# 4
# Management of L4–L5 instability with asymptomatic disc disease at L3–L4 or L5–S1

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## Introduction

Segmental instability at the L4-L5 level is a very common condition in lumbar pathology. Common causes of instability include advanced disc degeneration, spondylolisthesis, spondylolysis, and post-laminectomy syndrome. In many cases, L4-L5 is the only affected level, while adjacent segments show no critical illness. In some patients, an incipient deformity may be recognized together with the segmental instability, but the deformity is not severe or symptomatic.

Surgical management of L4-L5 instability consists of segmental fusion, which can be achieved through different techniques and approaches depending on the surgeon's preferences and the patient's condition. To provide guidance on the management of segmental instability at the L4-L5 level, the lead author (Matteo Pejrona (EP)) asked four expert spine surgeons (Pedro Berjano (PB), Ashish Diwan (AD), Emiliano Vialle (EV), and Claudio Lamartina (CL)) from three continents to advise on two case studies. A classification strategy is also presented to help clinicians determine appropriate treatment options for L4-L5 instability.

**Fig 4.1** Preoperative lateral and frontal full spine standing X-ray.

## Case 1

A 77-year old man in good general health presents with severe back and leg pain, and neurogenic claudication at 100 meters. He underwent L4-L5 decompression 13 years ago. The patient has a Oswestry Disability Index (ODI) score of 64, numeric rating scale (NRS) back pain score of 8, and NRS leg pain score of 7. He has experienced severe worsening of symptoms in the last 12 months; clinical examination shows no motor weakness in the lower limbs. Radiological findings (**Fig 4.1–4.3**) demonstrate L4 grade II degenerative spondylolisthesis associated with Schizas grade C (severe) segmental stenosis.

**Fig 4.2** Preoperative sagittal T1 (left) and T2 (right) MRI imaging.

**Fig 4.3** Preoperative axial MRI imaging at L4-L5 level.

## Comments from experts

AD:

Issues: The three considerations whilst offering surgery in this already decompressed L4-5 are 1) Mono-segmental pathology, 2) Does the patient have osteoporosis or osteopenia? and 3) The first impression is that sagittal balance is good, with a good sagittal vertical axis (SVA) without hip or knee flexion. I will now delve deeper into each of these three considerations.

At L4-L5 there is significant grade II listhesis leading to spinal column translation, no disc space posteriorly with possible bone "lock-in", large facets laterally with post-surgical scarring centrally. I also note that the segmental lordosis is good (to hyper) at L4-L5.

In relation to the quality of bone, the patient should be evaluated by a bone-mineral endocrinologist. In the event that Danusomab is prescribed, I may or may not choose to wait prior to offering surgery, based on the patient's own symptomatology and scheduling requirements. This is because of the angle in which the screws will be inserted under navigation to get maximum length (up to 55 or 60 mm), which overcomes fixation issues the majority of times.

Patients films should undergo spino-pelvic measurements on Surgimap with the key focus in this instance on pelvic tilt (PT). Anything more than 20-23 degrees would cause me some anxiety, as a more decompensated PT would suggest unrecognized sagittal imbalance, negating my first impression above. Being a mono-segmental issue, PI-LL mismatch should be studied, but the focus should remain on maintaining the existing lordosis at L4-L5, or at the least not flattening that segment.

Fusion strategy: I will now consider fusion strategies alone, including anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (LLIF), posterior lumbar interbody fusion (PLIF), and transforaminal lumbar interbody fusion (TLIF). Given the psoas anatomy (Mickey Mouse Ears) in the axial magnetic resonance imaging (MRI) at L4-5, LLIF is contraindicated. In relation to ALIF, I would have some concerns about mobilizing the segment with two large arthritic facets, and about any bone quality issue that could give rise to issues with fixation. I have stopped performing PLIF in favor of minimally invasive TLIF, which would be my choice of surgery here.

Technique: Under O-arm and Stealth Navigation, on the side the tracker is placed, skin incisions to subcutaneous fat are made under navigation to direct the screws from the lateral superior part of the pedicle to the middle and inferior part of the bodies of L4 and the mid or inferior part of the L5 pedicle to the L5 superior body or parallel to the end plate. The entire length allowed within the vertebral body under navigation is utilized. This orientation of the screws allows for later stage reduction while maintaining inter-screw distance for lordotic compression of screw heads.

