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Adjacent Segment Disease After Lumbar Spinal Fusion: A Systematic Review of the Current Literature

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The objectives are to comprehensively define adjacent segment disease; highlight advances in the approach to spinal disorders, present the identified risk factors; examine outcomes; and summarize current recommendations. The literature supports previous degeneration and altered biomechanics of the spine as causes of adjacent segment disease. Excessive facet degeneration is a risk factor. Clinical outcome scores show improvement irrespective of procedure type. The number of spinal segments fused, fusion level, and age yield conflicting reports regarding their contribution to adjacent segment disease. Arthroplasty, dynamic stabilization, and interspinous process implants are effective in decreasing incidence.
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KEYWORDS adjacent level degeneration, adjacent segment degeneration, adjacent segment disease, lumbar fusion, spine

Lumbar fusion has increasingly become a standard treatment modality for numerous spinal disorders during the past few decades.[1,2] The indications for lumbar fusion range from segmental instability because of spondylolisthesis to neurologic impairment and trauma.[1,3-8] Among the many indications, degenerative spinal disorders have been cited as the most common indication for spinal fusion[8] (Table 1). Although lumbar spinal fusion has yielded good clinical results in decreasing pain and fatigue with high union rates,[7,9-13] it has also been associated with an increased incidence of adjacent segment disease (ASD).[14] This fusion-degeneration cycle poses an interesting dilemma for spine surgeons and has sparked debate on both the etiology of ASD as well as the appropriate management of spinal disease. For spine surgeons and patients alike, the development of ASD is problematic because it often requires reoperation and has adverse effects on long-term clinical outcomes.[15] As a result, the initial favorable results after a spinal fusion frequently degrade over time.[2] This phenomenon has drawn even more attention as the number of spinal fusion procedures being performed on younger patients has been increasing.[1]

The purpose of this review is to define the problem of ASD, discuss the risk factors for developing ASD, and summarize the current recommendations for management of ASD.

Defining ASD

Understanding the etiology of ASD is complicated by the fact that there is no consensus on its definition. The term *adjacent segment disease* has been used in many cases to cover a number of diagnostic entities. Clinically, the various working definitions of ASD have led to inconsistent reporting of the incidence and prevalence. This has limited the ability to effectively translate outcomes data into evidence-based guidelines for clinical decision making.[4]

Lee et al[6] defined ASD on the basis of 3 factors: the length of time (minimum of 6 months) for which the patient showed symptom relief after surgery, the correlation of the newly developed clinical findings with radiographic pathology, and the need for revision surgery for the problem. Harrop et al[16] further distinguished adjacent segment disease (ASDis) from adjacent segment degeneration (ASDeg). ASDis is defined as "the development of clinically symptomatic junctional degeneration," whereas ASDeg is "the radiographic presence of disc deterioration adjacent to the surgically treated disc, without symptoms." They further note that the literature sometimes combines ASDis and ASDeg under the term adjacent segment deterioration (ASDet).[17] In a goat spinal fusion study conducted by Hoogendoorn et al,[14] ASDeg was considered "degeneration of the motion segment developing above or below another fused spinal segment". Korovessis et al[3]

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Table 1 Indications for Lumbar Fusion

• Degenerative spinal disease
• Spondylolisthesis
• Persistent severe back pain
• Neurologic impairment
• Trauma
• Disk herniation
• Discogenic pain
• Spinal stenosis
• Segmental instability
• Revision surgery

considered nearly any abnormal process developing in the mobile segment adjacent to a spinal fusion to be an instance of ASDeg.

Other studies used more specific postoperative complications to define ASDeg. These complications included accelerated disk degeneration, disk height narrowing of more than 2 mm, decreased lordosis or increased kyphosis of more than 5 degrees, herniation of the nucleus pulposus, acquired spondylosis, segmental instability, spinal stenosis, spur formation, translation of more than 2 mm, spondylolisthesis, retrolisthesis, sclerosis of the adjacent endplate, and arthritis of the posterior facet joints.[9,18,19]

