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Technical Note

Minimally invasive posterior cervical decompression using tubular retractor: The technical note and early clinical outcome

Jung-Woo Hur, Jin-Sung Kim, Myeong-Hoon Shin, Kyeong-Sik Ryu

Spine Center, Department of Neurosurgery, Seoul St. Mary's Hospital, The Catholic University of Korea, Seoul, South Korea

E-mail: Jung-Woo Hur - neurotique79@gmail.com, neurotique@nate.com; *Jin-Sung Kim - mddavidk@gamil.com, mddavidk@dreamwiz.com; Myeong-Hoon Shin - novice97@naver.com; Kyeong-Sik Ryu - nsdoc35@catholic.ac.kr
*Corresponding author

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Abstract

Background: The aim of this work is to present a novel decompression technique that approaches cervical spine posteriorly, but through minimal invasive method using tubular retractor avoiding detachment of posterior musculature.

Methods: Six patients underwent minimally invasive posterior cervical decompression using the tubular retractor system and surgical microscope. Minimally invasive access to the posterior cervical spine was performed with exposure through a paramedian muscle-splitting approach. With the assistance of a specialized tubular retraction system and deep soft tissue expansion mechanism, multilevel posterior cervical decompression could be accomplished. This approach also allows safe docking of the retractor system on the lateral mass, thus avoiding the cervical spinal canal during exposure. A standard operating microscope was used with ×10 magnification and 400 mm focal length. The hospital charts, magnetic resonance imaging studies, and follow-up records of all the patients were reviewed. Outcome was assessed by neurological status and visual analog scale (VAS) for neck and arm pain.

Results: There was no significant complication related to operation. The follow-up time was 4-12 months (mean, 9 months). Muscle weakness improved in all patients; sensory deficits resolved in four patients and improved in two patients. Analysis of the mean VAS for radicular pain and VAS for neck pain showed significant improvement.

Conclusions: The preliminary experiences with good clinical outcome seem to promise that this minimally invasive technique is a valid alternative option for the treatment of cervical spondylotic myelopathy.

Key Words: Cervical spondylotic myelopathy, cervical spine, minimal invasive technique, tubular retractor

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INTRODUCTION

Cervical spondylotic myelopathy (CSM) is one of the most common disorders of the cervical spine characterized by development and progression of degenerative changes associated with aging process. Patients with cervical spinal stenosis have tendency to suffer chronic myelopathy and also have high risk of acute spinal cord injury following to trauma. In most cases, cervical canal stenoses result from normal degenerative processes of ventral cord compression by bulging discs and osteophytes and posterior compression from facet hypertrophy and ligamentum flavum thickening. The average diameter of normal cervical canal on plain radiograph is 17 mm, whereas symptomatic stenosis occurs when diameter is less than 13 mm.[32]

Various anterior and posterior approaches for the treatment of CSM and studies showing many different results comparing anterior approach and posterior approach have been reported.[8,15,19-21,23,24,27] There are many debates still, however, with the disadvantages of detaching the cervical paraspinal muscles from the laminae and the spinous processes in conventional posterior approaches,[7,25] anterior approach became more dominant among spine surgeons. The operative trauma to the extensor cervical muscles is a major cause of numerous postoperative complications;[2,14,17,35] persistent neck and shoulder pain, postoperative kyphosis, spinal instability, etc., This current trend toward anterior fusion surgery, even in patients who could be operated posteriorly, is concerning, given the more troublesome complications such as adjacent level disease, recurrent laryngeal and esophageal injury seen.[1,5,9,16]

Recently, with the wide spread of minimally invasive techniques, there has been renewed interest in the posterior approach for cervical spine disorders.[4,6,13] Using the tubular retractor system with microscope, minimal invasive posterior cervical decompression became possible. These developments have led to less tissue damage during operation, which reduce postoperative pain, shorten hospital stays and allow a quicker return to daily living activities. Even safe multilevel decompression is possible with this minimal invasive approach.

The purpose of this study is to describe the minimally invasive surgical technique accomplishing multilevel posterior cervical decompression using a tubular retractor system and to document the early clinical outcome for this minimal invasive surgery.

