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Microscope-assisted anterior cervical discectomy and fusion combined with posterior minimally invasive surgery through tubular retractors for multisegmental cervical spondylotic myelopathy

A retrospective study

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Abstract

This study aimed to investigate the clinical efficacy and outcome of combined microscope-assisted anterior cervical discectomy and fusion (ACDF) with posterior minimally invasive surgery through tubular retractors for patients with multisegmental cervical spondylotic myelopathy (MCSM).

This retrospective study included 28 patients (19 males and 9 females) with multisegmental cervical spondylotic myelopathy, who underwent combined microscope-assisted ACDF with posterior minimally invasive surgery through tubular retractors in our single center between January 2012 and December 2016. The evaluated postoperative clinical outcomes were operation time, length of hospitalization, blood loss, levels of creatine phosphokinase isoenzyme MM (CPK-MM), Japanese Orthopedic Association (JOA) scores, visual analogue scale (VAS) scores, Cobb angle of C2–C7, and radiological assessments (included X-rays, computed tomography scans, and magnetic resonanceimaging images).

The mean surgery time was 198.42 ± 17.53 minutes, the average hospitalization length of hospital was 7.59 ± 1.38 days, and the mean follow-up time was 13 ± 2.45 months. On average, about 36.42 ± 10.15 mL of blood was lost and CPK-MM increased to 331.75 ± 23.15 IU/mL postoperatively ($P < .001$). The mean modified JOA scores increased from 8.21 ± 0.69 preoperatively to 13.96 ± 1.57 postoperatively ($P < .001$), whereas the mean VAS scores decreased from 6.64 ± 1.28 preoperatively to 0.39 ± 0.50 postoperatively ($P < .001$). Cobb angle of C2–C7 increased from $13.86° \pm 5.69°$ preoperatively to $14.10° \pm 5.56°$ postoperatively ($P = .16$).

In conclusion, combined microscope-assisted ACDF with posterior minimally invasive surgery through tubular retractors appears to be a safe and effective treatment for patients with MCSM.

Abbreviations: ACDF = anterior cervical discectomy and fusion, CPK-MM = creatine phosphokinase MM isoenzyme, JOA = Japanese Orthopedic Association, VAS = visual analogue scale, CT = computed tomography, MRI = magnetic resonance imaging, ACCF = anterior corpectomy and fusion.

Keywords: anterior cervical discectomy and fusion, cervical spondylotic myelopathy, minimally invasive surgery, tubular retractors

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The authors report no conflicts of interests.

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1. Introduction

Cervical spondylotic myelopathy (CSM) is the most common diagnosis of spinal cord impairment in adult patients with nontraumatic paraparesis and tetraparesis.[1] CSM can occur as a result of degenerative disc disease, spondylosis, hypertrophy of ligamentum flavum, or other progressive degenerative chronic compressions of the cervical spinal cord. Although the CSM prognosis can be poor, surgical intervention can rapidly eliminate the chance of neurological deterioration.[2] The purpose of surgery is to completely alleviate spinal cord and nerve roots compression, by either anterior or posterior approach. There are a number of surgical procedures, including anterior cervical discectomy and fusion (ACDF), anterior cervical corpectomy and fusion (ACCF), artificial disc replacement, single open-door or double-door laminoplasty, laminectomy, and laminectomy with fusion. However, the optimal surgical treatment for patients with MCSM is still debatable.[3,4]

Our center regularly performs combined microscope-assisted ACDF with posterior minimally invasive surgery through tubular retractors for patients with MCSM, diagnosed by dynamic x-ray, 3D reconstructive computed tomography (CT), and magnetic resonance imaging (MRI). Thus, our study aimed to investigate the clinical efficacy and outcome of this procedure in patients with MCSM.

2. Material and methods

2.1. Ethics statement

Study participants voluntarily agreed to participate in the study and provided written informed consent before enrollment. The study was approved by the Ethics Committee of Fujian Medical University Union Hospital. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

2.2. Patient population

This study included 28 consecutive patients with multisegmental cervical spondylotic myelopathy treated in the Department of Neurosurgery of the Affiliated Union Hospital of Fujian Medical University, between January 2011 and March 2016. Documents and imaging data were extracted retrospectively from medical records. Inclusion was based on the following criteria: patients with MCSM (≥3 herniated intervertebral discs) diagnosed by clinical and radiographic methods; compression of cervical spinal cord or nerve roots with anterior and posterior approach; and minimum follow-up time of 12 months. The exclusion criteria were as follows: traumatic or degenerative cervical vertebra instability; patients with advanced MCSM or with bed-ridden paralysis for several years; concomitant thoracic and lumbar symptoms; cervical kyphosis, spinal trauma, neoplasm, or infections; and medical history of cervical spine or neck surgery.

