Clinical Practice Guidelines for the Minimally Invasive Treatment of Lumbar Spinal Stenosis: A Postprint Interpretation of the 2022 American Society of Pain and Neuroscience Guidelines

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Abstract

Lumbar spinal stenosis (LSS) is one of the common diseases in orthopedics. To improve the clinical efficacy of minimally invasive treatment for LSS, the American Society of Pain and Neuroscience (ASPN) published a new version of practice guidelines for minimally invasive treatment of LSS in 2022. The guidelines included a total of 7 LSS treatment methods—percutaneous image-guided lumbar decompression (PILD), interspinous spacers (ISP), interspinous fusion (ISF), intrathecal drug delivery systems (IDDS), spinal cord stimulation (SCS), epidural steroid injection (ESI), and open decompression. Based on these guidelines and combined with actual clinical situations, this article reflects on and discusses the research progress in minimally invasive treatment of LSS, aiming to provide a reference for clinicians and further related research.

Full Text

Preamble

Interpretation of Best Practices for Minimally Invasive Lumbar Spinal Stenosis Treatment 2.0 (MIST): Consensus Guidance from the American Society of Pain and Neuroscience (ASPN) in 2022

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Abstract

Objective: Lumbar spinal stenosis (LSS) is a common orthopedic condition. To improve clinical outcomes of minimally invasive LSS treatment, the American Society of Pain and Neuroscience (ASPN) published updated practice guidelines in 2022. The guidelines encompass seven LSS treatment modalities: percutaneous image-guided lumbar decompression (PILD), interspinous spacers (ISP), interspinous fusion (ISF), intrathecal drug delivery systems (IDDS), spinal cord stimulation (SCS), epidural steroid injections (ESI), and open decompression. This article provides critical analysis and discussion of research advances in minimally invasive LSS treatment based on these guidelines and clinical realities, aiming to serve as a reference for clinicians and future research.

Keywords: Lumbar spinal stenosis; Neurologic manifestations; Minimally invasive treatment; Guidelines interpretation

Introduction

Lumbar spinal stenosis (LSS) is classified as primary or secondary based on etiology, with secondary LSS being most common in clinical practice. Secondary LSS is a prevalent condition among middle-aged and elderly patients, causing low back pain, leg pain, and functional limitations [1]. Epidemiological estimates indicate a prevalence of approximately 11% in the general population, rising to 47% in those over 60 years of age [2,3]. LSS represents the most common indication for spinal surgery in patients over 65. While traditional open decompressive surgery demonstrates good efficacy, it carries significant drawbacks including extensive spinal structure damage, substantial blood loss, slow recovery, persistent postoperative low back pain, and high costs. In recent years, evolving minimally invasive concepts and technologies have gained increasing acceptance among both patients and physicians.

In 2022, the American Society of Pain and Neuroscience (ASPN) released updated minimally invasive treatment practice guidelines for LSS [3] (hereinafter referred to as "the guidelines") to provide contemporary treatment protocols and enhance therapeutic outcomes. The guidelines adopt the evidence grading and certainty levels established by the United States Preventive Services Task Force (USPSTF) (Table 1 and Table 2), combined with expert consensus to establish best practice recommendations.

LSS is defined as a condition where congenital or acquired factors cause abso-

lute or relative narrowing of the lumbar spinal canal, leading to compression of the cauda equina or nerve roots and resulting in a spectrum of neurological dysfunction. In 1954, Dutch neurologist VERBIEST [4] proposed quantitative criteria for LSS that remain widely accepted: spinal canal diameter $ $12 mm indicates relative stenosis, while $ $10 mm indicates absolute stenosis. Based on anatomical structures, LSS is primarily categorized as central canal stenosis, lateral recess stenosis, or foraminal stenosis. Patients with isolated central canal stenosis typically present with neurogenic claudication (NC), characterized by unilateral or bilateral low back pain, leg pain, numbness, heaviness, or weakness that manifests during upright walking or lumbar extension and improves with rest or lumbar flexion. Patients with isolated lateral recess stenosis primarily exhibit sensory abnormalities, muscle weakness, or diminished reflexes corresponding to specific nerve root compression. Foraminal stenosis may present with lower extremity sensory deficits, muscle weakness, diminished or absent reflexes, and positive straight leg raise tests.

