

# Recovery of paraplegia following postoperative epidural hematomas in lumbar canal stenosis surgery by closed kinetic chain (CKC) exercises

## A case report

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### Abstract

**Rationale:** A postoperative spinal epidural hematoma (PSEH) is among the most devastating complications following spine and spinal cord surgery, and it should be considered before performing microendoscopic decompression as part of minimally invasive surgery, since early recovery is one of the advantages of this procedure.

**Patient concerns:** A 70-year-old woman with lumbar spinal stenosis at L4-5 underwent tubular surgery with the assistance of endoscopic laminectomy (MEL), but 2 days after the surgery, the patient noticed decreased lower limb sensation and power of the right leg, and she developed numbness from the level of L5 and weakness from the L4, 5 myotome distally.

**Diagnoses:** An epidural hematoma at the L4-5 surgical site was found on magnetic resonance imaging of the lumbar spine and evacuated operatively. This rare complication appears to be the result of a PSEH. In the present case, complete neurological recovery was not achieved, despite rapid surgery.

**Interventions:** The patient's course and physical therapy, which focused on attitude maintenance practice and muscle-strengthening exercise of the closed kinetic change (CKC) type from the early stage of paraplegia, were specifically examined.

**Outcomes:** The patient recovered complete motor function with attitude maintenance practice and muscle strengthening exercises after 3 months. CKC exercise in particular may contribute to improving caudal muscle weakness, including the L4, 5 innervated area (e.g., tibialis anterior [TA], extensor hallucis longus [EHL], flexor hallucis longus [FHL], gastrocnemius [GC], etc.).

**Lessons:** Prevention of PSEH is needed to not only avoid neurological deterioration, but also avoid delaying the patient's recovery. CKC exercise may contribute to improving the prolonged paralysis associated with a PSEH. Future studies should involve larger numbers of patients to evaluate the clinical features of PSEH and treatment by rehabilitation with more effective muscle exercises and stretches.

**Abbreviations:** ADL = activities of daily living, CKC = closed kinetic chain, EHL = extensor hallucis longus, FHL = flexor hallucis longus, GC = gastrocnemius, MED = microendoscopic discectomy, MEL = microendoscopic laminectomy, MRI = magnetic resonance imaging, OKC = open kinetic chain, PED = percutaneous microdiscectomy, PSEH = postoperative spinal epidural hematoma, TA = tibialis anterior.

**Keywords:** hematoma, lumbar spine surgery, microendoscopic laminectomy (MEL), neurological deficit, neurological injury, postoperative spinal epidural hematoma (PSEH), tubular surgery

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## 1. Introduction

Tubular surgery with the assistance of endoscopic lumbar discectomy and laminectomy has become routinely performed as a minimally invasive spinal procedure for lumbar degenerative disorders.<sup>[1]</sup> However, several complications have attracted our attention, such as nucleus pulposus herniation and lumbar spinal canal stenosis with nerve root injury, dural tear, retroperitoneal hematoma, and surgical site infection. Even more important in spinal surgery is the rare but devastating complication of a postoperative spinal epidural hematoma (PSEH), which is among the most devastating complications that occur after spine and spinal cord surgery.<sup>[2]</sup> Though its incidence is not high, a PSEH is a major complication that can lead to severe neurological deficits that require prompt surgical management.<sup>[3]</sup> A symptomatic PSEH requiring evacuation surgery occurs less frequently; its incidence is reported to be 0.1% to 0.7%,<sup>[4-7]</sup> but its consequences, including bowel and bladder dysfunction, sciatica, motor weakness of the lower extremities, saddle anesthesia, and

sexual dysfunction, which are also seen in cauda equina syndrome, can be devastating.<sup>[8]</sup> Therefore, when a patient develops new neurological deficits following lumbar spine surgery, a symptomatic PSEH should be considered. Moreover, when diagnosis and treatment of a PSEH are delayed, there is a risk of permanent paralysis. Thus, when severe neurological symptoms such as paralysis or bowel dysfunction occur with a PSEH, surgical intervention is needed as early as possible to avert a poor outcome.<sup>[3,9]</sup> Knowing the risk factors and the prognosis of PSEH can help surgeons make a timely diagnosis of this severe complication that can have important medical and legal implications. Complete neurological recovery and a good clinical outcome are most likely with rapid diagnosis and prompt surgical evacuation of a PSEH. Moreover, the early recognition of a symptomatic lumbar PSEH often depends on the skill of the perioperative nursing personnel.

