MINI-REVIEW

Current status of minimally invasive thoracolumbar spine surgery for treating neoplastic, traumatic, and infectious spine diseases

Jiann-Her Lin a,b,*

a Department of Neurosurgery, Taipei Medical University Hospital, Taipei, Taiwan
b Graduate Institute of Neural Regenerative Medicine, College of Science and Medicine Technology, Taipei Medical University, Taipei, Taiwan

Received 14 November 2014; received in revised form 14 January 2015; accepted 16 February 2015
Available online 16 May 2015

KEYWORDS
infection; minimally invasive spine surgery; spine; tumor; trauma

Summary The application of minimally invasive spine surgery (MIS) for treating thoracolumbar spine disorders and injuries has evolved rapidly, and the technical feasibility and safety of MIS has been well established. The successful use of MIS for treating degenerative spine diseases has broadened its scope, and this technique is now used for treating nondegenerative diseases. For spinal neoplastic diseases, MIS is suitable for patients with intradural extramedullary tumors limited to one or two spinal segments. However, the feasibility of MIS in treating intramedullary or complicated large intradural extramedullary tumors remains unclear. For traumatic spine diseases, the outcomes of percutaneous pedicle screw instrumentation are comparable with those of open pedicle screw instrumentation for treating thoracolumbar compression fractures without neurological deficits. However, the efficacy and safety of MIS for patients with advanced-type thoracolumbar fractures or neurological deficits remain debatable. Percutaneous endoscopic lavage and drainage facilitates prompt and sensitive antibiotic therapy against the offending pathogens in infectious spine diseases and is particularly suitable for patients with early-stage spinal infections or serious medical conditions. With the advances in MIS techniques and the improved knowledge regarding diseases and the anatomy of the spine, MIS can be used for treating various spine diseases.

Copyright © 2015, Taiwan Surgical Association. Published by Elsevier Taiwan LLC. All rights reserved.

Conflicts of interest: The author has none to declare.
* Department of Neurosurgery, Taipei Medical University Hospital, No 252, Wu-Shing Street, Xin-Yi District, Taipei, Taiwan
E-mail address: jiannher@me.com.

http://dx.doi.org/10.1016/j.fjs.2015.02.002
1682-606X/Copyright © 2015, Taiwan Surgical Association. Published by Elsevier Taiwan LLC. All rights reserved.
1. Introduction

The application of minimally invasive spine surgery (MIS) for treating thoracolumbar spine disorders and injuries has evolved rapidly, and the technical feasibility and safety of MIS has been well established. MIS can be defined as a spine operation based on the following basic principles: prevention of muscle crush injuries and preservation of the tendon attachment sites of crucial muscles using self-retaining retractors, using known anatomic neurovascular and muscle compartment planes, and minimizing collateral soft tissue injuries by limiting the width of the surgical corridor. The use of these basic principles in MIS has led to significant reductions in intraoperative blood loss, postoperative pain, and surgical morbidity compared with the traditional midline posterior approach. Thus, MIS has become an alternative to conventional open surgery for treating various spine diseases, particularly degenerative spine diseases. Recently, MIS has been used for treating non-degenerative diseases. In this review, we present evidence that supports the use of MIS for treating an increasingly wide range of spinal pathologies and elucidate the current role of MIS in nondegenerative spine diseases such as neoplasms, infections, and traumatic spine diseases.

2. Spine neoplasm

1. Recommended indications: single-level intradural extramedullary or extramedullar tumors
2. Recommended contraindications: multilevel or intramedullary tumors
3. Complications: dura tear, cerebrospinal fluid (CSF) leakage, postoperative new neurological deficits, and infections

