

A Patient-Centred, Stage-Gated Decision Protocol for Lumbar Spinal Decompression in Nerve Root Compression and Radiculopathy

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Abstract

Lumbar nerve root compression with radiculopathy is a common cause of leg pain, sensory loss, weakness and reduced walking capacity. Decompression surgery can relieve symptoms when compression is clinically relevant, but outcomes depend on correct patient selection, concordance between symptoms and imaging, the response to conservative care and the patient's own goals. In routine practice these elements are often considered informally and inconsistently. This paper presents a patient-centred, stage-gated protocol that organises the decision process into seven stages—screening, clinical characterisation, imaging correlation, structured conservative care, shared decision-making, decompression planning with peri-procedural safety, and rehabilitation with outcome review—separated by three explicit gates for red flags, clinical–imaging concordance and patient preference. The protocol was developed from a structured synthesis of trial evidence and clinical guidelines, stakeholder mapping and a set of design principles that place safety and patient goals alongside technical criteria. A concordance matrix links clinical presentation to imaging findings and assigns an action to each combination, and a follow-up schedule specifies validated outcome measures at six time points. The protocol is a design contribution: it does not report patient outcomes, and its content validity and clinical performance remain to be established through expert consensus and prospective evaluation.

Index Terms—*Lumbar radiculopathy, nerve root compression, spinal decompression, clinical protocol, shared decision-making, patient-centred care, imaging concordance, outcome measures*

1. Introduction

Lumbar nerve root compression arises when a disc herniation, facet or ligamentum flavum hypertrophy, foraminal narrowing or spondylolisthesis narrows the space available to a nerve root. The resulting radiculopathy produces dermatomal leg pain, paraesthesia, sensory loss, weakness or reflex change, and in central or lateral recess stenosis it may present as neurogenic claudication that limits walking. For many patients symptoms improve with time and conservative care, but a substantial group has persistent or progressive symptoms and is considered for decompression.

Randomised and cohort evidence shows that decompression can provide faster or greater relief than continued non-operative care in carefully selected patients with spinal stenosis [1] or sciatica [2], and current reviews describe decompression as the standard surgical option when symptoms are disabling and concordant with imaging [3]. The same evidence also shows that many patients improve without surgery, that benefits vary between individuals and that the choice between operative

and non-operative care is sensitive to preferences [2], [3]. Decisions therefore depend on more than the radiological finding: they depend on whether the imaging explains the symptoms, whether conservative care has been adequate, whether red flags are present and what the patient wants to achieve.

In practice these considerations are frequently applied implicitly, which leads to variation in selection, documentation and follow-up. This paper derives from a doctoral thesis that proposed a developmental approach to a patient-centred decompression protocol. Its contributions are:

- 1) A seven-stage, stage-gated pathway from screening to outcome review, with explicit safety, concordance and shared-decision gates.
- 2) A clinical–imaging concordance matrix that assigns a defined action to each combination of presentation and imaging.
- 3) Planning and safety components that link the extent of decompression to the compressive lesion and limit fusion to defined instability.

- 4) A follow-up and outcome schedule based on validated measures that supports audit and later evaluation of the protocol.

2. Related Work

2.1 Decompression Versus Conservative Care

The Spine Patient Outcomes Research Trial compared surgery with non-operative treatment for lumbar stenosis; in the as-treated analysis, patients who underwent decompression had greater improvement in pain and function over two years, although crossover limited the intention-to-treat comparison [1]. For sciatica caused by disc herniation, early surgery produced faster relief than prolonged conservative treatment, but outcomes at one year were similar between groups [2]. Clinical guidelines for degenerative stenosis recommend decompression for patients with moderate to severe symptoms and identify the need for better-defined selection criteria [4], and recent reviews emphasise matching treatment to symptom severity and patient preference [3].

2.2 Decompression Versus Fusion

Adding fusion increases operative time, cost and complications. In a randomised trial of patients with lumbar stenosis, with or without degenerative spondylolisthesis, decompression plus fusion did not improve outcomes at two and five years

compared with decompression alone [5]. In a trial limited to stable degenerative spondylolisthesis, adding fusion produced a modest improvement in physical health scores and fewer reoperations, but more blood loss and longer stays [6]. Together these results support decompression alone as the default and fusion only when instability is documented.

