Thesis

Non-Instrumented Posterior Decompression: Correlation between Radiological parameters and functional outcomes

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Abstract

Background: Degenerative lumbar canal stenosis causes neurogenic claudication, radicular pain and reduced walking capacity. When conservative care fails or neurological deficits progress, surgical decompression is commonly offered. This prospective study evaluated pain, disability and health-related quality of life after posterior lumbar decompression and examined changes in spinopelvic parameters.

Methods: Consecutive patients undergoing 1–4 level decompression were assessed preoperatively and at 18 months using Visual Analogue Scale for back and leg pain, Oswestry Disability Index and Short Form-36. Standing lateral radiographs including femoral heads were used to measure pelvic incidence, pelvic tilt, sacral slope and lumbar lordosis. Standardized perioperative care and structured physiotherapy were applied.

Results: Significant and sustained reductions in back and leg pain were observed with large falls in VAS and ODI, and marked gains in SF-36 domains at final follow up. Radiographically, lumbar lordosis increased modestly and PI–LL mismatch decreased on average, but these changes did not reliably predict functional improvement.

Conclusion: Posterior decompression provides meaningful, durable symptomatic and functional benefit in well selected patients with degenerative lumbar canal stenosis; modest radiographic alignment changes may occur but are not required for clinical recovery. These findings support decompression as a safe, effective option when nonoperative care fails. Periodically monitored.

Keywords: Lumbar canal stenosis, Posterior decompression, Neurogenic claudication, Oswestry Disability Index, Lumbar lordosis, PI–LL mismatch.

Aims and objectives

Lumbar canal stenosis is a degenerative narrowing of the lumbar spinal canal and foramina that commonly presents with neurogenic claudication—leg pain, numbness or weakness precipitated by walking and relieved by sitting or flexion. Patients frequently report axial low back pain combined with limited walking distance and reduced quality of life. Nonoperative management, including activity modification, analgesics, supervised physiotherapy and selective injections, is often effective initially, but progressive or refractory symptoms and objective neurological decline are accepted indications for surgical decompression [14]. The surgical goal is to relieve


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neural compression, restore walking capacity and reduce pain while minimizing morbidity and preserving segmental stability. Approaches range from open laminectomy to minimally invasive unilateral laminotomy with bilateral decompression; technique selection depends on the distribution of pathology, the presence of instability and surgeon preference [15]. Outcome evaluation relies on validated patient-reported measures—Visual Analogue Scale for pain, Oswestry Disability Index for function and Short Form-36 for general health—and standardized radiographic assessment of sagittal alignment, including pelvic incidence, pelvic tilt, sacral slope and lumbar lordosis. Pelvic incidence is an anatomic constant that determines the lumbar lordosis needed for an upright balanced posture, while pelvic tilt and sacral slope are compensatory and may change with pain-avoidant posture. Restoration of pain-free posture after decompression may allow increased lordosis and decreased PI–LL mismatch in some patients, but the extent and clinical relevance of such changes remain debated. By measuring preoperative and 18-month postoperative PROMs and standing radiographs that include femoral heads for accurate pelvic parameter measurement, we sought to quantify the magnitude and durability of symptom relief and to test whether radiographic alignment changes correlate with clinically meaningful improvements. Findings aim to guide patient counselling and surgical planning. Specifically.

Aims and objectives

This prospective study aimed to evaluate the clinical effectiveness of posterior lumbar decompression in patients with degenerative lumbar canal stenosis and to relate clinical recovery to radiographic spinopelvic measures. Primary objectives were to quantify pain reduction using the Visual Analogue Scale for back and leg pain and to measure improvement in disability using the Oswestry Disability Index and health-related quality of life using the Short Form-36. Secondary objectives included calculating pelvic incidence, pelvic tilt, sacral slope and lumbar lordosis on standardized standing lateral radiographs before and after surgery and exploring correlations between radiographic change, including PI–LL mismatch, and patient-reported outcomes. The intent was to determine whether radiographic restoration of sagittal relationships parallels meaningful clinical recovery after decompression. We also sought to record perioperative complications, level-wise decompression details and the need for further intervention, to inform patient selection and counselling for decompression without routine fusion across enrolled patients to 18 months.