2.3. Surgical management

The indications for surgical treatment were based on physical neurological evidence of cervical myelopathy and MRI-detected compression of the spinal cord. Patients were installed cervical gear, when changing positions, and underwent general anesthesia for orotracheal intubation. All patients had permanent intraoperative neurological electrophysiological monitoring and the surgery was assisted by microscopy. ACDF surgery by a standard cervical anterior approach was previously described.[5,6]

2.3.1. Anterior approach procedure. Patients were positioned in supine position with their neck in slight flexion, by placing the torus at the neck and fixing the head with medical adhesive tape. A neurophysiological detection system was installed and the cervical segments were exposed for surgery by using a C-Arm.

A 3- to 4-cm long transverse incision arc was made from central neck line to the outer side of the anterior dermatoglyph of the sternocleidomastoid muscle. The prevertebral space between the sternocleidomastoid muscle and the carotid sheath was exposed by blunt dissection. Electrotome-separated longus colli muscle helped estimating the central line. Although a vertebral spreader braced the cervical vertebra, a microscope-assisted procedure was used to excise the disc and the ligamenta longitudinale posterius and cartilage endplate were removed clearly. A high-speed burr thinned out the cervical osteophytosis until it could be eliminated with a curet. The cervical vertebral fusion cage and the plate constantly adjusted the size to fit perfectly.

2.3.2. Posterior approach procedure. Patients were placed in prone position and cervical vertebrae were maintained flexed with a head-stock. Vertical incisions, 1.8- to 2.2-cm long, were made 2.0 to 2.5 cm outside the posterior midline. In our center, we generally use this posterior approach to treat disc herniation, spontaneous spinal epidural hematoma, ossification of the ligamentum flavum, and intraspinal tumors.[7–9] This procedure is analogous to a partial laminectomy, except for the use of tubular retractors (Fig. 1). The snake chain-connected tubular retractors with strut bars were installed in the surgery bed. The microscope-assisted blunt dissection was carried out on the soft tissue of the vertebral plate and laminar space. A high-speed burr was utilized to create a hole between upper and lower lamina, with a size dependent on the extent of ligamentum flava and lesion were removal. It is of vital importance for the posterior procedure to be carefully approached to reduce muscle injury and safeguard facet joints. The spinal dura mater was substantially exposed to allow for observing the regular pulse of the cerebrospinal fluid, which indicates adequate decompression of the spinal cord.

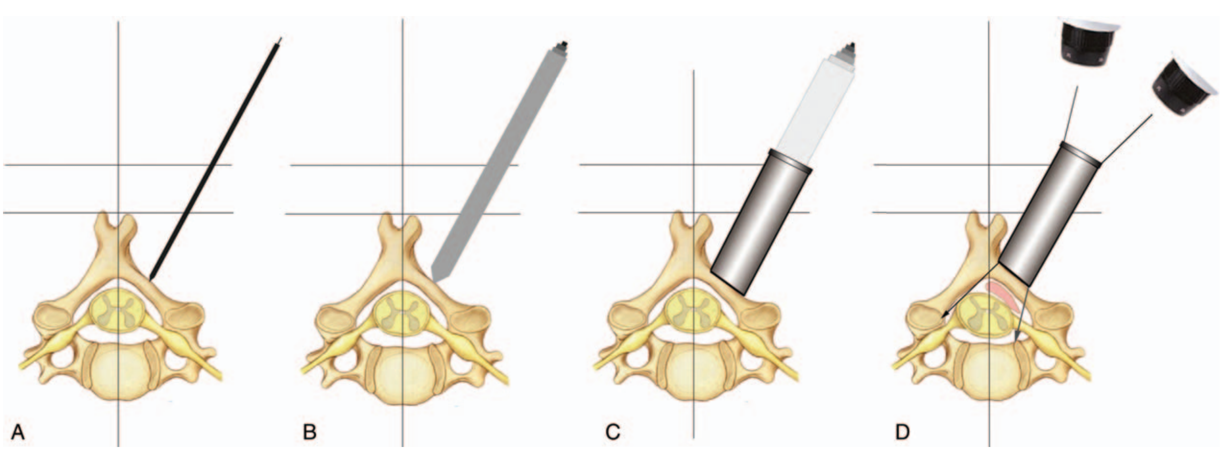

Figure 1. Schematic diagram of the posterior approach minimally invasive surgery through tubular retractors.