On the contralateral side, a longitudinal Wiltse approach incision is made to insert pedicle screws with retractor blades. A stealth-guided Midas Rex tool is used to complete a facetectomy, and entry into the disc space is made with blunt paddles. With the patient in a prone position, it is highly likely that the disc space will have opened up a bit to allow ease of entry. If not, these steps are performed under an image intensifier to prevent ploughing through bone. Complete disc clearance and space mobilization needs to be obtained. Using Spondy-reduction, I then evaluate the reducibility of the segment. If it is still stiff, a facetectomy on the other side is performed.

This is the stage when I decide whether to use a cage or proceed with cage-less interbody fusion. The considerations are as follows: Is the bone quality good enough, as determined during the use of interbody-paddles while preparing the disc space, to hold a cage without the cage sinking into the vertebral bodies (usually the cephalad end of the lower vertebra – here L5)? Do I have a cage small enough in length that it can be placed sufficiently anterior so that lordosis is gained (since taller cages lead to flattened segmental lordosis in my hands)? Do I have enough reduction (by this time the contralateral side is locked in with a temporary rod to maintain the gained reduction) to allow the cage to be pulled back when final reduction is done to the rods. With these considerations in mind, I use a funnel to pack the space with bone graft substitute, the quantity based on whether a cage will be used. Final rod tightening is performed with cage reduction in lordosis.

PB:

Patient presents with L4 grade II degenerative spondylolisthesis associated with Schizas grade C (severe) segmental stenosis, previously operated (posterior decompression). Global sagittal balance is preserved, no coronal deformity is observed.

In this case, the surgical strategy should focus on spinal decompression. Fusion is appealing for this patient due to the substantial displacement of the slipped vertebra, the likelihood of increasing instability as a consequence of decompression, and because of the increased value of treating back pain generated in the L4-L5 segment. With these considerations, I would favor indirect decompression via anterior transpsoas cage fusion and percutaneous pedicle screw fixation. The advantages of this choice are: good evidence of the ability to provide indirect decompression; large size implant with reduced risk of nonunion, and substantial and optimal mechanical stability; good control over sagittal alignment; no manipulation of roots or dura; reduced invasiveness in elderly patients; and partial reduction provided by the implantation of the cage without causing mechanical stress on the pedicle screws. The challenges to be weighed are: difficult anatomy due to grade II spondylolisthesis; and an increased risk of thigh symptoms due to the transpsoas approach.

The anatomy as seen in MRI shows the anterior limit of the lumbar plexus approximately at the middle of the anterior-posterior length of the disc space; in my opinion this requires mastering the technique and intraoperative use of triggered electromyography (EMG) in order to map the position of the lumbar plexus in the psoas. A risk of conversion to posterior surgery does exist, but is limited.

In my opinion, a posterior approach for decompression, fusion, and realignment (TLIF or PLIF) would be feasible in this specific case, with a somewhat increased risk of dural injury; moreover, reduced root mobilization due to scar tissue could prevent major disc release, leading to incomplete reduction (though disc release is not the major goal of surgery in this case, it does have biomechanical advantages). Any attempt to mobilize the roots in the presence of scar tissue has an increased risk of root damage.

Posterolateral fusion is also an option, but the risk of nonunion is probably higher and the likelihood of decompressing the roots in the foramina without increasing the interbody distance via an interbody cage is lower. In addition, controlling sagittal alignment without interbody implants is more difficult.

I would not consider ALIF as a first-choice treatment for an anterior approach at L4-L5 (due to medial positioning of iliac vessels, risk of iliolumbar vein injury).

In summary, I would opt for a transposas anterior interbody fusion with indirect decompression and posterior percutaneous fixation.

## What was done

L4-L5 direct lateral interbody fusion, indirect decompression, posterior percutaneous L4-L5 fusion (**Fig 4.4**).

