OUTCOMES OF SURGICAL TREATMENT OF ADJACENT SEGMENT DISEASE AFTER LUMBAR FUSION WITH LUMBAR I/F CAGES AND THE VARIABLE SCREW PLACEMENT SYSTEM

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Abstract

BACKGROUND CONTEXT: Radiographic changes of adjacent segment deterioration after lumbar fusion have commonly been reported in the literature. Symptomatic adjacent segment disease (ASD) requiring surgical treatment is less common. Clinical management of ASD is difficult, and in some cases surgery is indicated. The surgical treatment of adjacent segment stenosis or instability after lumbar fusion has been seldom addressed. In this study, posterior lumbar interbody fusion (PLIF) is applied as surgical treatment for symptomatic lumbar ASD.

PURPOSE: To report functional outcomes, radiographic fusion rates, further need for re-operation in the surgical treatment of ASD.

STUDY DESIGN/SETTING: This retrospective, single-arm cohort study of a community surgical practice evaluates ASD patients treated with PLIF.

PATIENT SAMPLE: Between 1999 and 2002, 44 patients underwent PLIF at an adjacent segment following a previous lumbar fusion. At more than three years, 34(77%) were available for follow-up.

OUTCOME MEASURES: Clinical outcomes were based on the modified Prolo score, evaluating pain, economic status, function and medication usage. Fusion success, on plain radiographs, was defined by continuous bone bridging the interbody and posterior-lateral fusion level, with no interrupting lucencies, on plain radiographs. The worst remaining adjacent level at the time of the index surgery was graded and compared to last follow-up. Lumbar lordosis, sagittal and coronal alignment was measured.

METHODS: Forty-four patients with previous lumbar fusion underwent second lumbar spine surgery for adjacent instability. All were treated with autogenous interbody and posterior-lateral arthrodesis and pedicle screw fixation in addition to decompressive laminectomy. Medical records and radiographs were reviewed, and final Prolo scores were obtained.

RESULTS: The clinical success was 88.2% with 55% rated as fair. Radiographic fusion success was 91.2%. After augmentation of the posterior-lateral fusion in three patients the fusion rate ultimately was 100%. One had revision of a displaced interbody cage. 18% had extension of fusion to adjacent levels. 43% had pedicle screw removal. 9% had non-device related complication including dural tear in one, post-operative seroma in two and one deep infection. The UCLA grades identified the worst adjacent degenerative level before the index adjacent level fusion averaged 1.3 and at last follow-up was average 2.4 with an average change of 1. The lumbar lordosis averaged 45 degrees (18-78 degrees). There were 14 (32%) with final lordosis below 40 degrees (average 30 degrees (18-39 degrees). The sagittal alignment was mildly abnormal in three (1.5 cm off plumb) and greater than 20 degrees scoliosis angulation from L1-S1 in two patients.

CONCLUSIONS: Adjacent segment disease may require surgical treatment when indicated for severe symptoms and loss of daily functional activities. Symptomatic ASD may be best treated with PLIF. When compared to previous series of treatment for ASD, PLIF gives comparable rates of clinical success and fusion success. When compared to our previous experience clinical success has more fair and poor results in ASD, and there is a statistically significant lower rate of fusion success in ASD.

Key words

PLIF (Posterior Lumbar Interbody Fusion)
PLF (Posterior-lateral Fusion)
Interbody fusion orthosis
Cage
Brantigan cage
Pedicle screw
Steffee plate
Adjacent segment degeneration
Adjacent segment disease
Intervertebral Disk/pathology/surgery
Lumbar Vertebrae/pathology/radiography/surgery
Postoperative Complications
Spinal Fusion/*instrumentation/*methods
Transitional Disease
Treatment Outcome

Introduction

Adjacent segment deterioration is commonly described after lumbar fusion. Adjacent segment deterioration includes the adjacent or second adjacent motion segment. The more common findings include disc degeneration, hypertrophic changes, multifactorial spinal stenosis; and instability. Adjacent segment disease (ASD) is the clinical syndrome characterized by Hillibrand as the development of new clinical symptoms correlating to the radiographic adjacent segment deterioration[20]. Although the development of adjacent segment deterioration is be a part of the normal aging process, this process may be accelerated by the altered mechanics that occur with lumbar fusion. Long-term studies of scoliosis and more limited lumbar fusion have suggested fusion increases degenerative changes at adjacent motion segments[13,16,20,26,28,30,35,38]. This radiographic deterioration may not be symptomatic[13,21,32]. In fact, in most series functional outcomes are largely unaffected by radiographic adjacent segment deterioration[2,13,14,16,23,28,30,32].

Surgical treatment of adjacent segment disease is not often required. Surgery is considered in ASD patients with radiographic deterioration and symptoms of back pain usually accompanied by radicular leg pain, not relieved by conservative measures. Surgical treatment of ASD is a form of revision spine surgery. The overall clinical success of revision spine surgery ranges from 60-80%[12,22]. The rate of fusion success in revision surgery is also less than primary results. This report identified 44 patients who had posterior lumbar interbody fusion (PLIF) at adjacent levels to a previous lumbar fusion for the indication of ASD. The purpose of this retrospective review is to report the clinical success, fusion success, need for further surgery, and complications of the surgical treatment of ASD.

