MINIMALLY INVASIVE SPINE SURGERY

HOW, WHEN AND WHY FOR ATHLETES?

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Minimally invasive spine surgery is a technique or a sum of different techniques that aim to address the patient's problem with the least amount of collateral damage. The concept of minimally invasive surgery (MIS) or less invasive surgery is to perform the required surgical procedure with the least amount of blood loss, tissue and muscle damage, while supporting the spinal column as much as possible by sacrificing the minimal amount of boney and ligamentous structures[1].

As a result, the patient should experience:

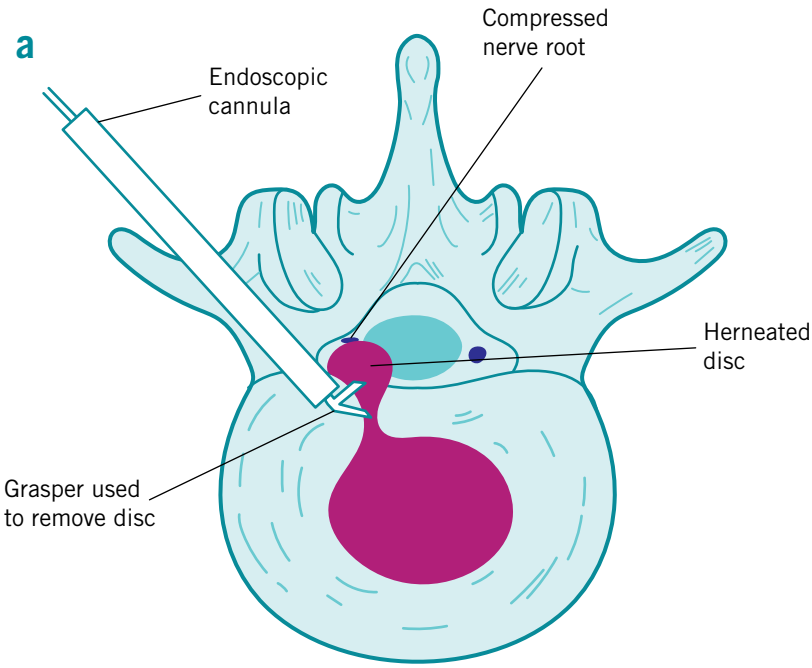
- Less postoperative pain.
- Less blood loss and need for blood transfusion.
- Less dependence on narcotic medication.
- Faster recovery and return to work/sport activities.
- Improved function.
- Less scarring and smaller incisions.
- Less damage to adjacent discs and subsequently less adjacent disc disease.

These hypothetical benefits, however, are contingent on a sound understanding of spinal mechanics and a strict adherence to proper surgical technique.

MIS spine procedures are becoming increasingly prevalent. In this article, we take a closer look at MIS spine procedures and provide a clinical reference guide for minimally invasive spine surgery. We define the most common MIS spine procedures, provide technical details of these approaches and discuss the risks, benefits and medical evidence for each procedure in the context of case discussions, to aid informed treatment decision-making with patients.

Conditions that may be amenable to MIS include:

- Disc herniation.
- Spondylosis (degenerative disc disease).
- Spondylolysis (pars defect), a very common condition among athletes.
- Spondylolisthesis (slipping of one vertebra on top of another).
- Scoliosis.
- Traumatic conditions, fractures and dislocation of the spine.
- Tumours.
- Infection.



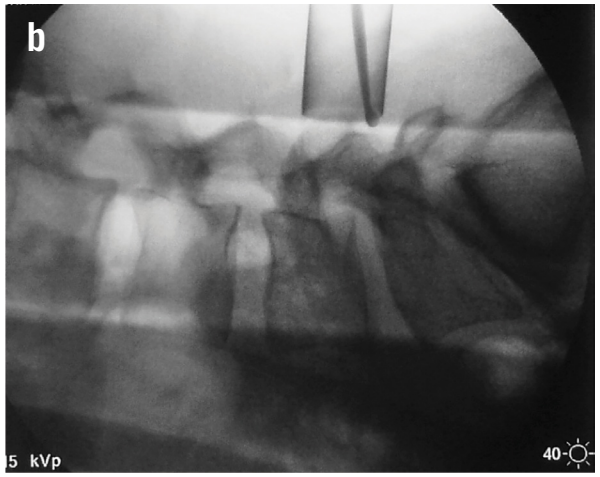


Figure 1: (a) Endoscopic discectomy. (b) Tubular laminectomy discectomy.