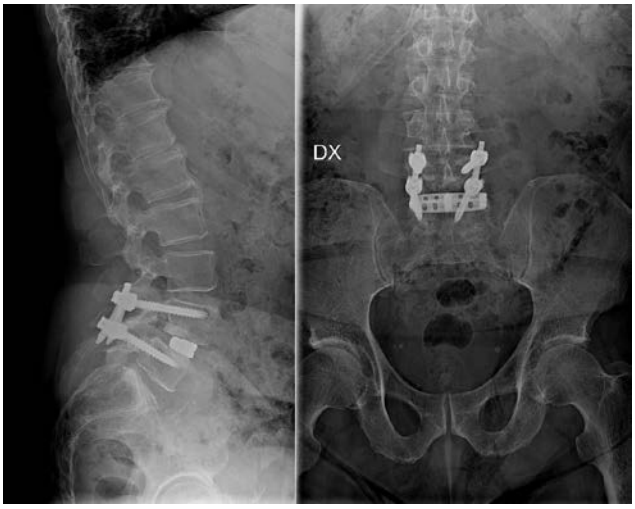


**Fig 4.4** Postoperative lateral and frontal standing X-ray.

## Case 2

A 55-year old female with no significant pathologies presents with chronic low back pain and right leg pain that has severely worsened in the last 3 years. ODI score of 44, NRS back score of 8, and NRS leg score of 6. No motor weakness is demonstrable in the lower limbs. Radiological findings indicate L4 grade I degenerative spondylolisthesis and Schizas grade C (severe) segmental stenosis (**Fig 4.5–4.7**).

### Comments from experts

AD:

Issues: A relatively young individual at 57 who has been suffering since she was 54 years old with almost equal back and leg pain in the absence of any neurological deficit. Has fullness of facets, reasonable disc height, and a grade-1 listhesis with overall good balance.

Surgical Strategy: I would have a long discussion with the patient focused on shared decision making. I would offer a surgical strategy, the fundamentals of which would be to do less to gain more while keeping potential adverse events to a minimum. I would suggest performing a L4-L5 decompression as a first step, with the understanding that there would be a 15–20% likelihood over 5 years that a fusion operation may be required. In the unlikely event that the patient rejects this suggestion and wishes to proceed with fusion, I would then offer the patient either a stand-alone ALIF or LLIF with posterior percutaneous screws (as indirect decompression choices).

Technique: Posterior decompression is a spinous process preserving paraspinous access strategy using operating loupes. The left paraspinous TL fascia and aponeurosis of the erector spinae muscles are incised. Blunt dissection identifies the insertion of the multifidus tendon to the L4 spinous process. This is taken down with a diathermy along the left side of the spinous process, lamina and to the groove just medial to the L4-L5 facet joint, where a Kocher is placed to confirm the level. Using a Midas Rex the spinous process is separated from the lamina at its base and then with micro lumbar discectomy (MLD) retractors retraction obtained. L5 pars is identified on both sides and so also the L4 pars. Using Midas Rex or an equivalent tool an inverted leaf foramino-laminotomy of L4-L5 is performed, and using curettes on the under-surfaces of

