



Hybrid decompression technique and two-level corpectomy are effective treatments for three-level cervical spondylotic myelopathy

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Abstract: The optimal surgical strategy for multilevel cervical spondylotic myelopathy (CSM) has not been defined, and few comparative researches between hybrid decompression and multilevel corpectomy have been conducted. Here, we reported 28 patients of three-level CSM, of whom 12 underwent hybrid decompression and 16 two-level corpectomy, with each type of procedure chosen according to radiologic characteristics of those patients. Clinical and radiologic parameters of both groups showed various degrees of improvement. However, no statistically significant differences in Japanese Orthopedic Association (JOA) score improvement rate, graft fusion rate, post-operative neck disability index (NDI) or segmental lordosis between the two groups were found. We conclude that both hybrid decompression and two-level corpectomy could obtain satisfying clinical efficacy in the management of three-level CSM for appropriate patients.

Key words: Three-level cervical spondylotic myelopathy (CSM), Hybrid decompression, Corpectomy

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INTRODUCTION

The optimal surgical approach for multilevel cervical spondylotic myelopathy (CSM) remains controversial, and anterior decompression and fusion operation is the most commonly used surgical option. If ventral compression of the cervical spinal cord and nerve roots results from the degenerated intervertebral disc that is located at or nearby the intervertebral space, multilevel discectomy and graft fusion with plate fixation will be an ideal strategy (Papadopoulos *et al.*, 2006; Hu *et al.*, 2009), while corpectomy may be considered for patients with a severely narrowed intervertebral space, and/or the ventral compression caused by retrovertebral disease. As for patients with three-level CSM unsuitable for consecutive three-level discectomy, a two-level corpectomy, or single-level corpectomy combined with discectomy of the adjacent level (hybrid decompression technique) may

be considered according to different radiologic characteristics. The purpose of this study was to summarize the efficacy of the two surgical procedures in the management of multilevel CSM according to clinical and radiologic parameters.

PATIENTS AND METHODS

Clinical data

From November, 2004 to September, 2008, a total of 28 three-level CSM patients underwent anterior cord decompression either by hybrid decompression technique or two-level corpectomy, as well as instrumentation-based fixation and graft fusion. There were 19 males and 9 females aged from 45–66 years (mean age 53.5 years) at surgery. The radiologic diagnoses were established in each case via routine pre-operative cervical antero-posterior, lateral, bilateral oblique and flexion-extension X-ray radiographs along with cervical magnetic resonance imaging

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(MRI) and computed tomography (CT). Twelve patients were managed with hybrid decompression, of whom 7 had their lesions located in C3~C6 and 5 in C4~C7. The remaining 16 patients, 10 of C3~C6 CSM and 6 of C4~C7, underwent the two-level corpectomy.

Surgical method

Under general anesthesia, all patients were managed with cervical anterior Smith-Robinson incision. In the hybrid decompression group (Fig.1), sequential discectomy was applied to the three degenerated discs, followed by the single-level corpectomy of the vertebra that has the most obviously narrowed intervertebral space and/or severe spinal cord ventral compression induced by retrovertebral disease existed. Intervertebral space decompression was performed on the superior or inferior adjacent level. For the complete decompression, all patients underwent routine posterior longitudinal ligament resection until

reaching the dura surface. The vertebra was reconstructed by implanting a titanium mesh cage packed with autologous local bone taken from the corpectomy site, followed by implantation of Solis cage (Stryker, USA) into its adjacent intervertebral space, and supplemented with titanium plate of appropriate length and curvature for fixation. Hybrid plates (Stryker, USA) were used in all patients of this group. In the two-level corpectomy group (Fig.2), sequential discectomy was applied to the three degenerated discs, followed by the two-level corpectomy and routine posterior longitudinal ligament resection until reaching the dura surface for a complete decompression. In this group, 2 patients were implanted with tricortical autologous iliac crest bone, and the remaining 14 patients implanted with a longer titanium mesh cage packed with autologous local bone taken from the corpectomy site. Titanium plates of appropriate length and curvature were also used for fixation, and 10 patients had Zephir plates (Medtronic, USA) and 6 had hybrid plates.