Several studies have made distinctions in terminology by classifying radiographic versus clinical ASD. Radiographic ASD has been diagnosed by using plain radiographs, computed tomography (CT) scans, and magnetic resonance imaging (MRI) and defined by many varying parameters, which include the development of spondylolisthesis >3-4 mm, retrolisthesis >4 mm, a decrease in disk height by more than 3 mm or 10%, complete collapse of the disk space, angle change >10° between adjacent vertebral bodies on flexion and extension radiographs, segmental kyphosis >10°, intervertebral angle at flexion <-5°, hypertrophic facet joint arthropathy, osteophyte >3 mm, scoliosis, compression fracture, or deterioration in the Weiner classification of 2 or more grades. Clinical or symptomatic ASD has been defined in the literature as an isolated decrease of 4 points or more on the Japanese Orthopaedic Association scale, symptomatic spinal stenosis, intractable back pain, or subsequent sagittal or coronal imbalance with accompanying radiographic changes as determined by comparison of preoperative and postoperative images.[5,2,15,20]

Other terms have also been used to qualify adverse effects of spinal fusion at adjacent segments. Glassman et al[4] used the term *adjacent level degeneration* to describe both those cases with adjacent level spondylolisthesis and those cases where there was adjacent level stenosis without radiographic instability but required an extension of the segments fused. Alternatively, Schulte et al[7] used quantitative disk height reduction (DHR) as a measure of ASD.

It is evident from a review of the literature that there is a variety of terms to describe the phenomenon of ASD. In this review, we will refer to these phenomena collectively as ASD and specify the parameters used for each study reported.

Epidemiology

There have been many studies that have chronicled the prevalence and incidence of ASD. Park and associates found that radiographic ASD occurred at a rate of 8%-100%, whereas symptomatic ASD occurred at a considerably lower rate, ranging from 5.2%-18.5%.[21-28] In a review conducted by the National Institute for Health and Clinical Excellence (NICE) in the United Kingdom, 27 case series were examined that included 2490 patients. The incidence of adjacent level degeneration was 14% in those treated with lumbar fusion.[29] In another NICE report on lateral interbody fusion of the lumbar spine, adjacent level degeneration was reported in 1 patient out of 20 cases (5%).[8] Etebar and Cahill[30] followed patients for an average of 4 years, during which time 14% developed symptomatic ASD. Ishihara et al[31] followed patients for a longer period. They found radiographic ASD in the upper adjacent level in 52% of their patients and found ASD in the lower adjacent level in 70% of their patients. In a study designed to assess the relationship between ASD and fusion length, Penta et al[32] found ASD in 32% of their patients. Notably, this rate of ASD was not influenced by the length of the fusion performed.

More recently Lee et al[6] performed a review of 1069 patients who underwent either instrumented lumbar or lumbosacral fusions for the treatment of degenerative conditions who were followed for at least 1 year postoperatively. Of these patients, 28 (2.62%) underwent a required revision procedure as a result of the development of ASD. D. Y. Lee et al[19] saw differences in the incidence of ASD above compared with below the level of fusion. In their study of 24 patients who underwent two-level anterior lumbar interbody fusion (ALIF) with percutaneous pedicle screw fixation (PSF), 8 of 24 patients (33%) developed ASD after 3-year follow-up. Furthermore, the ASD was in the cephalad segment in all 8 cases.

Cheh et al[2] evaluated 188 patients for a minimum of 5 years after posterior fusion with PSF. They found differences in ASD outcomes dependent on whether a radiographic or clinical definition was used. In this study, radiographic ASD occurred in 43% of patients, half of whom had evidence of clinical ASD. Thirty percent of the patients in the study group had clinical ASD, with only 21% having any radiographic criteria for ASD. This study demonstrates that most patients with clinical ASD have radiographic ASD, whereas most patients with radiographic ASD do not exhibit any signs of clinical ASD. Given such divergence in the literature, the rate of occurrence of ASD remains unpredictable.

Methods of Literature Review

To conduct this literature review, the PubMed search engine was used to search for clinical studies, review articles, and abstracts by using the key words "adjacent level disease," "adjacent segment disease," "adjacent level degeneration," "degeneration after spinal fusion," "degeneration after lumbar spinal fusion," "adjacent level disease after lumbar spinal fusion," "adjacent level degeneration spine," and "adjacent