The ability to maintain balance is one of the important factors in activities of daily living and depends on complex interactions among the nervous system, musculature, and skeletal system.<sup>[10]</sup> Therefore, balance control is an important part of the rehabilitation of many disorders of motor organs.<sup>[11]</sup>

It has been shown that, in typical adults, resistance exercises using either weight machines or body weight increase muscle strength, help rehabilitate patients, prevent injuries, and improve health. Resistance exercises have been categorized biomechanically into 2 types: open kinetic chain (OKC) and closed kinetic chain (CKC) exercises. OKC exercises involve isolated movement at a given joint; they are effective for isolated strengthening of selected muscle groups. On the other hand, CKC exercises involve the cocontraction of agonist and antagonist muscle groups. Both types of exercises are applied directly in everyday physical activities and exercise, and combined training with OKC and CKC exercises is recommended for treatment and rehabilitation.<sup>[12]</sup>

However, to the best of our knowledge, no previous reports have specifically examined the course and physical therapy with CKC exercises of postoperative hematomas after lumbar spine decompression surgery. In this report, a patient who developed

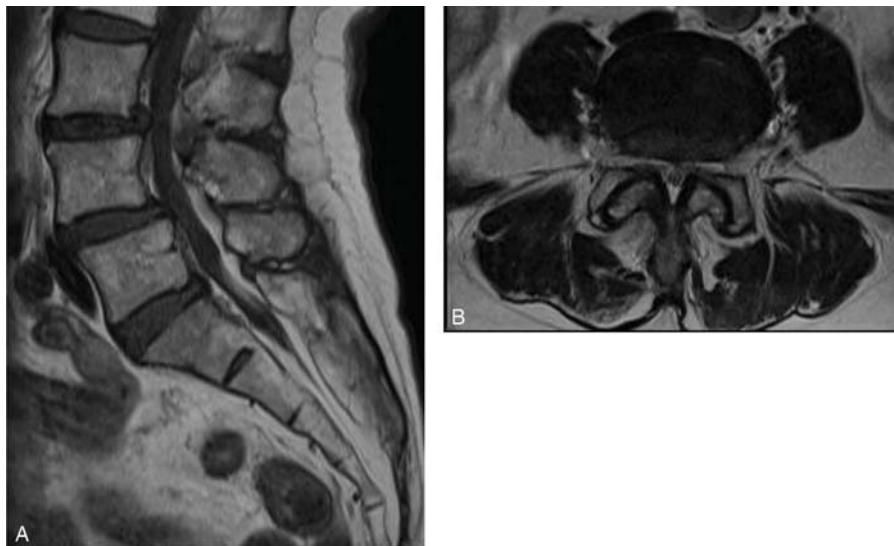
paraplegia on postoperative day 2 following tubular surgery with the assistance of MEL is described. Her course and physical therapy, which focused on attitude maintenance practice and muscle strengthening exercise of the CKC type from the early stage of paraplegia, were specifically examined. She recovered complete motor function with attitude maintenance practice and muscle strengthening exercise after 3 months.

## 2. Case report

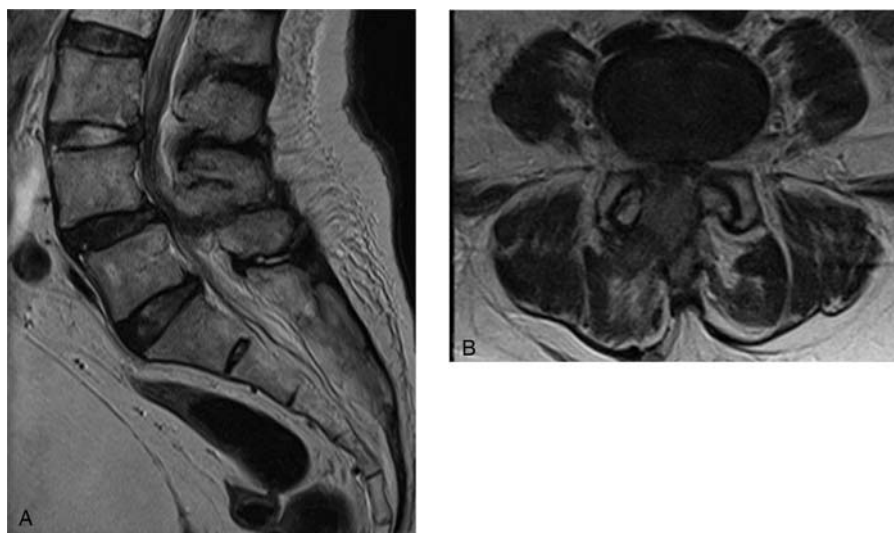
A 70-year-old Asian woman with a 6-month history of back pain and sciatica of the right side was referred to our hospital. On outpatient magnetic resonance imaging (MRI) of the lumbar spine, L4-5 spinal canal stenosis was diagnosed (Fig. 1). Her medical history included hypertension several years earlier. She was never diagnosed with behavioral disturbances. She had presented with ankle extension weakness, and no other myotomal weakness was detected preoperatively.