This article will review some of the most commonly-used treatment modalities and MIS techniques and discuss the potential benefits and complications of:

- Injection therapies such as epidural steroid injections, medial branch blocks, radiofrequency ablation (RFA).
- Endoscopic techniques.
- Percutaneous tubular techniques.
- Minimal access spinal fusions.

As with any medical condition, a careful history and physical examination, thorough diagnostic assessment, understanding of the natural history of the condition, appropriate training, plan for addressing confounding variables and a focus on function are the cornerstones of treatment.

INJECTIONS THERAPIES

Epidural steroid injections (ESI)

Increased inflammatory mediators such as inflammatory cytokines, tumour necrosis factor and others have been implicated as a source for radiculitis and nerve pain. As a result, the infiltration of anti-inflammatory agents such as steroid in the epidural space (as with ESI) has been commonly adopted. The efficacy of the ESI is unclear[2-4]. A Cochrane review of injection therapies for low back pain concluded that there is no strong evidence for or against the use of any type of injection therapy, but did not exclude that specific subgroups of patients may respond to a specific type of injection therapy[5]. Evidence-based guidelines recommend ESI as an option for short-term treatment in the presence of corroborative findings of radiculopathy, if used in conjunction with active rehabilitation and followed for functional improvement. Generally it should not be used, however, in the treatment of spinal stenosis or axial low back pain without radiculopathy.

Radiofrequency ablation

There are two types of RFA, thermal (or non-pulsed) and pulsed. Thermal ablation involves the percutaneous placement of a needle or electrode that destroys the bone lesion or nerves around the facet joint. Once the probe is placed, lesions or nerves are then targeted unilaterally or bilaterally for 40 to 90 seconds at temperatures of 60 to 90°C. The other type is pulsed RFA (PRFA), which has been introduced as a non-ablative alternative to RFA. PRFA delivers short bursts of radiofrequency (RF) current, of 2 Hz with temperatures not exceeding 42°C, instead of the continuous flow of RF current produced by continuous RF generators. The use of ablation therapies is still to be considered under investigation[6-8].

ENDOSCOPIC TECHNIQUES (FIGURE 1a)

Indications

Endoscopic techniques have primarily been applied to simple disc herniation without the need for spinal fusion or instrumentation.

Technique

This is typically a same-day procedure that utilises an endoscope through a very small incision to access a herniated disc.

Some studies have shown equivalent results with endoscopic techniques to open surgery, but with limited application and a high conversion rate to open discectomy[9]. One possible complication to be aware of with this technique is the potential for under-treatment of spinal disorders that could require larger decompression or fusion, which may result in ongoing or increased disability.

PERCUTANEOUS TUBULAR TECHNIQUES (FIGURE 1b)

Indications

Laminectomy, discectomy and short segment spinal fusions.

Technique

Progressive tubular dilation (typically 12 to 24 mm diameter) that allows muscle splitting and docking right on the site of pathology without disturbing surrounding muscles and normal structures.

Tubular discectomy and fusion have gained popularity since the 1990s with varied results. Most studies have shown equivalent outcomes with open discectomy and laminectomy and better outcomes of minimally invasive tubular transforaminal or posterior lumbar interbody fusion over open fusion surgery, with a lower complication rate, shorter hospital stay and lower cost for minimally invasive tubular transforaminal posterior interbody fusion[10-12].

PERCUTANEOUS PEDICLE SCREW PLACEMENT

One of the most dramatic changes in the field of spine surgery has been the adoption of percutaneous placement of pedicle screws, instead of full exposure of the spinal element which results in significant muscle damage.

The screws are placed by using image guidance (fluoroscopic or CT) in order to allow safe placement of a Jamshidi needle, followed by placement of flexible wire that guides the placement of the cannulated screws percutaneously. These screws are then connected together using a longitudinal rod that helps stabilise the spine. The accuracy and safety of this image-guided technique is now well established at improving patient outcomes.

DIRECT LATERAL AND ANTEROLATERAL APPROACHES

The author has developed and patented several techniques and technologies that allow access to the spine via posterior, posterolateral, lateral and anterolateral techniques and considers the latter to be the optimal technique in MIS for the reasons listed below.

Indications

Spinal fusions, spondylolisthesis and sagittal, coronal and axial deformity.

