

# A Brief Analysis of Degenerative Lumbar Spinal Stenosis and its Associated Variants in Relation to Specific Surgical Corrections

Mario Carvi Nuevas<sup>1,2,3\*</sup> and Eleftherios Archavlis<sup>1,2,4</sup>

<sup>1</sup>Interdisciplinary Spine Centre and Department of Neurosurgery, Elisabethen Hospital, Frankfurt, Germany

<sup>2</sup>European University Cyprus, School of Medicine, Frankfurt Branch, Germany

<sup>3</sup>J. W. Goethe University, Frankfurt, Germany

<sup>4</sup>IU University of Applied Sciences, Germany

**\*Corresponding author:** Mario Carvi Nuevas, Interdisciplinary Spine Center and Department of Neurosurgery, Elisabethen Hospital, European University Cyprus, School of Medicine, J. W. Goethe University, Frankfurt, Germany.

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## Introduction

Although the pathophysiology and the clinical signs and symptoms that lead to surgical intervention in patients with degenerative lumbar spinal stenosis (LSS) are now well established, the selection of the most appropriate surgical technique for each individual case remains a matter of debate. This is largely due to the multifactorial nature of the pathological changes that must be addressed surgically.

Importantly, this does not imply that initial management should necessarily be operative; rather, treatment with analgesics and anti-inflammatory medications, structured physical therapy, and weight reduction when indicated may allow surgery to be reserved for patients in whom these and other conservative measures have failed. Historically, LSS began to be recognized as a distinct clinical entity between the 1940s and 1960s. During this period, the predominant surgical approach consisted of extensive laminectomies, often including partial or complete resection of the facet joints. In many cases, this resulted in severe biomechanical compromise and poor long-term outcomes.

During the 1970s and 1980s, it became increasingly evident that extensive facet resection could induce iatrogenic instability. This recognition led to the adoption of lumbar arthrodesis combined with wide decompression in selected cases. Concurrently, more

selective surgical strategies emerged, supported by the description of the Kirkaldy-Willis degenerative cascade, which defined three functional stages of degeneration: dysfunction, instability, and restabilization. From the 1990s onward, surgical philosophy shifted toward preservation of the facet joints whenever feasible, reserving facetectomy for specific indications such as severe foraminal stenosis or associated spondylolisthesis. This paradigm facilitated the development of minimally invasive, microscopy-assisted decompression techniques. Nevertheless, despite improved postoperative outcomes, careful preoperative analysis remains essential to identify the specific anatomical components responsible for the patient's symptoms and to determine which of these require definitive surgical correction.

The clinical presentation of LSS typically includes several characteristic features, particularly in older adults. The hallmark symptom is neurogenic claudication, manifested by pain, heaviness, cramping, paresthesia, or weakness in the buttocks and/or lower extremities. These symptoms are precipitated by walking or prolonged standing and relieved by sitting or spinal flexion, often causing patients to adopt a forward-leaning or stooped posture. Neurogenic claudication is frequently accompanied by chronic mechanical low back pain, which tends to worsen with lumbar extension and may coexist with segmental instability, facet

arthropathy, or other degenerative conditions. Radicular symptoms radiating to one or both lower extremities are also common and reflect compression of one or more nerve roots. These may be associated with sensory deficits, motor weakness, and diminished or absent deep tendon reflexes. In advanced cases, and depending on the extent and nature of the compressive pathology, sphincter dysfunction, with or without sexual dysfunction, may occur, although this is relatively uncommon.

Regardless of clinical presentation, all radiographic and magnetic resonance imaging (MRI) studies should be systematically assessed to characterize the components and stages of degeneration. Key elements include the degree of disc bulging or protrusion; the presence and extent of segmental instability; hypertrophy of the facet joints and ligamentum flavum; the site of maximal stenosis (central canal or lateral recess); the direction and vector of compression (anterior, posterior, or circumferential); spontaneous fusion of the affected segment; the presence and grade of associated spondylolisthesis (with or without compensatory fusion); intraforaminal nerve root compression due to soft disc herniation or osteophytic encroachment; coexisting scoliosis with radicular symptoms; and associated pathologies such as synovial cysts or other space-occupying lesions within the spinal canal.