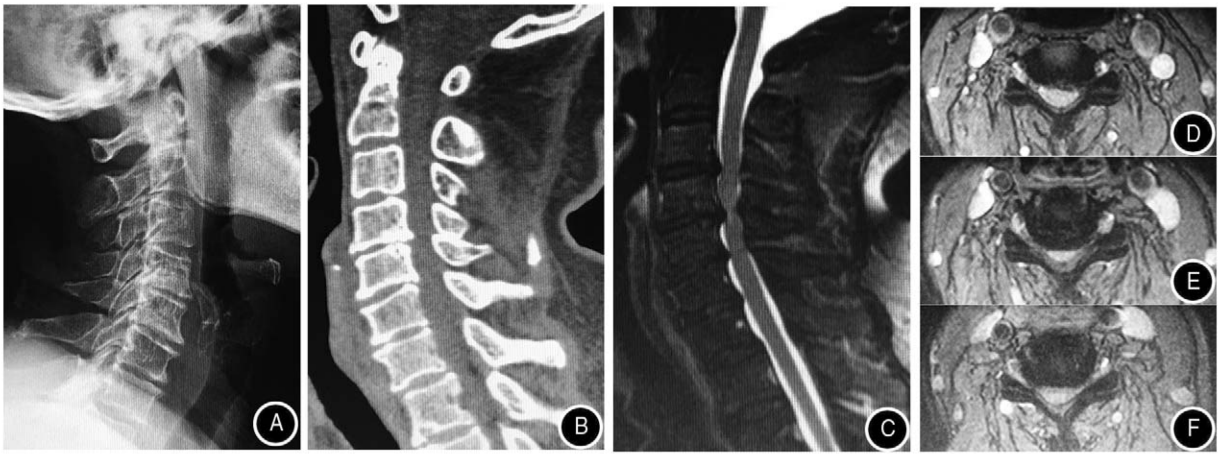

Figure 2. Spinal images of a 65-year-old female patient with bilateral upper limb numbness, accompanied by unsteady walking for 1 year. (A) Lateral preoperative radiograph of the cervical spine showing cervical kyphosis and osteophyte proliferation. (B) Preoperative cervical computed tomography scan showing cervical spinal canal stenosis at C3/4 and C5/6 (B). (C) Sagittal T2-weighted magnetic resonance imaging (MRI) showing ventral and dorsal spinal compression. (D–F) Horizontal T2-weighted MRI showing compression of the C3/4 (D), C4/5 (E), and C5/6 (F).

2.4. Radiological evaluation

Cervical x-ray, three-dimensional (3D) reconstruction CT, and MRI scans were obtained at 1 week before and 1 week, 3 months, and 6 months after the procedure. Preoperative cervical MRI was performed to evaluate the compressed segments of the spinal cord in all patients (Fig. 2). Postoperative MRI was used to inspect the spinal compression at the 12-month follow up. Static and dynamic flexion-extension lateral radiographs obtained postoperatively at each follow-up visit were used to examine lordosis or kyphosis of cervical alignment by measuring the Cobb angle of C2-C7, which was formed by lines along the inferior endplate of C2 to inferior endplate of C7 on the lateral radiographs in a neutral position.

2.5. Clinical evaluation

Clinical outcomes were evaluated based on operation time, hospitalization time, blood loss, creatine phosphokinase MM isoenzyme (CPK-MM) levels, and Japanese Orthopedic Association (JOA) and visual analogue scale (VAS) scores before and after surgery. The JOA score system was used to evaluate the neurological function. The recovery rate of neurological function was calculated using the following equation: (postoperative scores − preoperative scores)/(17 − preoperative scores) × 100%.[10] The recovery rate of neurological function was classified as unchanged or worse (≤25%), fair (>25%–≤50%), good (>50%–≤75%), and excellent (>75%–≤100%).[11] The VAS scores were used to evaluate the preoperative and postoperative pain of the neck and extremities.