Technique

The spinal column can be accessed from a lateral angle or through a slightly more anterior incision using an antero-lateral angle (Figure 2), rather than a posterior approach. Different companies have different names for the lateral approach techniques such as lateral Cougar, XLIF, Direct Lateral etc.

Advantages of both the lateral and antero-lateral techniques when applied appropriately include:

- The ability to address both simple and complex disorders.
- Suitability for short or long segment diseases.
- Reduction of post-operative pain.
- Shorter recovery period.
- Fewer complications such as infection, dural tears and nerve root injuries.
- Reduced cost.

Advantages of the anterolateral approach when applied appropriately include the following (Figure 3):

- Avoiding disruption or injury of the psoas muscle – which contains the lumbosacral plexus – resulting in thigh and leg burning and or weakness.
- Avoiding costly intraoperative neuro-monitoring that is necessary for a trans-psoas approach.
- A simpler technique to use, allowing access to and treatment of spinal disorders from the T12 to the S1 level.
- Improved access to the lumbar spine giving the ability to achieve more robust correction of disc height and sagittal and coronal deformities (Figure 4).

COST

One common misconception is that MIS is more expensive than standard open surgery. Despite more expensive novel implants, numerous studies show that MIS techniques are less costly than open surgery. Most of the cost reduction is due to the shorter hospital stay, less costly complications such as infection, reduced need for postoperative pain medication, as well as earlier return to normal daily activities. Cahil et al[13] showed a $5,453 saving per MIS discectomy vs open procedure and shorter hospital stay (0.9 days vs 1.5 days). Parker et al[12] concluded that multiple level decompression MIS has the same cost as the equivalent open surgery. Pelton et al[14] showed a 12% cost reduction in transforaminal lumbar interbody fusion (posterior fusion) in MIS vs open in a workers' compensation population.

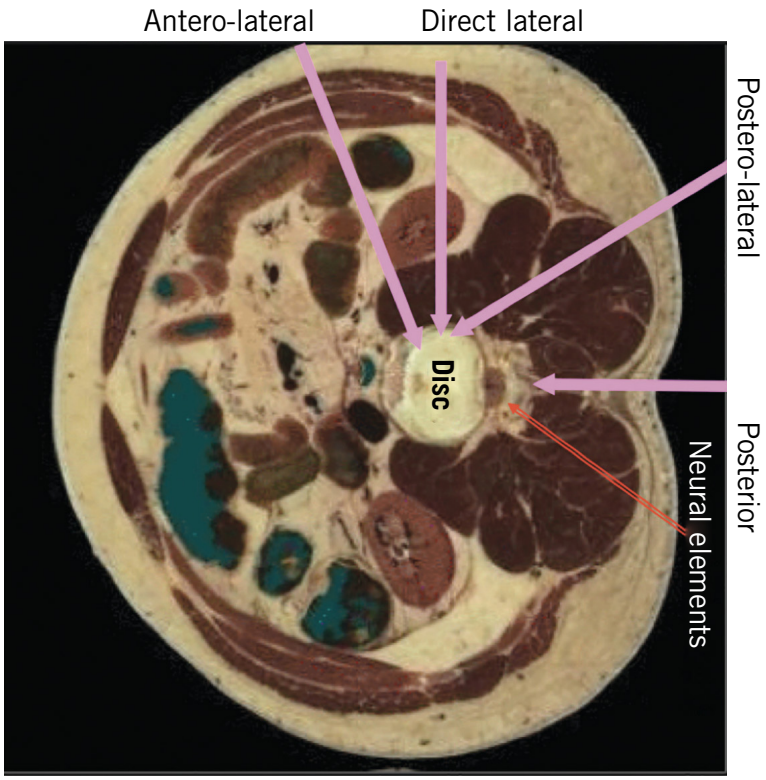
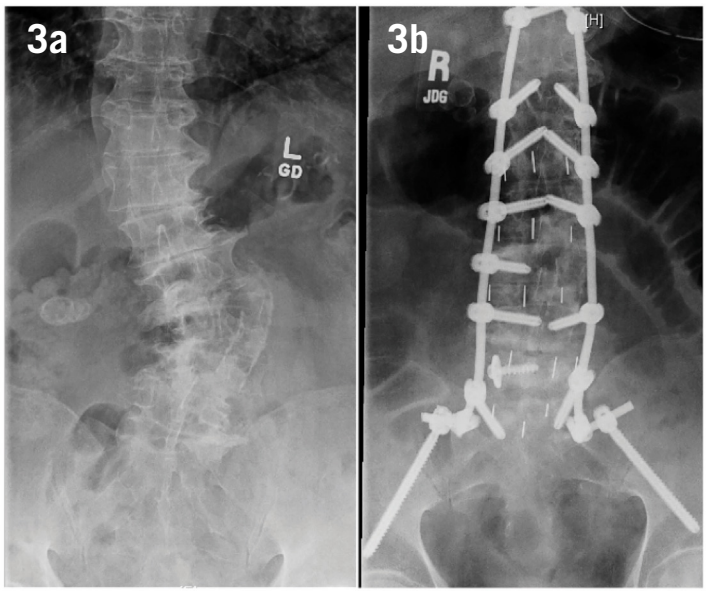