Review of literature

Lumbar canal stenosis is a common degenerative spinal disorder whose prevalence rises with age and that represents a frequent cause of chronic low back pain and walking limitation in older adults [1]. Pathology commonly reflects a combination of intervertebral disc height loss, facet joint arthropathy, osteophyte formation and ligamentum flavum hypertrophy that together narrow the central canal, lateral recesses and foramina producing neurogenic claudication and radicular symptoms [2, 3]. Historical descriptions linked nerve compression to leg symptoms and surgical pioneers developed decompressive operations aimed at relieving neural compromise while attempting to preserve spinal stability [4]. Contemporary surgical options range from wide open laminectomy to targeted laminotomy, unilateral over-the-top decompression and minimally invasive fenestration, with muscle-sparing approaches advocated to reduce soft-tissue trauma and accelerate recovery [5, 6]. Randomized and cohort studies generally show significant and durable symptom relief after decompression, though perioperative morbidity and recovery profiles vary by technique and patient factors. Less invasive techniques tend to reduce blood loss and hospital stay while producing comparable short-term patient-reported outcome measure gains. Systematic reviews emphasise that decompression reliably lessens pain and disability, but controversies persist about when to add fusion—particularly in the presence of low-grade spondylolisthesis [7].

Biomechanical models and clinical series highlight spinopelvic morphology as an important aspect of adult spinal mechanics. Pelvic incidence is a fixed anatomical parameter that influences the magnitude of lumbar lordosis required for balanced posture, while pelvic tilt and sacral slope reflect compensatory pelvic rotation [8]. Observational reports indicate that pain-driven flexed posture may partially reverse after decompression, allowing modest increases in lumbar lordosis and reductions in PI–LL mismatch when preoperative flexion is dynamic rather than structural [9,10]. Other studies caution that degenerative loss of lordosis due to disc collapse and chronic muscular atrophy may be less amenable to change without instrumented realignment, emphasising the need to distinguish reversible pain-adaptive postures from fixed deformity when planning surgery [11]. Outcome assessment has moved toward validated patient-reported outcome measures—Visual Analogue Scale, Oswestry Disability Index and Short Form-36—which capture pain, function and general health and facilitate comparison across series [12]. Finally, reported complications of decompression are well described and include dural tear, infection and rare progression to instability; most series report low rates manageable with standard techniques and targeted rehabilitation [13].

Materials and methods

This single-centre prospective study enrolled consecutive patients between October 2019 and December 2021 who met predefined inclusion criteria: age 40 years or older, symptomatic degenerative lumbar canal stenosis and planned posterior decompression at one to four levels. Exclusion criteria included grade ≥2 spondylolisthesis, prior lumbar fusion, infection, tumor, traumatic stenosis and inability to complete outcome scoring. Institutional ethical clearance and informed consent were obtained. Baseline assessment comprised a structured history, neurological examination and patient-reported outcome measures—Visual Analogue Scale for back and leg pain, Oswestry Disability Index and Short Form-36. Imaging included standing anteroposterior and lateral lumbar radiographs that included the femoral heads for accurate pelvic parameter measurement and MRI to localise levels of neural compression. Spinopelvic angles were measured using standard geometric definitions (PI = PT + SS; lumbar lordosis by Cobb angle from L1 to S1). Surgical procedures—open laminectomy, laminotomy or unilateral over-the-top bilateral decompression—were selected according to pathology and surgeon judgement with the aim of adequate neural decompression while preserving posterior supporting structures when feasible [16,17]. Perioperative care consisted of routine antibiotic prophylaxis, thromboprophylaxis where indicated, early ambulation and a structured physiotherapy pathway. Complications were recorded prospectively. Follow-up assessments, including PROMs and repeat standing radiographs, were performed at 18 months. Level-wise decompression, operative time, estimated blood loss and perioperative complications were documented. Missing data were handled and sensitivity analyses evaluated their effect on primary outcomes. Statistical comparisons used paired tests for preoperative and postoperative measures and Spearman correlation to explore relationships between radiographic change and patient-reported outcomes.

