Eur Spine J (2011) 20:899–904
DOI 10.1007/s00586-010-1642-0

ORIGINAL ARTICLE

Full-endoscopic technique for anterior cervical discectomy and interbody fusion: 5-year follow-up results of 67 cases

Nuzhao Yao · Cheng Wang · Wenjun Wang · Lushan Wang

Received: 29 June 2010 / Revised: 17 October 2010 / Accepted: 16 November 2010 / Published online: 11 December 2010

Abstract With minimally invasive technique becoming more popular, endoscopic operations such as arthroscopy or laparoscopy have become the standard of care in several other areas. In this study, we evaluated the 5-year follow-up outcomes of anterior cervical (Ahn et al. in Photomed Laser Surg 23:362–368, 2005) discectomy and interbody fusion (ACDF) performed via endoscopic approach. Sixty-seven patients who underwent anterior cervical discectomy and cage fusion performed using endoscopic technique were followed for at least 5 years. We reviewed the clinical and radiographic records of these patients. The postoperative radiographic measures accessed were the anterior intervertebral height (AIH) and the lordosis angle (LDA). Clinical outcomes were determined using the previously validated Japanese Orthopaedic Association (JOA) and the pain visual analog scale (VAS). Patients included had a minimal follow-up period of 5 years and based on the outcomes criteria (JOA, VAS), 86.6% of patients reported excellent or good results. The AIH increased on average 18.7% of the original height ($p < 0.01$), and the LDA were more physiologic at final follow-up. Of the 67 cases, there was no segmental instability, and the bone fusion rate was 100%. One patient required revision open ACDF due to adjacent segment disc herniation 6 years postoperatively. There were no intraoperative complications, dysphasia or esophageal injury in this study group. It indicated endoscopic technique for ACDF can obtain satisfactory results in patients with cervical disc herniation, cervical myelopathy, or radiculopathy. Compared with a traditional approach, this technique may be associated with less morbidity while improving cosmesis and postoperative recovery. Prospective randomized control trials are needed to directly compare these two procedures.

Keywords Cervical spine · Interbody fusion · Discectomy · Endoscopic microsurgery · Cage

N. Yao · C. Wang · W. Wang · L. Wang (✉)
Department of Spinal Surgery, 1st Affiliated Hospital, University of South China, Hengyang 412001, Hunan, People's Republic of China
e-mail: spinekitty@gmail.com

W. Wang
e-mail: sunorthop@yahoo.cn

Introduction

Cervical spondylotic myelopathy (CSM) is a common cause of neurologic morbidity and can substantially decrease quality of life [10, 18]. Due to the progressive stepwise neurologic deterioration, in most of these patients operative intervention is often warranted. Since its introduction in the 1950s, anterior cervical discectomy and interbody fusion (ACDF) has become a well-accepted surgical treatment for symptomatic cervical spondylosis. It is usually described as a safe and sufficient operation with reported fusion rates [17, 20]. Despite well-documented success, complications such as dysphasia, hematoma, recurrent laryngeal nerve palsy and esophageal perforation have been reported in the literature. With minimally invasive technique becoming more popular, endoscopic operations such as arthroscopy or laparoscopy have become the standard of care in several other areas.

Utilization of endoscopic technique is not new to spine surgery. Lumbar disc herniation can be treated with the full endoscopic technique and many authors have reported excellent clinical outcomes [6, 13, 21]. Fontanella described an endoscopic microsurgical technique for treating herniated cervical discs and obtained promising clinical

outcomes [8]. However, anterior cervical discectomy alone results in segmental kyphosis and postoperative axial pain [7]. In order to explore the feasibility of ACDF using a endoscopic technique, our department treated 76 patients with cervical disorders by this technique since 2000. In this study, we report our experiences and medium-term results about this cohort data.

Materials and methods

Patient demographics

Between January 2000 and January 2004, 76 patients with a mean age of 50.3 years (range 35–67 years, 43 M/33 F), underwent endoscopic ACDF for cervical disc herniation. Patients were followed for at least 5 years. A total of nine patients were lost to follow up. Thus, 67 patients were included in this study. All patients included in this study had single level myelopathy, radiculopathy or myeloradiculopathy that failed conservative treatment. The preoperative neurologic presentation included myelopathy in 21 patients (31%), radiculopathy in 35 patients (52%), and myeloradiculopathy in 11 patients (17%). Localization of the disc requiring surgery was determined based on neurologic and radiologic findings. The operated level was C3–C4 in 4 patients, C4–C5 in 28 patients, C5–C6 in 30 patients, and C6–C7 in 5 patients.

