Iatridis compared mechanical overloading to immobilization, which also creates an abnormal mechanical condition.[14] Park et al already stated the various factors contributing to the development of adjacent disc disease in the 2004 review. They also stated that the natural cause of adjacent disc degeneration is a major contributing factor.[15] The aim of this study was to analyze long-term functional outcome and to determine the rate of adjacent segment degeneration (ASD) 10 years after ALIF with additional posterior fixation.

Materials and Methods

Patients

Between October 1996 and February 1998, a prospective patient cohort of 32 consecutive patients underwent single-level ALIF. Surgical intervention was planned only after the persistence of pain for more than 6 months despite conservative treatment. Further inclusion criteria were body mass index between 20 and 35 and age between 18 and 65 years. Positive provocative discomanometric evaluation with adjacent-level negative controls between L3 and S1 was mandatory. Three patients had had previous decompressive surgery. Exclusion criteria were (inflammatory) diseases affecting the entire spine, pregnancy, smoking, and a history of pneumonia or pulmonary embolism. Patients with diabetes mellitus, metabolic bone disease, loss of bone stock, active infection, or metastatic disease were also excluded. After approval by our Institutional Review Board, we invited all 32 patients who underwent single-level fusion by telephone and regular mail to take part in this evaluation. Twenty-five patients (78%) agreed to participate in the study and were seen in the clinic by an investigator (P.H.) not involved in the primary treatment. Standing anteroposterior and lateral radiographs of the spine were obtained as well as an upright magnetic resonance imaging (MRI) of the lumbar spine to evaluate adjacent disc levels.

Radiological Evaluation

Radiographs were taken at the 10-year follow-up visit and consisted of standard standing anteroposterior and lateral images of the lumbar spine. Attention was given to development of radiolucency. An upright MRI was made to analyze the disc quality and identify facet joint osteoarthritis (FJOA) at the adjacent level as possible confounder in remaining low-back pain. A 0.6-Tesla Fonar Upright MRI (Fonar Corporation, Melville, NY) was used for this purpose. Disc degeneration was classified according to Pfirrmann et al into five groups.[16] We pooled the data from facet joint degeneration into two groups, either grade 3 FJOA or FJOA less than grade 3. Only grade 3 FJOA seems related to low back pain.[17] The examination protocol included T1- and T2-weighted images in sagittal and transverse planes above, at, and below the fusion level. If the fusion was performed at the lumbosacral junction, the S1–S2 level was not described. Fusion assessment of the lumbar spine is difficult, especially in the presence of metal artifacts. Absence of radiolucencies, screw breakage, and subsidence was used as a criterion for successful fusion. The fusion rate at 4 years was 100%. Because of this, we did not intend to redocument fusion rate in this follow-up.

Outcome Measures

Patients were asked preoperatively and again at 2, 4, and 10 years postoperatively to fill out visual analog scales (VAS) for back and leg pain and the Oswestry Disability Index questionnaires (ODI, version 1.0 in Dutch). VAS scores were measured on a 100-point scale, with 0 being no pain at all and 100 being the worst pain imaginable. The ODI is scored from none to total disability (0 to 100%) and rates the limitations of various activities of daily living such as personal care, walking, sitting, lifting, standing, sleeping, sex, and social life and traveling. Just one question specifically rates the intensity of pain. To evaluate general health we used the Short Form-36 General Health Instrument (SF-36).[18] The SF-36 includes a multi-item scale to rate the quality of life divided into eight dimensions: physical function, physical role, bodily pain, general health, social function, emotional role, mental health, and vitality. It is summarized into two categories related to physical and mental health. Each scale ranges from 0 (worst health state) to 100 (best health state). The SF-36 was not part of the preoperative evaluation, and therefore no relation to previous scores can be made. To be able to evaluate our 10-year follow-up results, we decided to compare the study population with three separate populations, the first being the general Dutch (reference) population, used for validation purposes of the SF-36 in the Netherlands.[19] The second population is a group of patients with surgical low back pain from a general spine practice (DDD only).[20] The third population is the group with multiple surgical low back pain diagnoses from the same study (herniated disc, central stenosis, DDD, spondylolisthesis, and lateral stenosis).

Statistical Analysis

A repeated-measure multivariate analysis of variance was used to identify changes over time. Because of missing data, sensitivity analyses were performed to determine the robustness of the findings and to estimate the degree and direction of potential confounding. Two methods for imputation were used: carry the last observation forward and imputing the individual preoperative values at each missing point. Data from the radiographic measurements were analyzed, and paired tests were performed when appropriate.

