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# CLINICAL ARTICLE

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## Lumbar fusion – indications and surgical options

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The sacrifice of motion to achieve spinal stability and pain relief has been practised since the early 20<sup>th</sup> century by means of iatrogenically induced ankylosis or fusion. Initially this was practised in the management of Pott's disease and indications have been expanded over the years to include trauma, deformity and degenerative conditions. In the last few decades there has been a proliferation of options as regards surgical technique and instrumentation. This often overwhelms the surgeon where more is perceived to be better, yet there is limited evidence that this is in fact so.

### Surgical indications for lumbar fusion

Indications for surgery in traumatic and infective pathologies are relatively clear. Once spinal stability is threatened fusion is indicated. This is based on the assessment of the anatomical structures and the appreciation of the Denis three-column or AO two-column systems. Denis describes the anterior, middle and posterior columns whereas the AO system limits their classification to the anterior and posterior columns only, suggesting that the middle column per se does not add much value in decision-making.

Once two or more columns in the Denis, or both columns in the AO classification are disrupted, an unstable situation is diagnosed. Should this involve a ligamentous injury (e.g. flexion distraction injury), spontaneous healing to a stable state is not expected and surgical fusion is indicated. Should the injury be purely bony (e.g. Chance fracture), non-operative care can be considered as spontaneous fracture healing will occur. The particular patient's circumstances need to be taken into account. Should there be a polytrauma situation with chest injury, early surgical spinal stabilisation may be beneficial to allow early mobilisation and safe nursing care.

In spinal deformity, fusion may be indicated to correct or arrest the progression of kyphosis or scoliosis. This is typically in the growing spine where the underlying pathology is expected to cause progressive deformity.

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### Most lumbar fusions are performed for degenerative conditions.

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Should the current or expected deformity threaten respiratory or neurological status, surgery should be undertaken. On occasion the effect on cosmesis and resultant psychological consequences is a driver to undertake surgery. Examples would be congenital abnormalities with significant abnormal growth potential such as a posterior hemivertebrae causing kyphosis or a lumbar sacral hemivertebrae with severe progressive scoliosis. More commonly the deformity is in the form of adolescent idiopathic scoliosis which presents during the pubertal growth spurt. Curves with Cobb angles approaching 45° and beyond would be considered for fusion surgery.

This is where the clarity ends. Most lumbar fusions are performed for degenerative conditions. The rationale for this is that the pain generator causes pain in response to mechanical stress, i.e. movement, which may be more than normal. The pain generator may be musculature, the facets or disc.

There is an increasing focus on the disc as the source of lumbar pain. This still provides many challenges as all discs degenerate with age, yet only a few cause significant debilitating pain. It remains difficult to correlate degeneration with axial back pain in a highly predictable manner. This opens the way for excessive spinal surgery in degenerative conditions and demands firm clinical indications to achieve the best outcomes. A recent review of randomised trials comparing lumbar fusion surgery to non-operative care in chronic back pain concluded that "although surgery may be more efficacious than unstructured non-surgical care it may not be more efficacious than cognitive behaviour therapy".<sup>1</sup> The use of "may" indicates that the outcome of surgery in this context is still not proven despite widespread use.

Essentially the mainstream indication for fusion in axial back pain is significant pain unresponsive to active non-operative care for a period of 6 months, where the pain generator has been determined by imaging and possible provocative discography.

This is extremely broad and open to varied interpretation which explains the different approaches among surgeons. Significant pain to one patient (and surgeon) is different from another and is influenced by many factors.

Patients with associated severe sciatica for more than 6 weeks or reduced neurological function would be considered for surgery earlier.

Other considerations would be patients where decompression for stenosis would result in instability, e.g. foraminectomy and pars resection. The presence of a neural arch defect, such as a bilateral spondylolysis, with radicular and axial pain is a good indication. The presence of symptomatic and radiological instability is an indication. Instability itself is a difficult concept in degenerative conditions. White<sup>2</sup> describes it as a "loss of ability of the spine under physiological loads to maintain relationships between vertebrae..." It is this loss that leads to nerve root irritation and pain from structural changes. Translation of greater than 3 mm on flexion/extension or an angulation greater than 10° can be considered pathological. The evidence of the "vacuum sign", viz. the evidence of intra-discal gas on the X-ray and traction osteophytes (2-3 mm away from the endplate) suggests instability.

