Tubular surgery with the assistance of endoscopic surgery via midline approach for lumbar spinal canal stenosis: a technical note

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Abstract

Purpose We devised a tubular surgery with the assistance of endoscopic surgery via midline approach to the spinal canal to preserve the bilateral facet joints and the paravertebral muscles when treating lumbar spinal canal stenosis. We report details of this operative procedure.

Methods A 2-cm incision is made in the skin in the midline of the intervertebral level to be decompressed. The spinous process on the cranial side is partially excised, and incisions along the ligament fiber are made in the midline of the supraspinous and interspinous ligaments to expose the ligamentum flavum. After the lamina and the inferior parts of the bilateral facet joints are adequately excised, the microendoscopic discectomy system is inserted. With this procedure, no muscular tissue is seen in the surgical site. The portal approach is small, but if full advantage is taken of the spinal microendoscope's merits, the bilateral facet joints are preserved and wide decompression of deep parts is possible. The microendoscope is positioned above the spinal canal to provide a good symmetrical field of view to enable easy anatomical orientation.

Results Bilateral intervertebral joints were satisfactorily preserved in ten patients who received this surgery. All became ambulatory on the day after surgery and the clinical results remained favorable 3 years after the operation.

Conclusion Tubular surgery with the assistance of endoscopic surgery via a midline approach is a minimally

invasive surgical procedure with favorable results that enables preservation of paravertebral muscles and bilateral facet joints.

Keywords Tubular surgery · Midline approach · Lumbar spinal canal stenosis · Facet joints · Paravertebral muscles

Introduction

The microendoscopic discectomy (MED) system was developed as a surgical tool for treating lumbar disc herniation [1]. Currently, this system is also used for decompression when treating lumbar spinal canal stenosis. A unilateral approach for bilateral decompression in lumbar spinal canal stenosis is widely used [2–5]. With this procedure, a paramedian skin incision is made and the MED system is inserted into the paravertebral muscles with a unilateral approach that expands the spinal canal to decompress nerves. In cases where the lamina is narrow, however, it may sometimes be difficult to preserve the facet joint on the approach side and limited working space may make it difficult to exfoliate nerves and to achieve good anatomical orientation. To solve these and other problems, we developed a method of tubular surgery with the assistance of endoscopic surgery via a midline approach. With this procedure, soft tissue is separated on either side without cutting the paravertebral muscles, and decompression is performed under microendoscopy. The advantage of this procedure is that the paravertebral muscles and the bilateral facet joints can be preserved. Furthermore, the microendoscope is positioned at the midline of the spinal canal, so it provides a good symmetrical field of view. This is a detailed report of our procedure.

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Fig. 1 Partial excising the spinous process (*resection range of the spinous process). **a** A small hole is created in the cranial spinous process using a high-speed drill. **b** Via the small hole, the tip of the drill is inserted into the spinous process and drilling proceeds left, right and caudally for excision that preserves the periosteum in the form of an eggshell. **c** Drilling towards the cranial side of the base part of the spinous process

Surgical procedure

Before inserting the MED system

Under fluoroscopic guidance, a needle is inserted as a guide into the spinous process at the level of the inferior edge of the cranial vertebral body to be decompressed. At this position, the excision range of the superior edge of the spinous process is determined, and a 2-cm incision is made in the skin in the midline. The thoracolumbar fascia and supraspinous ligament are then cut with a sharp pointed scalpel. There is almost no bleeding at the midline incision. After the posterior periosteum of the cranial spinous process has been partially peeled, a small hole is made using a high-speed drill. Via the small hole, the tip of the drill is inserted into the spinous process and drilling proceeds towards the surrounding cortical bone. Drilling is continued left, right and caudally for excision that preserves the periosteum in the form of an eggshell (Fig. 1). A Gelpi self-retaining retractor is inserted into the cavity created inside the bone and extended on both sides, and excision is continued up to the caudal spinous process with the supraspinous ligament, interspinous ligament and periosteum remaining connected. Drilling towards the cranial side of the base of the spinous process expands the range of motion of the MED system in the cranial to caudal direction.

If the procedure is continued from a small skin incision, deeper areas are dark making it difficult. Inserting a light source into the surgical field with the microendoscope enables the procedure to continue in a bright field of view. Using a microscope or loupe makes the procedure even safer.

Drilling is continued towards the base part of the spinous process until the ligamentum flavum can be seen on the caudal side (Fig. 2). The ligamentum flavum will become visible in the midline if bone is excised equally to the left and right, which facilitates easy anatomical orientation. After the spinous process, drilling is continued in the lamina and the medial parts of facet joints up to the ligamentum flavum (Fig. 3). The cranial lamina up to the entheses of the ventral ligamentum flavum is excised. Medial parts of the facet joints are excised to the width determined by computed tomography (CT) before surgery. With this approach, there is no muscular tissue in the surgical field.