Outcomes assessment

Clinical outcomes were accessed used previously validated measures. The visual analog scale (VAS) was used for evaluating the degree of local neck pain and radiculopathic pain in the arm or shoulder. The neurologic status was assessed using the Japanese Orthopedic Association (JOA) scoring system. The improvement rate (IR) was calculated as IR = (postoperative JOA score − preoperative JOA score)/(17 − preoperative JOA score) × 100%. The anterior intervertebral height (AIH) of the involved interbody space and lordosis angle (LDA) were measured on the lateral radiographs. Cervical fusion was evaluated as complete if no radiolucent gap or evident motion between the two adjacent vertebral bodies demonstrated on the flexion–extension images or if the endplates had disappeared in both adjacent vertebral bodies and the two vertebral bodies formed a block [19].

Surgical technique

Under general anesthetic with tracheal intubation, patients were placed in the supine position with neck slightly extended. The cervical spine was exposed through a standard left side anterior approach. The segment to be operated was confirmed by intraoperative C-arm radiography. A small transverse incision deep to the platysma was made at the target level on the left side. Subplatysmal structures were dissected bluntly using the index finger. Pushing the trachea or larynx toward the opposite side with the index and middle fingers, the surgeon then slipped the fingers inside towards the front of the vertebral body until the prominence of the anterior edge of the disc to be treated was felt, while the carotid was held laterally. Endoscopic dilators were introduced sequentially under fluoroscopic control between the carotid artery and the esophagus (Fig. 1a), by the time the last dilator was placed, the muscles were stretched to an opening roughly the size of a nickel. Over the last dilator, a working channel (2 cm in diameter) was positioned; this circular retractor holds back the muscles and the dilators were removed. The retractor was held in place by a mechanical flexible arm attached to the operating table. After confirming the correct level with the aid of the C-arm, the endoscope system (DragonCrown, Shandong Province, China) was installed (Fig. 1b). The anulus fibrosus of the involved disc was incised using a microknife device, then the nucleus pulposus and the

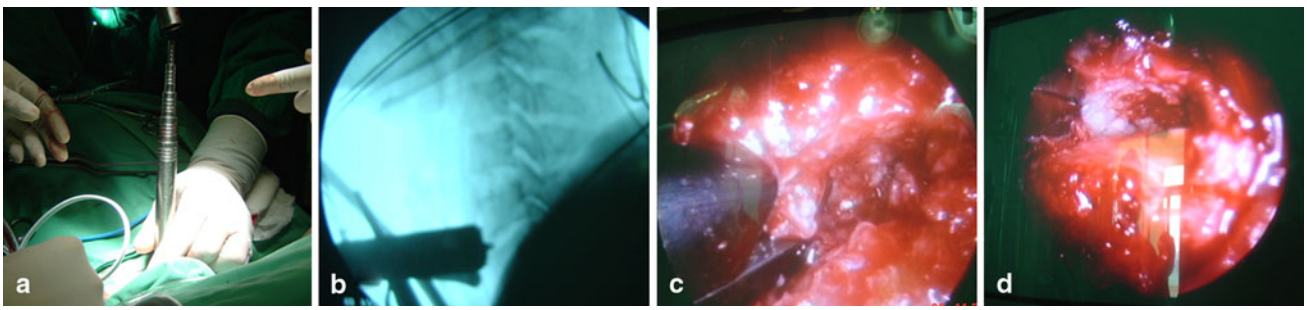

Fig. 1 Intraoperative endoscopic views. **a** Endoscopic dilators were introduced sequentially between the carotid artery and the esophagus. **b** Working channel was set up under fluoroscopic control. **c** The anterior osteophyte of vertebral bodies adjacent to the disc was removed endoscopically by a small kerrsion. **d** Endoscopic view after removal of intervertebral disc