Results

Twenty-five patients (78%) were available for 10-year follow-up. One patient had died of unrelated causes (and was reported not to have complained about his low back pain

Table 1 Patient Characteristics

Patient Characteristics	10-y Follow-Up ($n = 25$)
Female:male	19:6 (76%)
L5-S1:L4–5	15:10 (60%)
Current age (range)	46 (37–62)
TLS:PS	23:2 (92%)

TLS, translaminar screws; PS, pedicle screw fixation.

after single-level fusion), and two patients were lost to follow-up. One patient was admitted to a psychiatric hospital and declined participation. One patient had a full-time working schedule and refused to take time off to visit the clinic for evaluation. One patient refused to take part without specifying the reason. One additional patient had to be excluded from the database because the surgical level (L2–3) was above the area of interest. Patient characteristics at 10-year follow-up are given in ►**Table 1**. Reoperations at 10-year follow-up consisted of seven procedures in three patients. One patient had the translaminar screws (TLS) removed at 4 years postoperatively due to recurrent low back pain and osteolysis around the TLS. Testing of the fused segment during the procedure showed a solidly fused segment. Screw removal improved her complaints. One patient had a combined adjacent segment decompression and TLS removal at 1 year due to persistent LBP and slight neurogenic claudication complaints. Subsequent intradiscal electrothermal annuloplasty and later an interspinous spacer (placed 5 years after the index procedure) did not result in relief of the persistent low back pain. One patient had a provocative discography and interspinous spacer placement two levels above the index level 8 years after the index procedure. The additional procedure improved her complaints. No other procedures were recorded. The partial loss of 2-year good results at 4 years has not progressed at 10 years. There is no significant difference between the VAS and ODI scores at 48 months and at latest follow-up, summarized in ►**Figs. 1** and **2**. Results at 10 years postoperatively are significantly better than preoperative scores. Preoperative ODI was 42.8,

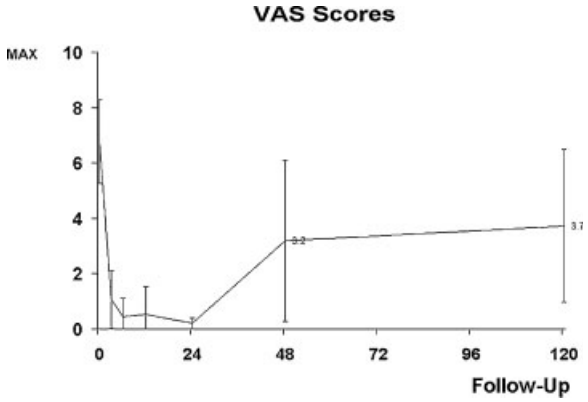

Figure 1 Visual analogue scale (VAS) scores of the study population during the 10-year follow-up.

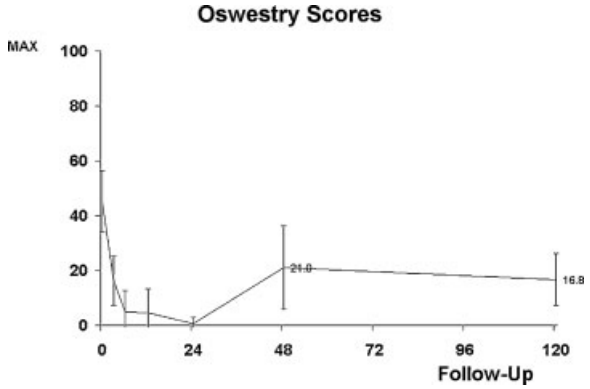

Figure 2 Oswestry Disability Index scores of the study population during the 10-year follow-up.

compared with 25.8 at 10-year follow-up. For the VAS, the preoperative score was 6.6 compared with 3.7 at 10-year follow-up. Radiological evaluation revealed no radiolucencies around the cage, subsidence of the cage, or screw breakage. Lordosis was maintained as in our 4-year report. No pseudarthrosis was documented. MRI findings are depicted in ►**Table 2**. Advanced disc degeneration was seen in 3/25 (12%) discs above the index level and 2/10 (20%) discs below the index level. Modic changes were noted only above the index levels. FJOA grade 3 was seen in 2/25 (8%) above the index level, and in 1/10 (10%) below. All appeared unilaterally. All appeared to have developed in the course between the 4-year follow-up and this 10-year evaluation. No significant correlation was found between the data regarding ASD (disc classification and FJOA) and either VAS or ODI scores. FJOA did not occur without disc degeneration. Regarding the data for the SF-36 as well as the relation between SF-36 and ODI scores, the results at this 10-year follow-up are favorable and are just slightly lower than the general Dutch population[19] (►**Table 3**).