Fig. 2 Cutting the supra- and interspinous ligaments and revealing the ligamentum flavum. **a** Leaving the periosteum of the partially excised cranial spinous process and the supra- and interspinous

ligaments connected, cutting is continued as far as the caudal spinous process. **b** Drilling is then continued towards the proximal part of the spinous process to reveal the ligamentum flavum

Fig. 3 Excising the lamina and the medial parts of facet joints. The lamina and the medial parts of facet joints are drilled to reveal the ligamentum flavum

Fig. 4 Placing the tubular retractor. The approach is from the midline incision in the supra- and interspinous ligaments and periosteum of the spinous process, so no muscular tissue is seen on the field of view

Tubular surgery with the assistance of endoscopic surgery

The MED system tubular retractor (16 mm diameter) is positioned in the space secured with the above procedures (Fig. 4). We use the METRx[®] lumbar endoscopic system (Medtronic Sofamor Danek, Memphis, TN, USA). The ligamentum flavum is detached from the ventral enthesis of the cranial lamina using a curette. Next, an L-shaped probe with a dull point is used to bluntly split the ligamentum flavum along the midline towards the caudal side. Even in severe cases of central type stenosis, in the midline, since strong adhesion between the dura and ligamentum flavum

is almost never observed, this procedure is comparatively easy. If the ligament is thick, excise the shallow layer of the ligament first. After halving the ligamentum flavum up to the caudal lamina, the enthesis at the superior edge of the caudal lamina is excised. The superior edge of the lamina is cut from the midline towards both sides using a high-speed drill or Kerrison rongeur. Since the cranial end of the ligamentum flavum is already separated, a large mass of ligamentum flavum can be excised by separating the caudal end with this procedure. Finally, the microendoscopic system is tilted to view the external side, and the ventrally protruding bone spur and superior articular process are excised together with the adhering ligamentum flavum. The

Fig. 5 Facet joint preservation. The microendoscopic system is tilted, and taking advantage of the merits of the oblique-viewing microendoscope, decompression is performed while preserving the facet joints. A discectomy can be performed from both sides of the dural tube

facet joints can be sufficiently decompressed from inside the spinal canal with lateral recess decompression with no loss of intervertebral stability. In addition, tilting the MED system brings the intervertebral disc, the inner wall of the pedicle and the entry zone of the foramen into the surgical field (Fig. 5). If necessary, the intervertebral disc can also be excised from both sides of the dural tube. For a multiple intervertebral operation, skin incisions are made between the intervertebral spaces to achieve decompression.

Wound closure

To prevent postoperative epidural hematoma, a drain tube is inserted firmly into the epidural space. The deep layer of the interspinous ligament is removed because it is connected to the yellow ligament. Bilaterally developed thoracolumbar fascia, supraspinal ligament, and periosteum and the superficial layer of the interspinous ligament are securely sutured with absorbable thread for reconstruction.

Aftercare

Patients are allowed to get out of bed once they have sufficiently recovered from the general anesthetic. They do

not need to wear a corset unless they underwent a simultaneous discectomy.

Case series

This surgery method was employed for patients with lumbar spinal canal stenosis whose main complaints were nerve root symptoms or cauda equine symptoms. Shown below are the results of ten patients who were operated on during the early stage of development of this surgery method. There were five male and five female cases, with a mean age of 65.6 years (range 54–72). In terms of the type of nerve involvement, there were four cases of radicular type, two of cauda equine type and four of mixed type. In two patients, one level decompression was made, and two level decompressions were made in the remaining eight patients. The mean surgical time for each level was 134.4 min (range 83–225), and the mean blood loss was 70.7 g (range 5–230). All patients were able to walk the day after surgery.

The Japanese Orthopaedic Association (JOA) score was used for evaluation of clinical results. One of the authors examined the patients before surgery and at an observation

Table 1 Scoring system for low back pain disease by Japanese Orthopaedic Association (JOA score)

I Subjective symptom	(9 points)		
A. Low back pain			
a. None	3		
b. Occasional mild pain occasional severe pain	2		
c. Frequent mild or occasional severe pain	1		
d. Frequent or continuous severe pain	0		
B. Leg pain and/or tingling			
a. None	3		
b. Occasional slight symptom	2		
c. Frequent slight or occasional severe symptom	1		
d. Frequent or continuous severe symptom	0		
C. Gait			
a. None	3		
b. Able to walk farther than 500 m although it results in symptom	2		
c. Unable to walk farther than 500 m owing to symptom	1		
d. Unable to walk farther than 100 m owing to symptom	0		
II. Clinical signs	(6 points)		
A. Straight-leg-raising test			
a. Normal	2		
b. 30°–70°	1		
c. <30°	0		
B. Sensory disturbance			
a. None	2		
b. Slight disturbance (not subjective)	1		
c. Marked disturbance	0		
C. Motor disturbance (MMT)			
a. Normal (grade 5)	2		
b. Slight weakness (grade 4)	1		
c. Marked weakness (grade 3)	0		
III Restriction of ADL (activity of daily living)	(14 points)		
	Very difficult	Difficult	Easy
a. Turn over while lying	0	1	2
b. Standing	0	1	2
c. Washing face	0	1	2
d. Leaning forwards	0	1	2
e. Sitting (about 1 h)	0	1	2
f. Lifting or holding heavy objects	0	1	2
g. Walking	0	1	2
IV Urinary bladder function	(–6 points)		
a. Normal	0		
b. Mild dysuria	–3		
c. Severe dysuria	–6		
Total	29		

point 3 years post-surgery, to obtain neurological findings and score the examination results. Evaluation using the JOA score (Table 1) [4, 6] showed a mean preoperative score of 15.2 (range 5–22) improves to a postoperative score of 26.0 (range 21–28), for an improvement rate of

78.3 %. Postoperative CTs showed that more than half of the facet joints were preserved in all of the cases. A complication of dural tear occurred in one subject, which was repaired under the operative field of the microendoscope. Representative cases are shown in Fig. 6.