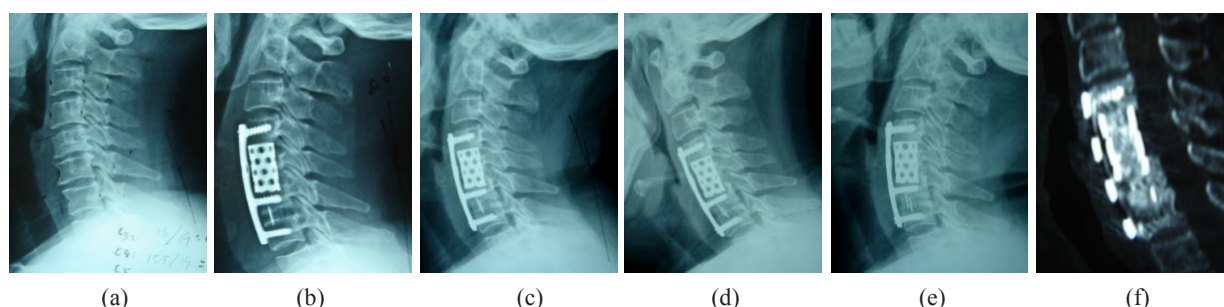


Fig.1 Hybrid decompression group. (a) X-ray lateral view of pre-operative three-level (C4~C7) CSM. Fused segmental lordosis: 2°; (b) X-ray lateral view 1 week post-operation. Fused segmental lordosis: 8°; (c) X-ray lateral view 6 months post-operation. Fused segmental lordosis: 8°; (d, e) Post-operative flexion-extension X-ray images showed that fused segments were stable; (f) Post-operative sagittal reconstruction of CT scanning showed bony fusion

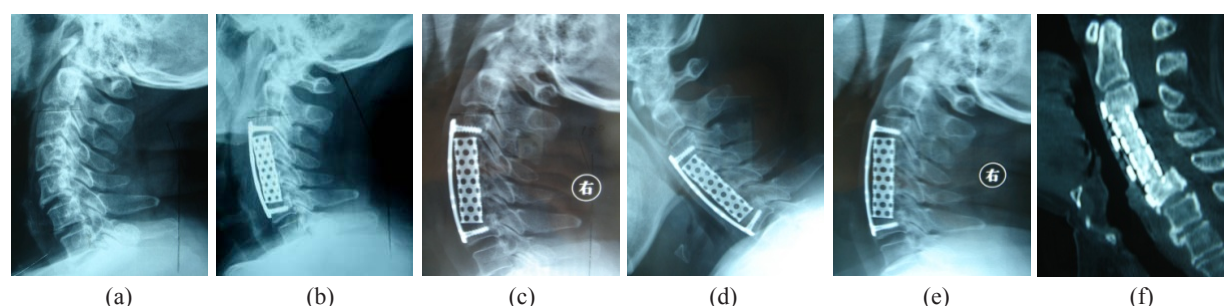


Fig.2 Two-level cervical corpectomy group. (a) X-ray lateral view of pre-operative three-level (C3~C6) CSM. Fused segmental lordosis: 20°; (b) X-ray lateral view 1 week post-operation. Fused segmental lordosis: 20°; (c) X-ray lateral view 6 months post-operation. Fused segmental lordosis: 18°; (d, e) Post-operative flexion-extension X-ray images showed that fused segments were stable; (f) Post-operative sagittal reconstruction of CT scanning showed bony fusion

