Acta Neurochir (2016) 158:1859–1867
DOI 10.1007/s00701-016-2908-z

CLINICAL ARTICLE - SPINE

Cervical corpectomies: results of a survey and review of the literature on diagnosis, indications, and surgical technique

Sebastian Hartmann[1] · Anja Tschugg[1] · Jochen Obernauer[1] · Sabrina Neururer[2] · Ondra Petr[1] · Claudius Thomé[1]

Received: 28 March 2016 / Accepted: 27 July 2016 / Published online: 25 August 2016

Abstract
Objectives Cervical corpectomy is an uncommon procedure and there are only limited data on the procedure's indications, surgical approaches, and complications. The diagnosis, indications, surgical planning, and complications of cervical corpectomy were therefore surveyed to clarify the treatment strategies used by spinal surgeons in central Europe, with special attention to preoperative planning and decision-making for additional dorsal approaches in multilevel cases.
Materials and methods An online survey with 18 questions on the preoperative, intraoperative, and postoperative management of cervical corpectomies was conducted. The relevant specialist societies in Germany and Austria provided 1137 contacts for surgeons, and the responses were compared with recent literature reports.
Results In all, 302 surgeons (27 %) completed the survey, with wide variability in the treatment options offered. Most (51 %) perform fewer than five anterior cervical corpectomy and fusion (ACCF) procedures per year; 35 % do 5–20 per year. Anterior cervical discectomy and fusion (ACDF) was preferred by 41 % of the participants to laminoplasty/laminectomy (19 %/16 %) and ACCF (12 %). Most indications for ACCF involved degenerative (27 %), traumatic (17 %), and neoplastic (20 %) conditions. Intraoperative and postoperative complications were mainly associated with hardware failure. One-third of the surgeons tend to use an additional dorsal approach to increase the corpectomy construct's stability for either two-level or three-level corpectomies.
Conclusions There is no current consensus in central Europe on the treatment of complex cervical disease and cervical corpectomy. The procedure is still rare, and the need for additional dorsal fixation is unclear. Further studies are needed in order to establish evidence-based standards for patient care.

Keywords Cervical corpectomy · Survey · Circumferential instrumentation · Implant-related complication · Second dorsal approach

✉ Sebastian Hartmann
sebastian.hartmann@i-med.ac.at

[1] Department of Neurosurgery, Medical University of Innsbruck, Anichstrasse 35, 6020 Innsbruck, Austria

[2] Department of Medical Statistics, Informatics and Health Economics, Medical University of Innsbruck, Innsbruck, Austria

Introduction

Degenerative, traumatic, or metastatic disease in the cervical spine can compress the spinal canal, with consecutive spinal cord injury that may become as severe as tetraplegia. Anterior cervical corpectomy with fusion (ACCF) is an option for preventing or relieving neurological deficits. Although these are established procedures in spine surgery, they are associated with a high rate of complications, mainly as a result of hardware failure due to the construct's long lever arm [11, 37]. These hardware failures themselves often entail massive neurologic deficits and even death. Biomechanically, these failures could be reduced by carrying out supplemental dorsal instrumentation after multilevel corpectomy, as this significantly reduces load failure in the anterior portion of the cervical spine [17, 24, 40, 49]. This additional surgery, however, is associated with significant complications, and a second operation therefore needs to be well indicated and scheduled early [5, 23].

Currently, there is a lack of sufficient data on treatment strategy, preoperative planning, intraoperative decision-

making, and postoperative follow-up standards. A questionnaire survey was therefore carried out to assess the treatment strategies and approaches used in spine centers in Germany, Austria, and Switzerland. The online survey was not intended to identify a clear treatment path, but rather to clarify variations in the practice of corpectomy procedures. Special attention was given to preoperative planning and decision-making for additive dorsal approaches in multilevel cases. In addition, a review of the literature was carried out to compare all of the questions and responses given in the survey with the currently available literature data.

Materials and methods

An online survey consisting of 18 questions on the preoperative, intraoperative, and postoperative management of cervical corpectomy patients was carried out. All contacts with surgeons were provided by the German Spine Society (DWG), German Society for Neurosurgery (DGNC), Austrian Spine Society (ASS), and Austrian Society for Neurosurgery (OEGNC). Thus, both neurosurgeons and orthopedic/trauma surgeons were included in the analysis. Due to data protection guidelines, data on the discipline and the respondents' training status are not available.