2.6. Statistical analysis

Continuous variables were presented as mean ± standard deviation. Our center used a repeated measures analysis of variance to examine the improvement of disease severity scores and CPK-MM levels before versus after surgery, and used a paired-sample *t* test to examine variation of Cobb angles before versus after surgery. Unless stated otherwise, a 2-tailed $P<.05$ was considered statistically significant. Statistical analyses were performed using SPSS version 19.0 software (SPSS Inc, Chicago, IL).

3. Results

3.1. Radiography results

Segments of cervical compression are shown in Figure 3. The most prevalent lesion levels were C4/5 and C5/6, followed by C6/7 and C3/4. Eight patients had 3-level lesions and 20 had 4-level lesions (C3–C6 levels in 8 cases, C4–C7 levels in 13 cases, and C3–C7 in 7 cases). The Cobb angles increased from 13.86° ± 5.69° preoperatively to 14.10° ± 5.56° at 6 months postsurgery ($P=.16$). No complications of lordosis or kyphosis of cervical alignment were observed during the postoperative cervical x-ray examination (Fig. 4) and 3D reconstruction CT. Postoperative cervical MRI revealed enlarged cross-sectional areas of the cervical canal, indicating adequate decompression around the spinal cord and spinal dura mater (Fig. 5).

3.2. Clinical results

This study included 19 males and 9 females, with a mean age at the time of surgery of 64 ± 3.72 years (range, 41–73 years). Characteristics of patients with MCSM in this study are shown in Table 1. The mean follow-up time was 13 ± 2.45 months (range, 12–48 months). The mean operation time was 198.42 ± 17.53

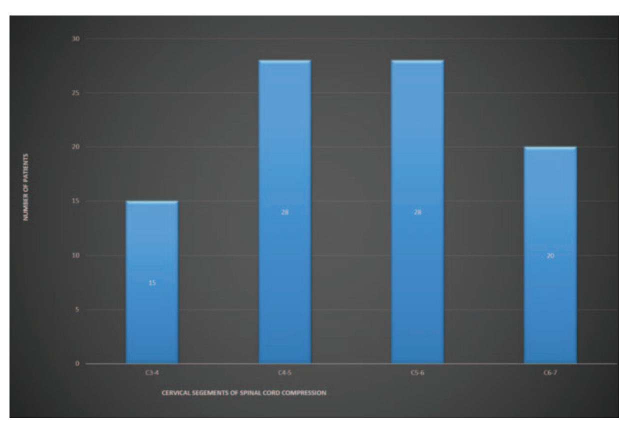

Figure 3. Incidence of spinal cord compression segments.