## Fusion options

There are multiple fusion options which can be divided by technique and approach.

The lumbar spine can be fused by means of posterior or posterolateral fusions, or interbody (via the disc space).

The latter can be achieved via the anterior or posterior surgical approach. In addition, the procedures can be performed with or without the use of instrumentation, and a variety of bone graft options.

## Posterior/posterolateral fusion

Posterior fusions, where graft was placed directly on the lamina, are largely historical. Posterolateral fusions have however remained a commonly utilised technique. After sub-periosteal exposure and decortication of the lamina, pars interarticularis, facet joints and transverse processes, bone graft is applied. Although superficially simple, it is a demanding procedure especially in the male pelvis with narrow space between the posterior crests and large erector spinae muscle bulk. This may explain the wide variation of reported fusion rates from 60–90%.<sup>3,4</sup> This technique demands visualisation of the bony elements and retraction/removal of the intervening muscles and tendons. With a meticulous technique fusion rates of 90% and above can be achieved.<sup>3</sup> This posterolateral space provides for a large volume of graft which when mature provides good stability as it is closer to the compression side of the spine than the previously used posterior on lay fusions.

The advantages are that although meticulous attention to detail is required, it is a simple and low cost technique with high fusion rates. It does not require the lamina to be intact and is thus useful as an adjunct to a decompression. There is no violation to the neurological structures with a low risk approach.

The disadvantages are that extensive muscular dissection is required. This is technically demanding in the muscular patient, especially male. This can be avoided by the muscle splitting (Wiltse) technique where through a midline incision, the lumbar fascia is exposed and a plane developed laterally. The fascia is opened longitudinally about 2.5 cm lateral to the midline, where there is a palpable groove in the erector muscles indicative of the gap between multifidus and longissimus. Blunt dissection with an educated finger tip locates the facet and transverse process. This is easiest at L4/5 as distally the fascia inserts into the crest. However once the plane is identified at L4/5 it can be extended distally and the muscle detached appropriately. This is bloodless and prevents the muscle bulk being retracted against the iliac crest. Through this approach the transverse processes, facets and pars are easily visible allowing easy decortication and bone grafting.

Criticism of the posterolateral technique is that it does not change or improve the sagittal profile and does not directly address the pain generator. The degenerate disc remains and is unloaded once fusion occurs. Should there be instability such as a spondylolisthesis, brace wear may be required and patients may be slower to mobilise than other fusion options.

### Instrumented posterolateral fusion

The addition of instrumentation to provide immediate rigidity has been shown to accelerate fusion as well as increase fusion rates in the animal model.<sup>5,6</sup>

Historically spinous process wiring, Steffee plates and facet screws have been tried, but presently the mainstay of posterior instrumentation is the pedicle screw. It allows three-dimensional control of the vertebral body with the passage of screw from the base of the junction of the transverse process, superior articular process and pars down the pedicle into the body. With the large pedicles in the lumbar spine this is technically easy in trained hands although there is still a reported incidence of misplacement in the region of 10%. Many of these are minor cortical violations which are clinically insignificant.

Zdeblick<sup>4</sup> compared cohorts undergoing uninstrumented, pedicle screw plate and newer pedicle screw rod procedures. He found a 65% fusion rate in the former and 95% in the latter. It has been suggested that instrumented patients have a lower postoperative analgesic requirement, and are more rapidly mobilised with a reduced hospital stay.

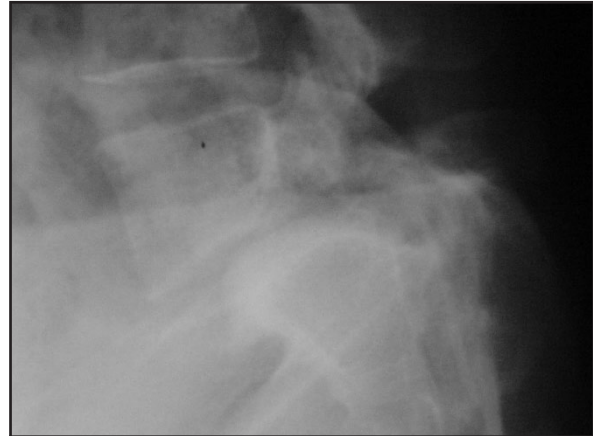
This has not been the author's experience and one wonders whether this has more to do with the surgeon's confidence than patient factors. There is no doubt that more exposure, i.e. muscle stripping, is required to insert the screws safely, which must have an adverse effect on the patient. This adds operative time and blood loss.