Issues in preoperative management were addressed using questions about the pathology indicating corpectomies, the number of patients treated per year, and preoperative imaging with or without densitometry (quantitative computed tomography). Queries were also included about the risk factors that made circumferential approaches necessary and the number of resected levels at which dorsal support appeared to be appropriate.

The intraoperative situation was inquired into using questions about skip corpectomies (ACCF combined with discectomy and fusion), the use of anterior grafts or type of dorsal instrumentations, and the time at which dorsal support was performed if it had been preoperatively planned. In addition, the participants were asked to explain the most important factors for ensuring anterior stability (bicortical screw placement or bone mass density, etc.).

Questions on the postoperative course evaluated complications during the hospital stay, standard postoperative care with or without collars, the postoperative visit plan and the standard follow-up imaging technique. The respondents' answers were represented in relative and absolute numbers as a function of total replies.

For statistical analysis, an expert group and a non-expert group were defined relative to the numbers of procedures performed per year (<5 per year at 50.7 % vs. > 5 per year at 39.0 %), to evaluate whether there were any differences in treatment strategy relative to the extent of the surgeons' experience.

In addition, the centers were divided into two groups: those at which a circumferential approach is used after a two-level ACCF and those at which circumferential instrumentation is considered to be indicated only after a three-level ACCF.

Binomial proportions were analyzed using the Chi-square test and Fisher's test. The level of significance was set at $p < 0.05$. Bonferroni correction for multiple testing was used.

Results

A total of 302 surgeons (27 %) out of 1137 contacts responded. The surgeons' subspecialties (neurosurgery, orthopedic surgery, and trauma surgery) and their country of origin were not analyzed.

Preoperative management

The majority of surgeons (41.1 %) preferred anterior cervical discectomy and fusion (ACDF) to laminoplasty or laminectomy (18.6 and 16.1 %, respectively). ACCF procedures and combined ventrodorsal approaches were the fourth most often used to treat long-segment pathologies (both 12.1 %) (Table 1a). Half of the participants (50.7 %) carried out fewer than five ACCF procedures per year (Table 1b) and most of these were performed for degenerative changes in the cervical spine (Table 1c).

The preoperative imaging methods used before ACCF consisted mainly of magnetic resonance imaging (MRI; 33.8 %) and radiography (30.7 %), supplemented with computed tomography (CT; 29.2 %) without densitometry (Table 1d). CT with densitometry (quantitative CT) was used in the preoperative setting in 2.5 % of cases, whereas only 6.0 % of the centers carried out densitometry as part of standard preoperative planning (Table 1e). Additional dorsal instrumentation to maintain stability was chosen by 33.3 % of the specialists for patients with both two-level and three-level ACCF, followed by kyphotic malalignment (19.4 %) and patients with osteoporosis (11.8 %) (Table 1f). The most important risk factors for implant failures and for indications of additional dorsal instrumentation were osteoporosis (25.4 %) and ankylosing spondylitis (25.1 %) (Table 1g).

Intraoperative management

Skip corpectomies were performed by 29.6 % of the surgeons, while the remaining 70.4 % did not use this hybrid solution consisting of ACDF and ACCF (Table 2a).

Expandable cages (28.5 %) were preferred as anterior intervertebral spacers, rather than mesh cages filled with autologous tissue (21.5 %) (Table 2b). For dorsal instrumented augmentation, lateral mass screws (LMS; 42.1 %) were preferred (Table 2c).