2.3 Shared Decision-Making

Shared decision-making is a process in which clinician and patient consider the options, the evidence on benefits and harms, and the patient's values before reaching a decision. A widely used model describes three steps: introducing choice, describing options and helping patients explore preferences [7]. A Cochrane review found that decision aids improve knowledge and the accuracy of risk perception and reduce decisional conflict, without worsening health outcomes [8]. Spine surgery is a preference-sensitive decision, which makes it a natural setting for structured shared decision-making.

3. Research Objectives

The protocol was designed to meet the objectives in Table I. Each objective is linked to the protocol component that addresses it.

TABLE I OBJECTIVES OF THE PROTOCOL AND THE COMPONENTS THAT ADDRESS THEM

No.	Objective	Protocol component
O1	Identify patients who require urgent assessment before elective planning	Gate A: red-flag screening
O2	Confirm that imaging findings explain the clinical presentation	Stage 3 and Gate B: concordance matrix
O3	Ensure that conservative care has been structured and adequate	Stage 4: conservative care with defined review
O4	Include the patient's goals and preferences in the decision	Gate C: shared decision node
O5	Match the extent of decompression to the lesion and protect stability	Stage 5: decompression planning
O6	Reduce peri-procedural harm	Stage 5: safety checklist
O7	Measure outcomes consistently and feed them back into practice	Stages 6–7: follow-up and audit

4. Methodology of Protocol Development

The protocol was developed in six steps (Fig. 1). First, design principles were defined: patient safety, clinical relevance, patient-centredness, transparency of reasoning, feasibility in routine practice and measurability. Second, stakeholders were mapped—patients, spine surgeons, physiotherapists, radiologists, anaesthetists, nurses and administrators—to identify the decisions and

information each contributes. Third, evidence from randomised trials, cohort studies and guidelines was synthesised for each decision point [1], [2], [4], [5], [6]. Fourth, the decisions were grouped into domains, and fifth, explicit safety gates were placed at points where an error would be hard to reverse. Finally, the draft was prepared for expert review and pilot testing, which are described in a companion validation design.

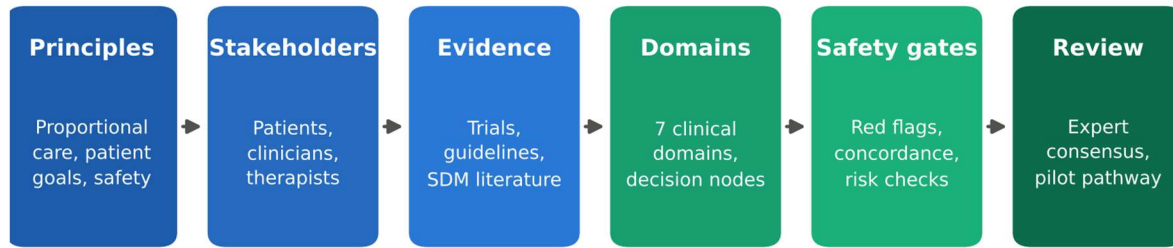


Fig. 1. Six-step development process for the patient-centred decompression protocol, from design principles to structured expert review.

The development steps are summarised as a procedure in the box below. The procedure is iterative: review findings at the final step return to the domain and gate definitions until the protocol is stable.

Procedure 1: Development of the stage-gated protocol

Input: design principles, stakeholder list, trial and guideline evidence

Output: staged protocol with gates, matrices and outcome schedule

- 1) Define principles: safety, relevance, patient-centredness, transparency, feasibility, measurability
- 2) Map stakeholders and the decision each one informs
- 3) For each decision, extract the evidence and the recommended criterion
- 4) Group decisions into stages; order stages from least to most invasive
- 5) Insert a gate wherever an error is irreversible or safety-critical
Gate A: red flags; Gate B: concordance; Gate C: informed preference
- 6) Attach outcome measures and time points to each stage
- 7) Submit to expert review; revise steps 3–6 until consensus is reached

5. The Proposed Protocol

5.1 Protocol Architecture

Fig. 2 shows the pathway. Patients move through seven stages in order, and three gates determine whether they may proceed. Each gate has an explicit alternative route, so that a patient who does not pass is redirected rather than left without a plan. The final stage feeds outcome and complication

data back into the earlier stages, so that the protocol can be refined using local evidence.