The patient gave her informed consent for surgery. She also gave her written, informed consent for publication of the case, including the accompanying images. At our institution, ethical approval is not required for reporting individual cases.

Under uneventful general anesthesia, the patient underwent tubular surgery with the assistance of MEL in the prone position. During the surgical procedure, there were no dural tears or bleeding (surgical blood loss of 40 mL). After the surgery and before the patient was transferred to the recovery room, the patient recovered from leg pain and numbness. There were no apparent complications, and somatosensory and motor-evoked potentials were both normal. Closed suction drains were maintained for approximately 48 hours postoperatively. All closed suction drains were used with full negative suction pressure. However, 2 days after the surgery, the patient noticed decreased lower limb sensation and power of the right leg, and she developed numbness from the level of L5 and weakness from the L4, 5 myotome distally. On examination, big toe extension, ankle flexion and extension, knee extension, and thigh abduction were weak in both legs. Loss of sensation in her legs was noted.



**Figure 1.** Preoperative sagittal and axial magnetic resonance (MR) images at the L4–L5 level with degenerative spondylolisthesis and spinal stenosis at L4–L5. Preoperative midsagittal (A) and axial (B) T2-weighted MR images demonstrating severe central and lateral recess stenosis at L4–L5 and grade 1 anterolisthesis.



**Figure 2.** Postoperative MR images of the lumbar spine showing the previous surgical region with evacuation of the epidural hematoma. Midsagittal (A) and axial (B) T2-weighted MR images of the patient's lumbar spine obtained 2 days after operation. The axial image is at the L4/5 level. There is an associated recurrent epidural hematoma causing compression of the dural cord.

Based on the clinical examination, urgent MRI was performed and demonstrated a large T2 hyperintense collection within the vertebral canal extending from approximately L4 to L5, suggesting the presence of a PSEH (Fig. 2). It was thought that emergent re-exploration would be beneficial because these findings were suggestive of hemorrhage in the L4-5 space. Thus, surgical exploration was performed immediately. An emergent wide laminectomy was performed, and obvious hemorrhage and compression due to hematoma were observed. The patient could not move her leg after the surgery, and there was no recovery in the strength and sensation of her legs. She immediately started rehabilitation with stretch exercises for weakness of the limbs due to the PSEH. From the early stage, the focus was on attitude maintenance practice and muscle strengthening exercises (CKC). In particular, it was thought that reduced standing balance ability due to decreased hip joint extension and abductor muscle strength and muscle weakness around the ankle joint were the causes of her decreases in activities of daily living (ADL). The first stage of the closed chain exercise was holding a static standing position by a physical therapist and having slight knee flexion (about 10–15 degrees). The goal was to keep standing for 2 minutes (Fig. 3). Due to her inability to maintain the standing position, attention was paid to the balance disorder in the sagittal plane due to the decrease of muscular strength of the dorsal flexor muscles of the joints, and treatment intervention was performed under load. The second stage was holding the standing posture that forced center of gravity movement (back and forth) (Fig. 4A, B). As in the first stage, when the patient was able to remain standing for 2 minutes, she achieved the goal. In the third stage, in addition to holding static standing, active center of gravity movement (back and forth, left and right, up and down) was added as a task (e.g., a half-squat exercise was done). Active center of gravity movement (back and forth, left and right) was performed to the extent that the patient could control her posture. Half squat was performed to flex the extended knee about 30 degrees and hold this position for 3 seconds, then fully extend the knee. At this time, the physical therapist provided feedback on the patient's posture disorder. Training started by focusing on balance movement in the standing position. By moving the



**Figure 3.** Attitude maintenance practice with assistance. Due to her inability to maintain the standing position, attention was paid to the balance disorder in the sagittal plane due to the decreased muscular strength of the dorsal flexor muscles of the joints, and treatment intervention was performed under load.





**Figure 4.** Muscle strengthening exercise, closed kinetic chain (CKC). A, Standing position: Heel raising. B, Standing position: toe elevation. C, Walking: balance training with a posture close to walking.

patient's body center of mass back and forth while making the patient aware of the center of gravity, balance sense and control of the patient's standing posture were enhanced. In the fourth stage, the patient performed balance training with a posture close to walking (Fig. 4C). This is because exercise in a posture close to walking is important to learn the walking function. Even at this stage, the goal was to keep standing in the walking posture for 2 minutes. In the fifth stage, she started accelerated walking for a short distance with a T-shaped cane (Fig. 5).

Muscle power improved progressively after 3 months, but slight paralysis and sensory loss remained in the left lower limb. Three years after surgery, the neurological findings were within the normal range of motion, and slight numbness of the legs remained.