Table 1 Preoperative management in patients undergoing cervical corpectomy

Questions in survey	%	*n*
a. What treatment options do you use in patients with multilevel cervical disease?		
Multilevel ACDF	41.1	51
Multilevel ACCF	12.1	15
Laminectomy	16.1	20
Laminoplasty	18.6	23
Laminectomy combined with anterior approaches	12.1	15
b. How many ACCF procedures do you perform per year?		
Never	10.3	14
Less than 5 ACCF procedures per year	50.7	69
5–20 ACCF procedures per year	35.3	48
More than 20 ACCF procedures per year	3.7	5
c. What types of disease do you treat using ACCF? (multiple answers possible)		
Cervical spondylotic myelopathy (CSM)	17.1	99
Ossification of the posterior longitudinal ligament (OPLL)	9.8	57
Cervical spondylodiscitis	14.3	83
Neoplastic infiltration of cervical vertebrae	19.8	115
Realignment due to postoperative kyphotic misalignment (ventral or dorsal)	12.2	71
Pseudarthrosis after ACDF procedures	9.9	57
Cervical spinal fractures	16.9	98
d. What type of preoperative imaging technique do you use? (multiple answers possible)		
CT	29.2	116
CT angiography	3.8	15
CT with BMD evaluation	2.5	10
MRI	33.8	134
AP/lateral radiography with functional imaging	30.7	122
e. Do you carry out a standardized preoperative BMD evaluation?		
Yes	6.0	8
No	67.7	90
Age-dependent	26.3	35
f. At what number of resected levels do you perform additional dorsal instrumentation?		
1-level corpectomy	0.5	1
2-level corpectomy	33.3	62
3-level corpectomy	33.3	62
4-level corpectomy	1.7	3
All patients with low BMD/ osteoporosis, regardless of the number of resected levels	11.8	22
All patients with kyphotic misalignment	19.4	36
g. What risk factors require additional dorsal instrumentation in order to prevent implant failures?		
Age > 70	6.4	26
Smoker	6.7	27
Low BMD/ osteoporosis	25.4	102
Ankylosing spondylitis (Bechterew disease)	25.1	101
Kyphotic misalignment	20.2	81
Corpectomy ending at C7	16.2	65

ACCF anterior cervical corpectomy and fusion, *ACDF* anterior cervical discectomy and fusion, *AP* anteroposterior, *BMD* bone mass density, *CT* computed tomography, *MRI* magnetic resonance imaging

The respondents considered the postoperative sagittal alignment (45.9 %) to be the most important factor followed by bone mass density (BMD; 30.3 %) for ensuring anterior stability (Table 2d).

In case the surgeons felt that additional dorsal instrumentation is necessary for sufficient stability, the second (dorsal) intervention is usually (56.9 %) planned 5–10 days after the corpectomy. Approximately one-third of the surgeons

Table 2 Intraoperative management of cervical corpectomies

Questions in survey	%	*n*
a. Do you perform skip corpectomies?		
Yes	29.6	34
No	70.4	81
b. Which intervertebral cage system do you use for corpectomies?		
TMC without filling	5.0	17
TMC filled with autologous bone from the corpectomy	21.5	73
TMC filled with allogenous bone	4.7	16
TMC filled with tricortical iliac crest bone graft	2.1	7
Tricortical iliac crest bone graft	13.2	45
TMC filled with osteoinductive materials (DBM, beta-TCP)	8.2	28
TMC filled with osteoconductive materials (BMP)	0.3	1
PEEK cages with or without filling	13.8	47
Expandable cages	28.5	97
Fibula grafts	2.7	9
c. What type of dorsal screws do you use?		
Lateral mass screws (LMS)	42.1	125
Pedicle screws (PS)	30.7	91
Lamina hooks	7.7	23
C2 isthmus screws	19.5	58
d. What is the most important factor for maintaining anterior stability after corpectomy?		
Type of plate	7.4	9
Diameter of the screws	2.5	3
Bicortical screw placement	13.9	17
Bone mineral density	30.3	37
Postoperative sagittal alignment	45.9	56
e. At what time do you perform the additional dorsal procedure?		
In the same session as the anterior corpectomy	32.3	42
5–10 days after the index procedure	56.9	74
>10 days after the index procedure	10.8	14
Never	0	0
f. Which intraoperative complications occur most frequently?		
High loss of blood	48.1	90
Injury to the spinal cord	1.1	2
Injury to major vessels (carotid or vertebral artery)	0	0
Injury to the esophagus/trachea	3.2	6
Implant-related complications	29.4	55
Incidental durotomy	18.2	34

BMP bone morphogenetic protein, *DBM* demineralized bone matrix, *PEEK* polyetheretherketone, *TCP* tricalcium phosphate, *TMC* titanium mesh cage

(32.3 %) tended to perform the supplemental dorsal procedure in the same session, while the remainder (10.8 %) carry it out more than 10 days after the index procedure (Table 2e). Intraoperative and postoperative complications are illustrated in Tables 2f and 3a.