MATERIALS AND METHODS

Six patients suffering from CSM underwent minimally invasive posterior cervical decompression using the tubular retractor and surgical microscope. The operations were performed between April 2012 and November 2012. The indication for surgery was i) presence of CSM confirmed by radiologic imaging studies, ii) presence of symptomatic myelopathy for more than 6 months, iii) compression ratio less than 0.4 indicating flattening of the cord, iv) transverse area of the cord less than 40 mm^2, v) predominant dorsal cord compressing pathology such as ossification of ligament flavum, and vi) failure of conservative treatment over a period of 6 weeks. The exclusion criteria were cervical myelopathy with tumor, trauma, severe ossification of posterior longitudinal ligament (OPLL), herniated disc, rheumatoid arthritis, pyogenic spondylitis, and other combined spinal lesion. The pathologic level and extent of spinal cord compression was confirmed by magnetic resonance imaging (MRI) and postmyelography computed tomography (CT). In addition, cervical MRI was performed with three different neck positions (neutral, flexion, and extension) in all patients to determine whether the spinal canal was more dominantly compressed by posterior than anterior pathology. Cases with more dominant anterior compression (such as multilevel interverterbal disc bulging) were excluded from the study and underwent alternative anterior approach surgery. Demographic and intraoperative data of patients are listed in Table 1. The study included two men and four women. All patients presented with symptoms of cervical myelopathy; clumsiness, numbness of upper and lower extremities, gait disturbance, urinary disturbance, etc., Their average age at the time of operation was 58.8 years (±17.2) and average body mass index was 26.2 (±4.4). Visual analogue scale (VAS) of preoperative neck pain and radicular arm pain were 6.2 (±2.2) and 8.9 (±2.8), respectively, and average duration of pain was 17.4 (±8.7) months. One of the patients underwent previous anterior cervical fusion at local clinic for disc herniation. Two patients were operated at one segment, one patient at two segments, and three patients at three segments, respectively.

The hospital charts, radiologic imaging studies, and follow-up records of all the patients were carefully reviewed. Outcome was assessed preoperatively and postoperatively by Japanese Orthopedic Association scoring system for cervical myelopathy[33] (C-JOA score), recovery rate calculated by Hirabayashi's method,[12,33]

Table 1: Patient demographics and intraoperative data

Characteristics	Mean (SD) (range)*
Gender (no. (%))	
Male	2 (33)
Female	4 (66)
Age (yrs)	58.8 (±17.2)
Body mass index	26.2 (±4.4)
Preoperative symptoms	
VAS neck pain	6.2 (±2.2)
VAS radicular pain	8.9 (±2.8)
Duration of pain (months)	17.4 (±8.7)
Previous spinal surgeries (no. (%))	1 (16%)
Intraoperative blood loss (ml)	61 (±33)
Operating time (h)	1.7 (±0.3)
Length of hospital stay (days)	1.4 (±0.5)
Segments operated on (%)	
1 segment	2 (33)
2 segment	1 (16)
3 segment	3 (50)

SD: Standard deviation, *Unless otherwise indicated, VAS: Visual analog scale modified version of the Oswestry index, called the Neck Disability Index[29,37] (NDI) and VAS score for neck and radicular arm pain.[37]

All parameters were analyzed statistically. The data were expressed as mean and standard deviation (mean ± SD). A result was considered statistically significant if the *P* value was less than 0.05.

Surgical technique

Before surgery, the patient must have dynamic radiographs to rule out obvious instability and MRI or postmyelography CT to define the extent of the surgery. Routine medical and laboratory evaluations are obtained. The anesthesia team must be informed prior to the surgery for the need of possible fiberoptic intubation. The operation is done under general anesthesia and interoperative somatosensory evoked potentials (SEP) monitoring was done in all patients.

Patient is settled to prone position and head fixation with Mayfield head fixator in a slightly flexed position. The Mayfield attachment to the operation bed was fully extended to prevent interference with C-arm fluoroscopic localization. Skin preparation and drapping was done with usual sterile manners. 14-16 mm minimal skin incision is made in a vertical fashion above targeted level approximately 1.5-2 cm lateral to the spinous process [Figure 1]. Using the C-arm fluoroscope, it is usually easy to count down from the atlas and it is also possible to count up from the first thoracic lamina. The left or right paramedian approach may be used, depending on patient symptoms.

