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ORIGINAL ARTICLE

Two-level cervical corpectomy—long-term follow-up reveals the high rate of material failure in patients, who received an anterior approach only

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Abstract

In contrast to a one-level cervical corpectomy, a multilevel corpectomy without posterior fusion is accompanied by a high material failure rate. So far, the adequate surgical technique for patients, who receive a two-level corpectomy, remains to be elucidated. The aim of this study was to determine the long-term clinical outcome of patients with cervical myelopathy, who underwent a two-level corpectomy. Outcome parameters of 21 patients, who received a two-level cervical corpectomy, were retrospectively analyzed concerning reoperations and outcome scores (VAS, Neck Disability Index (NDI), Nurick scale, modified Japanese Orthopaedic Association score (mJOAS), Short Form 36-item Health Survey Questionnaire (SF-36)). The failure rate was determined using postoperative radiographs. The choice over the surgical procedures was exercised by every surgeon individually. Therefore, a distinction between two groups was possible: (1) anterior group (ANT group) with a two-level corpectomy and a cervical plate, (2) anterior/posterior group (A/P group) with two-level corpectomy, cervical plate, and additional posterior fusion. Both groups benefitted from surgery concerning pain, disability, and myelopathy. While all patients of the A/P group showed no postoperative instability, one third of the patients of the ANT group exhibited instability and clinical deterioration. Thus, a revision surgery with secondary posterior fusion was needed. Furthermore, the ANT group had worse myelopathy scores ($mJOAS_{ANT\ group} = 13.5 \pm 2.5$, $mJOAS_{A/P\ group} = 15.7 \pm 2.2$). Patients with myelopathy, who receive a two-level cervical corpectomy, benefitted from surgical decompression. However, patients with a sole anterior approach demonstrated a very high rate of instability (33%) and clinical deterioration in a long-term follow-up. Therefore, we recommend to routinely perform an additional posterior fusion after two-level cervical corpectomy.

Keywords Two-level cervical corpectomy · Cervical instability · Cervical myelopathy · Neck pain · Posterior fusion

Introduction

Cervical corpectomy is a safe, effective, reliable, and established approach to address anterior pathologies in patients with cervical myelopathy caused by degenerative, traumatic, neoplastic, or infectious diseases. Nevertheless, there are wide differences concerning the surgical techniques. While long-term data of patients with one-level corpectomy and additional cervical plate show very good results with a high fusion rate and acceptable perioperative complication rates [3], only very limited data exists concerning the long-term follow-up of patients with multilevel corpectomy. Indeed, the neurological outcome of patients, who received a multilevel corpectomy, is good, but the longer the anterior instrumentation, the higher the risk of material failure and clinical worsening. A few studies have suggested that a corpectomy of ≥3 levels mandates an additional dorsal instrumentation to avoid cage dislocation, which is very likely with a stand-alone cages or cages with only additional anterior plate. Concerning two-level corpectomy, it remains unknown which strategy should be recommended in terms of routine posterior instrumentation [3, 16, 21]. Thus, there is no scientific consensus concerning the operative techniques and postoperative complications show a very wide range in the current literature. The aim of our study was to

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investigate the long-term stability and the clinical course of patients, who received a two-level cervical corpectomy.

Materials and methods

Study design and ethics approval

The study was approved by the local ethics committee (reference number: EA2/093/13). Data analysis was performed in a retrospective manner. Due to the retrospective chart review, a patient consent was not required.

Clinical data acquisition

Between 2006 and 2013, we identified 21 patients with cervical myelopathy, who received a two-level cervical corpectomy in our department. Patients included in the study suffered from cervical myelopathy and neck pain as the leading symptoms caused by degeneration ($n = 13$), tumor ($n = 4$), and infection ($n = 4$). All 21 patients (11 females, 10 males, mean age 59 years [range 42–78 years] completed follow-up appointments in the outpatient department and their outcome scores were retrospectively analyzed.