Fig. 6 Using this procedure for the L3/4 level of a 54-year-old female with the chief complaint of cauda equina intermittent claudication. Preoperative MRIs (T2 weighted images) showed marked stenosis (**a**, **b**) at the L3/4 level of the spinal canal. Five-year postoperative MRIs (**d** and **e**) showed the decompression effect had been maintained, with no large changes observed in signal intensity or area of cross-section of the paravertebral muscles. CTs (**c**, **f**) before and after surgery showed the bilateral facet joints had been preserved

Fig. 7 Comparison of working space and field of view in a case with narrow lamina. Compared with a unilateral approach for bilateral decompression, this method provides a wide working area. The field

of view is bilateral, enabling satisfactory orientation. **a** Working space with a unilateral approach for bilateral decompression. **b** Working space with our method

Discussion

The MED system is a surgical tool developed by Smith and Folly [1] to treat intervertebral disc herniation. Until then, there had been reports of satisfactory short-term results obtained using a spinal microendoscope in a unilateral approach for bilateral decompression to treat lumbar spinal canal stenosis [2–5]. With a unilateral approach, a paramedian skin incision is made, the system is inserted into the paravertebral muscles, and both left and right sides of the spinal canal are decompressed. In 2003, we adopted the MED system and at the same time began using a unilateral approach for bilateral decompression for lumbar spinal canal stenosis. With this method, postoperative wound pain is not severe and patients can quickly return to daily life and work, making it a useful procedure.

When a paramedian approach is selected for patients with narrow lamina width or for the superior lumbar spine, preservation of the inferior articular process of the superior lumbar spine may become difficult. Ikuta reported a case of intraoperative fracture of the inferior articular process with the use of a paramedian approach [4]. We also experienced a case in which the facet joint on the approach side could not be preserved when the lamina was narrow.

If bone excision is minimized to preserve facet joints on the approach side, decompression may not be sufficient or the working space may become small. Until the surgeon becomes skilled at tubular surgery with the assistance of endoscopic surgery, peeling the dura and ligamentum flavum and performing decompression in a narrow working space is difficult. A narrow field of view can also make it difficult to determine anatomical orientation.

We applied the microscopic decompression for lumbar spine (MILD) procedure developed by Hatta et al. [7] to

the tubular surgery with the assistance of endoscopic surgery approach to overcome these problems.

The tip of a spinal microendoscope is angled at 25° to provide an oblique view. The first advantage of the spinal microendoscope is that using a fine, curved, long surgical tool enables decompression while observing the outside of the 16-mm diameter tubular retractor. Taking advantage of the merits of the MED system and approaching from the midline allow decompression while preserving the bilateral facet joints, even in cases with a narrow lamina or when performing cranial lumbar spine surgery (Fig. 7).

With this method, where a medial incision is made to the supra- and interspinous ligaments and the periosteum of the spinous process, direct damage is not caused because muscle tissue is not present in the operative field. A 16-mm tubular retractor is placed between the spinous processes on the median line, maximum compression of 8 mm will be applied to each of the outer bilateral multifidus muscles via the periosteum and the ligament, each of which was split at the median. When decompressing two or more intervertebral spaces, compression of the muscle persists throughout the operation when using the paramedian approach because two intervertebral spaces are decompressed in the same portal. In contrast, this method will reduce persistent pressure on the muscles compared with the paramedian approach because the portal changes every hour.

The third advantage is that placing the microendoscope in the dorsal midline of the spinal canal provides a bilateral field of view at the midline, making anatomical orientation extremely easy. Since the procedure is performed with a field of view directly above the level for decompression, compared with the unilateral approach for bilateral decompression, which approaches the level for decompression at an angle, it enables easier peeling of the dura

and ligamentum flavum, and easier decompression. Once basic training on the use of a microendoscope is completed, the procedure is comparatively easy.

A biomechanical study reported instability following detachment of the supraspinous ligament [8], whereas another researcher reported that resection of the interspinous ligament did not impair stability of the lumbar spine [9]. Although a part of the spinous process and deep layer of the interspinous ligament are resected with this method, a shallow layer and the supraspinous ligament can be constructed by retaining sufficient tension. Instability was not observed in any of the patients 3 years after surgery, but the impact of this approach on spinal stability has not been clarified. This is a limitation of our method and further long-term observation is necessary.

Conflict of interest All named authors declare that we have no conflicts of interest.

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