Discussion

Fusion for low back pain is controversial because of contrasting outcomes in the literature.[11,12] Bono and Lee presented a review of the literature regarding the trends and effects of spinal fusion for DDD.[7] They concluded that spinal fusion has evolved from a more "biological" (less implants) to a more "technical" (more implants) procedure. Their review stated that although an increased use of implants was noted over two decades, there is no significant beneficial effect on either fusion rate or clinical outcome. Regarding ALIF, the fusion rate increased significantly, but there was no significant improvement in outcome. Fusion of the lumbar spine for painful DDD has shown to be effective. Short- to intermediate-term follow-up showed favorable results for surgical treatment compared with nonoperative management.[10,21] There are only limited data on long-term follow-up of spinal fusion. Results are in favor of circumferential fusion compared with posterolateral fusion.[18] Our preference for additional TLS instead of pedicle screw fixation (PS) is based on the provision

Table 2 Scoring ASD Above and Below Fusion Level

	Pfirrmann Class. (Grades 1–5)[16]	Modic Changes (Grades 1–3)[29]	FJOA (Grade 3)[17]
Above fusion ($n = 25$)	Grade 1:1	Grade 1:2	Left: 2
	Grade 2:0	Grade 3:1	
	Grade 3:21		Right: 0
	Grade 4:3		
Fusion level	N/A	N/A	N/A
Below fusion ($n = 11$)	Grade 1:1	All grade 0	Left: 1
	Grade 2:3		
	Grade 3:6		Right: 0
	Grade 4:1		

of similar fixation with less invasive and less patient morbidity.[22–24] Surgical procedure time for TLS in our hands is significantly less for TLS compared with PS. Also, during placement, in contrast to PS there is no interference with adjacent cranial facet joints that might account for residual or recurrent low back pain or influence the natural cause of FJOA. In our setting, the placement of two TLS is more economical than a single-level PS system (€27 versus €1690). Long-term outcome of TLS fixation of the lumbar spine is recently published. In this retrospective cohort study, no interbody support was used. The single most significant predictor of good outcome was reduced disc height (less than 80%). In our opinion, this can be explained by reduced motion at the intervertebral disc level, a situation comparable with placement of an interbody support.[25] In our first report, the advantages of ALIF with a titanium box cage and supplementary posterior fusion are extensively discussed, including restoration of lordosis and disc height and the maintenance of correction over time.

Subsidence is absent in our previous report, and correction is maintained over a prolonged period of time. Radiographic control at 10 years does not show any changes compared with 4-year follow-up at the fusion level, so correction of coronal and sagittal balance is stable 4 years after fusion. MRI findings show degenerative disc changes (greater than Pfirrmann grade 3) in three patients above and two patients below fusion level. Modic changes were noted only above the index levels. FJOA grade 3 was seen twice above the index level and once below, both unilaterally. Comparable to previous reports, FJOA did not occur in the absence of disc degeneration.[26,27] In our study, FJOA occurred with discs grade 3 and 4. FJOA is a gradual process and might take a long time to develop.[26] Whether FJOA grade 3 is a clinically relevant entity in low back pain is subject to debate. This is due to the innervation of the facet joints, which comes from two different levels, and because of nonspecific evidence regarding facet joint infiltrations.[28] We could not correlate these findings to the final results. Modic type 1 changes are related to low back pain.[17,29,30] Toyone describes disc degeneration as a decreased signal from both nucleus and inner annulus, resulting in loss of differentiation between both.[30] This description is comparable with Pfirrmann grade 4 and has been used previously.[16,17,31] Correlation between MRI-documented disc degeneration and symptomatic discogenic low back pain has been extensively discussed over the past years, concluding that there is a relation between Modic type 1 changes and low back pain, but Modic 1 changes may be present in asymptomatic individuals as well.[31–34] The role of discography as "gold standard" is a continuing subject of discussion, especially regarding the recent suggestion of its role in subsequent segment degeneration (Carragee, personal communication, ISSLS Miami, 2009). In our study population, the standard preoperative evaluation included both MRI and provocative discography with obligatory adjacent segment negative control. However, we did not find a significant correlation between degenerative changes at the adjacent

