

# Evaluation of the Effectiveness of Cervical One-Hole Split Endoscopic Keyhole Surgery for Cervical Radiculopathy

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**Purpose:** One-hole Split Endoscopy (OSE) is a newer surgical modality that can be applied to posterior cervical foraminotomy (PCF), lumbar discectomy, laminectomy, and decompression. It incorporates intervertebral foraminotomy, open surgery, and other lumboendoscopic techniques with a wide observation field, free space, and compatibility with various spinal surgical techniques and instruments. This study investigated the clinical efficacy of minimally invasive posterior cervical nucleus pulposus removal for cervical spondylotic radiculopathy (CSR) by OSE-Keyhole technique.

**Patients and Methods:** This was a retrospective study of 63 patients treated with OSE keyhole treatment for CSR between May 2021 and September 2023 at Qilu Hospital of Shandong University, Qilu Hospital of Shandong University (Qingdao, China), and Second Hospital of Shandong University, respectively. Clinical outcomes included patients' preoperative and postoperative visual analogue scale (VAS) - arm and neck, Japanese Orthopaedic Association Assessment Treatment Score (JOA) - cervical spine, which were collected at baseline, two days postoperatively, one month postoperatively, and three months postoperatively after the last follow-up visit for evaluation, and perioperative indicators, including intraoperative bleeding, length of hospital stay, postoperative complications, and reoperations, which were also collected.

**Results:** Statistical analyses were performed for the baseline data and follow-up results of 63 patients. Compared to the preoperative baseline values, the follow-up results two days, one month and three months after surgery showed significant improvements in VAS-arm, neck and JOA scores in the operated patients ( $P < 0.05$ ) as well as a reduction in all perioperative-related indices.

**Conclusion:** In the treatment of cervical pain and disability due to radiculopathy, OSE keyhole removal of the posterior cervical nucleus pulposus is a better clinical option as it is less invasive and recovers better postoperatively.

**Keywords:** nerve root type cervical spondylosis, unilateral cervical disc herniation, posterior cervical laminectomy, single-channel endoscopy

## Introduction

Cervical spondylotic radiculopathy (CSR) is a common disorder treated in spinal surgery. It causes neurogenic arm pain symptoms, usually caused by herniated discs on the lateral side of the cervical spine or bony growths within the neural foramina.<sup>1</sup> Current treatments include medications (nonsteroidal anti-inflammatory drugs, muscle relaxants and steroid injections), conservative treatments such as traction therapy and physiotherapy, and surgery, with many patients opting for surgery to relieve symptoms after conservative treatments have failed.<sup>2</sup>

However, the optimal surgical approach for unilateral radiculopathy remains controversial. The traditional surgical approach is anterior cervical discectomy and fusion (ACDF), first proposed by Smith and Robinson in 1958,<sup>3</sup> which has become the standard procedure for the treatment of cervical disc herniation;<sup>4</sup> However, this surgical procedure touches tissues of the trachea, oesophagus, and recurrent laryngeal nerves, resulting in postoperative discomfort such as

esophageal fistulas, tracheal and recurrent laryngeal nerve injuries, and is more traumatic due to the need for fusion of implants and fixation with titanium plates.

With the continuous development and maturation of the technique, Papavero proposed the "Minimally Invasive Posterior Cervical Foraminotomy (MI-PCF), also known as keyhole technique, in 2012, which has many advantages, and several studies have proved, that the application of the keyhole technique for posterior cervical discectomy (PCD) is also one of the pioneering procedures,<sup>5–7</sup> such as the posterior cervical endoscopic-assisted discectomy (PC-EAD) technique,<sup>8</sup> percutaneous endoscopic cervical foraminotomy (PECF)<sup>9</sup> and so on.

The One-hole Split Endoscopy (OSE), a spinal endoscope, combines the two channels of a unilateral biportal endoscopy (UBE) into a single port by splitting the instruments and mirror, thus combining the free, direct and minimally invasive features of the keyhole microscope and UBE. Considering the outstanding advantages of OSE and keyhole technique, we hypothesized that the application of OSE keyhole technique would be a good choice for minimally invasive removal of posterior cervical medullary nucleus in CSR. Therefore, the aim of this study was to evaluate the clinical outcomes of minimally invasive posterior cervical nucleus pulposus removal with the OSE keyhole technique for the treatment of CSR three months postoperatively, which are summarized as follows.

## Materials and Methods

The Ethics Committee of Qilu Hospital of Shandong University examined and approved this study, and conducted following the Declaration of Helsinki. Informed consent was obtained from all participants, including photographs of patients. In this study, 63 CSR patients who underwent OSE in the orthopedics department of Qilu Hospital of Shandong University, Qilu Hospital of Shandong University (Qingdao, China), and the Second Hospital of Shandong University from 2021 and May 2023 were included.