Figure 2: Different approaches to the spine.



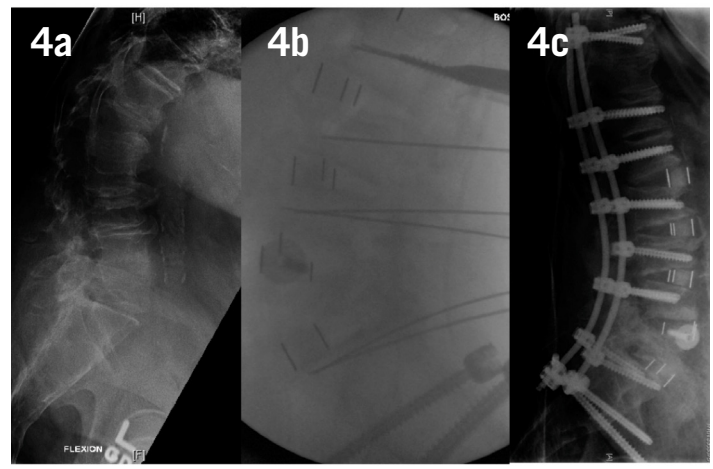


Figure 3: Front view showing a scoliosis before (a) and after (b) correction.

Figure 4: Correction of severe deformity via MIS techniques. (a) Severe kyphosis: forward hunched back, (b) percutaneous correction over the wires, (c) perfect lordosis spinal alignment.

COMPLICATIONS

Minimally invasive spinal surgery does share most of the complications of open spine surgery, however, at different rates. Some of the most relevant complications are:

- Infection: the infection rate has fallen dramatically with the use of MIS techniques, mainly due to the reduction in tissue damage and postoperative dead space. For most procedures, the infection rate dropped by 60 to 90%. In a meta-analysis of the literature, the infection rate was 0.6% versus 4% with a cost saving of $24,000 per infection. In a report from the Scoliosis Research Society worldwide database (containing more than 11,000 surgeries), the infection rate was reduced dramatically in the MIS group (0.4 vs 1.1% for the discectomy group and 1.3 vs 2.9% for the fusion group)[15].
- Neurological injuries: most studies showed equivalent or reduced risk of neurological injuries[10,16,17] with MIS approaches.
- Accuracy of hardware placement: counter-intuitively and despite percutaneous targeting of the spinal elements instead of open visualisation, MIS has been associated with a much-reduced rate of misplaced hardware. This improved accuracy is most likely related to the abundant use of advanced image guidance for spinal navigation[16-19].
- Deformity correction: MIS techniques have been shown to achieve good coronal alignment. One of the main limitations of MIS techniques, however, is the limited ability of the correction of sagittal balance. The anterolateral approach allows for correction of sagittal balance because of the ability to perform anterior tether release and to re-establish normal disc heights (Figure 4).

CONCLUSIONS

As education, training and research evolve, more traditional open surgical management is being augmented or replaced by minimally invasive technologies and approaches. Minimally invasive spinal surgery can be a safe, effective and cost-saving procedure when performed by well-trained and specialised surgeons. The author cautions readers, however, that minimally invasive spine surgery is used as a marketing tool by some surgeons who may or may not have the proper training to achieve the full benefits from these promising techniques. As with any technology, training is critical and the use of technology should not replace critical thought and clinical reasoning. Also, smaller incisions do not always mean a better outcome. By understanding some of the current and emerging terms, techniques, approaches and potential complications and benefits, non-spine surgeons can better assist their patients to navigate the often confusing and controversial landscape of spine injury treatment.

References
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