Patients with severe deformities, who needed additional posterior decompression or posterior fusion for correction of the spinal alignment, were identified and excluded from our study.

Radiographic parameters

As a standard imaging procedure in our department, all patients received a preoperative computerized tomography (CT) scan, a flexion and extension lateral x-ray of the cervical spine, and a cervical magnetic resonance imaging (MRI) or a CT scan with a myelogram. Postoperatively, we used x-ray and CT scans to control for implant position. Patients with clinical deterioration or lacking postoperative improvement received an additional MRI scan.

Lateral cervical radiographs were used to determine the pre- and postoperative cervical lordosis (CL, angle was formed by the two vertical lines of the two tangential lines to the inferior endplate of C2 and C7 vertebral bodies) and the segmental lordosis (SL, angle between the lines drawn parallel to the cranial endplate of the cranial vertebra of the fused segment and the caudal endplate of the caudal vertebra of the fused segment).

Surgical therapy

Cervical two-level corpectomy

The anterior two-level cervical corpectomy and fusion (ACCF) was performed via a standard anterior cervical approach [14]. After corpectomy, an ADD vertebral body displacement cage (Ulrich medical®, Ulm, Germany) was used and a cervical plate was fixed in the adjacent vertebras (ABC/Quintex, Aesculap, Tuttlingen, Germany) (Fig. 1a).

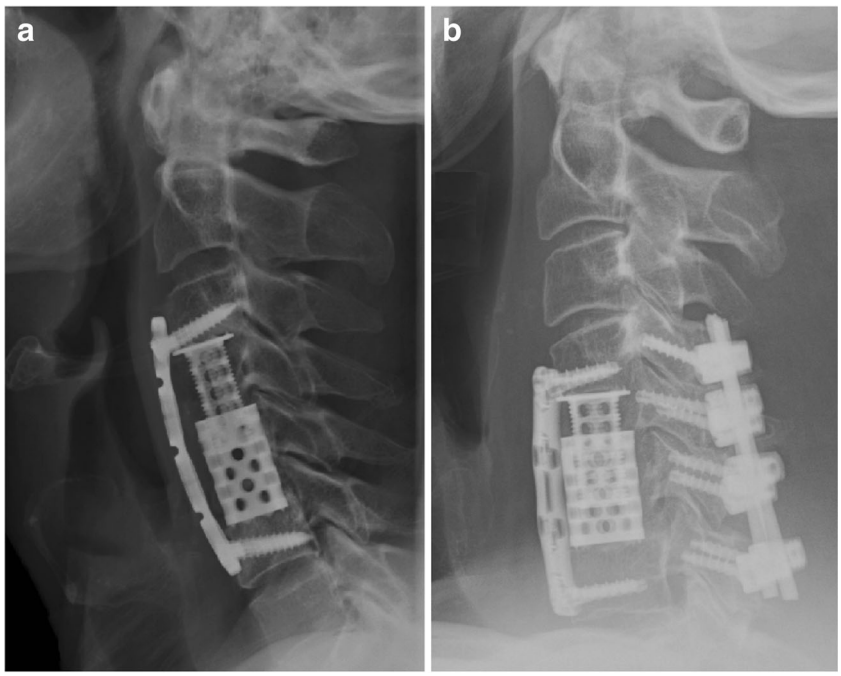

Fig. 1 Representative radiographs (postoperative lateral x-ray) of patients of the two groups, who underwent a two-level corpectomy. **a** In the anterior group (ANT group), patients received a two-level corpectomy with implantation of an anterior distraction device and cervical plating. **b** In the anterior/posterior group (A/P group), patients received a combined surgery with anterior two-level corpectomy, anterior plating, and additional posterior fusion with lateral mass screws or pedicle screws

Dorsal instrumentation

Dorsal instrumentation was performed via a dorsal midline approach. Lateral mass screws or pedicle screws were placed on the affected levels (S4 cervical, Aesculap, Tuttlingen, Germany) [8, 17] (Fig. 1b).