After subcutaneous dissection, fascia is incised sharply for the entire length of the skin incision. If more than one level is to be decompressed, it is helpful to extend the incision cranially and caudally to allow manipulation of the working channel. Once facial incision was done, gentle finger dissection followed to the extensor muscles of the posterior neck until lamina and facet joint were palpated. Cheek retractors may be used to allow gentle spreading of the fascia and the fibers of the paraspinal muscles overlying the lamina and facet to facilitate dilation and exposure. Serial dilators of the Insight tubes system (Synthes GmbH, Oberdorf, Switzerland) were applied under gentle controlled motion avoiding slippage into the wide interlaminar space. Then 16 mm tubular retractor is positioned safely on lateral mass and secured to the flexible arm of the Insight retractor mounted to the table side rail [Figure 2]. The introduction of dilators and the working channel is performed under C-arm guidance. Care should be taken to optimize the trajectory and fluoroscopy must be used to confirm placement at the correct level and trajectory. After final fluoroscopic confirmation of the working channel position, the serial dilators were removed. This approach allows safe docking of the retractor system on the lamina or lateral mass, thus avoiding the cervical spinal canal during exposure. A flexible arm of the tubular retractor system allows angulating movements, providing optimum direction of vision and access as well as and secure anchorage at the surgical site. The C-arm is removed out of operation field but kept sterile for possible subsequent localization and confirmation.

After docking tubular retractor, operating microscope is introduced [Figure 3a] and under high magnification the soft tissue is removed using electrocautery and pituitary forcep. The tube is then angled medially midway between the lamina of interest. After laminar/facet junction is identified, careful ipsilateral hemilaminectomy is performed to expose the underlying ligament with specially designed high-speed drill (Medtronic Midas Rex, Fort Worth, Texas) and an adjustable guard. After unilateral hemilaminectomy, the working tube is angled more medial and parallel to ground and the base of the spinous process and contralateral inner lamina is undercut with the high-speed drill while guard placed between the cutting surface and the ligament. After adequate drilling, Kerrison's rongeurs were used to continue the removal of the lamina. Care should be taken to leave the ligament intact at this point to protect the spinal cord. This procedure is performed to the medial aspect of the

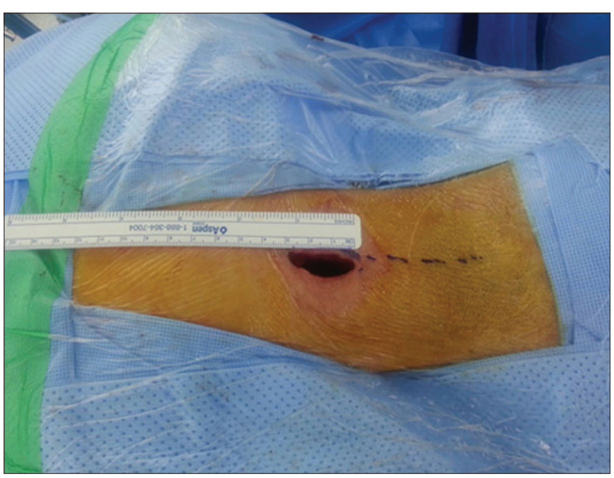

Figure 1: Minimal skin incision is made on posterior neck above targeted level approximately 2 cm lateral to the spinous process

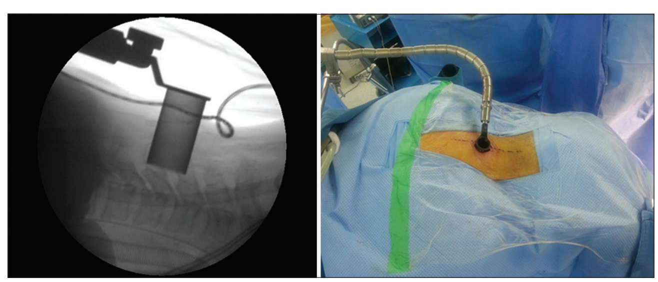

Figure 2: C-arm fluoroscopy showing lateral orientation used for localization and docking with tubular retractor, tubular retractor is now positioned on C5 lamina

contralateral facet. Through this "unilateral laminectomy bilateral decompression (ULBD)" technique, we can enlarge diameter of canal by unilaterally without damaging the interspinous ligament or the splenius cervicis muscle. The central canal decompression can be combined with additional focal foraminal decompression for coexisting radiculopathy. The decompression is continued cranially and caudally at each level with stenosis and approximately up to three levels can be safely performed per skin incision if the entry point is carefully chosen. After adequate bone removal has been accomplished, the ligamentum flavum is carefully removed using upward curettes and ball hook. When the ligament was completely removed, the dural pulsation was observed [Figure 3b]. Once all the stenotic levels have been decompressed, the tubular retractor is gently removed and the wound is closed in layer by layer manner [Figure 4].