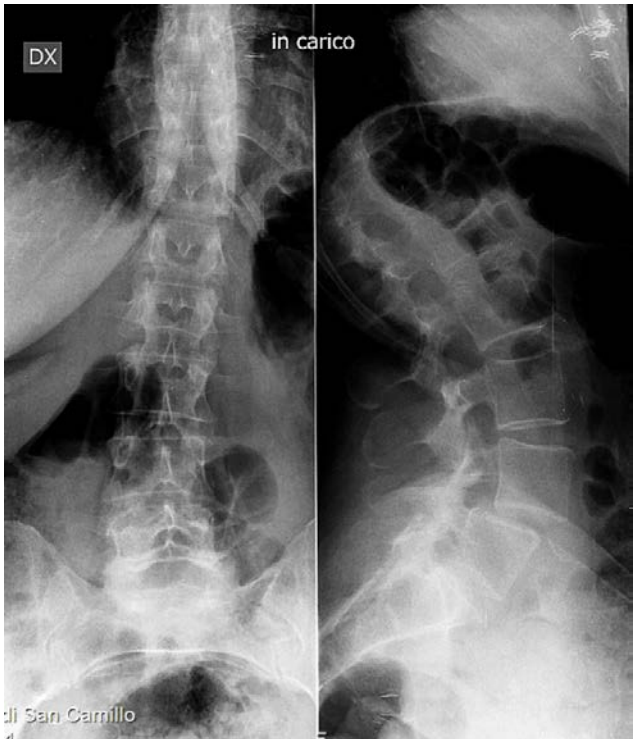


**Fig 4.5** Preoperative frontal and lateral standing lumbosacral spine X-ray.


**Fig 4.6** Preoperative sagittal T1 (left) and T2 (right) MRI imaging.

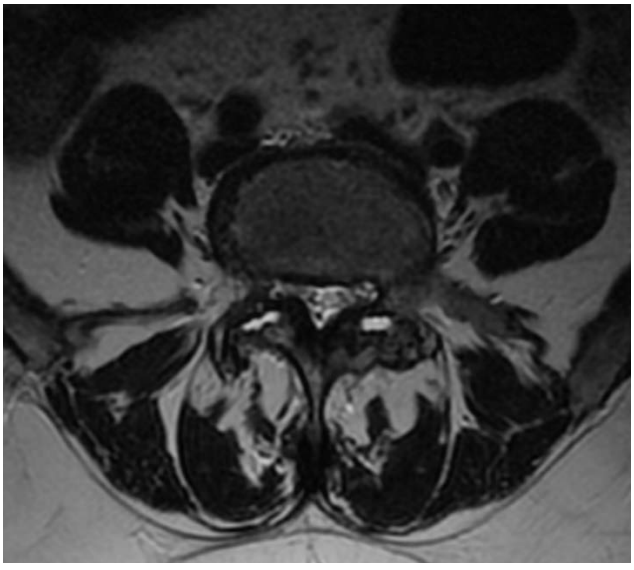

**Fig 4.7** Preoperative axial MRI imaging at L4-L5 level.

the L4 lamina and lateral recess the thinned ligamentum flavum is separated. Using Kerrison rongeurs, osteophytes in the right (symptomatic) recess are decompressed. No osteotomy is required. If preoperative examination revealed a positive straight leg raise (SLR) test, it is essential to explore the disc for a disc bulge at this stage. After bilateral decompression and a Valsalva evaluation, a tight closure in layers is performed.

PB:
Patient presents with L4 grade I degenerative spondylolisthesis and Schizas grade C (severe) segmental stenosis; not previously operated. Mild right convex lumbar scoliosis is also visible. As for the previous case (case 1), the main goal is to obtain spinal realignment and neural decompression.

I would not consider decompression alone in this relatively young patient because of the signs and symptoms of spinal instability (back pain, spondylolisthesis, MRI findings of facet joints fluid effusion); instead, I would opt for decompression and fusion to fix axial and peripheral symptoms and to avoid potential recurrence of the stenosis. Given that no previous surgery was done, both anterior and posterior approaches could be chosen, but to maximize postoperative recovery a combined minimally-invasive anterior-posterior indirect decompression and fusion would be my choice here.

As described earlier, I would avoid ALIF in favor of LLIF (both sides seem approachable considering no critical anatomy or asymmetric disc collapse).

## What was done

L4-L5 transforaminal interbody fusion (TLIF) with bilateral direct decompression (**Fig 4.8**).

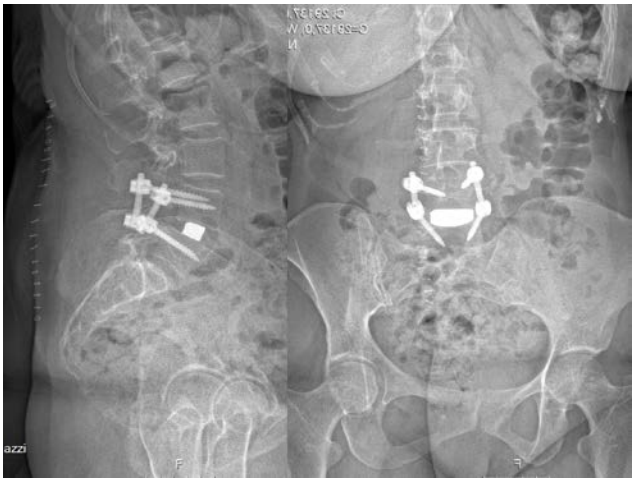

**Fig 4.8** Postoperative lateral and frontal standing X-ray.

## Discussion

For case 1, the previous surgery may have resulted in substantial scar tissue, which can prevent root decompression, proper disc identification, and cage positioning, and is therefore a threat to any neural elements. These concerns were more influential than others in the choice to perform indirect decompression and fusion through a lateral approach. The case itself could be considered challenging for such an access because of the psoas anatomy suggesting an anterior plexus position.