endplate were removed using a set of microforceps and small curettes. The anterior osteophyte of vertebral bodies adjacent to the disc needed to be removed by a long-stem drill or small kerrsion. The excision of the posterior osteophyte or area of OPLL by using a small curette was essential for complete neural decompression (Fig. 1c, d). The special lamellar curettes were used not only to remove the cartilage endplates but also to enlarge the intervertebral space. The intervertebral space was irrigated with saline solution in order to clear away the remaining fragment. Manual cervical traction was also used to enlarge the interbody space. The manual traction was performed as follows: The patient's head was pushed a little up by an anesthetics while his two arms were pulled down by a nurse. Several templates were tried before a proper carbon fiber reinforced polymer (CFRP) cage (Depuy, USA) was selected. Once the correct size was determined the CRFP cage was selected and filled with autogenic iliac crest bone graft prior to definitive placement. The wound was closed in standard fashion with the placement of a same drain.

Statistical analysis

The paired sample *t* test was used for JOA, VAS, AIH and LDA before and after operation. The result was considered significant if the *p* value was <0.05.

Results

All endoscopic surgeries were completed without changing to open procedures. The mean operation time was 107 min (range 88–160). There was no measurable blood loss. There were no operation-related complications, persistent dysphasia or esophageal injury reported. All patients were followed up of a minimum of 5 years (5–8 years).

Clinical results

Excluding one patient revised by means of open ACDF because of adjacent segment disc herniation after 6 years postoperatively, the other patients suffered no recurrence of symptoms at the last follow-up. According to the improvement rate (IR) criteria [11] 38 patients (56.7%) reported excellent results, 20 (29.9%) reported good results, while 6 (9.0%) and 3 (4.4%) patients reported fair and poor results, respectively. There was significant improvement in all JOA, VAS neck, and VAS arm scores following surgery as illustrated in Table 1 ($p < 0.01$). There is a constant and significant ($p < 0.01$) improvement in arm pain and activities of daily living following surgery (Fig. 2).

Table 1 The mean values of clinical parameters measured before surgery, after surgery and at the last follow-up (mean ± SD)

Parameters	Preoperative	Postoperative	Last follow-up
VAS (neck)	7.3 ± 0.86	2.32 ± 0.75*	2.47 ± 0.93*
VAS (arm)	8.14 ± 0.78	2.18 ± 0.82*	1.94 ± 0.98*
JOA score	8.4 ± 2.3	14.1 ± 1.9*	13.6 ± 2.1*

* Comparing with the preoperative data, $p < 0.05$

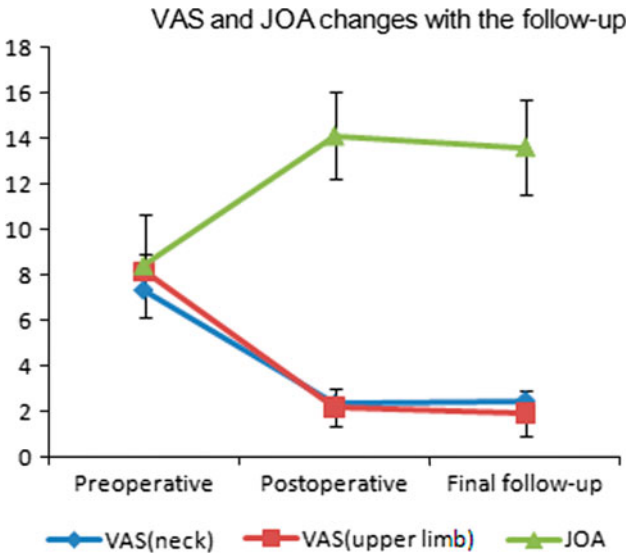

Fig. 2 The VAS neck, VAS upper limb and JOA changes during the follow-up

Radiographic findings

At 6 months postoperatively, bony fusion was achieved in 61 (91.1%) patients and at 1 year postoperatively, solid fusion was observed in all patients. No anterior or posterior migration of the CRFP cage was noted during the entire follow-up period. AIH of disc was significantly great than before surgery and the compression on spinal cord was disappeared on MRI image postoperatively. But, with increasing time, AIH slightly decreased when compared with that measured immediately after operation (Fig. 3). Subsidence of CRFP cage was observed in four (6.0%) patients. The sagittal alignment of the cervical spine was evaluated with the LDA. Prior to surgery, 10 patients (14.9%) were lordotic (LDA >0°), 31 patients (46.3%) were straight (LDA >0°), and 26 patients (38.8%) were kyphotic (LDA <0°). Immediately after surgery, lordosis was preserved in all patients. However, at the final follow-up, 42 patients (62.7%) were lordotic, 19 patients (28.4%) were neutral, and 6 patients (8.9%) had mean kyphotic alignment (Table 2).