Clinical outcome parameters

All outcome data were collected from preoperatively and at the follow-up recorded scores from our outpatient department.

As clinical outcome parameters for neck pain, we analyzed the pre- and postoperative numerical pain rating scale (NPRS) for neck pain and the Neck Disability Index (NDI). To assess the degree of myelopathy with its neurological deficits, the Nurick grading and the modified Japanese Orthopaedic Association score (mJOAS) were analyzed [2, 13, 15].

Furthermore, the postoperative health-related quality of life (HRQOL), which had been assessed by the Short Form 36-item Health Survey Questionnaire (SF-36) [23], was analyzed as well as the patients satisfaction assessed by Odom's criteria.

Statistical analysis

Statistical analysis and graph design were performed with the help of GraphPad Prism 5 (San Diego, CA, USA). In dependence of the normal distribution analysis of variances, a Student's t test or the Mann–Whitney U test was performed in the group comparison. p values below 0.05 were considered as significant.

Results

We examined 21 patients with cervical myelopathy and following cervical two-level corpectomy with implantation of a cervical plate. All patients could be followed in our outpatient department with a mean follow-up of 37 and a minimum follow-up of 30 months. Twelve patients received only an anterior approach (Fig. 1a), whereas nine patients received an additional posterior instrumentation as a primary treatment (Fig. 1b). The two different techniques were a consequence of individual decisions of the surgeons. We could not determine a preference for a surgical technique dependent on the underlying pathology. Therefore, we assigned retrospectively 12 patients to the anterior group (ANT group) and 9 patients to the anterior/posterior group (A/P group). The two groups showed similar demographic parameters concerning age, gender, follow-up time, and the cause of cervical myelopathy. Further, there was no difference concerning non-hardware-related complications. The ANT group showed a slight predominance of the females, which was not statistically significant. In both groups, the mean follow-up time was very similar with about 37 months (range 24–87 months, Table 1).

Radiographical parameters

In both groups, surgery could achieve a significant sagittal correction partly with restoration of the cervical lordosis. There was no statistical difference in both groups concerning the kyphotic misalignment preoperatively and the degree of lordosis postoperatively of the segmental and the cervical lordosis (Table 2). After long-term follow-up in both groups, a loss of correction with increasing cervical kyphosis could be observed. A difference in both groups concerning loss of lordosis could not be illustrated (Table 2).

Baseline clinical parameters

There was no significant difference in preoperative clinical scores in both groups. Back pain scores with NPRS, NDI, and myelopathy scores with Nurick scale and mJOAS were very similar (Table 3).

Clinical outcome parameters

Postoperatively, both groups showed a significant reduction of neck pain after two-level cervical corpectomy ($\Delta NPRS_{ANT}$

Table 1 Patients data

	Anterior group	Anterior/posterior group	p (btw. groups)
Follow-up (months)	37 ± 34	37 ± 10	0.19
Age (years)	58 ± 12	60 ± 16	0.74
Gender	m = 5, f = 7	m = 5, f = 4	0.60
Underlying disease	7/3/2	6/1/2	0.78
CSM/tumor/infection			
Complications	1/4/2	0/3/1	0.81
Pneumonia/temporary hoarseness/temporary dysphagia			

Follow-up time, age, gender (f, female; m, male), and the underlying disease and non-hardware-related complications did not offer significant differences in both groups. Values are given as mean values ± standard deviation