Inclusion criteria:

- (1) Clinical presentation of unilateral cervical radiculopathy with arm pain and, or sensory deficits or loss of motor function without spinal cord compression;
- (2) Imaging suggestive of a herniated disc on the lateral side of the spinal cord without cervical instability;
- (3) Conservative treatment was ineffective for at least three months, with appropriate shortening of the duration of severe pain or neurogenic symptoms Conservative treatment time.

Exclusion criteria:

- (1) History of cervical spine surgery;
- (2) Cervical spine infection or tumor;
- (3) Multisegmental cervical disc herniation with severe degeneration;
- (4) Cervical vertebral deformity;
- (5) Severe cervical stenosis, ossification of posterior longitudinal ligament, or severe calcification of the intervertebral discs;
- (6) Disc herniation located in the medial or anterior part of the spinal cord;
- (7) Herniation to the side, non-central herniation. All procedures were performed by a single spine surgeon with more than five years of experience in endoscopic spine surgery.

## Surgical Technique

Patients were placed in a prone position under general anaesthesia, the head was fixed on a Mayfield surgical frame and the cervical spine was positioned 10–15 cm above the heart.

We observed and identified the target segments under C-arm fluoroscopy. We made a 1.5 cm vertical skin incision at the medial edge of the confluence of the superior and inferior joints. The surgeon used a scalpel to make a thorough incision through the outer layer of skin to the deep fascia, inserted the trocars sequentially and gradually until the trocars were 1.5 cm long, and turned on the switch for continuous injection of sterile saline. The surgeon cauterised the tissue with a bipolar radiofrequency ablator to obtain the appropriate space for endoscopic and OSE instrumentation, and then searched for the V-point where the superior and inferior joint tips meet and the ligamentum flavum lies therein, and switched to a 4-mm endoscope drill to drill the medial part of the small joint until the attachment point of the ligamentum flavum was exposed. After circumferential dissection along the path of the exiting nerve root, we carefully stopped the bleeding and removed the excess ligamentum flavum by biting

on the bone forceps to visualise the shoulder of the nerve root and the protruding disc tissue. The surgeon then pulled out the nerve root moderately with a nerve stripper or a nerve root pulling hook and removed the protruding nucleus pulposus with a nucleus pulposus forceps. In some cases, the nucleus pulposus was located in the axilla of the nerve root, and the nucleus pulposus was removed through the axilla. All procedures were performed gently, taking care to avoid the nerve roots when using radiofrequency ablation. After re-exploration to ensure complete removal of the protruding nucleus pulposus, a gelatin sponge soaked in lidocaine and ropivacaine was applied to the exposed nerve root. After careful hemostasis, the surgeon inserted a drain and closed the surgical wound layer by layer.

## Evaluation Index

We collected demographic and anamnestic data, including age and gender. Clinical outcomes included patients' preoperative and postoperative visual analog scale (VAS) - arm and neck, Japanese Orthopedic Association Assessment Treatment Score (JOA) - cervical spine, which was collected at baseline, two days, one and three months postoperatively after the last follow-up visit for assessment, and perioperative indicators, including intraoperative bleeding, length of hospital stay, postoperative complications and reoperations, were also recorded.

### Visual Analog Scale (VAS) Score

The VAS score is primarily a simple assessment of the patient's pain using a numerical measure. The total score is ten, with a score of 0 indicating no pain and a score of 10 indicating unbearable severe pain. The patients' postoperative pain improvement rate were assessed by analyzing the data from the preoperative, two-day, one-month and three-month postoperative VAS scores.

### Japanese Orthopedic Association (JOA) Score

The JOA score indicates limb function, sensation and bladder function, and the full score is 17. The improvement rate of the JOA score was calculated based on the scores before and after surgery. Excellent was all healed as 100%, remarkable as 60% to 100%, effective as 25% to 60%, and ineffective as 25% or less.

The improvement rate of the JOA score (%) =  $\times 100\%$ .

## Statistical Analysis

All data were statistically analyzed using SPSS 26.0 software. Normally distributed measurements were expressed as mean  $\pm$  standard deviation ( $\bar{x} \pm s$ ), and one-way ANOVA was used for comparison at each time point before and after surgery. The difference was statistically significant, corresponding to a  $P < 0.05$ .

