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MINI-REVIEW

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

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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.
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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.[1–3] The use of these basic principles in MIS has led to significant reductions in intraoperative blood loss, postoperative pain, and surgical morbidity[3–7] 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 nondegenerative 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 extradural 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.[8] 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.[9] However, this approach was limited to one or two levels. Therefore, in that series, one female patient with three neurofibromas required surgery twice.[9] 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.[10] All these intradural extramedullary tumors were limited to one or two levels.[10] 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.[11] 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.[11] Furthermore, two retrospective case series of patients with intradural medullary or extradural tumors demonstrated that MIS was a feasible and safe procedure.[12,13] 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 ^{125}I implantation with those of regular radiation therapy for treating spinal osteoblastic metastasis. The clinical efficacy of PVP combined with ^{125}I 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.[14] 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.[15] PVP can effectively relieve pain, stabilize the spine, improve the quality of life, and reduce the occurrence of paraplegia in patients with spinal osteoplastic 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.[16] A retrospective three-case series showed that kyphoplasty was an effective, simple, and safe alternative for treating vertebral collapse consequent to multiple myeloma.[17]

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, pseudoarthrodesis, 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

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