In surgical planning, it is also essential to consider the complex innervation of the lumbar spine, which involves three principal neural systems that may be variably affected by degenerative and compressive processes. These include the dorsal rami of the spinal nerves, which exit the neural foramina and innervate posterior elements such as the facet joints, ligamentum flavum, supraspinous and interspinous ligaments, paraspinal musculature, and adjacent dorsal skin; the sinuvertebral nerve of Luschka, formed by branches of the anterior spinal nerve and the sympathetic chain, which supplies the dura mater, posterior longitudinal ligament, and posterior annulus; and the ventral sympathetic rami, which innervate the anterior longitudinal ligament and the anterior and lateral portions of the intervertebral disc.

Only through integration of this anatomical, radiological, and clinical information can an appropriate surgical strategy be selected, tailored to the specific pathological mechanisms present in each patient. Among contemporary techniques, one of the most commonly employed is the **undercutting technique**, which consists of selective microscopic bony decompression achieved by bilateral milling of the inner surfaces of the laminae and facet joints. This approach enlarges the spinal canal while preserving the integrity and stability of the posterior elements. It can also be safely applied in patients with grade I spondylolisthesis according to the Meyerding classification, provided that functional imaging confirms spinal stability and that careful decompression of the lateral recesses is performed at the level of the listhesis step, which may represent an additional source of neural compression.

Interspinous devices, which were previously promoted as forms of “dynamic stabilization” and intended to increase the spinal canal diameter, have gained popularity in the past. However, there is insufficient evidence to demonstrate that these implants

provide meaningful benefit beyond conventional decompression or that they offer significant segmental stabilization. When additional compressive or stress-related factors are present (such as focal disc protrusion, extrusion of nuclear material through an annular tear, or synovial fluid collections arising from adjacent arthritic zygapophyseal joints), targeted treatment of these lesions is necessary to achieve optimal surgical outcomes. In all cases, the surgeon should strive to preserve the functional integrity of the treated segment and limit fusion procedures to those situations in which they are clearly indicated. Prophylactic fusion in the absence of true instability frequently leads to accelerated degeneration of adjacent segments, often necessitating subsequent fusion surgeries and, in some cases, multiple reoperations.

For this reason, even in patients with posterior arch stenosis associated with medial disc protrusion (referred to by some authors as circumferential compression), a less aggressive resection of the laminae and spinous processes may be preferable. Avoiding disc removal when osteophytic remodeling is sufficient to prevent postoperative reherniation may further enhance postoperative stability. When the compressive vector is attributable to a soft, subligamentously sequestered disc causing significant anterior compression, but without evidence of segmental instability (regardless of the presence or absence of cauda equina dysfunction), preservation of the posterior support pillar through minimally invasive techniques becomes particularly important. In such cases, disc excision can often be performed without the need for supplemental instrumentation and fusion.

These patients may be candidates for **unilateral biportal endoscopic decompression (UBED)**, with or without discectomy. This technique has demonstrated efficacy even in cases of cauda equina syndrome and may be limited to decompression alone or supplemented, when indicated, with endoscopic lumbar fusion.

In selected cases, a hybrid approach combining **oblique lumbar interbody fusion (OLIF)** with complete endoscopic decompression of the spinal canal can also be effective in treating LSS associated with nucleus pulposus prolapse. Another effective alternative is the **contralateral biportal sublamina endoscopic approach**, which is particularly useful in LSS associated with contralateral foraminal and extraforaminal stenosis. This technique allows for the resection of prominent osteophytes, juxtafacet cysts, and associated foraminal disc herniations.

When spinal canal stenosis and disc protrusion are accompanied by spondylolisthesis with established or potential instability, decompression combined with fusion is indicated, using either microscopic or endoscopic techniques according to surgeon expertise and patient-specific factors. In patients with lumbar scoliosis associated with LSS and intraforaminal disc herniation at the apex of the deformity, **minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF)** represents a valuable option. This approach addresses the foraminal and disc pathology, alleviates stenotic symptoms, and may contribute to partial correction or stabilization of the scoliotic deformity. Finally, it must be emphasized that lumbar spinal canal stenosis (whether

central or involving the lateral recess) constitutes an absolute contraindication to prosthetic disc replacement, as implantation of a mobile disc device does not increase the axial cross-sectional area of the lumbar spinal canal.

### **Acknowledgement**

None

### **Conflict of Interest**

No Conflict of Interest.