Results

One hundred and forty consecutive patients were included (86 males, 54 females) with a mean age of 57.7 years (range 28–81) and mean BMI 26.4 kg/m^2. Distribution of decompressed levels was single level 43.6%, two levels 33.6%, three levels 18.6% and four levels 4.3%. Mean symptom duration was 17.9 months, and 70.4% of patients reported claudication within 100 metres of walking. Comorbidities included hypertension and diabetes in a substantial subset.

Functional outcomes improved markedly. Median preoperative VAS was 7 for back pain and 9 for leg pain; median VAS fell to 4 immediately postoperatively and to 1 at 18 months for both domains. Mean ODI decreased from 58.1 preoperatively to 36.5 early after surgery and to 20.9 at final follow up. SF-36 domain scores rose across physical function, pain and general health, with the overall median SF-36 rising from 42.1 to 78.1 ($p < 0.001$).

Radiographic analysis available for 112 patients showed a modest increase in lumbar lordosis (median 44.31° pre-op to 48.06° at 18 months) and a reduction in PI–LL mismatch (median 1.81° to –0.07°, $p = 0.008$). Complications included six intraoperative dural tears and one spondylodiscitis requiring reoperation; most complications were managed without long-term adverse effect. No deaths.

Discussion

This prospective cohort demonstrates that posterior decompression reliably reduces leg and back pain and improves function in patients with degenerative lumbar canal stenosis. Most patients had marked early benefits that were sustained at 18 months, reflected in large falls in VAS and ODI and gains in SF-36 [5, 7, and 18]. On imaging we found modest but consistent increases in lumbar lordosis and reductions in PI–LL mismatch at the group level. This pattern likely reflects reversal of a pain-avoidant, flexed posture rather than true structural realignment, since many patients assume a guarded stance to lessen neural tension. Relief of neural compression removes nociceptive drivers and allows functional gains even in the absence of large radiographic shifts [9, 11].

Several reports of non-instrumented decompression describe clinical benefit with only modest alignment change, underscoring that sagittal parameters are one piece of a multifactorial outcome picture [4, 6]. We included patients treated with varied decompression techniques, including chimney sublaminar approaches described by Lin and colleagues, which can achieve neural release while conserving posterior elements [19]. Complications were uncommon; dural tears were repaired intraoperatively and one deep infection required reoperation, but most adverse events were managed without lasting functional loss. These results highlight the importance of meticulous technique, prompt recognition and treatment of complications, and a structured rehabilitation pathway to consolidate gains [13, 20].

Limitations temper the strength of our conclusions. This single-centre series used heterogeneous operative approaches and experienced some loss to follow up, which may introduce selection effects and limit generalizability. Only a subset had complete radiographic datasets, reducing power for subgroup analyses and making it difficult to define which baseline spinopelvic profiles predict radiographic or clinical trajectories. Future studies stratifying PI, spondylolisthesis and preoperative lordosis will better guide fusion decisions [8, 20].

Conclusion

Posterior lumbar decompression in patients with degenerative lumbar canal stenosis produces substantial and sustained reductions in back and leg pain and meaningful improvements in disability and overall health-related quality of life. Modest group-level increases in lumbar lordosis and reductions in PI–LL mismatch may occur after surgery, but these radiographic shifts did not reliably predict the extent of symptomatic recovery in this cohort. Therefore, while spinopelvic assessment offers valuable anatomical context for surgical planning, restoration of sagittal parameters should not be viewed as a prerequisite for clinical benefit following neural decompression. Emphasis should remain on careful patient selection, meticulous decompressive technique, standardised perioperative care and structured rehabilitation to optimize outcomes. Longer-term and subgroup analyses are needed to determine whether particular patients derive additional advantage from alignment restoration or fusion procedures. Shared decision-making that explains expected symptomatic improvement and the uncertain role of radiographic change will aid personalized care planning over time.

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