The guidelines include seven LSS treatment modalities: percutaneous image-guided lumbar decompression (PILD), interspinous spacers (ISP), interspinous fusion (ISF), intrathecal drug delivery systems (IDDS), spinal cord stimulation (SCS), epidural steroid injections (ESI), and open decompression. Based on comprehensive review of the guidelines and clinical realities, this paper critically examines research advances in minimally invasive LSS treatment to inform clinical practice and future investigations.

USPSTF Evidence Grading System

Table 1 Meanings and practice recommendations of USPSTF recommended grades

Grade	Meaning	Practice Recommendation
A	High certainty that the intervention has substantial net benefit	Recommend this intervention
B	High certainty of moderate net benefit, or moderate certainty of moderate to substantial benefit	Recommend this intervention

Grade	Meaning	Practice Recommendation
C	Selectively offer this intervention to appropriate patients based on professional judgment and patient preferences. Moderate certainty of small net benefit	Selectively recommend based on individual circumstances
D	Moderate to high certainty that the intervention has no benefit or that harms outweigh benefits	Do not recommend this intervention
I Statement	Insufficient evidence to assess balance of benefits and harms. Evidence is lacking, of poor quality, or conflicting; balance cannot be determined	Read "Clinical Considerations" in USPSTF recommendation statements. If offering this intervention, patients should understand the uncertainty regarding benefit-harm balance

Table 2 USPSTF certainty levels on net benefits

Certainty Level	Description
High	Available evidence typically includes consistent results from multiple well-designed, well-conducted studies in representative primary populations, evaluating the effect of preventive interventions on health-related outcomes. Future research is unlikely to substantially alter the conclusion. Evidence level: I-A—At least one randomized controlled trial
Moderate	Available evidence is insufficient to determine the effect of the preventive intervention on health-related outcomes, with limited certainty due to: (1) Number, sample size, or quality of studies; (2) Inconsistent results; (3) Limited generalizability to routine primary care practice; (4) Lack of coherence in the evidence chain. Additional information may change the observed effect strength or direction sufficiently to alter conclusions. Evidence level: I-B—Observational clinical studies following STROBE guidelines (case-control studies); I-C—Retrospective cohort or large case series (>20 participants)

Certainty Level	Description
Low	Available evidence is insufficient to evaluate effects on health-related outcomes due to: (1) Limited number of studies; (2) Major flaws in study design or methods; (3) Inconsistent results; (4) Gaps in the evidence chain; (5) Lack of generalizability to routine primary care practice; (6) Lack of information on important health-related outcomes. Additional information may enable estimation of health-related outcomes. Evidence level: II—Expert opinion based on case reports

Note: USPSTF defines certainty as "the likelihood that the USPSTF assessment of net benefit for a preventive service is correct." Net benefit is defined as the difference between benefits and harms when a preventive intervention is applied to a general primary prevention population. USPSTF determines certainty levels based on all evidence regarding net benefit assessment.

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2. Treatment Modalities

2.1 Percutaneous Image-Guided Lumbar Decompression (PILD)

PILD is recommended for patients with central canal LSS presenting with NC symptoms and ligamentum flavum hypertrophy $ $2.5 mm. Recommendation grade: A; Certainty level: High; Evidence level: I-A.

PILD is a highly effective, low-risk, minimally invasive lumbar decompression procedure performed under imaging guidance through a small percutaneous incision. It involves partial removal of the lamina and ligamentum flavum at the stenotic level, preserving lumbar mobility and reducing pain while avoiding general anesthesia, large incisions, or internal implants. Multiple studies have demonstrated PILD' s efficacy and safety in treating central canal LSS caused by ligamentum flavum hypertrophy.