MIS has been used for treating spinal neoplasms and theoretically reduces postoperative instability. According to a finite element analysis comparing traditional and minimally invasive intradural tumor exposures, minimally invasive hemilaminar exposure preserves the structural integrity of the lumbar spine and minimizes postoperative alterations to segmental motion. The feasibility of MIS for treating patients with intradural extramedullary tumors limited to one or two spinal segments has been thoroughly documented. In a retrospective case series of 10 patients with thoracolumbar neurofibromas, the authors used unilateral limited laminectomy for tumor removal, sparing the joint and ligamentum interspinosum. No complications, particularly new neurological deficits, were observed, and watertight dural closure was performed using 5-0 or 6-0 stitches in each case. However, this approach was limited to one or two levels. Therefore, in that series, one female patient with three neurofibromas required surgery twice. Another retrospective case series of six patients demonstrated that MIS was a feasible technique with an operative time of 247 minutes, estimated blood loss of 56 mL, and a hospital stay of 57 hours. All these intradural extramedullary tumors were limited to one or two levels. In a retrospective study of 15 patients with spinal schwannomas, the authors reported that gross total resection was achieved in all cases by using MIS, and none of the patients necessarily required a fusion procedure, although the tumor extensions caused problems for the surgeons in approach, tumor resectability, and spine stability. The authors suggested using laminectomy for removing intradural tumors, hemilaminectomy for removing extradural lesions, the paramedian route for removing the extraspinal part of the tumor, and costotransversectomy for removing tumors in the thoracic region. Furthermore, two retrospective case series of patients with intradural medullary or extramedullary tumors demonstrated that MIS was a feasible and safe procedure. All these studies suggest that MIS, when performed by an experienced surgeon, may serve as an alternative to traditional open tumor resection for treating intradural extramedullary tumors and potentially reduces blood loss, the hospital stay duration, and disruption to local tissues. However, the role of MIS in treating intramedullary tumors or complicated large intradural extramedullary tumors remains unclear. In a retrospective case series, the authors used MIS for treating one intramedullary tumor (inclusion tumor) without remarkable complications. Percutaneous vertebroplasty (PVP) has been proven to effectively relieve pain associated with spinal metastasis. A randomized controlled trial comprising 100 patients compared the clinical efficacy and safety of PVP combined with 125I implantation with those of regular radiation therapy for treating spinal osteoblastic metastasis. The clinical efficacy of PVP combined with 125I seeds was more satisfactory than that of regular radiation therapy (p < 0.05) according to the visual analog scale (VAS) of pain and Karnofsky performance scores during the follow-up period of 6 months to 5 years. In a retrospective case series of eight patients with spinal metastasis of the spinal canals, all patients underwent percutaneous transpedicular coblation corpectomy that was immediately followed by balloon kyphoplasty and then radiation therapy for 2 weeks. PVP can effectively relieve pain, stabilize the spine, improve the quality of life, and reduce the occurrence of paraplegia in patients with spinal osteoblastic metastasis. In a retrospective case series of 26 patients with pathological compression fractures who underwent combined kyphoplasty and spinal radiosurgery treatment, axial pain improved in 24 (92%) patients during the follow-up period of 7–20 months. A retrospective three-case series showed that kyphoplasty was an effective, simple, and safe alternative for treating vertebral collapse consequent to multiple myeloma.

3. Traumatic thoracolumbar spine fractures

1. Recommended indications: burst fracture without neurological symptoms
2. Recommended contraindications: flexion rotation spine injuries
3. Complications: dura tear, CSF leakage, postoperative new neurological deficits, infection, pseudoarthrosis, and postoperative kyphosis

Traumatic fractures of the thoracolumbar spine, particularly the thoracolumbar junction (T10–L2), are the most common fractures of the spinal column. Percutaneous pedicle screw instrumentation (PPSI) has been used for
treating various trauma patterns. For patients with thoracolumbar compression fractures (type A3 according to Magerl/AO classification) without neurological deficits, PPSI was reported to have comparable outcomes with open pedicle screw instrumentation (OPSI) and a shorter post-operative recovery period. In a retrospective study of 21 patients, patients who received PPSI treatment had significantly less intraoperative blood loss but a longer operative time, and most importantly, comparable radiographic or clinical outcomes relative to those who received traditional open treatment 5 years after implant removal. Another retrospective study of 38 patients who had similar injuries and received PPSI at an average follow-up of 11.6 months revealed significant reductions in blood loss, operative time, hospital stay duration, blood transfusion, the proportion of analgesic supplements, and the postoperative incisional VAS pain score. However, the anterior height of the fractured vertebra was shorter in patients treated using PPSI, indicating that PPSI may be less effective in restoring the anterior height of the fractured vertebra than OPSI. A retrospective study examined 35 patients treated with short-segment fixation by using PPSI or OPSI (fixation 1 level above and below the injury). Patients treated using PPSI had significantly shorter operative times, less blood loss, less postoperative pain, and comparable radiographic and clinical outcomes relative to those treated using OPSI at 2-year follow ups. Another retrospective comparative study of 59 patients confirmed that both OPSI and PPSI were safe and effective for treating thoracolumbar burst fractures. Although both groups showed favorable clinical and radiologic outcomes at the final follow up, OPSI without bone grafts provided early pain relief and more favorable functional outcomes. Only one prospective randomized trial compared OPSI (paraspinal approach) and PPSI. Similar to the retrospective studies, the prospective randomized trial reported that PPSI was associated with significantly less intraoperative blood loss, shorter operative times, shorter hospital stays, less pain, and more favorable functional outcomes at 3 months and had comparable outcomes for more than 3 years relative to OPSI. However, the author reported that compared with PPSI, OPSI resulted in more satisfactory correction of kyphosis and restoration of vertebral height for patients in whom intraoperative postural reduction could not be achieved.