5.2 Safety Gate and Red Flags

Gate A is applied at the first contact and again whenever symptoms change. Findings that suggest cauda equina syndrome, progressive neurological deficit, infection, malignancy or fracture bypass the elective pathway (Table II).

TABLE II GATE A: RED-FLAG FINDINGS AND REQUIRED ACTIONS

Category	Example findings	Action
Cauda equina syndrome	Saddle anaesthesia, new bladder or bowel dysfunction, bilateral leg symptoms	Emergency imaging and surgical review
Progressive deficit	Worsening motor weakness, e.g. new foot drop	Urgent imaging and surgical review
Infection	Fever, immunosuppression, intravenous drug use, recent spinal procedure	Urgent investigation; exclude from elective pathway
Malignancy	History of cancer, unexplained weight loss, night pain	Urgent investigation; oncology input
Fracture	Significant trauma, osteoporosis, long-term steroid use	Imaging; manage per fracture protocol

This gate protects the patient from the main risk of a staged pathway, namely that time spent on conservative care delays treatment of a condition in which delay causes permanent harm.

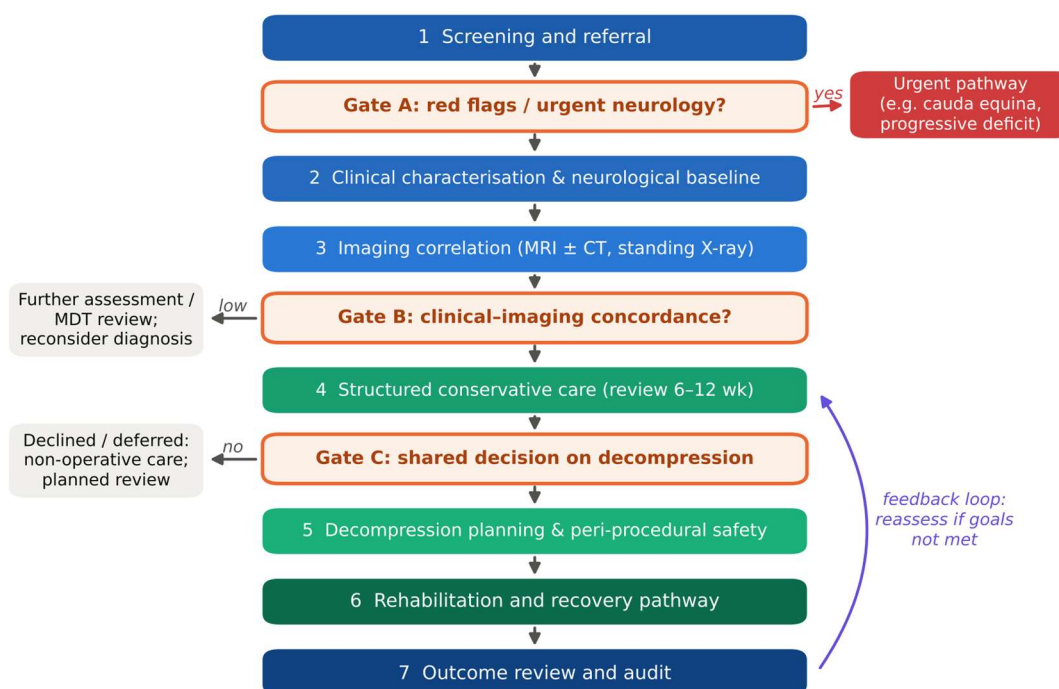


Fig. 2. Stage-gated clinical pathway. Gate A redirects red-flag presentations to an urgent pathway; Gate B requires clinical–imaging concordance; Gate C requires an informed patient decision. Outcome review feeds back into earlier stages.