BROWN [5] conducted the first randomized controlled trial (RCT) of PILD for LSS in 2012, randomly assigning 38 LSS patients to PILD or lumbar ESI. At 12-week follow-up, the PILD group showed significantly greater improvement

in Oswestry Disability Index (ODI), Zurich Claudication Questionnaire (ZCQ), Visual Analogue Scale (VAS) scores, and patient satisfaction, with no adverse events. A 2016 RCT of over 300 patients with central canal LSS due to ligamentum flavum hypertrophy similarly demonstrated PILD' s superiority over ESI at 1- and 2-year follow-up [6]. A recent prospective RCT comparing PILD combined with conventional medical management (CMM) (including physical therapy, analgesics, ESI, facet joint blocks and ablation, back braces, walkers, and chiropractic manipulation) versus CMM alone showed superior outcomes for the combined approach at 6 months, with no adverse events [7].

Regarding age effects on PILD efficacy, the guideline development committee conducted pooled statistical analysis of 4 high-quality studies selected from 149 existing studies, finding no correlation between patient age and PILD outcomes. A critical concern is whether severe lumbar degeneration or extreme canal narrowing, which may preclude epidurography, affects PILD safety. POPE et al. [8] retrospectively studied 147 PILD patients, finding that although some patients could not undergo epidurography at the operative site, no adverse events occurred, demonstrating that PILD can be safely performed without epidurography.

2.2 Interspinous Spacers (ISP)

For patients with mild to moderate stenosis and spondylolisthesis ≤Grade I, ISP is recommended when imaging shows 25%-50% reduction in central canal and/or foraminal diameter compared to adjacent levels, with any of the following: (1) dural sac/cauda equina compression, (2) nerve root compression, or (3) facet joint hypertrophy causing canal encroachment. Symptomatic criteria include: (1) ZCQ score $ $2 indicating moderate functional impairment, and (2) ability to sit $ $50 minutes or walk $ $50 feet without pain. Recommendation grade: A; Certainty level: High; Evidence level: I-A.

ISP implantation between spinous processes limits extension while allowing flexion, increasing cross-sectional area of the spinal canal and neural foramina to relieve NC symptoms. Biomechanical studies confirm ISP' s efficacy in increasing canal area and reducing intracanal pressure [9]. ZUCHERMAN et al. [10] conducted a multicenter prospective RCT evaluating the X-STOP interspinous process decompression system for neurogenic intermittent claudication, demonstrating significant symptom improvement at 2-year follow-up. However, ISP is contraindicated in patients with spondylolisthesis >Grade I, spinal instability, osteoporosis, or previous surgery at the index level.

2.3 Interspinous Fusion (ISF)

For patients with mild to moderate LSS and spondylolisthesis ≤Grade II, ISF is recommended when imaging shows 25%-50% reduction in central canal and/or foraminal diameter compared to adjacent levels, with dural sac/cauda equina compression, nerve root compression, or facet joint hypertrophy causing canal

encroachment. Symptomatic criteria include ZCQ score $ $2 and ability to sit $ $50 minutes or walk $ $50 feet without pain. Recommendation grade: B; Certainty level: Moderate; Evidence level: I-B.

ISF provides both decompression and stabilization, particularly suitable for LSS with degenerative spondylolisthesis. KIM et al. [11] reported preliminary 1-year follow-up results comparing ISF with pedicle screw fixation for degenerative lumbar disease, finding similar clinical outcomes with shorter operative time and less blood loss in the ISF group. POSTACCHINI et al. [12] conducted a prospective study proving that ISF combined with minimally invasive decompression provides fusion for most LSS patients with degenerative spondylolisthesis, with significant outcome improvements and no instability at 2-year follow-up. A multicenter RCT of 122 LSS patients comparing ISF with decompression versus decompression alone showed superior composite endpoints (ODI, secondary surgery/injection, neurological status, adverse events) for the ISF group at 2-year follow-up, with the decompression-only group more likely to require secondary intervention [13]. However, no prospective RCTs have evaluated ISF as a standalone treatment for LSS, limiting evidence for its independent use.

