Minimally Invasive Spine Surgery

Dr. Daniel WK Ng  MBBS(NSW), FRCSEd (Surgical Neurology), FCSHK, FHKAM(Surgery)
Department of Neurosurgery, Pamela Youde Nethersole Eastern Hospital

Introduction
Problems of the spine encompass a wide range of disorders including those of degenerative, developmental, neoplastic, and traumatic nature. Spine surgery usually gives the impression of being a major surgery with prolonged recovery. However, in recent years surgery of the spine, as with other branches of surgery, has evolved along the lines of minimal invasiveness and problems that were dealt with by open surgery are now being treated with minimally invasive techniques. In this article, several minimally invasive techniques in the treatment of spine diseases will be discussed.

Biomechanics of the spine
It is important to understand the basis of spinal stability to appreciate the importance of preserving as much anatomical structure as possible. Spinal stability has always been difficult to define but for our purpose we can adopt the definition from White and Panjabi\(^1\) defined as the ability of the spinal column to withstand physiological stress. Different concepts have been proposed to describe the biomechanical basis of spinal stability. The two column theory can provide a useful model for our discussion.

The vertebral body, intervertebral disc, and connecting ligaments comprise the anterior column while the posterior elements including the facets, the lamina and the posterior ligamentous complex constitute the posterior column. Generally speaking, the anterior column supports axial load of the body while the posterior column serves as a tension band. The two columns complement each other in terms of function, i.e. one column cannot function adequately without the other.

Posterior approach
The traditional posterior approach to the spinal canal is laminectomy. Laminectomy involves the removal of the bony lamina and spinous processes, ligamentum flavum, as well as the interspinous and supraspinous ligament. The removal of these structures damages the tension band mechanism and significantly weakens the posterior column. This can lead to instability and post-laminectomy deformity has been reported.\(^2\)\(^3\)

Apart from the aforementioned structures, the paraspinous muscles also play an important role in stabilisation of the spine. Stripping of the paraspinous muscles in performing laminectomy may lead to muscle atrophy\(^4\) and can contribute to instability. Also the wide exposure of the spinal canal from a laminectomy may contribute to epidural scarring.

Lumbar disc disease
Lumbar disc herniations typically present with back and leg pain which tends to be worse with physical activities. Tension signs can be positive on physical examination. MRI will reveal the diagnosis.

Different approaches have been developed for treatment of disc herniations in the lumbar spine. The standard procedure of laminectomy or fenestration and diskectomy via a midline approach involves destruction of the posterior elements as described above. Therefore performing microdiskectomy with the aid of a microscope can help to minimise tissue trauma and laminectomy is not required to remove disc fragments. By using a paramedian approach\(^5\) the midline ligamentous structure can be preserved making deformity less likely. Less trauma to the paraspinal muscles also minimise postoperative muscle atrophy. Other minimally invasive techniques using endoscopic technology has also been developed.\(^6\)\(^7\)

Microsurgical decompression of lumbar spinal stenosis
Patients with degenerative spinal stenosis usually present with back, buttock, thigh, and calf pain. Neurogenic claudication is another feature with this entity. Again the diagnosis is made with MRI.

Using a similar paramedian approach, spinal stenosis caused by hypertrophy of the ligamentum flavum and facet joints can be decompressed using minimally invasive microscopic techniques.\(^8\) Fig. 1. Undercutting of the base of the spinous process together with tilting of the operative table allows access to the contralateral spinal canal and adequate decompression without disturbing much of the posterior structures. Hypertrophied ligamentum flavum and facet joints can be resected with rongeurs and high speed drill.

Minimally invasive approach to extramedullary spinal tumours
Extramedullary spinal tumours often present with...
neurological deficits as a result of neural compression. Alternatively it can present with pain. The commonest extramedullary tumour in the spine is neurilemoma followed by meningioma.

A relatively new development is the development of minimally invasive approach to treatment of intradural extramedullary spinal tumours by using the minimally invasive technique9 Fig. 2. Traditionally the laminectomy is required for exposure for treatment of these tumours which requires opening of the dura. Using the same principle as outlined above, these tumours can be approached via a paramedian approach with undercutting of the spinous process. One major concern is the possibility of CSF leakage after dural opening. Our experience shows that primary closure of the dura is possible with this technique and where this is not possible with dural defects, synthetic onlay dural substitute can be used. No new neurological deficit or postoperative CSF leak has been observed so far with this technique. Whether this technique can be used with intramedullary tumours or large extramedullary tumours remains to be seen. However, this technique can be converted to the traditional approach if needed without much difficulty.

Minimally invasive lumbar spine instrumentation

The standard approach for fixation of the lumbar spine with instrumentation involves exposure of the posterior elements of the lumbar spine. Techniques have been developed to allow percutaneous placement of pedicle screws and rods to provide rigid fixation from posteriorly10. Tissue trauma associated with this approach is considerably less than the conventional approach.

Microscopic approach to the anterior aspect of the lumbar spine has also been developed to allow interbody fusion to be done along natural tissue plane with minimal access11. Interbody fusion can also be accomplished by Posterior Lumbar Interbody Fusion (PLIF)12, and Transforaminal Lumbar Interbody Fusion (TLIF)13 where anterior approach is not necessary. In PLIF and TLIF the disc space is approached posteriorly after resecting the medial and lateral part of the facet joints respectively. Interbody fusion cages can then be inserted. Combined with posterior instrumentation this will provide fixation of both anterior and posterior columns of the spine.

Conclusion

The development of minimally invasive spine surgery marks a new era in the treatment of spinal problems. With more preservation of normal structures, functional outcome can hopefully be improved. It is, however, important to note that traditional approach forms the basis of spine surgery and has been proven reliable and remains so. It is perhaps more important to realise the limitations in the problems that can be treated by minimally invasive techniques. Careful preoperative planning is imperative and familiarity with spinal anatomy is a must before attempting minimally invasive technique. One should also note the learning curve associated with this technique and be prepared to convert to traditional approach when necessary.

References