5.3 Clinical–Imaging Concordance

Degenerative findings on magnetic resonance imaging (MRI) are common in people without symptoms, so the presence of compression does not by itself justify decompression. Gate B therefore requires that the clinical presentation and the imaging point to the same level and side. Fig. 3

assigns an action to each combination: high concordance allows the patient to proceed to shared decision-making if the other criteria are met, partial concordance requires further assessment such as selective diagnostic injection or multidisciplinary review, and discordance leads to reconsideration of the diagnosis.

		Compression at the matching level	Imaging finding Compression at other or multiple levels	No significant compression
Clinical presentation	Symptoms and signs localise to one root / level	High concordance → eligible for SDM if criteria met	Partial → MDT review, level confirmation	Discordant → reassess diagnosis
	Compatible pattern, not localising	Partial → further work-up (e.g. neurophysiology)	Low → non-operative care, review	Low → non-operative care
	Pattern not compatible with compression	Discordant → do not attribute symptoms to image	Discordant → alternative diagnosis	Not indicated → alternative diagnosis

Fig. 3. Clinical–imaging concordance matrix used at Gate B. Rows describe the clinical presentation; columns describe the imaging finding. Each cell states the action required.

Clinical characterisation uses the dermatomal distribution of pain, straight-leg raise or femoral stretch tests, myotomal strength, reflexes and sensory testing, recorded at baseline so that later deterioration can be detected. Imaging is interpreted with the clinical findings in hand. MRI is the

primary modality, computed tomography is added where bony anatomy matters, and standing radiographs, including flexion–extension views when indicated, assess alignment and dynamic instability.

5.4 Structured Conservative Care and the Shared Decision Node

Stage 4 provides structured conservative care—education, analgesia, graded activity and physiotherapy, with epidural steroid injection where appropriate—and a defined review at 6–12 weeks. Failure of conservative care is defined by persistent disabling symptoms after an adequate trial, not by

the passage of time alone. Gate C is then applied. Following the three-step model [7], the clinician explains that there is a choice, describes the options and their likely benefits and harms, and helps the patient relate them to personal goals (Table III). Decision aids can support this step [8]. A patient who declines or defers surgery continues non-operative care and may re-enter the pathway later.

TABLE III GATE C: ELEMENTS OF THE SHARED DECISION NODE

Element	Content	Record
Choice talk	There is more than one reasonable option, including continued conservative care	Options discussed
Option talk	Expected benefit, time course and risks of decompression and of non-operative care	Risks and benefits explained
Goal exploration	Patient's priorities: leg pain, walking distance, work, recovery time, risk tolerance	Patient goals in own words
Decision	Proceed, defer or decline; plan for review	Decision and date; decision aid used

5.5 Decompression Planning and Peri-Procedural Safety

Stage 5 plans the operation from the concordant findings: the level, the side, the extent (unilateral, bilateral or foraminal) and the approach (open, microscopic, tubular or endoscopic). Tissue-preserving techniques are preferred when they achieve adequate decompression, because preservation of the facets and midline structures protects stability. Fusion is not added by default; it is reserved for documented dynamic instability or for cases in which the decompression required would itself destabilise the segment, consistent with trial evidence [5], [6]. Contingency planning covers dural tear, bleeding and unexpected findings.

Peri-procedural safety follows a checklist that confirms the patient, level and side, imaging availability, consent, antibiotic prophylaxis and thromboembolism risk assessment. Intra-operative level confirmation by fluoroscopy is mandatory. Post-operatively, neurological status is compared

with the baseline examination, and any new deficit triggers immediate review. Discharge criteria include stable neurology, controlled pain, independent mobility and wound review, together with written advice on warning symptoms.

5.6 Rehabilitation, Follow-Up and Outcome Review

Rehabilitation begins with early mobilisation and progresses to graded activity and return to work. Outcomes are recorded on the schedule in Fig. 4. Disability is measured with the Oswestry Disability Index (ODI) [9], and change is interpreted against minimal important change values—for example, about 10 points or 30% improvement on the ODI [10], with similar thresholds reported for surgical populations [11]. Health-related quality of life is measured with the EQ-5D-5L [12]. Pain intensity, walking capacity, neurological status, satisfaction, complications and return to work complete the set.