A drain was placed at operated level to prevent epidural hematoma after surgery. Since there is no muscle deflected, ambulation encouraged in all patients after 4 h of operation without a neck support.

RESULTS

Six patients underwent minimally invasive posterior cervical decompression using the tubular retractor system and surgical microscope. The follow-up time was 4-12 months (mean, 9 months). Average intraoperative blood loss was 61 (±33) ml, average operating time was 1.7 (±0.3) h, and the average length of hospital stay was 1.4 (±0.5) days, respectively [Table 1]. Those with sedentary jobs usually returned to work within a week after discharge. Muscle weakness improved in all patients; sensory deficit resolved in four patients and improved in two patients. Analysis of the mean VAS scores for radicular pain and neck pain showed significant improvement [Figure 5]. VAS scores for neck pain was decreased from 6.2 (±2.2) to 5.8 (±2.0) immediate postoperatively, reaching 2.1 (±1.3) at 3 months, and 1.8 (±0.9) on last follow up. VAS scores for radicular arm pain also decreased from 8.9 (±2.8) preoperatively to 3.6 (±1.4) on immediate postoperatively, reaching 1.8 (±0.9) at 3 months, and 0.9 (±0.4) on last follow up. Mean NDI decreased significantly from 68.3 ± 9.1 preoperatively to 13.3 ± 10.4 at final follow-up. Mean C-JOA scores also improved from preoperative values of 11.2 ± 2.6 to 16.2 ± 3.1 at last follow-up and recovery rate calculated by Hirabayashi method averaged 53.2 ± 22.0%, respectively [Table 2]. There were no significant operation-related complications such as cerebrospinal fluid leakage, postoperative infection, instability, etc.

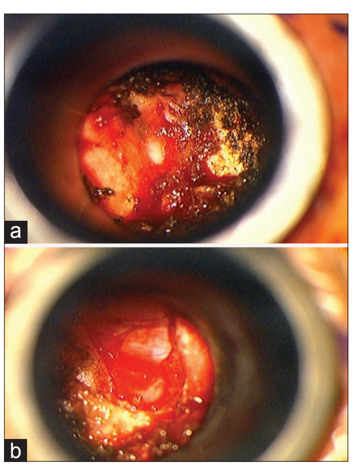

Figure 3: (a) View of lamina after safe docking of tubular retractor (Zeiss Pentero surgical microscope 400 mm, ×10), (b) View after decompression through 14 mm working channel (Zeiss Pentero surgical microscope 400 mm, ×10)

CASE REPORT

A 65-year-old female visited our clinic complaining neck pain and severe right side radicular arm pain with hand grip weakness for 12 months. She was conservatively treated at local clinic for 8 months without improvement. The cervical MRI showed right side neural foraminal stenosis from C3 to C6 levels and central spinal canal stenosis from C4 to C6 levels with myelopathy due to ossification of ligament flavumm (OLF). Cervical dynamic (flexion-extension) MRI showed aggravation of canal stenosis by posterior pathology on extension [Figure 6a]. Her VAS scores for neck pain and

Table 2: C-JOA score and recovery rate calculated by Hirabayashi's method after surgery

	Preoperative	Final follow-up
C-JOA score (points)	11.2±2.6	16.2±3.1
Recovery rate* (%) (JOA score)	-	53.2±22.0
NDI (points)	68.3±9.1	13.3±10.4

C-JOA score: Japanese orthopedic association scoring system for cervical myelopathy, NDI: Neck disability index, * Recovery rate calculated by Hirabayashi's method

Figure 4: Postoperative incision scars, 3 months after the minimal invasive approach