Clinical and radiological analyses

Cervical brace support was prescribed for 8~12 months for all patients prior to surgeries. Patients received antero-posterior and lateral X-ray radiographies 1 week post-operation. Cervical antero-posterior, lateral, flexion-extension X-rays and cervical CT scanning with sagittal reconstruction were performed 3, 6, and 12 months post-operation for the purpose of assessing graft fusion and calculating fusion rate. Radiographic bony fusion indications included the absence of motion between the spinal processes on flexion-extension radiographs, the absence of lucent lines between the graft and the endplate, and the presence of bridging bony trabeculae at the graft-endplate junction (Papadopoulos *et al.*, 2006). Pre-operative and 6-month post-operative neurological function was evaluated with Japanese Orthopaedic Association (JOA) score and JOA score improvement rate. The latter was calculated as follows: JOA score improvement rate (%) = $[(JOAS_{\text{post}} - JOAS_{\text{pre}}) / (17 - JOAS_{\text{pre}})] \times 100\%$, where $JOAS_{\text{post}}$ is post-operative JOA score, and $JOAS_{\text{pre}}$ is pre-operative JOA score. Using neck disability index (NDI), pre-operative and 6-month post-operative neck-shoulder symptoms were also evaluated. In addition, the pre-operative and the last follow-up post-operative fusion segmental lordosis was measured with the Cobb method. Adjacent segmental degeneration was investigated at the last follow-up, including intervertebral space height adjacent to the fusion segments, vertebra translation, as well as intervertebral angular motion changes. In this study, junctional disease was defined as new signs of cervical spondylosis at a level adjacent to the fusion site with symptomatic radiculopathy, myelopathy, or axial neck pain (Papadopoulos *et al.*, 2006).

Statistical analysis

All analyses were performed with SPSS 11.5 software for Windows (SPSS Inc., Chicago, Illinois, USA). Mean value independent samples *t*-test was used to compare clinical and radiologic parameters for the pre- and post-operative JOA scores, JOA score improvement rate, pre- and post-operative NDI, pre-operative and the last follow-up post-operative segmental lordosis, between the hybrid decompression group and the two-level corpectomy group. Graft fusion rate was also compared between these two groups by using χ^2 test. Besides, pre- vs post-operative JOA scores, NDI and segmental lordosis were also compared within each group by using paired samples *t*-test. $P < 0.05$ was considered statistically significant.

RESULTS

Patients were followed up for 6~36 months post-operatively, with an average of 17.3 months, all patients showed various degrees of symptom relief. As shown in Table 1, the mean pre- and post-operative JOA scores and JOA score improvement rate were 11.167 ± 0.807 , 14.333 ± 0.536 , and $(55.833 \pm 3.961)\%$, respectively, in the hybrid decompression group and were 10.875 ± 0.646 , 14.344 ± 0.651 , and $(56.831 \pm 8.850)\%$, respectively, in the two-level corpectomy group. The mean pre-operative and 6-month post-operative NDI were 34.250 ± 2.832 and 14.917 ± 2.778 , respectively, in the hybrid decompression group, and were 34.625 ± 3.364 and 17.188 ± 3.038 , respectively, in the two-level corpectomy group. The graft fusion rates of the hybrid decompression group and the two-level

Table 1 Clinical and radiologic parameter comparisons between the hybrid decompression (HD) group and two-level corpectomy (TLC) group

Group	JOA score		NDI		Segmental lordosis (°)		JOA score improvement rate (%)	Graft fusion rate (%)
	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op		
HD (n=12)	11.167±0.807	14.333±0.536	34.250±2.832	14.917±2.778	3.750±9.450	10.667±3.676	55.833±3.961	100
TLC (n=16)	10.875±0.646	14.344±0.651	34.625±3.364	17.188±3.038	5.063±11.980	13.000±4.351	56.831±8.850	94
<i>P</i>	0.297	0.964	0.758	0.053	0.757	0.146	0.720	0.378

Pre-op: pre-operative; Post-op: post-operative. JOA score, NDI, and segmental lordosis (mean±standard deviation) were significantly different pre-operatively to post-operatively within each group ($P < 0.05$). Significance was assessed using paired samples *t*-test

corpectomy group were 100% and 94%, respectively. The mean pre-operative and the last follow-up segmental lordosis was $3.750^{\circ} \pm 9.450^{\circ}$ and $10.667^{\circ} \pm 3.676^{\circ}$ in the hybrid decompression group, respectively, and $5.063^{\circ} \pm 11.980^{\circ}$ and $13.000^{\circ} \pm 4.351^{\circ}$ in the two-level corpectomy group, respectively. The differences of all the above clinical and radiologic parameters were not statistically significant between these two groups, while the differences between pre- and post-operative JOA scores, NDI and segmental lordosis within each group were all statistically significant.