Table 2 Radiological parameters

	Anterior group	Anterior/posterior group	*p* (btw. groups)
CL (°)	− 1.3 ± 7.0	− 1.2 ± 11.7	0.97
preoperative CL (°)	8.0 ± 15.4	8.2 ± 6.6	0.97
postoperative CL (°)	5.7 ± 9.7	3.0 ± 12.0	0.64
last follow-up Δ CL (°)	7.0 ± 4.2	4.2 ± 13.2	0.37
SL (°)	− 2.8 ± 8.0	− 2.5 ± 14.9	0.96
preoperative SL (°)	3.2 ± 10.8	8.8 ± 10.4	0.33
postoperative SL (°)	1.4 ± 5.5	4.3 ± 14.1	0.58
last follow-up Δ SL (°)	4.5 ± 5.4	6.6 ± 13.6	0.95

Cervical alignment: cervical lordosis (CL) and segmental lordosis (SL) before surgery (preoperative), immediately after surgery (postoperatively), and at the last follow-up (last follow-up) show a severe kyphosis in preoperative imaging that can be restored in part due to surgical realignment from anterior in both groups. After 2–4 years, minor kyphotic changes of the operated segments and a loss of lordosis can be observed in both groups. Values are given as mean values ± standard deviation

Table 3 Clinical parameters

	Anterior group	Anterior/posterior group	*p* (btw. groups)
VAS neck preop.	5.3 ± 2.4	4.6 ± 2.8	0.56
VAS neck follow-up	2.7 ± 2.2	2.1 ± 1.6	0.52
p (preop. vs. follow-up)	0.01	0.03	
Δ VAS neck	− 2.6 ± 2.3	− 2.5 ± 2.4	0.97
NDI neck preop. (%)	37.3 ± 14.8	36.9 ± 18.2	0.95
NDI follow-up (%)	24.7 ± 13.8	20.2 ± 11.8	0.45
p (preop. vs. follow-up)	0.04	0.03	
Δ NDI (%)	− 10.3 ± 17.2	− 15.8 ± 14.3	0.45
Nurick scale preop.	2.8 ± 1.4	2.9 ± 0.9	0.71
Nurick scale follow-up	2.1 ± 1.6	1.8 ± 1.1	0.64
p (preop. vs. follow-up)	0.22	0.04	
Δ Nurick scale	− 0.75 ± 1.055	− 1.1 ± 1.1	0.64
mJOAS preop.	13.2 ± 2.7	12.6 ± 3.6	0.66
mJOAS follow-up	13.5 ± 2.5	15.7 ± 2.2	0.05
p (preop. vs. follow-up)	0.75	0.04	
Δ mJOAS	− 0.4 ± 5.9	− 2.2 ± 3.0	0.21
Odom's criteria	Satisfied: 58%	Satisfied: 89%	
	excellent: 3	excellent: 4	
	good: 4	good: 4	
	fair: 3	fair: 1	
	poor: 2	poor: 0	
SF-36 PCS	35.0 ± 6.5	37.3 ± 8.6	0.55
SF-36 MCS	40.9 ± 9.5	46.4 ± 8.5	0.19

Neck pain scores: Both groups benefitted significantly concerning the postoperative numerical pain rating scale for neck pain (NPRS neck) and Neck Disability Index (NDI)

Myelopathy parameters: Only in the anterior group, a significant benefit of the myelopathy scores after surgery could be observed (Nurick scale, modified Japanese Orthopaedic Association score (mJOAS))

The clinical scores were measured before surgery (preop.) and at the last follow-up (follow-up) and their change after surgery was calculated (Δ…);

Odom's criteria ("good" and "excellent" are considered as satisfied patients) showed a higher patient satisfaction in the anterior/posterior group compared to the anterior group

Differences concerning the health-related quality of life after surgery could not be observed in both groups (Physical and Mental Component Score of short form 36 (SF-36 PCS, SF-36 MCS))

$_{group} = -2.6 \pm 2.3$, $\Delta NPRS_{A/P\ group} = -2.5 \pm 2.4$). In terms of disability in both groups, significant improved scores regarding NDI ($\Delta NDI_{ANT\ group} = -10.3 \pm 17.2$, $\Delta NDI_{A/P\ group} = -15.8 \pm 14.3$) were found. However, there were differences between the groups concerning cervical myelopathy scores. In the ANT group, the postoperative Nurick scale and mJOAS were not significantly better compared to preoperative values. In contrast, group 2 showed a significant better postoperative scale and mJOAS. The postoperative mJOAS was significantly better in the A/P group compared to the ANT group. All in all, the A/P group showed a better benefit in terms of cervical myelopathy scores.