Materials and Methods

In a single surgical practice from 1999 to 2002, 44 patients were identified by chart review as having undergone PLIF specifically for treatment of ASD. All had disabling back and/or radicular pain refractory to conservative management associated with adjacent segment deterioration on imaging. Demographic data were recorded, including age, gender, number and type of prior back surgeries, diagnosis, surgical levels, complications, re-operations including revisions. The Lumbar I/F cage and the Variable Screw Placement System have been previously described [7]. The surgical technique features autograft filled interbody cages and posterior-lateral fusion with pedicle screw fixation[6,7]. Exploration of adjacent previous fusion was done and if stable, hardware was removed.

Standard biplanar x-rays of the spine with flexion and extension views were reviewed of the pre-operative and last visit for each patient. The lateral x-ray was measured for inter-vertebral disc height, the anterior-posterior translation and angular motion of the vertebral bodies. Sagittal balance and lumbar lordosis were recorded. Radiographic evidence of instability was defined, as described by Wiltse and Winter, as >4 mm of translation or >10° of angular motion between adjacent end plates on lateral flexion and extension radiographs when compared with the adjacent cephalic and caudal levels[54]. A degenerative grade was assigned at each lumbar disc level at the pre-operative and last visit. The amount of lumbar degeneration was classified according to the University of California at Los Angeles grading scale as described by Ghiselli et al (Table 1) [15]. The worst adjacent segment was identified before the index surgery and followed to the last available radiograph.

Clinical success was defined according to previous published literature parameters used over many years and modeled after an expanded Prolo scale[6,7,40]. The 5-point Likert scales for pain, function, economic status, and medication usage are added to a combined 4- and 20-point scale[33]. This study defined a patient's result as a clinical success when the final rating was excellent (17 to 20 points) or good (13 to 16 points), or fair (9 to 12 points) if the patient achieved a minimum improvement of three points or more in the combined 20-point scale. Interviews of the patients by telephone were done, in order to obtain their final Prolo scores. At the time of the original Brantigan carbon fiber cage report in 1990, there was little agreement regarding optimum outcome measures in a spinal fusion study. To our knowledge, the Prolo Scale has not had a thorough examination of its statistical validity. In the original IDE and the ten-year follow-up, it has been shown that the Prolo Scale produces results that can be compared with literature reports over many years[6,7,40,47].

Fusion success within the interbody space was defined by previous published parameters of radiographic fusion assessment of Brantigan and Steffee[45]. Two observers evaluated the fusion from Ferguson anterior-posterior (AP) (parallel to the vertebral endplates), and lateral radiographs. A level was regarded as fused if there was radiographic evidence of bone bridging the disc space without lucency. If lucency was seen to extend across the cage, the level was considered not fused. The posterior-lateral fusion was graded by the method of Lenke et al[29]. Each level and each side was judged individually. Continuous bridging fusion mass on at least one side was considered fusion success at that level. For patients undergoing multiple-level fusion, all surgically treated segments must be fused for the patient to be considered a fusion success.

Results

The 44 patients in this study included 21 men (47.4%), age 39-78, mean 57, and 23 women (52.3%), age 51-83, mean 67. Of 44 patients, four were deceased and six could not be found. The remaining 34 (77%) included 15 men (71.4%) and 19 women (82.6%). The interval from previous surgery to the index ASD surgery was 79 months (7-377 months). The length of follow-up from the index ASD surgery was 77 months (36-112 months). The number of levels fused at the index ASD surgery was 1 level in 13, 2 levels in 19, and multiple levels in 12.

Clinical Outcomes.

30 of 34 (88%) patients achieved clinical success. Excellent scores (17-20) were achieved in 5 (15%), good scores (13-16) in 6 (18%), fair scores in 19 (56%) and poor in 4 (12%). The four patients with poor scores did not achieve clinical success. One required two augmentations of the posterior-lateral fusion.

Fusion Outcomes.

Initially after the index surgery and before additional surgical augmentation of the PLF, fusion success graded radiographically was 91% and pseudarthrosis was seen in 3/34 9%. The fusion success rate was ultimately 100%. The three pseudarthrosis patients required PLF augmentations in order to heal.

Radiologic Review.

The UCLA grades identified the worst adjacent degenerative level before the index adjacent level fusion averaged 1.3 (range 1-3) and at last follow-up was average 2.4 (range 1-4) with an average change of 1 (range 0-2). There were 3 grade 4 patients that had progressed from grade 1 or 2 to grade 4 by last follow-up. The lumbar lordosis averaged 45 degrees (18-78 degrees). There were 14 (32%) with final lordosis below 40 degrees (average 30 degrees (18-39 degrees). The sagittal alignment was mildly abnormal in three (1.5 cm off plumb) and greater than 20 degrees angulation from L1-S1 in 2 patients.