Postoperative management

Postoperative immobilization with hard or soft collars is used in most cases after all types of cervical procedure, regardless of anterior or posterior approaches, as well as the anterior type of operation (48.3 %). Of the respondents, 23.6 % and 18.0 %, respectively, stated that they used a hard or soft collar after two-level corpectomies or after all types of cervical corpectomy (Table 3b). The average periods for which these braces were worn were 3–6 weeks (41.4 %) (Table 3c).

Most of the participants considered 4 weeks (46.6 %) a sufficient interval for the first postoperative outpatient follow-up appointment (Table 3d). At this time, the majority of the specialists (73.1 %) carried out radiography

Table 3 Postoperative management of cervical corpectomy

Questions in survey	%	*n*
a. Which postoperative complications occur most frequently?		
Dysphagia	53.4	87
Recurrent nerve palsy	4.9	8
Persistent cervical myelopathy	11.0	18
Paraplegia, tetraplegia	0	0
Radicular symptoms (C5 palsy)	1.9	3
Implant-related complications (subsidence of the graft and screw/plate dislocation)	28.8	47
b. Do you use postoperative immobilization with soft or hard collars?		
All anterior cervical spine approaches (ACDF, ACCF), regardless of the number of levels treated	23.6	21
All anterior cervical spine approaches (ACDF, ACCF), including two cervical segments	10.1	9
ACCF, regardless of the number of levels resected	18.0	16
ACCF with two levels resected	23.6	21
All anterior and posterior cervical spine approaches, regardless of the levels treated	24.7	22
c. What postoperative bracing period do you use?		
1–3 weeks	12.1	14
3–6 weeks	41.4	48
6–12 weeks	24.1	28
>12 weeks	1.7	2
Never	20.7	24
d. When do you perform the first postoperative outpatient check-up?		
After 4 weeks	46.6	61
After 8 weeks	36.6	48
After 12 weeks	16.8	22
Only in case of any deterioration	0	0
e. Type of imaging technique at the first outpatient check-up?		
AP/lateral radiography	73.1	95
CT	26.9	35
MRI	0	0

ACCF anterior cervical corpectomy and fusion, *ACDF* anterior cervical discectomy and fusion, *AP* anteroposterior, *CT* computed tomography, *MRI* magnetic resonance imaging

(anteroposterior and lateral) to evaluate the implants and sagittal alignment (Table 3e).

No significant differences were noted between the surgeons who performed more than five ACCF procedures per year and the surgeons who did fewer than five per year ($p > 0.05$). Nor were there any significant differences between surgeons who preferred a supplemental dorsal approach after two-level corpectomies and those who used this approach after three-level corpectomies ($p > 0.05$).

Discussion

Anterior cervical corpectomy and fusion is predominantly used for multilevel compression of the cervical spine resulting in myelopathy. However, many studies have reported high rates of implant-related failure with anterior cervical multilevel corpectomies in the absence of additional dorsal instrumentation [11, 18, 23, 27]. These complications are mainly associated with the number of segments resected. Increased rates of implant-related complications are reported particularly when two-level corpectomies are extended to three-level or multilevel procedures [5, 23, 24, 40]. Although supplemental posterior instrumentation provides circumferential stability and promotes fusion, the additional surgical procedure is associated with increased morbidity [1, 4, 5, 25, 38, 39, 42]. Corpectomy procedures in the cervical spine, especially in older patients and those with comorbidities, are associated with high complication rates, and extensive perioperative assessment and planning may therefore be able to obviate complications [5].

Currently, there is no consensus in central Europe on the treatment of complex cervical diseases and the use of cervical corpectomy. Overall, the procedure is still rarely performed and the need for additional dorsal fixation is unclear among

surgeons. There are many confounding factors—particularly bone quality, as mentioned above—that influence decision-making in connection with a supplemental dorsal approach. The results of the present survey show that one of the risk factors for implant failure—low BMD—is recognized, but is not regarded as indicating a preoperative check-up and possible adaptation of the surgical strategy. In patients with osteopenia, some studies thus mention the use of a dorsal support or even halo immobilization postoperatively to avoid anterior screw toggling or loosening [4, 11, 18]. Most of the biomechanical data published show a significant relationship between BMD and screw pull-out forces, so that decreased screw anchorage can be assumed in patients with a low BMD [9, 21, 30, 31, 35]. No conclusive recommendations on carrying out preoperative BMD evaluation were identified, although osteoporosis predisposes towards implant complications [41, 53]. In contrast, ankylosing spinal diseases are often associated with decreased BMD. The combination of low BMD and a long lever arm due to ankylosed spinal segments is associated with a fivefold increase in the risk of spinal fractures. The standard procedure for this condition usually consists of anterior–posterior stabilization, particularly if anterior decompression due to corpectomy is required [13, 33, 50].