Another important point for the clinical outcome is the number of reoperations. In the anterior group, 4 of 12 patients (33%) presented with clinical worsening and instability in control imaging. All of them needed a revision surgery. Two patients received revision surgery of the anterior instrumentation first, and all patients received a secondary posterior fusion. One patient appeared with a worsening of the neurological symptoms and severe neck pain. The x-ray showed a severe cage displacement with complete dislocation of the anterior plate (Fig. 2a). Two patients suffered from severe back pain after some weeks and showed a severe cage subsidence in x-ray and control CT (Fig. 2b). One patient had a worsening of his ataxia. Imaging demonstrated an instability, which leads to a spinal cord compression due to movement of the non-fused segments after 6 months of follow-up. By contrast, none of the nine patients (0%) in the A/P group presented with a postoperative instability and a subsequently reoperation. The patients Odom's criteria reflect this circumstance. The A/P group showed a satisfaction rate of 89% (Odom's criteria; excellent, 4; good, 4; fair, 1; poor, 0) whereas only 58% rate with good or excellent in the ANT group (Odom's criteria; excellent, 3; good, 4; fair, 3; poor, 2) (Table 3).

The postoperative health-related quality of life was determined using the SF-36 score, which consists of Physical Component Summary (PCS) and Mental Component Summary (MCS). There were no significant differences between both groups; the A/P group showed a slightly better MCS and PCS ($PCS_{ANT\ group} = 35.01 \pm 6.5$, $PCS_{A/P\ group} = 37.27 \pm 8.6$; $MCS_{ANT\ group} = 40.9 \pm 9.5$, $MCS_{A/P\ group} = 46.4 \pm 8.5$), which were statistically not significant.

Discussion

In the present study, we could illustrate the long-term clinical outcome of patients with cervical myelopathy, who received a two-level cervical corpectomy. Our data shows that a cervical two-level corpectomy for the treatment of cervical myelopathy has a good clinical outcome. Both groups benefitted in terms of pain and disability. However, we found a remarkable difference between patients, who received only an anterior approach with a two-level corpectomy and a cervical plate without dorsal instrumentation compared to patients, who primarily received a 360° instrumentation. There was a high material failure rate of 33% in the ANT group. Reoperations were necessary because of instability, partly with cage dislocation with consecutive clinical worsening concerning neck pain and neurologic symptoms. In contrast, the failure rate was 0% in the anterior/posterior group. Patients with an additional posterior instrumentation, which leads to a significantly increased stability, showed no postoperative instability or material dislocation. As a result, there was a higher satisfaction