Further Surgery

Of 44 patients, there were 22 further operations in 20 patients (38%). One early revision for a displaced cage was required. 11 (18%) had extension of fusion to adjacent level and 19 (43%) had removal of pedicle screws.

Complications

One device related complication required removal of a retropulsed cage. There were no pedicle screw complications. Non-device related complications included one dural tear, two seromas that were culture negative, each requiring one debridement and primary closure, and one definite infection that required multiple debridements, long term antibiotics, and was reported to have hematogenously seeded the patient's hip, resulting in a girdlestone procedure.

Discussion

Incidence

Adjacent segment deterioration after lumbar fusion is of great concern and it accounts for a substantial amount of revision spine surgery. Although some of the progression of degeneration may be attributed to natural processes of aging, this process is influenced by the abnormal stresses that occur following lumbar fusion[3,11,13,14,48,50]. Natural deterioration risk factors for segment degeneration have been well described, including laminar inclination, facet sagittalization and tropism, increased age, osteoporosis, female gender and post-menopausal state[5,13,19,33,51]. Several studies have found no statistical relationship to the length of fusion or the presence of degeneration of the adjacent segment prior to the surgery[14,35,36]. Park concluded radiographic asymptomatic adjacent segment disease is common but does not predict poor outcomes[36]. Others have related increased incidence of ASD with complete laminectomy, multiple fusion levels, severe degenerative spondylosis, facet trophism or violation by pedicle screw, failure of restoration of sagittal balance and lordosis, and extension of fusion to the sacrum[15,17,24,25,43]. At 5-10 years following lumbar fusion radiographic adjacent segment deterioration is commonly 30-60% and clinically symptomatic adjacent segment disease is 10-20%[6,14,30,32].

Biomechanics

Biomechanical studies have shown that lumbar fusion produces increased motion and increased intradiscal pressure at the adjacent levels[9-11,18,27,31,41,44,49,52]Two clinical radiographic analyses of posterior fusion patients also has shown an increase in mobility of the free segments above a fusion [13,46], while Pellise et al found no change at two adjacent motion segments[37]. The importance of sagittal realignment and maintenance of lordosis during fixation have been documented in clinical studies, and clinical experience suggests that lumbar fusion in a nonanatomic sagittal alignment can cause a deleterious effect at the adjacent level[1,34].

Results of Surgical Treatment

Whitecloud et al. reported 58% clinical success and 83% fusion success with noninstrumented posterior-lateral fusion[53]. Most had only modest improvement in pain with continued need for narcotic medication[53]. Schlegel et al. reported 70.3% clinical success, 89.2% fusion success with noninstrumented posterior-lateral fusion, and 19% required further surgery [42]. Phillips et al. reported 80.8% clinical success, 86.4%, fusion success with non-instrumented posterior-lateral fusion, and 27% re-operation rate [39]. Chen et al. reported successful clinical success in 76.9% and fusion success in 94.9% of instrumented posterior-lateral fusion [8]. Bertagnoli et al. report clinical success at 86% for treatment of ASD with artificial disc[4]

Clinical success

A comparison of clinical success in this ASD group (88.2%) was not statistically different to the Brantigan et al IDE study (85.9%)[7] and 10 year follow-up (87.9%)[6] as well as Chen et al (76.9%)[8], Schlegel et al(70.3%)[42], and Phillips et al (80.8%)[39], although this ASD group had significantly more poor and fair Prolo scores compared to those of both of the Brantigan IDE (chi square= 20.49, p-value=0.0216) and 10 year follow-up (chi square= 4.276,p-value =0.0387).

Fusion Success

The fusion success was statistically significantly less in the ASD group (91.2%) than in the Brantigan IDE study (98.9%) (chi square= 7.3497, p-value=0.0067) but was not significantly different compared to the 10 year follow-up (96.7%) (chi square= 0.8199, p-value=0.3652) or to series from the literature that used non-instrumented fusion and Chen et al (94.9%) who used instrumented fusion.

Need for further surgery

Further surgery (38%) was statistically less compared to the Brantigan 10 year follow-up (69%) (chi square= 6.6656, p-value=0.0098) and significantly greater than Chen et al (5%) (chi square= 12.1952, p-value=0.0005), but not different than the Brantigan IDE (46%), and Phillips et al. (27.3%).

Conclusion

Adjacent segment deterioration should be considered a long term complication of lumbar fusion[36]. Clinical management of symptomatic ASD is difficult. When surgical treatment is elected for ASD, PLIF will result in clinical and fusion success similar to the original lumbar fusion.

Table 1: University of California at Los Angeles Disc degeneration grading scale[15]

Grade	Disc-Space Narrowing	Osteophytes	End Plate Sclerosis
I	-	-	-
II	+	-	-
III	+	+	-
IV	+	+	+

*The assigned grade was based on the most severe radiographic finding evident on plain radiographs. These categories are mutually
exclusive when used for grading. Patients were rated on the basis of the worst category satisfied. + = present, - = absent, and ± = either
present or absent.

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