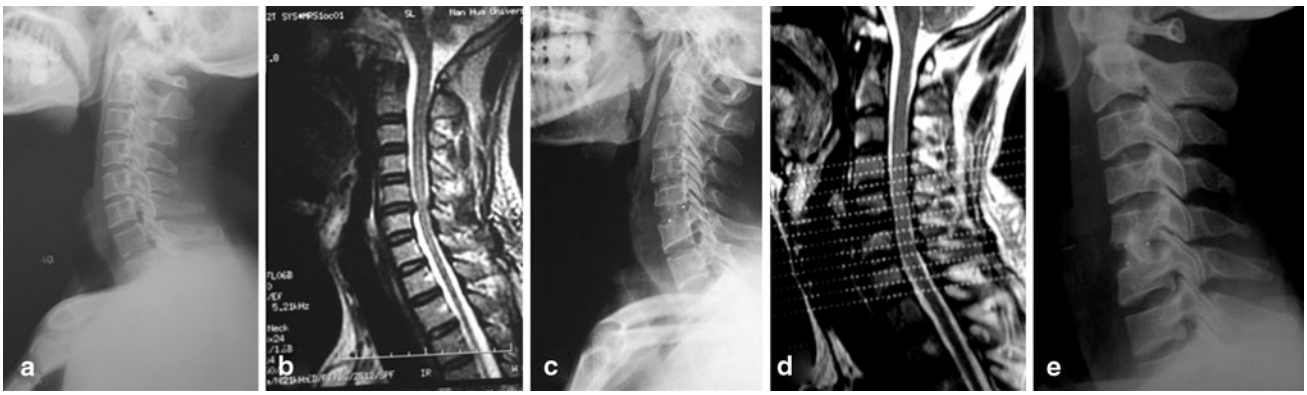

Fig. 3 Radiographic data obtained from a patient who underwent endoscopical ACDF. **a** Preoperative lateral plain X-ray image shows the narrow intervertebral space at C5–C6 level. **b** MRI image shows C5–C6 disc herniation. **c** Lateral X-ray image shows the excellent position of CFRP cage and increasing the intervertebral space postoperatively. **d** MRI shows good decompression on spinal cord postoperatively. **e** X-ray image shows satisfactory bone fusion but the cervical lordosis disappeared at the last follow-up (7 years after surgery)

Table 2 The mean values of radiological parameters measured before surgery, immediately after surgery, and at the last follow-up

Parameters	Preoperative	Postoperative	Last Follow-Up
AIH (mm)	7.16 ± 1.05	9.01 ± 1.1*	8.03 ± 1.23
LDA (degree)	1.21 ± 0.24	10.4 ± 1.2*	5.61 ± 2.01*,▲

* Comparing with the preoperative data, $p < 0.05$

▲ Comparing with the immediately postoperative data, $p < 0.05$

Discussion

Anterior cervical discectomy and interbody fusion has been supported in the literature as an effective treatment of cervical disc degenerative disorders, with advantages of this procedure including direct decompression of spinal cord and nerve roots, immediate stability of involved segments, restoration of cervical lordosis and intervertebral height [2, 9]. The tricortical iliac autograft has often been used as bone graft in interbody fusion after anterior intervertebral decompression with high fusion rates, but it has often been reported to have donor site complications [5, 19]. The use of stand-alone cages for ACDF has been increasing in popularity recently, as these cages may attain fusion rates comparable to tricortical iliac crest grafts in single level disorder without the associated morbidity of bone graft harvest [4, 14, 16].