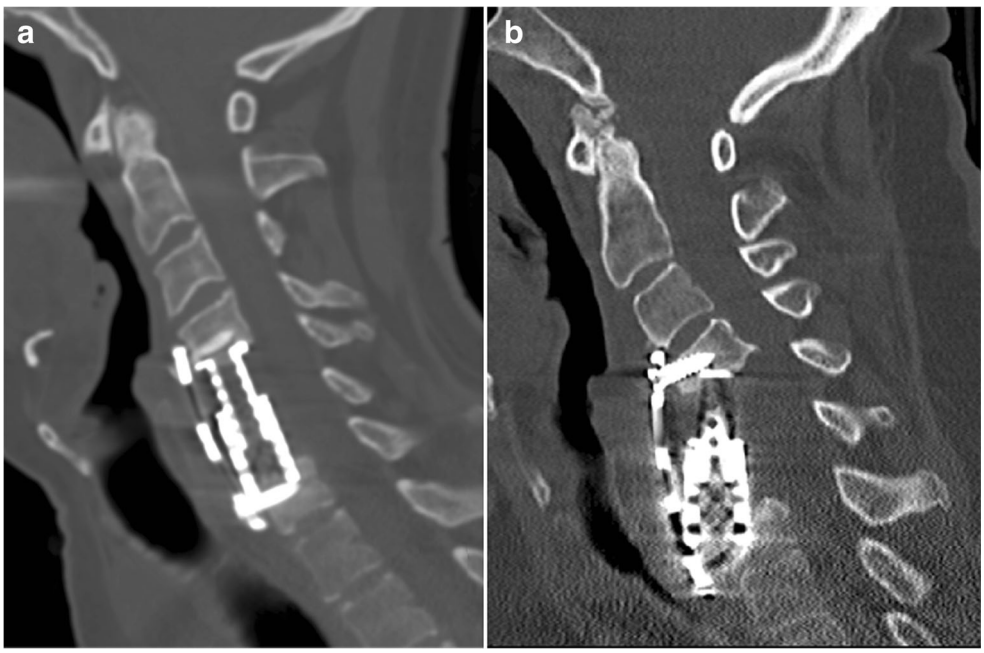

Fig. 2 Representative radiographs (follow-up CT scans) of patients, who suffered from dislocation of the anterior device within the first year after two-level corpectomy. **a** Severe cage subsidence 9 months after anterior surgery resulting in radicular pain and cervical back pain and requiring revision surgery with additional posterior fusion. **b** Severe cage dislocation with fracture of the adjacent vertebral bodies 6 months after two-level corpectomy resulting in strong neck pain and neurological deterioration. A revision surgery with four-level corpectomy and additional posterior fusion was needed

rate and a better outcome concerning the myelopathy in the A/P group when compared with the ANT group.

Our study might be limited by its retrospective design and by a low number of patients caused by a low incidence of pathologies, which make a two-level corpectomy necessary. Additionally, our findings may not apply to patients with severe deformities of the cervical spine, as these were excluded from our study. In most of these cases, a dorsal reconstruction might be necessary anyways [20]. Further, the pooling of infectious disease, tumor disease, and cervical spondylotic myelopathy might influence the outcome of our study. Tumor disease and infectious disease could be associated to a higher material failure rate as there are studies focusing on degenerative disease only, in which the material failure rate is lower [10, 16]. However, the material failures of the ANT group in our study are not associated to infection or tumor pathologies, but rather three of four patients with material failure belong to the subgroup with cervical spondylotic myelopathy. Furthermore, other studies confirmed high material failure rates after two-level corpectomy only [3]. Thus, the fact that tumor and infectious disease are included should not influence the result and should not increase the material failure rate of our study. The decision for the surgical technique and whether a dorsal instrumentation is needed was conducted by the individual surgeon. We could not determine a pathology influencing the surgical decision as there was a similar distribution of underlying disease in both groups (Table 1). Furthermore, severe deformities were excluded from our study anyways. The possibility to perform a posterior fusion only without corpectomy was not investigated in our paper. An isolated posterior approach leads to a lower complication rate compared to the multilevel anterior approach [24]. However, the aim of our study was to investigate outcome and risk factors of patients, who received a two-level corpectomy.

The mJOAS and the Nurick scale were established in the first place for patients with cervical spondylotic myelopathy. Nevertheless, several authors used them to demonstrate the neurological condition of patients with myelopathy caused by tumor or instability due to an infectious disease as well. The myelopathies of all patients in our study were caused by a mechanical compression of the spinal cord. Therefore, these scores should be suitable for our patient cohort [4, 12, 25, 26].