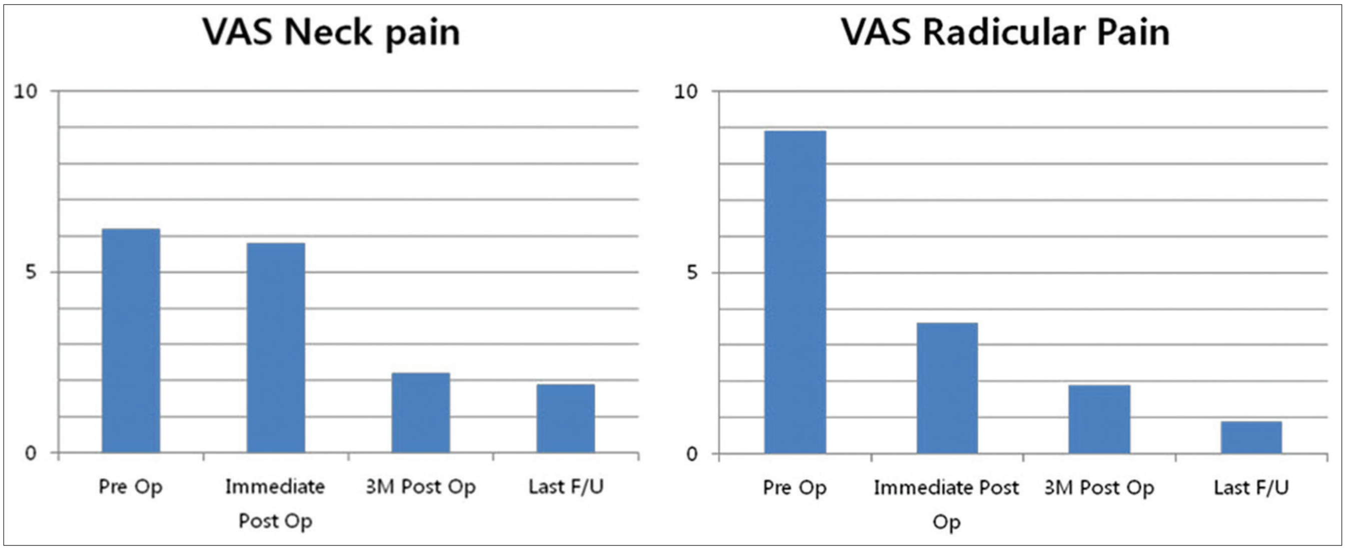

Figure 5: VAS neck pain and VAS radicular pain improvement after surgery

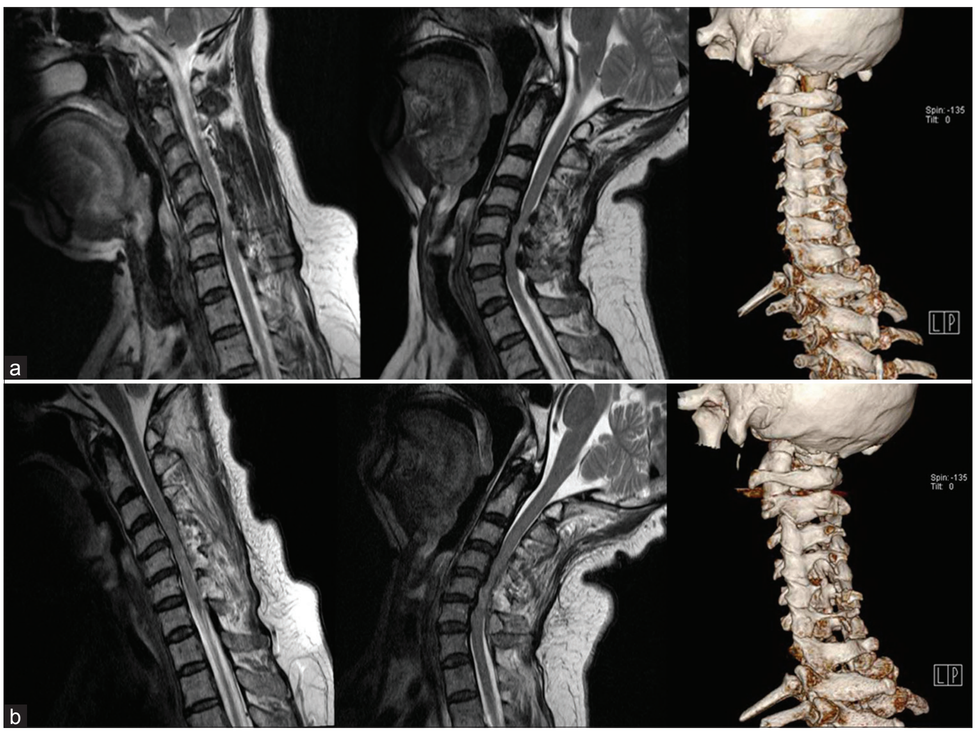

Figure 6: (a) Preoperative flexion/extension MRI shows severe canal stenosis with myelopathy from C3 to C7 levels due to OLF. Canal stenosis aggravates within neck extension. Preoperative 3D reconstructed CT shows occified ligament flavum. (b) Postoperative MRI shows enlarged spinal canal on both flexion and extension image. 3D reconstructed CT image shows hemilaminectomy on C4, C5, C6 vertebrae with bilaterally decompressed by ULBD technique