Anterior cervical discectomy and interbody fusion has had very favorable outcomes in the treatment of single and multilevel cervical spondylosis. However, complications such as dysphasia, hematoma, recurrent laryngeal nerve palsy and esophageal perforation have been documented in the literature [15]. Over the past decade, minimally invasive treatment of spinal disorders has become popular with the application of endoscopic technologies, such as thoracoendoscopy and lumbar microendoscopic discectomy (MED). These approaches to spinal problems preserve healthy tissues, shorten hospital stays, cause less postoperative pain consequently enabling faster patient recovery [3, 12, 22]. This technology and its clinical success have led to similar minimally invasive approaches to the cervical spine.

Endoscopic ACDF may be considered a good alternative to the traditional open ACDF for treating cervical disc herniations and single level spondylosis. Authors have reported satisfactory clinical outcomes utilizing this minimally invasive percutaneous endoscopic technique with cervical discectomy [1]. One noted drawback to the utilization of this endoscopic technique is limited visibility, which can restrict the use of certain implants such as fusion cages and other fixation devices. In order to explore the feasibility of endoscopic ACDF, we used a 2 cm diameter port, which allowed inspection of relevant anatomy while also provided sufficient exposure for discectomy and insertion of a fusion cage. Besides, utilization of a 2 cm working channel allows passage of the surgical tools such as microforceps and drill, as well as the fusion devices. Secondly, the resolution and clearness of endoscopic vision is improved, we can explore the intradiscal and epidural anatomy in detail. In this study, All patients were undergone endoscopic ACDF successfully, and the patients got the satisfactory clinical and radiographical outcomes following endoscopic decompression and fusion with excellent or good subjective improvement in 86.6% of patients following surgery. Similar subjective improvement has been reported with ACDF following a traditional open surgical approach [12]. This suggests endoscopic cervical anterior discectomy and fusion is feasible and possible with an improvement of this already successful procedure. Theoretically speaking, utilization of endoscopic technique

for cervical surgery may have many potential advantages, which include rapid rehabilitation and less morbidity associate with this procedure. We acknowledged the limitations of this study, which include the lack of analyze of the laboratory findings, postoperative MRI data and a control group to assess these benefits. So we could not draw the benefits from the current study directly.

In this study, we only selected the patients with single level disc herniation, and the patient selection with a mean age of 50.3 years, no patient with severe spondylosis was included in our group. Because there is a steep learning curve for surgeons using the endoscopic technique, at the stage of exploring feasibility of this technique, we worry about the possibility of difficulties in distracting intervertebral space in severely degenerative patients. The seriously narrowed space for manipulation is restricted. On the other hand, although the patients look like a young population, which potentially could be candidates for cervical artificial disc replacement (ADR), they had not been performed ADR with the endoscopic technique. These considerations may explain this issue. The ADR was an emerging technique and not so popular at the beginning of this study. It needs standard and rigorous surgical procedure and should be performed by surgeons who have received special training even for open approach. Finally, no traction devices could be used in the endoscopic procedure.

A potential challenge with the use of minimal invasive technique is the control of intra-operative bleeding, which often occurs from the anterior vertebral arteriola, the surrounding venous plexus or from the dura mater of the posterior vertebral canal and surrounding cancellous bone. In this study, hemostasis was achieved utilizing the following methods; (1) lavaging the surgical field with cool saline of 4°C, or using 1,500,000 adrenalin saline if necessary; (2) saline soaked cotton-piece can be inserted into the wound for 3–5 min, with the help of suction when needed. This method is adoptable when cool saline does not work alone; (3) gelatin sponge with or without prothrombin can be put into the bleeding field. Lastly, when a hemorrhage is unmanageable, a conversion to an open surgery is required immediately.

In conclusion, endoscopic ACDF with a 2 cm port appears to be a safe and potentially advantageous augmentation to this already successful procedure. High-resolution working channel endoscope allows us to remove the herniated disc while minimize the trauma to surrounding soft tissues. This may reduce the associated morbidity of this procedure, improve patient satisfaction, and decrease overall costs of this surgical treatment. Randomized blinded control trials are need in order to compare endoscopic versus traditional ACDF to substantiate these claims.

Acknowledgments We thank the education department of Hunan province for providing the grant.

Conflict of interest None of the authors has any potential conflict of interest.