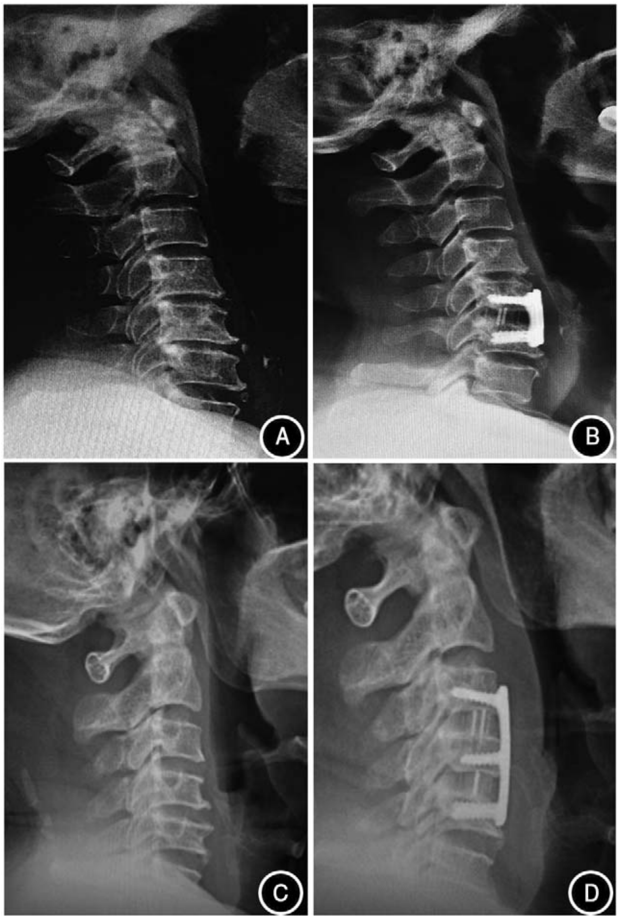

Figure 4. Spinal images (A) and (B) of a patient who underwent combined microscope-assisted C5-C6 ACDF with posterior C3/4, C4/5, C6/7 minimally invasive surgery through tubular retractors decompression. spinal images (C) and (D) of a patient who underwent combined microscope-assisted C3-C5 ACDF with posterior C5/6 minimally invasive surgery through tubular retractors decompression.

minutes. The average hospitalization length was 7.59 ± 1.38 days and the mean blood loss was 36.42 ± 10.15 mL. CPK-MM increased to 331.75 ± 23.15 IU/mL on postoperative day 1 ($P < .001$), but no significant difference was reported at day 5 ($P = .795$). The mean VAS scores decreased from 6.64 ± 1.28 preoperatively to 0.39 ± 0.50 at 6 months postoperatively ($P < .001$). All pre- and postoperative JOA and VAS scores are shown in Table 2. The mean modified JOA scores increased from8.21 ± 0.69 preoperatively to 13.96 ± 1.57 at 6 months postsurgery ($P < .001$). The recovery rate of neurological function as measured by the JOA scores after surgery was excellent in 12 patients (42.86%), good in 11 patients (39.29%), fair in 4 patients (14.29%), and unchanged or worse in 1 patient (3.57%).

There were no serious complications, such as cerebrospinal fluid leakage, screw loosening, implant displacement, delayed healing, or death after the surgical procedure. Radicular neuralgia was relieved immediately in 10 patients and after 2 weeks of conservative treatments in 2 other patients. Limb muscle strength improved significantly in 5 patients immediately after surgery and was completely recovered after 1 to 2 months of rehabilitation treatments.

4. Discussion

A variety of surgical treatments are currently available for MCSM, including anterior approach, posterior approach, and combined anterior and posterior approaches. The anterior approach usually includes ACDF, ACCF,[12] and artificial disc replacement.[13] Spinal cord and nerve root compression owing to herniated disk, posterior marginal osteophytes, or ossification of the posterior longitudinal ligament can be directly relieved by an anterior approach in the ventral part. However, spinal cord or nerve root secondary injuries can be induced by forcible removal of osteophytes and ossification of the posterior longitudinal ligament with massive adhesions to spinal dura mater. Posterior approach methods include laminectomy,[14] hemilaminectomy, single open-door cervical laminoplasty, and double-door laminoplasty.[15] The purpose of this approach is to expand the capacity of spinal canal, resulting in indirect decompression of the spinal cord and nerve roots. However, the posterior approach does not produce direct and complete decompression, and thus, the stability of the cervical spine could be destroyed because of vertebral lamina and facet joint destruction, resulting in less satisfactory outcome compared with anterior direct decompression.[16]

A 2-stage surgery combined the anterior with the posterior approaches, by expanding the spinal canal capacity through a posterior approach, followed by a second anterior approach surgery. Two surgeries generally require longer hospitalization time and incur higher operating costs for patients. Generally, multisegmental laminectomy needs for internal fixation in the posterior approach for patients with MCSM.[17] In this study, the Cobb angles increased from $13.86° \pm 5.69°$ preoperatively to $14.10° \pm 5.56°$ at 6 months postsurgery ($P = .16$), We have found that even if we did not use internal fixation in the posterior approach, there was no kyphosis for patients with MCSM. Based on the JOA scores, VAS scores, and recovery rate of neurological function in our study, the outcomes of patients with MCSM were appreciably improved and maintained for about 2 years. Surgical treatment consisting of microscope-assisted ACDF combined with posterior minimally invasive surgery through tubular retractors for MCSM, without using internal fixation in the posterior approach, appears to have significantly improved neurological function in the patients presented here. Thus, anterior ACDF with posterior minimally invasive surgery through tubular retractors may be an effective treatment option for MCSM.