radicular pain were 5 and 8, respectively. She underwent posterior Rt. side ULBD decompression with tubular retractor from C4 to C6 levels [Figure 6b]. There was no complication during surgery except asymptomatic spinous process fracture discovered only after postoperative CT was taken. The operation time was 1.5 h and EBL was 40 cc after surgery, the VAS score for neck pain reduced from 5 to 3 and VAS score for radicular pain reduced from 8 to 3. She was discharged a day after surgery.

DISCUSSION

Cervical spinal decompression is usually performed from an anterior or posterior approach depending on various factors, including extent of disease, sagittal curvature of cervical spine, prior surgery, general condition of the patient, skill and familiarity of the surgeon, severity of canal compression, and intervertebral mobility at maximum compressed level. The anterior approach offers a simpler route to the spine and a means to decompress the ventral spinal cord, which is often the site of pathology. Disadvantages include potential complications involving the anterior neck structures, dysphagia, recurrent laryngeal nerve injury, and adjacent segment degeneration following loss of one or more motion segments.

On the other hand, posterior decompression technique gives more space for the thecal sac and avoids many of the hazards of the anterior exposure. However, anterior compressing pathologies such as disc herniation, osteophytes, or OPLL could be neglected. Although a simple multilevel laminectomy or laminoplasty is a relatively straightforward procedure, it often results in more postoperative neck pain and longer hospitalization. In addition, cerebrospinal fluid (CSF) leakage, wound problems, postoperative kyphosis, and instability are not uncommon.

With the recent advent of more specialized instruments and access devices, minimally invasive spinal surgery has proven to be a useful tool for the treatment of spinal disease while minimizing soft tissue damage. Application of this novel technique to the cervical spine followed naturally, and posterior minimal invasive cervical approach was performed recently in many institutes to determine the feasibility and efficacy of such procedures. Recent studies using a transmuscular working channel to perform a minimally invasive decompression for radiculopathy and myelopathy concluded that the basic technique was safe and feasible.[4,31]

Although there are a few reports of posterior cervical decompression by different minimally invasive techniques, we have introduced more challenging "ULBD" technique to minimize paraspinal muscle injury and extent of laminotomy. Moreover, the routine three-position cervical MRI for cervical spondylotic myelopathic patients was performed to evaluate characteristics of canal compression pathology and to aid surgeon's decision in selecting appropriate surgical technique. The cervical dynamic MRI is useful to determine more accurately the number of levels where the spinal cord is compromised, and to better evaluate narrowing of the canal.[3,36] With the radiologic information obtained, we have selected cases of more dorsal compression than ventral pathology for the present study. As mentioned earlier, those with more dominant anterior compression were excluded to undergo alternative anterior surgery. There are many important factors that may influence the choice of approach and surgical techniques in cervical spine surgery and dynamic MRI may provide crucial information for troubling surgeons. In our study, six patients (13 segments) underwent minimally invasive posterior tubular decompression with ULBD technique. No perioperative complications were noted and successful improvement of neck pain and radicular pain were achieved.

The tubular retractor provides wide visualization through the small skin incision and successive angulations of the working channel into a more medial position allow access to the contralateral dorsal spinal canal, which is superior to that of the unilateral open technique. Visualization of the spinal canal, ligamentum flavum, and existing nerve root interface is facilitated by operating microscope (Zeiss Pentero surgical microscope, Jena, Germany) to provide three-dimensional view and with the microscope-assisted procedure we could accomplish bilateral decompression via a unilateral approach, the so-called "unilateral approach and bilateral decompression (ULBD)".[18,22,28] Repositioning the working channel more medially enables us to drill out the base of the spinous process and ventral surface of the contralateral lamina. Exposure of the contralateral attachment of ligamentum flavum is critical to ensuring adequate bilateral decompression and it is important to keep the ligament intact to protect the spinal cord.