2.4 Intrathecal Drug Delivery Systems (IDDS)

For LSS patients with chronic pain refractory to medication management and other interventions, IDDS is a viable option. Recommendation grade: B; Certainty level: Moderate; Evidence level: I-B.

IDDS delivers analgesic medications directly to the intrathecal space, providing effective pain control for chronic refractory pain. The Polyanalgesic Consensus Conference (PACC) provides recommendations for IDDS best practices and guidelines [14]. HAYEK et al. [15] reported optimized combination therapy with intrathecal hydromorphone and bupivacaine for post-laminectomy syndrome using patient-activated bolus devices. GRIDER et al. [16] conducted a prospective 36-month study on low-dose intrathecal opioid trialing and maintenance dosing for chronic nonmalignant pain, demonstrating long-term efficacy. However, IDDS requires careful patient selection and management due to risks of infection, catheter malfunction, and medication side effects.

2.5 Spinal Cord Stimulation (SCS)

For patients with intractable pain including LSS-related low back and leg pain, chronic postoperative pain, complex regional pain syndrome types I and II, chronic radiculopathy, and peripheral neuropathy, SCS is recommended. Recommendation grade: B; Certainty level: Moderate; Evidence level: I-B.

SCS delivers electrical stimulation to the spinal cord dorsal columns, modulating pain signal transmission. Chinese expert consensus indicates SCS efficacy for chronic pain [17]. DUARTE et al. [18] systematically reviewed randomized placebo/sham-controlled SCS trials, highlighting methodological considerations.

COSTANTINI et al. [19] demonstrated SCS efficacy for chronic pain in LSS patients. KAMIHARA et al. [20] specifically evaluated SCS for leg pain associated with LSS, showing significant pain reduction. However, SCS requires careful patient selection and may be contraindicated in patients with uncontrolled psychiatric disorders, inability to comply with treatment, or systemic/local infection.

2.6 Epidural Steroid Injections (ESI)

ESI is recommended for degenerative LSS, particularly central or lateral recess stenosis, when epidural injections fail to improve NC and/or radiculopathy symptoms. Recommendation grade: I (Insufficient evidence); Certainty level: Low; Evidence level: II.

ESI delivers corticosteroids into the epidural space to reduce inflammation and nerve root edema, providing pain relief. The North American Spine Society (NASS) 2011 clinical practice guidelines for degenerative LSS [21] indicated that ESI can provide short-term improvement in NC or radiculopathy symptoms (2 weeks to 6 months), but long-term (21.5-24.0 months) evidence is contradictory. Image-guided multi-level transforaminal or caudal ESI provides medium-term analgesic effects (3-36 months). Multiple prospective clinical studies have demonstrated ESI efficacy for LSS, but heterogeneous methodologies, follow-up durations, and outcome measures limit definitive conclusions. This aligns with the ASPN 2022 practice guideline for non-surgical interventions for LSS-related NC [22], which did not recommend ESI for short-term pain relief and functional improvement due to uncertain benefits, high resource requirements, costs, and training demands.

2.7 Open Decompression

Open decompression is recommended when physicians determine that benefits outweigh risks and neurological deficits are progressive or severe. Recommendation grade: A; Certainty level: High; Evidence level: I-A.

Open decompression remains the gold standard for LSS, providing direct visualization and thorough decompression of neural structures. However, it carries higher risks of complications, longer recovery, and greater costs compared to minimally invasive alternatives. Recent advances include unilateral biportal endoscopy (UBE) and other minimally invasive decompression techniques that reduce tissue damage while maintaining efficacy [23]. Surgical treatment is generally reserved for patients with severe or progressive neurological deficits, significant functional limitation, or failure of conservative management [24]. Risk factors for reoperation and readmission after lumbar surgery include advanced age, comorbidities, and surgical complexity [25].