Minimally invasive spine surgery with a tubular retractor system develops rapidly and shows significant effects not only for disc herniation treatment, but also spinal stenosis.[18] In this study, we performed minimally invasive surgery through a system of the posterior paravertebral tubular retractors with an inner diameter of 1.4 to 2.2 cm. Minimal paraspinal muscle injury is persistent, as shown by MM-CPK level variation, but appears consistent with previous studies.[19,20]

The maximum cervical vertebrae angle in anteflexion and hypsokinesis position was observed presurgically when patients were awake, and the patient's posture during surgery did not exceed that angle. Patients were installed cervical gear, when position was changed by operator, and underwent general anesthesia by orotracheal intubation with laryngoscopy, to avoid exceeding the anteflexion and hypsokinesis angle and causing iatrogenic spinal cord and nerve injury.

The microscope-assisted anterior approach avoids the need for partial removal of the diseased vertebral body to widen the

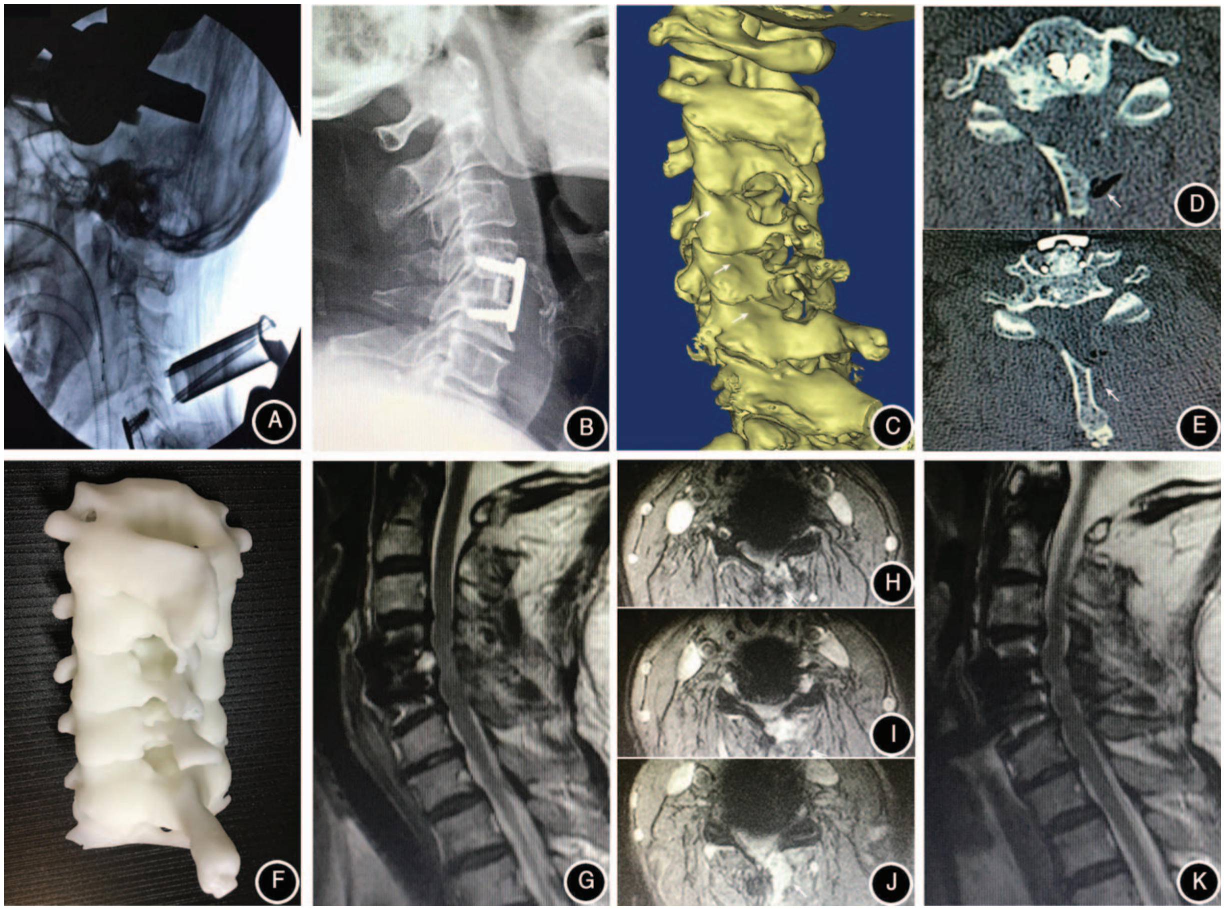

Figure 5. Spinal images of a patient who underwent combined microscope-assisted C4/5 ACDF with posterior C3/4, C4/5, C5/6 minimally invasive surgery through tubular retractors decompression. (A) Tubular retractors were installed in the back. (B) Lateral radiograph of the cervical spine showing the physiological curvature returned to normal and displacement of internal fixation not observed at 6 months postsurgery. (C–E) Cervical 3D reconstruction computed tomography scan showing the range of the partial laminectomy at 6 months postsurgery. (F) Muscle injury and safeguard of the facet joints not observed in this 1:1 scale 3D-print model. (G–J) T2-weighted magnetic resonance imaging (MRI) scan showing no evidence of ventral and dorsal compression of the spinal cord at 1 year postsurgery. (K) T2-weighted MRI image showing no evidence of ventral and dorsal compression of the spinal cord at 2 years postsurgery.

visual field. The high-speed drill can effectively remove all small ossification and vertebral osteophytes, which could cause spinal cord compression when incompletely removed. The posterior minimally invasive surgery through tubular retractors completely removed the ligamentum flavum compression, without the need for wide laminectomy, thus avoiding spinal instability. Single-segment or 2-segment ACDF was performed to avoid multisegmental cervical fusion surgery and to reduce the incidence of adjacent segment degeneration and the rate of titanium mesh cage subsidence.