For this patient, there were no complications during or after surgery; lateral access to the disc (left side approach) was safe, no lumbar plexus injury was observed nor abnormal bleeding. However, reducing plexus retraction time is recommended, especially in such situations. Postoperative plain radiographs showed complete reduction of the misalignment; clinical results were satisfactory with resolution of claudication at 6 months follow-up; ODI score of 2 (before surgery was 64), NRS back and leg scores of 1 (before surgery NRS for back was 8 and for legs was 7).

For case 2, our team of experts considered it to be unsafe for anterior approaches (ALIF, LLIF) because of vessels and plexus anatomy; as can be seen from MRI, iliac veins run lateral on the disc margin of both sides (especially on the right), and on the left side the lumbar plexus seems anterior. Considering the absence of a safe corridor for an anterior or lateral approach to the L4-L5 disc space, the patient was treated with a posterior transforaminal interbody fusion (TLIF) with bilateral direct decompression.

In both cases all authors suggested 360° fusion with interbody grafting, demonstrating a substantial consensus in the need for circumferential fusion when facing spinal instability. The choice of approach (posterior, anterior, direct lateral) may not be considered univocal. In case 1 both posterior and lateral access were proposed by our team of surgeons; the suboptimal psoas muscle anatomy with anterior plexus played a role in favoring posterior access. A factor supporting anterior access was the previous surgery and the opportunity to avoid issues with the scar tissue. Similar considerations were made for case 2, where a posterior approach was preferred because of an unsafe corridor for anterior and lateral access to the L4-L5 disc; however, other surgeons would have opted for an anterior approach.

Even if not particularly prominent in these sample cases, an issue that plays an important role in the choice of approach is the amount of stenosis associated with segmental instability. Schizas grade D (extreme) segmental stenosis is preferentially treated with direct decompression. In the two sample cases stenosis could be defined as moderate (case 2) or severe (case 1) so both direct or indirect decompression are acceptable.

These cases demonstrate how each surgeon's preferences and technical skills can orient the kind of treatment recommended in controversial cases, while maintaining the same goal (decompression and fusion).

## Classification strategy for treating L4-L5 instability

The sample cases discussed above represent two clear examples of instability, which is sometimes not so obvious to identify. Therefore, we present here a classification strategy developed by Dr. Emiliano Vialle, which focuses on some key aspects of identifying instability and proposes appropriate management (conservative, surgical) for different scenarios. Cases of "hidden" instability, beyond hyper-mobility in flexion-extension films and sagittal misalignment, can be revealed by disc degeneration grade and facet orientation, which are frequently associated phenomena and may direct the surgeon to choose a fusion strategy.

EV
Clinical case scenarios for L4-L5 degeneration/instability are presented below, followed by several treatment options that are rated as more or less appropriate for different situations.

The variables are:

- Disc degeneration
  (Pfirmann grade, Modic, High Intensity Zone)
- Facet joint arthritis (Fujiwara classification)
- Muscle atrophy
  (paraspinal, psoas–Goutallier classification)
- LL-PI mismatch
- Presence of spondylolisthesis
  (mobile or not, Meyerding grade)
- Stenosis (central, recess, foraminal)

These six variables lead to a minimum of 18 clinical scenarios when combined with two modifiers (stenosis and clinical–see **Fig 4.9**).

Scenarios 7–12 include the same situations without mismatch but with listhesis.
Scenarios 13–18 include the same situations with mismatch AND listhesis.
In each scenario, the patient would also need to be tested for the degree of stenosis.
Furthermore, patient symptoms (back pain, claudication, neurologic deficit) need to be added.

| Scenario | Disc | Facet | Muscle |
|---|---|---|---|
| 1 | I/II | I/II | ? |
| 2 | III/IV | I/II | ? |
| 3 | V | I/II | ? |
| 4 | I/II | III/IV | ? |
| 5 | III/IV | III/IV | ? |
| 6 | V | III/IV | ? |

**Fig 4.9** Proposal of clinical scenarios (no mismatch, no listhesis).

The treatment options that could be proposed are:
- physical therapy
- pain management (including foraminal and facet blocks)
- decompression
- posterolateral fusion +/- decompression
- PLIF/TLIF +/- decompression
- LLIF +/- decompression
- ALIF +/- decompression

When planning surgical treatment, I basically use the flowchart shown in **Fig 4.10**.