## Results

### Operation

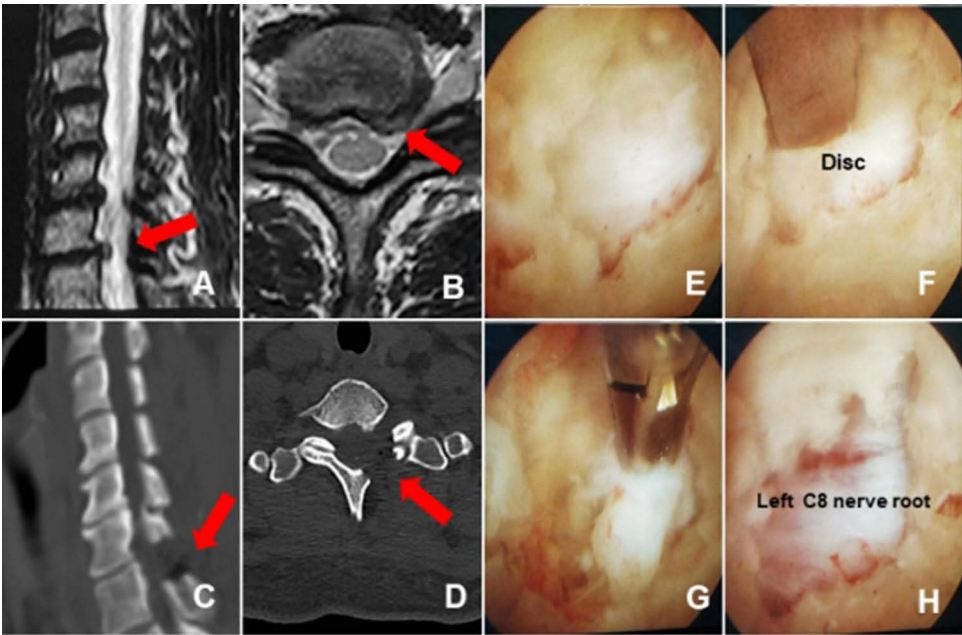
A total of 63 patients were effectively treated with this procedure and included in the final analysis. There were no significant differences in patient demographics and preoperative data (Table 1). The mean total operative time for minimally invasive posterior cervical nucleus pulposus removal using the OSE keyhole technique was  $68.84 \pm 4.32$  minutes, the mean blood loss was  $37.27 \pm 3.53$  milliliters, and the mean hospital stay was  $6.63 \pm 0.83$  days. No patient required a second surgical intervention for treatment.

### Clinical Efficacy

Intraoperative visualization and postoperative image comparison showed good decompression of the nerve root (Figure 1). The VAS arm score, the VAS neck score and the JOA score showed a statistically significant improvement two days, one and three months postoperatively compared to the preoperative situation ( $P < 0.01$ , Table 2). At the last follow-up, the VAS scores for arm and neck were  $0.87 \pm 0.68$  and  $0.43 \pm 0.50$ , respectively, and the improvement rate of the JOA score was  $67.38\% \pm 11.32\%$ . The patients' pain decreased more compared to the preoperative period and the recovery of individual functions was effective. In conclusion, minimally invasive removal of the posterior cervical nucleus pulposus using the OSE keyhole technique has good clinical efficacy in the treatment of CSR, which can significantly reduce patients' pain and improve symptoms.

Table 1 Demographic and Perioperative Data

Variable	Age (yr)		
	46.13±2.03 (A)	55.80±2.49 (B)	65.11±2.89 (C)
Sex (male: female)	3:5	4:6	4:5
Level			
C3/4	2	3	2
C4/5	3	2	2
C5/6	2	2	3
C6/7	1	2	2
C7/T1	0	1	0
Operation time (skin to skin, min)	66.25±5.50	69.9±4.48	68.89±4.34
Intraoperative hemorrhage (mL)	38.50±3.42	37.10±3.38	37.44±1.94
Length of hospital stay (until discharge after surgery day)	6.75±1.04	6.60±1.07	6.78±0.67



**Figure 1** (A) 49-year-old female patient who suffered from radiating pain and motor weakness in the left upper extremity that had occurred 3 months previously. (A and B) Images of preoperative magnetic resonance imaging (MRI) demonstrating left C7–T1 foraminal encroachment of the herniated intervertebral disc, red arrows point to the protruding nucleus pulposus and the compressed nerve root. (C) and (D) A well-decompressed state was confirmed by computed Tomography (CT) at 3 days postoperatively, red arrows point to the postoperative lamina structure and decompressed nerve roots. (E) and (F) Intraoperative endoscopic finding of the extruded disc which compressing the left C8 nerve root. Intraoperative endoscopic finding during discectomy (G) and after discectomy (H).