Indications and Contraindications

Table 3 Indications and contraindications of seven treatments for LSS

Treatment	Indications	Contraindications
PILD	(1) Symptomatic LSS with NC(2) Imaging-confirmed stenosis(3) Ligamentum flavum hypertrophy $ $2.5 mm	**Absolute:**(1) Previous surgery at index level(2) Local infection**Relative:**(1) Spondylolisthesis >Grade II(2) Bleeding tendency or coagulopathy(3) Systemic infection
ISP	(1) Imaging shows 25%-50% reduction in central canal and/or foraminal diameter vs. adjacent levels with: Dural sac/cauda equina compression Nerve root compression Facet hypertrophy causing encroachment(2) Symptoms: ZCQ score $ $2 (moderate functional impairment) Ability to sit $ $50 min or walk $ $50 feet without pain	(1) Allergy to titanium/titanium alloy(2) Spinal anatomy/pathology unsuitable for device or causing instability: Spondylolisthesis >Grade I Ankylosis at stenotic level Spinous process, pars, or lamina fracture Scoliosis (Cobb angle >10°)(3) Cauda equina compression causing neurogenic bladder/bowel(4) Osteoporosis (DXA T-score ≤-2.5)(5) Systemic/local infection(6) Previous fusion/decompression at index level(7) Morbid obesity (BMI >40 kg/m^2)(8) Bleeding tendency or coagulopathy

Treatment	Indications	Contraindications
ISF	(1) Mild to moderate LSS with spondylolisthesis ≤Grade II(2) Imaging shows 25%-50% reduction in central canal and/or foraminal diameter vs. adjacent levels with dural sac/cauda equina compression, nerve root compression, or facet hypertrophy causing encroachment(3) Symptoms: ZCQ score $ $2 and ability to sit $ $50 min or walk $ $50 feet without pain	(1) Spondylolisthesis >Grade II(2) Spinal instability(3) Osteoporosis(4) Previous surgery at index level(5) Systemic/local infection(6) Bleeding tendency or coagulopathy
IDDS	(1) Chronic pain refractory to medication management and other interventions(2) LSS with persistent pain despite conservative treatments(3) Appropriate for patients requiring long-term intrathecal analgesia	(1) Active systemic or local infection(2) Anatomical barriers to catheter placement(3) Allergy to implant materials(4) Untreated opioid use disorder(5) Bleeding tendency or coagulopathy(6) Inability to obtain medical care/follow-up
SCS	(1) Intractable pain including LSS-related low back/leg pain(2) Chronic postoperative spinal pain(3) Complex regional pain syndrome types I & II(4) Chronic radiculopathy(5) Peripheral neuropathy	(1) Uncontrolled psychiatric disorders(2) Inability to comply with treatment(3) Systemic/local infection(4) Immunosuppression(5) Bleeding tendency or coagulopathy

Treatment	Indications	Contraindications
ESI	(1) Degenerative LSS, especially central/lateral recess stenosis(2) NC and/or radiculopathy symptoms unresponsive to conservative treatment	(1) Spinal instability(2) Bleeding tendency or coagulopathy(3) Systemic/local infection(4) Allergy to corticosteroids or local anesthetics
Open Decompression	(1) Progressive or severe neurological deficits(2) Failure of conservative management(3) Significant functional limitation	(1) Uncontrolled psychiatric disorders(2) Inability to comply with treatment(3) Systemic/local infection(4) Immunosuppression(5) Bleeding tendency or coagulopathy

Note: PILD=percutaneous image-guided lumbar decompression, ISP=interspinous spacers, ISF=interspinous fusion, IDDS=intrathecal drug delivery systems, SCS=spinal cord stimulation, ESI=epidural steroid injection, NC=neurogenic claudication, LSS=lumbar spinal stenosis, ZCQ=Zurich Claudication Questionnaire.

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