The scoring system, retrospectively based on my team's case series, is the following:

- Disc evaluation
  - Pfirmann 1,2,5 = zero points
  - Pfirmann 3,4 = 1 point
  - Symptomatic disc herniation = 1 point
- Facet evaluation
  - Vertically oriented facets (>40 degrees) = 1 point
  - Horizontal facets = zero points
- Flexion extension films
  - Movement (>2mm) = 1 point
  - Stable = zero points
- Osteophytes
  - Anterior osteophytes = -1 point
  - Lateral osteophytes = -1 point
  - Laterolisthesis (>3mm) = 1 point
- Decompression
  - Unilateral only = zero points
  - Bilateral = 1 point
- Sagittal alignment
  - Sva<5cm = zero points
  - SVA>5cm = 1 point
  - PI-LL mismatch = 1point
  - L1S1-L4S1 mismatch = 1 point

Suggested treatments based on total score:
1–2 points = decompression only
3–4 points = decompression and fusion maintaining alignment (post instrumentation +/- TLIF)
5 points and above = post instrumentation with TLIF and post osteotomy or circumferential surgery.

## Conclusion

Given the need for fusion in L4-L5 instability, the choice of the most appropriate approach depends on several factors. Anterior approaches may be considered in cases involving previous posterior surgery, to avoid issues with scar tissue and potential dural tears, to prevent soft tissue injury, and to promote faster recovery. The choice of posterior instrumentation allows for direct decompression (i.e., Schizas Grade D stenosis) and is of course necessary when there is no "safe corridor" (vessels, nerves) for anterior or lateral approaches.

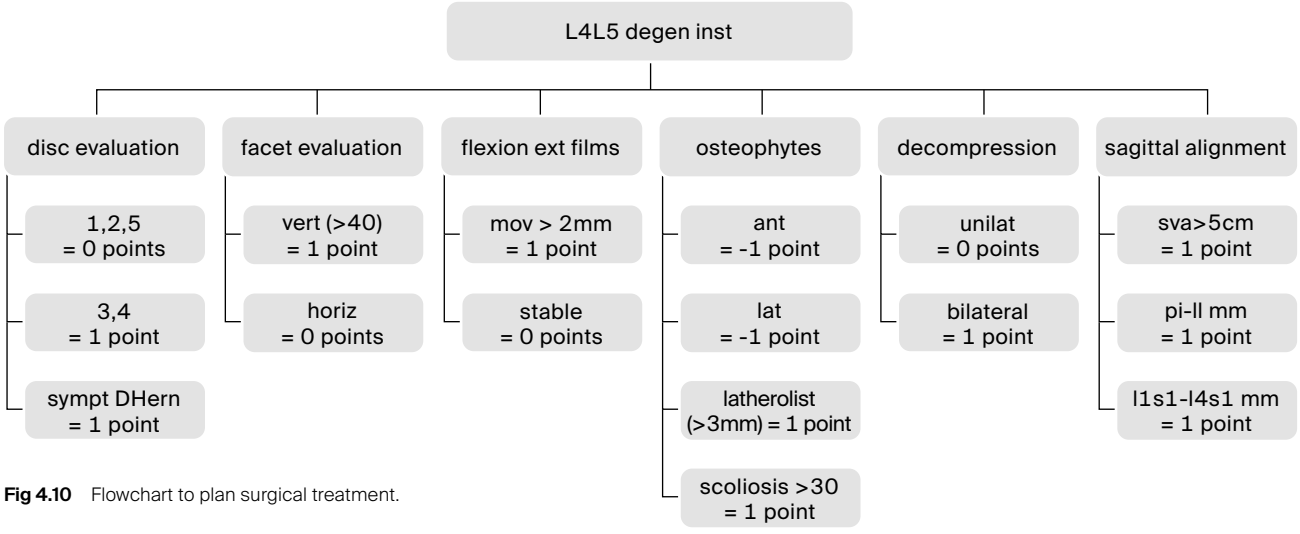


**Fig 4.10** Flowchart to plan surgical treatment.