For patients with flexion–distraction injury (type B according to Magerl/AO classification), a retrospective study of 38 patients showed similar benefits of PPSI over a mean follow-up period of 18.5 months. However, the authors used PPSI only in patients without neurological deficits. In conclusion, the advantages of PPSI relative to OPSI include preservation of posterior musculature, less blood loss, shorter operative time, lower infection risk, less postoperative pain, shorter rehabilitation time, and shorter hospital stay; however, its limitations include the inability to achieve direct spinal canal decompression and lack of the option to perform a fusion.

Although substantial evidence has shown that PPSI is both effective and safe for patients with thoracolumbar compression fractures (type B according to Magerl/AO classification), only a few studies have addressed thoracolumbar fractures with neurological deficits or flexion rotation fractures (type C according to Magerl/AO classification). In a retrospective analysis of patients with thoracolumbar junction fractures, the authors used video-assisted thoracoscopic surgery with a minimally invasive approach (minithoracotomy) for reconstructing the anterior spinal column followed by PPSI for treating four patients with type C fractures, and the patients were satisfied with the outcomes. There is an obvious tendency to treat such patients by using PPSI with a minimally invasive approach for decompressing the spinal canal or reconstructing the anterior column. However, the efficacy and safety of these methods for treating patients with advanced-type thoracolumbar fractures or neurological deficits remain debatable.

4. Infection

1. Recommended indications: single-level diskitis
2. Recommended contraindications: multilevel diskitis and osteomyelitis
3. Complications: dura tear, CSF leakage, and postoperative new neurological deficits

Although treating spinal infections by using MIS seems unfeasible because of their variable presentations and complicated course, the role of MIS in treating infections has recently been explored. In a retrospective case series of 21 patients with lumbar infectious spondylitis, the authors reported that percutaneous endoscopic lavage and drainage (PELD) was effective in obtaining a bacteriological diagnosis, relieving the patients’ symptoms, and facilitating the eradication of lumbar infectious spondylitis, and they suggested that the indications of this minimally invasive procedure could be extended to spinal infections, such as paraspinal abscesses, and postoperative recurrent infections. In another retrospective case series of 15 patients with pyogenic spondylodiskitis in the thoracic or lumbar spine, the authors reported that immediate back pain reduction after surgery was achieved using PELD, and the infections were successfully treated using subsequent parenteral antibiotics for an average duration of 3.7 weeks. In a similar retrospective case series of 14 patients with infectious spondylodiskitis who were treated using percutaneous endoscopic debriement and drainage, 10 patients recovered without any complications, and two patients experienced recurrent infections and underwent anterior spinal fusion operations. The authors suggested that percutaneous endoscopic debriement and drainage had a high diagnostic efficacy and enabled adequately retrieving specimens, thereby facilitating prompt and sensitive antibiotic therapy against the offending pathogens. This method was particularly suitable for patients with early-stage spinal infections or serious medical conditions.

5. Conclusion and future perspectives

The current status of MIS and its role in nondegenerative spine diseases are described in this review (Table 1). MIS is feasible for patients with intradural extradural tumors that are limited to one or two levels. However, the role of MIS in treating intradural tumors or complicated large
intradural extramedullary tumors remains unclear. PVP has been proven to effectively relieve pain associated with spinal metastasis. In traumatic spine diseases, PPSI has comparable outcomes with OPSI for treating thoracolumbar compression fractures without neurological deficits. However, PPSI may less completely restore the anterior height of the fractured vertebra compared with OPSI. For more complicated traumatic spine diseases, an obvious tendency is to treat such patients by using PPSI combined with a minimally invasive approach for decompressing the spinal canal or reconstructing the anterior column. However, the efficacy and safety of these methods for treating patients with advanced-type thoracolumbar fractures or neurological deficits remain debatable. For treating infectious spine diseases, PELD enables adequately retrieving specimens with a high diagnostic efficacy, thereby facilitating prompt and sensitive antibiotic therapy against offending pathogens. This method is particularly suitable for patients with early-stage spinal infections or serious medical conditions. With advances in MIS techniques and improved knowledge regarding the diseases and anatomy of the spine, MIS can be used for treating various spine diseases.

References