The minimally invasive posterior cervical decompression using the tubular retractor technique had many advantages such as small skin incision, gentle tissue dissection, excellent visualization, and ability to achieve results equivalent to conventional open techniques. Open posterior cervical approach requires paraspinal muscles dissection and partial facetectomy. Stripping of the muscles may damage their innervation and blood supply, which may cause postoperative neck pain with temporary or persistent functional disturbances and possibly affecting stability in multiple level procedures.[14,35] Minimal skin incision provides cosmetic effect and minimizing paraspinal muscle trauma contributes decrease of postoperative neck pain and dysfunction. The conventional laminoplasty causes cervical instability and kyphosis when more than 50% of unilateral facet jointw or 25% of bilateral facet joints are resected.[10] Our minimal invasive technique can minimize facet joint resection by using ULBD technique, which requires only partial hemilaminectomy to enlarge canal size. Moreover, the operating time, EBL and hospital stays were also relatively smaller in our patients compared with published data of conventional open surgeries.[11,12,30,34]

On the other hand, minimally invasive decompression has higher risk of dura and nerve injury, CSF leakage and postoperative seroma formation compared with conventional laminectomy or laminoplasty.[4,26,31] Because of using high-speed drill to undercut spinous process and contralateral lamina through tubular retractor, restricted operation field can cause dura injury by high-speed drill. Incidental durotomy can generally be managed by dural sealant materials, but persistent leakage may require a direct repair followed by a lumbar drain. Careful use of bipolar cautery, both to minimize excessive bleeding from venous plexus and to avoid neural injury, is an important consideration. The high-speed drill may cause local thermal injury, and careful irrigation must be ensured. Like any other minimally invasive techniques, there is also a chance of postoperative seroma formation within 24-72 h after surgery. Owing to smaller canal diameter in cervical spine, relatively small amount of seroma can cause cord compression even though postoperative drain is retained. To minimize the risk of postoperative seroma formation, we use few tips: i) use diamond drill instead of burr to minimize possible bone bleeding, ii) during tube insertion, we perform gentle finger dissection of posterior cervical muscle instead of mono-polar cautery to reduce muscle bleeding, and iii) we apply power-type absorbable hemostatic agent (Avitene™) over the decompressed cord, which is much thinner and does not compress dura like other hemostatic materials. Moreover, as described in our case presentation, asymptomatic spinous process fracture could be possible due to lateral angulation of tubular retractor in the cases requiring additional foraminal decompression. We have experienced two cases of single level spinous process fracture out of six patients, but neither had significant symptom related to it.

Furthermore, spinal canal enlarging is somewhat limited compared with conventional posterior techniques in that one is not able to push down the dura to obtain a better view as in lumbar surgeries. Decompression of canal stenosis, which occurred due to posterior pathologic lesion such as OLF, has great efficacy with this technique, but in case of anterior cervical pathologic lesions or multilevel canal stenoses with more than three segments, and developmental canal stenosis, anterior approach or conventional laminoplasty may be a better alternative option. Without the benefit of a wide viewing area as in conventional open surgery, the risk of incomplete decompression also exists, especially with the inexperienced hands.

This study demonstrates the feasibility of decompressing the cervical spinal canal using a unilateral tubular technique. Minimal invasive surgery techniques involve a very steep learning curve and considerable experience is required to decompress the neural structures adequately. The operation field of tubular retractor is limited, making it difficult to appreciate the amount of bony work that has been performed. Furthermore under the microscopic view it could be more disorienting. Ensuring a satisfactory canal decompression, while maintaining the integrity of neural elements clearly, requires hard training and experience. Long-term follow-up studies with larger sample series are required to determine its benefits compared with traditional open laminectomy.

CONCLUSION

In our preliminary clinical series aided by tubular retractor system based on minimally invasive spinal surgery, we demonstrate relatively safe procedures and good outcomes despite the limited number of patients and short follow-up periods. These techniques have the theoretical advantages of reducing morbidity, blood loss, perioperative pain, and length of hospital stay associated with conventional open posterior spinal exposure. This minimally invasive posterior technique could be considerable alternative in choosing a surgical method for cervical myelopathy. However, steep learning curve is required for this minimally invasive technique and risk of possible complications such as dura and nerve injury, CSF leakage, and postoperative seroma formation do exists. More studies are required to determine the exact benefits compared with open surgery.

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