Despite the reported improved radiographic fusion rates, this does not necessarily follow through to enhanced clinical outcome. Andersen<sup>7</sup> reports on a five-year outcome comparing instrumented and uninstrumented posterolateral fusions. Although there are the usual methodological problems inherent in these papers, they found no difference in the pain drawings, Dallas Pain Questionnaire and Low Back Pain rating scale. Overall 79% had some residual back pain and 69% leg pain. Sixty-two per cent of the pain drawings were classified as organic and 38% non-organic. This message was confirmed by Van Tulder<sup>8</sup> in his meta-analysis of eight trials with improved fusion rates but not statistically or clinically significant improvement in clinical outcomes.

### Posterior and transforaminal lumbar interbody fusion

The posterior lumbar interbody fusion (PLIF) is performed via the spinal canal. More extensive posterior canal exposure is required but the facets are left intact. Bilateral annulotomies are done, first one then the other. This requires significant medial retraction of the thecal sac which is the major concern. This is responsible for the postoperative neuritis and frequent CSF leaks seen. The disc space is cleared and prepared for fusion. Bone graft and usually a cage is passed bilaterally into the disc space.

The proposed advantages are that the pain generator (disc) is removed. The cage supports the anterior column where 80% of the force is transmitted.

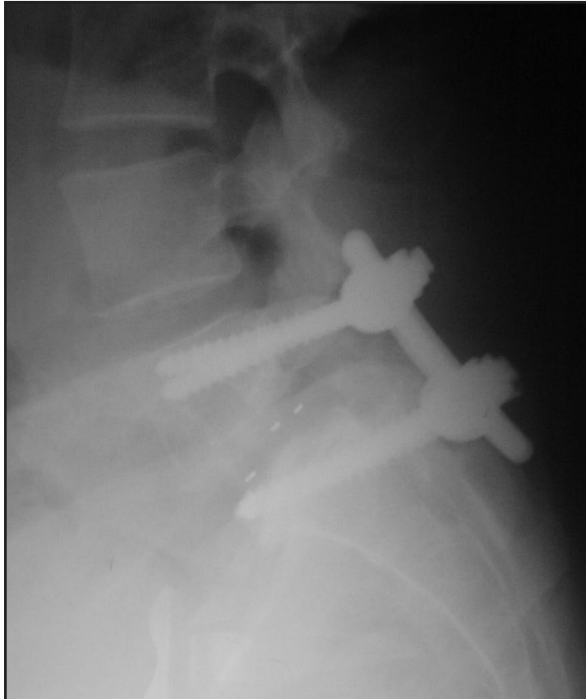


**Figure 1:**  
30-year-old patient with lytic listhesis, back and leg pain



**Figure 2:**  
MRI scan confirming foraminal stenosis

This allows foraminal height improvement without being kyphogenic such as simply distracting pedicle screws. Higher fusion rates have been demonstrated by PLIFs compared to posterolateral fusions, although only achieving the best reported results of PL fusions. The literature is varied on PLIF versus PL. Although there is a higher fusion rate in PLIFs, this is not borne out in clinical outcome studies. In addition PLIFs carry a higher complica-



**Figure 3:**  
Postoperative lateral view indicating TLIF cage *in situ*  
with reduction of slip and disc height

tion rate (30% vs 5.6%).<sup>9</sup>

The transforaminal lumbar interbody fusion (TLIF) reduces some of the neurological risk as less retraction is required. One facet is resected and the annulotomy done more laterally in the foramen where there is far more space. It requires only one side to be done. The author usually approaches via the symptomatic side so should there be some transient postoperative neuritis, it is not in the asymptomatic leg. The disc is cleared. Bone graft is placed anteriorly in the disc space and a C-shaped cage inserted and rotated round, before being impacted as far forward as possible. As with the PLIF technique, pedicle screws are a mandatory adjunct.