References

1. Ahn Y, Lee S, Shin S (2005) Percutaneous endoscopic cervical discectomy: clinical outcome and radiographic changes. Photomed Laser Surg 23:362–368
2. Baba H, Furusawa N, Tanaka Y, Wada M, Imura S, Tomita K (1994) Anterior decompression and fusion for cervical myeloradiculopathy secondary to ossification of the posterior ligament. Int Orthop 18:204–209
3. Bomback DA, Charles G, Widmann R, Boachie A (2007) Video-assisted thoracoscopic surgery compared with thoracotomy: early and late follow-up of radiographical and functional outcome. Spine J 7:399–405
4. Brooke NS, Rorke AW, King AT, Gullan RW (1997) Preliminary experience of carbon fiber cage prostheses for treatment of cervical spine disorders. Br J Neurosurg 11:221–227
5. Castro FP Jr, Holt RT, Majd M, Whitecloud TS (2000) A cost analysis of two anterior cervical fusion procedures. J Spinal Disord 13:511–514
6. Ditsworth DA (1998) Endoscopic transforaminal lumbar discectomy and reconfiguration: a postero-lateral approach into the spinal canal. Surg Neurol 49:588–598
7. Dowd GC, Wirth FP (1999) Anterior cervical discectomy is fusion necessary? J Neurosurg 90(Suppl 1):8–12
8. Fontanella A (1999) Endoscopic microsurgery in herniated cervical discs. Neurol Res 21:31–38
9. Fraser JF, Hartl R (2007) Anterior approaches to fusion of the cervical spine: a metaanalysis of fusion rates. J Neurosurg Spine 6:298–303
10. Ghogawala Z, Coumans JV, Benzel EC, Stabile LM, Barker FG (2007) Ventral versus dorsal decompression for cervical spondylotic myelopathy: surgeons' assessment of eligibility for randomization in a proposed randomized controlled trial: results of a survey of the Cervical Spine Research Society. Spine 32:429–436
11. Goto S, Mochizuki M, Watanabe T, Hiramatu K, Tanno T, Kitahara H et al (1993) Long-term follow-up study of anterior surgery for cervical spondylotic myelopathy with special reference to magnetic imaging findings in 52 cases. Clin Orthop 291:142–153
12. Kambin P, Schaffer J (1998) Percutaneous Lumbar discectomy. Review of 100 patients and current practice. Clin Orthop 238:24–34
13. Lew SM, Mehalic TF, Fagone KL (2001) Transforaminal percutaneous endoscopic discectomy in the treatment of far-lateral and foraminal lumbar disc herniations. J Neurosurg 94:216–220
14. Majd ME, Vadhva M, Holt RT (1999) Anterior cervical reconstruction using titanium cages with anterior plating. Spine 24:1604–1610
15. Ono K, Ebara S, Fuji T, Yonenobu K, Fujiwara K, Yamashita K (1987) Myelopathy hand. New clinical signs of cervical cord damage. J Bone Joint Surg Br 69:215–219
16. Park HW, Lee JK, Moon SJ (2009) The efficacy of the synthetic interbody cage and grafton for anterior cervical fusion. Spine 34:E591–E595
17. Raj DR, Krishnaj G, Kenny S (2006) Operative treatment of cervical spondylotic myelopathy. J Bone Joint Surg Am 88:1619–1640

18. Rao RD, Gourab K, David KS (2006) Operative treatment of cervical spondylotic myelopathy. J Bone Surg Am 88:1619–1640
19. Savolainen S, Rinne J, Hernesniemi J (1998) A prospective randomized study of anterior single-level cervical disc operations with long-term follow-up: surgical fusion is unnecessary. Neurosurgery 43:51–55
20. Silber JS, Anderson DG, Daffner SD, Brislin BT, Leland JM, Hilibrand AS et al (2003) Donor site morbidity after anterior iliac crest bone harvest for single-level anterior cervical discectomy and fusion. Spine 28:134–139
21. Suri A, Chabbra RP, Mehta VS, Gaikwad S, Pandey RM (2003) Effect of intramedullary signal changes on the surgical outcome of patients with cervical spondylotic myelopathy. Spine J 3:33–45
22. Yeung AT, Tsou PM (2002) Posterolateral endoscopic excision for lumbar disc herniation. surgical technique, outcome, and complications in 307 consecutive cases. Spine 27:722–731