In general, a cervical corpectomy is an effective therapy for patients with cervical myelopathy if the pathology is mainly compressing the spinal cord from anterior. A proper decompression can be achieved in most of the cases. The most frequently used procedure is a single anterior cervical corpectomy with cage implantation and an additional cervical plate [1, 5, 6]. It is well understood that the one-level corpectomy with an anterior cervical plate goes along with a high fusion rate [3]. However, several studies revealed a high risk of early implant failures and instability after multilevel (≥ 3 levels) cervical corpectomy [3, 11, 16, 21, 22] due to long lever arms that put stress on caudal screws leading to graft migration and displacement [6]. As a consequence, patients develop clinical worsening and a reoperation is required, which carries an additional risk. Thus, an additional posterior fusion for ≥ 3-level cervical corpectomy is highly recommended. The indication of posterior fusion for patients with two-level corpectomy is still controversial and the data concerning this surgery is low [3, 9, 16].

High complication rates in patients after multilevel corpectomy approaches suggest that a two-level corpectomy with anterior plating might lead to a certain amount of material failure as well with a two-digit percentage. On the other hand, it is important to keep in mind that an additional posterior instrumentation goes along with a higher rate of perioperative complications like neurological deficits and high blood loss, which can lead to a higher morbidity [20]. Therefore, some authors suggest that a solid fusion and good benefits can be achieved with an anterior plate for ≤ 2 levels and for ≥ 3 levels with additional posterior instrumentation [19]. Concerning a two-level corpectomy, the right choice of the surgical procedure is considered controversial. Biomechanical comparative studies showed a significant advantage of 360° instrumentation concerning the implant stability, if a two-level corpectomy with a cervical plate has to be performed [7, 9, 18]. However, these studies are not easily applicable to the clinical setting and are not able to show a realistic probability of material failures. Several authors published a high variety of complication rates with a range of postoperative material failures between 6 and 67% [3, 16, 21].

Vaccaro et al. showed an early failure rate of 9% in 33 patients with a two-level cervical corpectomy and an early failure rate of 50% in 12 patients, who received a three-level corpectomy. However, in this study, the follow-up time was with 3 months very short. Additionally, patients received a halo/collar for several weeks, which influences the early failure rate most likely [21]. Sasso et al. showed a lower rate of material failures with a 6% failure rate in 33 patients after two-level cervical corpectomy and a 71% failure rate in 7 patients, who received a three-level cervical corpectomy [16].

Against this, Daubs et al. reported significantly worse results considering the two-level corpectomy with a failure rate of 67% [3]. The dramatically different results of these studies show the importance for further investigations. Our results concerning the sole anterior approach with a 33% failure rate are in the mid-range of these past studies. In contrast, the results of the A/P group were impressively positive. Not even one patient received a reoperation due to instability and material failure. Also, in terms of myelopathy, these patients showed a significant better clinical outcome considering the mJOAS.

To avoid material failures and revision surgeries, an optimization of the surgical technique is essential. For two-level corpectomy, a preservation of the endplates is of great

importance. The diameter of the cage should be selected as big as possible to distribute the weight on the entire surface of the vertebral endplate. Expandable cages enable a better fixation of the cage and a better reconstruction of the cervical alignment. However, the distraction has to be performed carefully to avoid cage subsidence in patients with low bone density. To optimize posterior fusion, the facet joints should be decorticated before placing lateral mass screws or pedicle screws. The posterior rod should be fixed without traction to avoid screw loosening. Demineralized bone matrix or autologous spongiosa can be used to promote bony fusion.

This study provides long-term follow-up data for patients with cervical myelopathy after two-level cervical corpectomy. It directly compares a sole two-level corpectomy plus a cervical plate with a two-level corpectomy plus cervical plate and an additional posterior instrumentation. The data clearly demonstrates the advantage of the 360° approach. A two-level corpectomy with cervical plate should be followed by an additional posterior fusion to avoid material failure and clinical deterioration of the patients.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval The study was approved by the local ethics committee (reference number: EA2/093/13). Data analysis was performed in a retrospective manner.

Informed consent Due to the retrospective chart review, a patient consent was not required.

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