CASE REPORT

Thoracic Spine Degeneration Following Microlaminotomy for Spinal Cord Stimulator Placement and Subsequent Removal—a Case Report

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Introduction

Spinal cord stimulators (SCSs) have become increasingly popular as a treatment modality for neuropathic pain since their first description in 1967 [16]. Neuropathic pain can occur in the setting of spinal disease or in other conditions such as complex regional pain syndrome (non-spinal etiology of neurogenic pain). Neuropathic pain after spinal surgery may result from a variety of factors such as postoperative microinstability, epidural fibrosis, depression, residual or recurrent disc herniations, or intrinsic nerve cellular changes and has become a complex and expensive challenge for modern healthcare [2]. The increased incidence reported after complex surgery has not been ameliorated by the advances made in minimally invasive surgery [14, 15]. Patients with neuropathic pain stemming from spinal surgery are reported to have a decreased quality of life and frequently fail to find pain relief from conservative medical treatment modalities when compared to patients with chronic pain of another origin [17]. SCSs have been shown in limited studies to increase patients' quality of life and functional capacity while decreasing leg- and low back pain and utilization of analgesic medication. However, SCS results in increased costs to the health system over conventional therapies for these diagnoses [8, 10]. The placement of

SCSs after prior spinal surgery is frequently complex due to prior fusions and laminar overgrowth as well as epidural scarring which may prevent or complicate both the percutaneous placement of single-column leads as well as the microsurgical placement of wide paddle leads. Wide paddle leads offer broader terminal coverage and more numerous programming algorithms but require a more invasive microlaminotomy for insertion. Placement of leads above the cephalad extent of fusion may be required. If prior fusion extends to the upper lumbar segments, this may require thoracolumbar insertion of leads.

The spine transitions from a lordotic orientation to the kyphotic thoracic spine through the thoracolumbar junction. There are large biomechanical differences between the two regions. The lordotic lumbar spine posterior elements are under relative compression. In contrast, the thoracic and thoracolumbar spine posterior elements are exposed to a much larger tensile or distractive force—especially in the setting of age-related advancement of positive sagittal balance [11, 12]. Therefore, the posterior tension band of the vertebral segment is more critical in the thoracic spine. The rib cage and associated structures provide some support [1, 7, 13]. The free ribbed thoracolumbar segments from T10–L1 are a transition zone without rigid rib cage support. As a result, thoracic and thoracolumbar wide laminectomy has been historically associated with a risk of postoperative kyphosis. Removing the spinous processes and ligamentum flavum and undercutting the facet joints compromise the posterior tension band and subject the anterior column structures to increased kyphotic deforming forces. This phenomenon was seen particularly frequently in the pediatric patient population following tumor resection but has been extrapolated to apply to adults [3, 6, 18]. In theory, minimally invasive laminotomy approaches that preserve the posterior tension band structures may be protective [9]. We present a unique case of development of degenerative disc disease and severe stenosis following implantation and removal of a SCS through a minimally invasive laminotomy sight at

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T10–T11, cephalad to a prior fusion. The SCS device consisted of a wide paddle electrode and was intended for distal cord placement in a patient with chronic neuropathic pain.

Case Report

A 47-year-old female first presented to the outpatient clinic with disability due to severe lower back pain radiating into the bilateral lower extremities with reduced motor strength of the right extensor hallucis longus and tibialis anterior as well as paresthesias. The lower back pain commenced following a motor vehicle accident the prior year. Her medical history was significant for rheumatoid arthritis, steroid exposure, and osteoporosis. The radiographic examination revealed spinal stenosis in the setting of degenerative spondylolisthesis. At the time of presentation, she had failed significant conservative therapy including physical therapy, non-steroidal antiinflammatory drugs (NSAIDs), and epidural steroid injections. After failing conservative care and with decreasing functional capacity, she was indicated to undergo surgical intervention. Given her complex medical history, she underwent a preoperative metabolic bone consultation and preoperative Forteo therapy of 6-month duration.

The patient had a complex prior surgical history over a 10-year period. She previously underwent posterior spinal fusion from L4–S1 with an immediate improvement of symptoms. This was complicated by another MVA and fracture of the cephalad segment that required extension of the fusion to L3. At 2-year intervals, the patient required add-on surgery until she was successfully fused from L1–S1. At each additional surgery, anterior column support via a lateral approach was utilized in an attempt to maximize fusion rates. The patient responded with functional improvements but still complained of significant low back pain. Following a multidisciplinary discussion, the patient was deemed a candidate for a spinal cord stimulator.