Table 2 JOA Postoperative Improvement Rate

Variable	PRO Mean ±SD	PO(2d) Mean±SD	PO(1m) Mean±SD	PO(3m) Mean±SD	P value PRO vs PO (2d)	P value PRO vs PO (1m)	P value PRO vs PO (3m)
VAS-arm	8.41±0.50	4.30±0.47	1.89±0.75	0.74±0.71	<0.01*	<0.01*	<0.01*
VAS-neck	5.07±0.68	1.67±0.55	0.70±0.47	0.37±0.49	<0.01*	<0.01*	<0.01*
JOA	12.81±0.62	14.44±0.58	15.07±0.73	15.63±0.49	<0.01*	<0.01*	<0.01*

**Note:** \*P value with the statistical significance.  
**Abbreviations:** PRO, preoperative timepoint; PO (2d), 2-days postoperative timepoint; PO (1m), 1-months postoperative timepoint; PO (3m), 3-months postoperative timepoint.

## Complications

Three patients had considerable pain in two fingers on the lateral and radial side of the left forearm after removal of the drainage tube, two patients had dysesthesia. Their symptoms improved after treatment with mannitol and dexamethasone. No patients required a second surgery due to worsening or non-improvement of symptoms.

## Discussion

The optimal surgical treatment of CSR is still controversial. It includes posterior approaches, anterior approaches and combined anterior and posterior approaches. Posterior approaches include laminectomy, laminoplasty with widening of the spinal canal (single or double portal) and keyhole surgery.

Anterior cervical spine surgery causes more postoperative complaints such as dysphagia, laryngeal nerve injury, and esophageal fistulas.<sup>10–16</sup> Esophageal fistulas, where food can pass through the fistulas into the chest cavity, for example, can damage the titanium plates used for internal fixation during surgery, leading to multiple operations and even fatal and severe consequences.<sup>10</sup> In 1997, the percutaneous endoscopic posterior cervical laminectomy performed by Adamson for the treatment of unilateral neurogenic cervical spondylosis was first reported in the literature, which effectively reduced the complication rate while preserving motion segments.<sup>5</sup> In 2012, Papavero proposed the minimally invasive posterior cervical laminectomy (MI-PCF) also known as the keyhole technique, which is a relatively simple approach for patients with short and thick necks, shortens the operation time and hospital stay, better preserves the mobility of the cervical spine, and avoids the complications of anterior surgery,<sup>5,7</sup> but the access requirements are more demanding and the position is more precise, and it is unsuitable for central, paracentral, and bilateral pathologies.<sup>7</sup> In China, the OSE, which consists of an observation channel and a working channel, was first introduced and clinically applied in 2019. Compared to the unilateral biportal endoscopy (UBE) technique, two channels of the OSE are located in the same soft incision, which allows independent and free rotation and pivoting without the restriction of the fixed channels. Several studies have demonstrated the benefits of OSE in the treatment of degenerative pathologies of the lumbar spine.<sup>17–20</sup>

In our study, we applied the OSE keyhole technique to treat unilateral CSR. By retrospectively analyzing the postoperative outcomes of 63 patients, we found that minimally invasive posterior cervical nucleus pulposus removal with the OSE keyhole technique shortened the operation time and hospital stay, reduced intraoperative bleeding, and the posterior cervical approach bypassed tissues such as the trachea, esophagus, and nerves, thereby avoiding such complications, and also significantly reduced postoperative discomfort due to the small incision. Compared to the anterior cervical approach, the OSE keyhole technique has the advantage that the incision is smaller and located at the back of the neck, allowing the patient to use a hair band to cover the healed incision on the neck, which is more esthetically pleasing; the surgery is performed with a V-point bone decompression, which removes less bone, preserves bone better, has less impact on mobility, has high postoperative stability and does not require too many spinal nerves to be removed, so there is less nerve interference; there is no fusion of the prosthesis and no internal fixation to ensure the mobility of the neck, so it is suitable for people who have high demands on the mobility of their neck, such as traffic police officers, doctors, teachers and gymnasts.

This study therefore aims to present and evaluate the OSE keyhole technique for the treatment of unilateral radiculopathy of the cervical spine.

## Limitation

Drawbacks of the study include the retrospective study design, small sample size, short follow-up period, lack of additional evidence of clinical significance, and lack of controls, so we have obvious limitations in interpreting the results. We believe that the strength of this study lies in the first demonstration of the combined use of OSE and keyhole technique for the treatment of radiculopathy by minimally invasive removal of the posterior cervical nucleus pulposus. However, given the shortcomings and limitations of this study, we continue to collect relevant cases, establish controls



and extend the follow-up period and increase the evaluation indices to better demonstrate the benefits of the OSE keyhole technique.

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## Disclosure

The authors report no conflicts of interest in this work.

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