Fusion rates of up to 100% have been reported.<sup>9</sup> The interbody techniques are useful when sagittal plane correction is desired. A good indication is the patient with a lysis where, after decompression, there is minimal posterolateral bony surface available for fusion. There is the situation of a degenerative disc with foraminal stenosis. Here the TLIF cage will provide interbody distraction opening the foramina and facilitate interbody fusion with a large surface area from the endplates. The author finds this his primary indication for the TLIF technique. A less frequent indication is augmenting the L5/S1 level when applying a long posterior construct. In the older patient L5/S1 non-union is frequently seen with S1 screw lucency. The addition of the TLIF cage supports them without the need for an additional surgi-

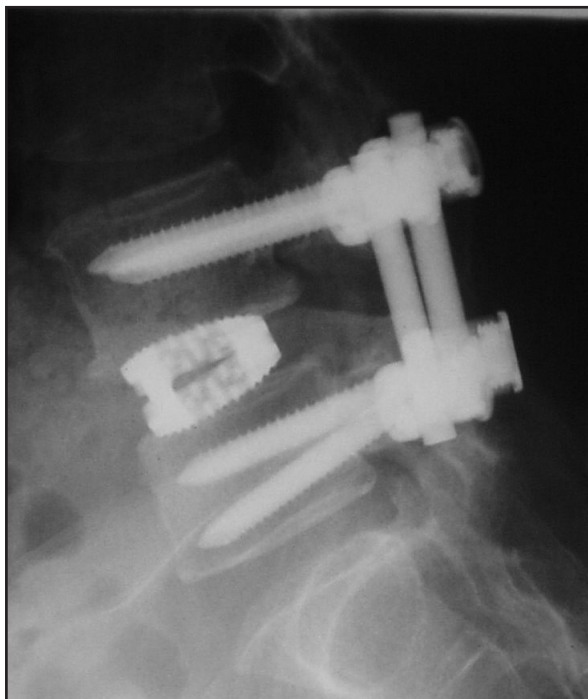


**Figure 4:**  
38-year-old woman with back and leg pain; lateral X-ray  
indicating instability of L4/5 on erect view

cal approach (Figures 1–3).

### Anterior lumbar interbody fusion (ALIF)

The ALIF is performed via the anterior approach. Thus it avoids opening the spinal canal but places the abdominal structures at risk. The retroperitoneal approach reduces the visceral problems but the vascular structures remain the concern. Although the L4/5 level can be approached from laterally, the ascending lumbar vein may be at risk. From directly anterior the vessel needs to be divided to allow medial mobilisation of the left iliac to allow access to the disc space if covered by the bifurcation. Both direct



**Figure 5:**  
Postoperative posterior decompression and fusion with an ALIF cage *in situ*

vascular injury and thrombosis have been reported.<sup>10</sup>

The rationale for ALIF is that the disc (pain generator) is removed, and foraminal height and sagittal balance can be restored. In the author's opinion this can be achieved with the posterior options although proponents argue that ALIF is superior in this regard but equal in clinical outcome.<sup>11</sup> It may still be indicated in management of discogenic pain only, i.e. when decompression is not required. Stand-alone ALIFs, i.e. without posterior fixation, have a risk of non-union and generally they involve a circumferential fusion. Newer anterior plates may obviate the need for posterior fixation but results have yet to be seen (Figures 4–5).

## Summary

Fusion of the lumbar spine is fraught with problems both in the indications and choice of fusion technique. The vast majority of surgery of the lumbar spine is for degenerative complaints where indications are vague and depend on the individual surgeon and patient's threshold.

Furthermore there are many options in surgical technique. Although they may offer intuitive and radiographic benefits these do not seem to translate to predictably improved patient outcomes. This may simply be because of the poor patient selection due to the available indica-

tions.

We therefore owe it to our axial back pain patients to be extremely conservative both in offering surgery and the technique employed.

*No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. This article is free of plagiarism.*

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