In addition, one patient undergoing the two-level corpectomy experienced unilateral deltoid weakness post-operatively, with a complete recovery after 3 weeks. No adjacent segmental disease, neither neurological nor the implant-related severe complications, was observed post-operatively in this patient.

DISCUSSION

Surgical selection of anterior approaches for three-level CSM

The longstanding, most commonly used anterior approaches for three-level CSM are three-level discectomy and two-level corpectomy plus graft fusion with plate fixation. When the ventral compression of the cervical spinal cord and nerve roots is caused by intervertebral disc degeneration located at or near the intervertebral space, the three-level discectomy is chosen, whereas if severe narrowing of the intervertebral space and/or retrovertebral disease induced ventral compression exists, the two-level corpectomy is applied.

In clinical practice, we found that the conditions of some of our patients were between these two circumstances, namely, the compression of cranial or caudal level was capable of being removed with discectomy, but the other two levels could not be decompressed just through the intervertebral space. According to previous experiences, those who were unsuitable for three-level discectomy were treated with two-level corpectomy.

From the traditional point of view, there were some weaknesses in multilevel corpectomy. Vaccaro *et al.* (1998) reported a 9% failure rate of the early

two-level corpectomy plus graft fusion with plate fixation. Macdonald *et al.* (1997) suggested that the more levels decompressed in multilevel corpectomy, the higher the risk of post-operation complications, thus recommending that additional posterior procedure or halo immobilization should be applied when more than two-level corpectomy was involved, or just use posterior expansive laminoplasty instead of anterior decompression. Oh *et al.* (2009) reported a longer operation time and a larger bleeding amount in the single-level corpectomy as opposed to two-level discectomy.

Singh *et al.* (2004) performed some mechanical testing in vitro and discovered that hybrid technique, a procedure involving the combination of corpectomy and discectomy, in which a vertebra is preserved intact within the area of decompression, is more favorable of intensifying cervical stability and enabling reconstruction of the sagittal alignment than two-level corpectomy. Ashkenazi *et al.* (2005) first published their clinical reports of applying anterior hybrid decompression technique in multilevel CSM patients. In this technique, the titanium mesh cage used for vertebral column reconstruction was shortened, reducing the rotational movements imposed on the implant-vertebra interface, which further augmented the post-operative cervical stability, and thus the author considered the hybrid decompression a safer and more effective technique in multilevel CSM management.

According to the radiologic characteristics of three-level CSM patients in this study, hybrid decompression was performed when cranial or caudal compression was capable of being removed through intervertebral disc levels, and two-level corpectomy was used if severe narrowing of the three intervertebral spaces existed and/or retrovertebral disease-induced ventral compression could not be eliminated just through these intervertebral spaces. The mean JOA score improvement rates of the hybrid decompression group and the two-level corpectomy group were $(55.833 \pm 3.961)\%$ and $(56.831 \pm 8.850)\%$, respectively, and the difference between the two groups was not statistically significant ($P=0.720$). This outcome was also in accordance with previous literatures (Ashkenazi *et al.*, 2005; Yuan *et al.*, 2006), indicating that appropriate decompression approaches had been chosen according to each patient's

characteristics, and thus all cases showed various degrees of symptom relief.