### 3. Discussion

Prevention of PSEH should be considered before undertaking microendoscopic decompression in minimally invasive surgery, because one of the advantages of this surgery is the early recovery it offers patients. A PSEH is considered a serious complication that leads to potentially serious neurological deficits, and, in most cases, paralysis improves following rapid surgical intervention. However, this report described the case of a patient who

developed paraplegia after tubular surgery with the assistance of MEL and recovered full motor function after 3 months.

In previous studies,<sup>[6,7]</sup> the rate of postoperative SEHs was reported to be 0.1%. In the study by Awad et al,<sup>[5]</sup> a total of 14,932 patients who underwent spinal surgery were reviewed, and the reoperation rate for PSEHs was 0.2%. These incidence rates were obtained from cases in which surgical intervention was required, and no reports have evaluated the actual incidence and clinical features of PSEH. Risk factors for PSEH have been reported to include age greater than 60 years,<sup>[5]</sup> preoperative coagulopathy,<sup>[13]</sup> multilevel procedures,<sup>[5,13]</sup> a history of surgery at the same site,<sup>[14]</sup> liver and autoimmune diseases, and heparinization after surgery.<sup>[15]</sup> The typical symptoms include a sudden onset of back pain, which is then followed by neurological deterioration that includes weakness, numbness, and incontinence.<sup>[16]</sup>

Microendoscopic posterior decompression (microendoscopic discectomy [MED] and percutaneous microdiscectomy [PED]) is a minimally invasive procedure for treating lumbar spinal stenosis. However, special precautions are needed to prevent PSEH during this microendoscopic procedure, because, unlike a conventional procedure such as open decompression surgery, a small dead space is formed, and a wound hematoma could develop. On the other hand, studies of open, MED, and PED



**Figure 5.** Accelerated walking for a short distance with a T-shaped cane.

procedures have reported mean PSEH rates of 0.5% (median 0.6%), 1.2% (median 1.2%), and 0.6% (median 0.8%), respectively; a meta-analysis showed no significant difference in reported hematoma complication rates.<sup>[17]</sup> A rapid diagnostic workup and emergency surgical treatment increased the likelihood of complete neurological recovery in cases of postoperative epidural hematoma.<sup>[7]</sup> However, in the present case, complete neurological recovery was not achieved, despite rapid surgery. Therefore, transient nerve root compression and poor expansion of the dural sac may delay initial recovery of nerve damage. In addition, spinal epidural hematomas may induce fibrosis of the epidural space during their regression.<sup>[18]</sup> This fibrosis would permanently prevent dural sac expansion and might cause nerve root irritation.<sup>[19,20]</sup> To prevent PSEH formation and delay in the patient's recovery, adequate hemostasis during surgery, correct application of the postoperative drain, and control of blood pressure in the postoperative period are necessary, thus improving clinical outcomes.

On the other hand, muscle strength decreases when lesions occur in muscular tissues or their nerves, with lesions in the joints controlled by the muscles, or with aging. In addition, if there is a long-term lack of muscle activity, muscle strength decreases through muscular atrophy. However, muscle strength increases gradually with resistance exercise.<sup>[21]</sup> In the present case, the focus was on attitude maintenance practice and muscle

strengthening exercise (CKC) from the early stage for the paraplegia caused by the PSEH. A previous study showed that the anterior-posterior, medial-lateral, and total displacements of the center of pressure, which represent dynamic balance ability, were significantly lower in the CKC group at post-test, while there were no significant differences in the OKC group.<sup>[22]</sup> Moreover, muscle activations of the gastrocnemius (GC) and tibialis anterior (TA) muscles were significantly increased only in the CKC exercise group, which indicates that CKC exercise can improve lower limb muscle strength and balance in patients with leg palsy, and it may improve functional performance.<sup>[23]</sup> The CKC exercises, such as squats, performed in this study were done while weight-bearing. The CKC exercises may have contributed to improving the prolonged paralysis. Treatment with CKC exercises under loading may improve muscle strength more than OKC exercises. In the paralyzed patient, rather than good improvement as paralysis improves, muscle weakness appears after the paralysis improves, and then the muscle weakness improves; it is thought that muscle performance is improved by inputs to muscles from inherent sensation and muscle stretching. CKC exercise in particular may contribute to improving the caudal muscle weakness including the L4, 5 innervated area (e.g., tibialis anterior [TA], extensor hallucis longus [EHL], flexor hallucis longus [FHL], and gastrocnemius [GC], etc.).

In conclusion, the present patient developed paraplegia after tubular surgery with the assistance of MEL and recovered complete motor ability 3 months later with CKC exercise. Thus, prevention of PSEH is needed to not only avoid neurological deterioration, but also avoid delaying the patient's recovery. CKC exercise may contribute to improving the prolonged paralysis of PSEH. Future studies should involve larger numbers of patients to evaluate the clinical features of PSEH and treatment by rehabilitation with more effective muscle exercises and stretches.

### Author contributions

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