Table 3 SF-36 Results From This Study Compared with the Dutch Reference Population[19] and a General Spine Surgical Population[20]

	PF	RP	BP	GH	VT	SF	RE	MH
This study	64	53	54	71	63	76	76	78
Aaronson[19]	83	76	75	71	69	84	82	77
Zanolli-DDD[20]	30	4	18	56	30	43	28	57
Zanoli-mean[20]	37	10	26	61	39	55	36	62

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Reprinted from Zanoli G, Jönsson B, Strömqvist B. Acta Orthop 2006;77:298–306, with permission from Informa Healthcare.[20]
PF, physical function; RP, physical role; BP, bodily pain; GH, general health; VT, vitality; SF, social function; RE, emotional role; MH, mental health.

levels and relapse in symptoms (indicated by increased VAS and ODI scores). Unfortunately, no preoperative SF-36 was available. Follow-up scoring is limited to the VAS and ODI changes over time. We tried to evaluate general function 10 years after spinal fusion by comparing SF-36 score with the scores from the general Dutch reference population used to validate the Dutch version of the SF-36.[19] To evaluate our results, we compared these with a surgical low back pain population, a group described by Zanoli et al consisting of a heterogenous group of surgical spine patients.[20] The preoperative scores in that study were lowest in the DDD group in every domain of the SF-36. The DDD subgroup, used in ►**Table 3**, gives an indication of preoperative SF-36 scores. Scores and therefore functional capacity increase clearly after surgical treatment.

Reviewing our own observations, scores remained stable over the past 6 years. There has been extensive discussions about ASD, the type of fusion promoting accelerated adjacent degeneration, and the impact of radiological adjacent disc degeneration on general outcome measures.[22–24,35] Diagnoses used to describe a pathological process at an adjacent segment include listhesis, instability, nucleus herniation, spinal stenosis, FJOA, spondylophyte formation, vertebral compression fracture, and scoliosis. These observations are all preceded by disc degeneration. A recent review by Park et al illustrated the issue clearly and stated that a single explanation as to which factor is the key in adjacent degeneration is not identifiable.[15] Harrop et al concur with Park in clearly stating that radiological degeneration of a segment adjacent to a fused lumbar or lumbosacral segment might not be symptomatic.[36] They separate the (radiological) diagnosis of ASD and adjacent segment disease. Several factors are known to influence or promote (progressive) disc degeneration.[25] Normal loading, environmental influence (smoking), normal aging, and genetic influence are all factors that affect intervertebral discs at any level. Although spinal fusion poses increased loads to the remaining mobile segments, this seems not to be of major importance in the development of ASD.[35] Throckmorton et al and Herkowitz et al raise serious doubts about the clinical significance of ASD.[37,38] The results of our study regarding ASD are comparable to those of Cheh et al, who concluded that younger age, shorter segment fusion, and lower instrumented vertebra were factors related to less ASD.[39] Circumferential fusion, with any technique in their study, seemed not to influence the development of ASD. Our results do not support the contention that total disc replacement might prevent ASD more efficiently compared with fusion in the lower lumbar area.

Reviewing Harrop et al, ALIF has comparable ASD rates in literature to total disc replacement .[36] Wai et al reported recently that even after long-term follow-up, the development of ASD seems more related to constitutional factors than ALIF.[40] Whether total disc replacement will have a more favorable outcome than the study population at 10-year follow-up remains to be seen. No evidence exists that every degenerating lumbar disc is generating pain by itself.[41] No evidence has been presented to date to solely correlate radiographic ASD to functional lower scores. Normalization of sagittal balance, and thus optimizing discal loads, may minimize symptomatic degeneration in part.[10,20,30,31] Single-level spinal fusion reduces pain and subsequent disability caused by the operated level, but it will not stop or reverse the degenerative process at adjacent levels. We believe that the results as presented justify the use of this surgical technique and implant with favorable long-term results. A stable situation is reached at 4-year follow-up, and good clinical results are maintained for a prolonged period of time. Factors influencing partial loss of primary good functional results, such as patient-related (psychological) factors, are already discussed in the primary report and seem to be no significant influence on the long-term outcome. Symptomatic degeneration at adjacent levels does not influence good results in this study.

We conclude that single-level ALIF for symptomatic disc degeneration is a good alternative for nonoperative management with good long-term follow-up regarding ASD as well as functional capacity.

Disclosures
Philip P. Horsting, None
Paul W. Pavlov, Consultant: Synthes
Wilco C.H. Jacobs, None
Marina Obradov-Rajic, None
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