Graft fusion was evaluated by using post-operative sagittal reconstruction CT images, representing a more accurate and reasonable method as opposed to the previously used X-ray images (Epstein *et al.*, 2002; Epstein and Silvergleide, 2003; Narotam *et al.*, 2003; Li *et al.*, 2005; Chuang *et al.*, 2006). The current study shows a higher graft fusion rate in the hybrid decompression group (100%) than in the two-level corpectomy group (94%); however, this difference was not statistically significant ($P=0.378$). One possible explanation is that, although the hybrid technique was considered capable of providing a higher mechanical stability, it also involved a multiple graft-bone interface fusion issue. Besides, Zephir titanium plate internal fixation was applied in 10 out of the total 28 patients, and hybrid titanium plate in the remaining 18 patients. Both types of the plates belong to dynamic plates, which share load more effectively than the rigid plates, particularly when grafts were undersized (Brodke *et al.*, 2001; Reidy *et al.*, 2004). Pitzen *et al.* (2009) reported that dynamic plate designs provided less implant complications and a faster fusion of the cervical spine compared with rigid plate designs. In addition, none of the patients recruited in this study were obviously osteoporotic, which might be another reason for obtaining such similar efficacy in both groups. In the previous investigations, Hee *et al.* (2003) and Thalgot *et al.* (2003) suggested additional posterior stabilization in the management of elderly osteoporotic patients undergoing multi-level corpectomy. However, whether these senile patients could tolerate multiple operations should also be considered. Ashkenazi *et al.* (2005) performed anterior hybrid decompression on 13 patients aged over 65 years, observing no mechanical failure. Thus, reasonably using hybrid technique could obviate the need for staged circumferential procedures.

Cervical lordotic curvature

The fused segments were stable 6 months post-operation and the last follow-up in this study. The NDI in both the hybrid decompression group and the two-level corpectomy group showed various degrees of improvement. Furthermore, no implant-related severe complications, such as screw breakage,

loosening or detachment from the titanium plate, or graft or titanium mesh/cage dislodgement, were observed. This quite satisfying follow-up outcome was due likely to the close association with the restoring and maintaining of the cervical lordotic curvature of our patients after operation. An increase in the kyphotic curvature of the fused segments occurred in about one half of the patients undergoing anterior operation without internal fixation, and the more obvious the kyphosis, the larger the incidence of cervical axial syndromes. Generally speaking, fusion would be accomplished in 6~12 months after anterior intervertebral bone grafting, and the cervical lordotic curvature also formed during that period of time, with no further progression afterwards. Katsuura *et al.* (2001) observed adjacent segment degeneration in 77% kyphotic patients, with 38.1% showing symptom exacerbating. With a zero angle, both end surfaces of the titanium mesh cage used in the early phase of this study did not fit the contour of its adjacent vertebral endplates, and thus went against the restoring and maintaining of cervical lordosis. With a tilt angle, the Solis cage implanted as well as the subsequently used artificial vertebral endplates flanking it was beneficial not only for restoring and maintaining of cervical lordosis but also for decreasing the risk of titanium mesh cage subsidence. Better cervical lordotic curvatures were obtained post-operatively in both the hybrid decompression and two-level corpectomy groups, without any adjacent segmental diseases observed in follow-up periods. However, the adjacent segmental degeneration was associated with several factors, including the actual number and location of fused segments, as well as the life style of the patients, etc., and the segmental curvature played only a partial role in the process of adjacent segmental diseases.

C5 nerve root palsy

One patient undergoing the two-level corpectomy experienced unilateral deltoid weakness post-operatively, with a complete recovery after 3 weeks. Ashkenazi *et al.* (2005) reported transient deltoid weakness occurred several days after operation in 12% (3/25) of multilevel CSM patients undergoing anterior hybrid decompression, and these patients completely recovered within a few weeks. Sakaura *et al.* (2003) reported a 4.3% mean incidence of C5 nerve root palsy, without reliable evidence for

any of the proposed mechanisms; and most patients with this complication experienced neurological and functional recovery. He also noted that a higher incidence of C5 palsy was observed in patients who had undergone multilevel decompression.

CONCLUSION

There are some limitations in this study; for example, the investigation was retrospective and the size of the patient sample was small. In addition, a longer-term follow-up was still required.

In conclusion, both the hybrid decompression and the two-level corpectomy are effective in the management of multilevel CSM in proper patients.

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