[21] We retained the cervical muscle ligament complex, thus reducing the incidence of axial symptoms.[22,23] However, supreme mastery is needed to apply this technique to multisegmental ossification of the posterior longitudinal ligament, given the serious adhesions to the ventral surface. Also, the surgery time is longer, requiring increased patient tolerance. Finally, the use of microscopes and tubular retractors necessitates additional learning of microsurgical manipulation techniques, spinal anatomy, and spinal mechanics.

Our single-center study had several limitations. First of all, this study is a single-center retrospective study, lacks randomization, and difficult to control making biases and confounding. Second, the case size of this study was small and limited to our additional statistical analyses. Consequently, the corresponding results should be interpreted with caution, and further studies with a larger sample size and longer follow-up periods are necessary to investigate the clinical outcomes of microscope-assisted ACDF

Table 1

Characteristics of patients with MCSM in this study.

Patient characteristics	Number of patients (N=28)
Mean age, y	64±3.72
Mean age	/
≤64 y	20 (71.4%)
>64 y	8 (28.6%)
Follow-up period, mo	13±2.45
Sex	/
Female	9 (32.1%)
Male	19 (67.9%)
The recovery rate	/
Excellent	12 (42.86%)
Good	11 (39.29%)
Fair	4 (14.29%)
Unchanged or worse	1 (3.57%)

MCSM=multisegmental cervical spondylotic myelopathy.

Table 2

CPK-MM levels, VAS, JOA, scores and Cobb angle before versus after surgery.

	Preoperative	Postoperative 1 day	Postoperative 3 mo	Postoperative 5 day	Postoperative 6 mo	F/*t*	*P*
CPK-MM	150.96±15.92	331.75±23.15*	269.00±24.53*	151.11±13.63†	/	1293.28	<.01
VAS	6.64±1.28	4.18±0.72*	3.04±0.74*	1.82±0.61*	0.39±0.50*	262.60	<.01
JOA	7.24±1.19	9.24±1.76*	10.63±1.61*	11.92±1.73*	13.82±1.47*	173.85	<.01
Cobb angle	13.86±5.69	/	/	/	14.10±5.56†	−1.45	.16

CPK-MM=MM isoenzyme of creatine phosphokinase, JOA=Japanese Orthopedic Association, VAS=visual analog scale.
* Statistically significant ($P<.05$) change between pre- and postoperative scores.
† No statistically significant ($P>.05$) change between pre- and postoperative scores.

combined with posterior minimally invasive surgery through tubular retractors for MSCM.

5. Conclusion

Combined microscope-assisted ACDF with posterior minimally invasive surgery through tubular retractors is a safe and effective treatment for patients with MCSM. The advantages of this surgical approach are minimal damage to the spinal structure and minimal muscle trauma of the regio colli posterior.

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