Attempts to place a percutaneous trial lead within the lumbar spine at the segments immediately cephalad to her instrumented construct failed because of the altered anatomy resulting from her prior surgery. Therefore, the patient was indicated to undergo wide paddle lead placement via a minimally invasive laminotomy cephalad to her instrumented construct and postsurgical epidural scar at the T10–T11 segment. The posterior tension band structures were preserved. A keyhole laminotomy was made followed by a small unilateral incision in the ligamentum flavum. No facet resection was performed. The large paddle generator of the SCS was placed over the dorsal column of the lower thoracic spinal cord at T8–9, and the generator battery pack was placed in the right flank of the patient (St. Jude Neuromodulation Octrode, Plano, TX, USA). The SCS alleviated the patient's complaints for 2 years when it stopped working. The patient subsequently had the SCS removed through a revision laminotomy due to irritation she was experiencing from the battery pack.

Four months after the removal of the SCS, the patient presented with progressive ataxia, neurogenic claudication,

and severe pain. The radiographic examination revealed no evidence of dynamic instability but severe cord compression at T10–T11 in the setting of severe degenerative disc disease and resultant stenosis. A timeline of MRI of the thoracolumbar spine reveals the de novo development of severe degenerative disc disease and stenosis at a non-adjacent segment to the fused L1–S1 construct. The T10–11 level specifically showed a vacuum disc as well as ligamentum flavum hypertrophy and facet arthrosis, which had not been present in imaging prior to the insertion of the SCS (Figs. 1 and 2). The patient subsequently underwent extension of her posterior spinal fusion to the T8 segment with decompression of the thoracolumbar junction (Fig. 3). At 6-month follow-up, the patients' gait impairment and pain were significantly improved and she was able to ambulate with a cane.

Discussion

Chronic neuropathic pain following complex spine surgery presents a difficult management challenge. Although controversial, SCS placement may offer some degree of palliation. The placement of leads in this setting can be challenging due to the presence of fusion mass and epidural scarring. Placement at levels cephalad to previous surgery is often necessary. If the cephalad most level of prior surgery

Fig. 1. MRI T1 fat suppressed image showing healthy discs in the thoracic spine prior to insertion of the spinal cord stimulator.

Fig. 2. Left image showing a preoperative sagittal CT image prior to insertion of the spinal cord stimulator without radiographic signs of degenerative disc disease. Right image showing a sagittal CT myelogram, with signs of degeneration at the T10/11 level (*arrow*). Signs of degeneration include changes such as vacuum disc formation, posterior osteophyte formation, and ligamentum flavum ossification leading into narrowing of the central canal and foramina.

Fig. 3. Lateral thoracic ray showing status post extension of previous fusion construct to the T8 segment and decompression of the thoracolumbar junction.

is at the L2 or L1 level, a thoracolumbar lead placement may be required for distal thoracic spinal cord coverage. Wide paddle leads offer broader terminal coverage and more numerous programming algorithms but require a microlaminotomy for insertion. The microlaminotomy technique involves releasing and dilating a small opening in the paraspinal muscle mass, making a keyhole opening in the lamina, and partial isolated resection of the ligamentum flavum at the operative motion segment. There is minimal impact to the facet complex and spinous process and associated supraspinous ligament complex. Laminectomy and laminotomy in the lumbar spine have not been associated with progression of degenerative disc disease [5]. As discussed, the thoracolumbar spine represents a unique

biomechanical environment. The spine here is transitioning to the lordotic lumbar segments to the kyphotic thoracic segments with the benefit of a rigid thoracic rib cage. The forces in this transition zone may be higher in elderly patients with higher positive sagittal balance [4]. In this setting, even minor biomechanical changes to the posterior tension band may significantly increase the shear forces through the disc segment in the anterior column of the spine potentially hastening degeneration.

SCS may offer some palliation in refractory cases following complex spinal surgery. If thoracolumbar lead placement is required, percutaneous small lead placement with tunneling should first be attempted. If unsuccessful, or if wide leads are indicated, caution should be used when considering microlaminotomy surgical placement at the thoracolumbar junction. If necessary, these patients should be counseled to the possibility of developing more rapid degenerative disc disease that may require additional

surgical intervention. These patients should be carefully monitored for the development of thoracolumbar spinal stenosis-related symptoms. Further study is needed to better quantify this risk and to further differentiate from the development of adjacent segment disease.

Compliance with Ethical Standards

Conflict of Interest: Janina Kueper and Lukas P. Lampe, MD have declared that they have no conflict of interest. Alexander P. Hughes, MD reports grants from NuVasive, Inc. and personal fees from MiMedx Group, Inc. outside the work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was waived from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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