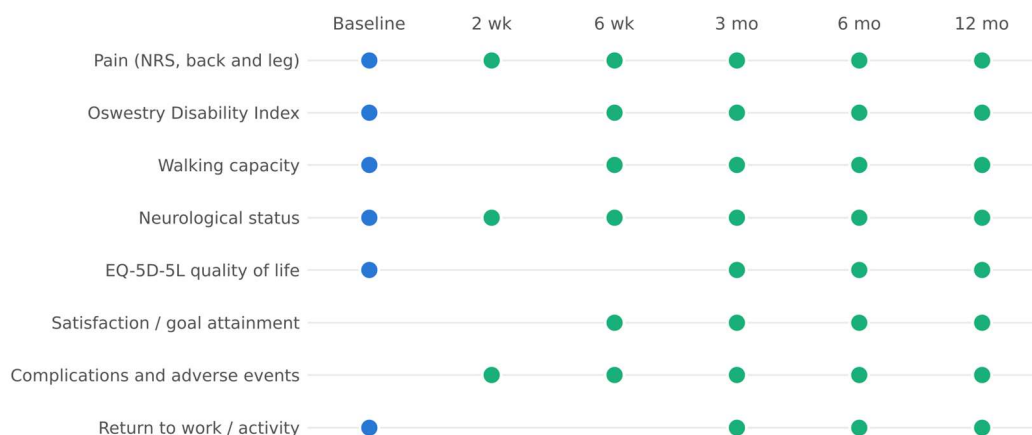


Fig. 4. Follow-up schedule. Filled markers indicate the outcome measures recorded at each time point from baseline to 12 months.

Stage 7 aggregates these data for audit. Indicators include the proportion of patients with a documented red-flag screen, a recorded concordance judgement and a documented shared decision, as well as complication rates and the completeness of patient-reported outcomes. Results are reviewed periodically and are used to revise criteria in earlier stages.

6. Discussion

6.1 Contribution of the Stage-Gated Design

The protocol makes explicit the reasoning that experienced clinicians often apply implicitly. Its main value lies in the gates: each gate converts a judgement into a recorded decision with a defined alternative. This supports consistency between clinicians, makes the basis of a decision visible in the record and allows audit of whether the protocol is being followed. Because the stages run from least to most invasive, the pathway is consistent with the evidence that many patients improve without surgery [2], while the red-flag gate prevents the staged structure from delaying urgent care.

6.2 Patient-Centredness

Patient-centredness is embedded in three places rather than treated as a final consent step: goals are recorded at the shared decision node, outcomes include patient-reported measures, and satisfaction and goal attainment are part of the follow-up schedule. This matters because the choice between decompression and continued conservative care depends on how individual patients weigh speed of relief against surgical risk [3], [8].

6.3 Practical Implementation

The protocol can be implemented with standard clinical tools: structured assessment forms, a concordance worksheet, a decision aid and a safety checklist. The main costs are clinician time for shared decision-making and staff time for follow-up data collection. Electronic forms with mandatory gate fields would reduce the documentation burden and provide audit data automatically.

6.4 Limitations

The protocol is a design contribution. It was developed from published evidence and clinical reasoning, and no original patient dataset was used; it therefore makes no claim about clinical effectiveness. Its content has not yet been validated by an independent expert panel, its thresholds may need local adaptation, and its feasibility in different

health-care settings is untested. These limitations define the next steps: formal content validation, pilot implementation and prospective outcome evaluation.

7. Conclusion and Future Work

This paper presented a patient-centred, stage-gated protocol for decompression in lumbar nerve root compression and radiculopathy. The protocol organises care into seven stages separated by red-flag, concordance and shared-decision gates; it links decompression planning to the concordant lesion and reserves fusion for documented instability; and it specifies validated outcome measures and audit indicators. Future work will establish content validity through a Delphi consensus of spine clinicians, test feasibility in a pilot implementation and evaluate patient outcomes prospectively against minimal important change thresholds.

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