The survey also did not suggest any conclusions regarding the number of resected anterior levels at which dorsal instrumentation appears to be appropriate. This underlines the absence of a community-based consensus, and the choice of posterior support after cervical corpectomy still continues to be a decision taken on a patient-to-patient basis. It is therefore difficult to establish surgical guidelines. Clinical and biomechanical studies in the literature have included recommendations about the use of dorsal support after two-level resection, but there are also several studies reporting favorable results after three-level or even multilevel corpectomy procedures without dorsal support [1, 11, 18, 23, 29, 37, 40, 41, 43, 48, 49].

The survey also inquired about the interval observed before additional dorsal instrumentation. The supplemental procedure may be performed in the same session, as there is a high rate of returns to the operating room with corpectomies in general and particularly in those without dorsal instrumentation [4, 5, 15, 37, 41]. Moreover, patients who undergo repeat surgery have a significantly higher mortality rate and account for more than one-third of all complications, as Boakye et al. note [5]. The main complications observed in the present survey were blood loss, implant-related failures and dysphagia, and this is consistent with recent literature findings [4, 52].

With regard to implant failures, several studies have shown that the larger the number of levels resected and the longer the anterior graft, the higher the likelihood of implant failures is [5, 11, 37, 52]. In contrast, the likelihood of anterior implant failure involving more than two levels was shown to decrease anterior strut graft dislodgement when circumferential cervical fusion was used [4, 19, 20, 37, 43]. To reduce the high complication rate, several techniques for anterior reconstruction after excessive decompression are available. Expandable cages are well established and have sizes that can be adjusted to the corpectomy defect, providing solid anterior spine stabilization without morbidity in the bone graft site [3, 6, 7, 28, 54]. Secondly, titanium mesh cages (TMC) filled with autologous bone are alternative devices for reconstructing the cervical spine, although fitting these intraoperatively without compromising the integrity of the endplate is often still technically demanding [1, 8, 47, 48]. Synthetic PEEK cages are less rigid than other types of implant, but they have led to favorable results in recent clinical studies [22, 26, 34]. Finally, the specific use of the various reconstruction methods depends on surgeons' own preferences, as well as patient-related factors resulting from the etiopathology. With all types of reconstruction device, the use of a plate is recommended in order to restore lordotic alignment and inhibit graft dislodgement or migration [15].

Lordotic alignment may also play an important role in transferring axial loads adequately through the cervical spine. For this reason, optimal load-sharing between the plate and the intervertebral device has to be available, so that stress shielding can be avoided and sufficient bony fusion can occur (in accordance with Wolff's law) [51]. In addition, increased postoperative kyphotic angulation has been linked to a significantly increased level of chronic neck pain in two-level corpectomies [2]. The combination of a cervical lordotic alignment and bicortical screw placement with the appropriate plate is considered to be a stability-maintaining factor, as the results of the present survey also show. Bicortical screw placement or screws with a thicker diameter may not influence the pull-out strength significantly in comparison with monocortical fixation or a standard screw [30]. In contrast, screw length and cemented-augmented anterior screws have been found to be significantly associated with higher pull-out forces [9, 21, 30–32].

Dysphagia is one of the main complications following anterior cervical spine surgery, as mentioned above. It seems that dysphagia is substantially underreported in most cases, due to a consistently poor correlation between surgical records and patient surveys [10, 12]. This may be the reason for the inconclusive findings in the literature [5, 12, 44–46]. Postoperative dysphagia may also occur due to denervation of esophageal nerves, swelling due to hematoma formation, or postoperative bleeding associated with compromised airways [10, 16]. In the study by Boakye et al., which is by far the largest collection of retrospective data on corpectomies, the rate of dysphagia was reported to be less than 1 % [5]. This may be underreported in comparison with other published data [36]. In addition, misplaced halo fixations or prolonged cervical immobilization in hyperextended positions due to collars or braces may also be causes of postoperative dysphagia.

Intuitively, postoperative immobilization is expected to provide additional stabilization in order to align the corpectomy defect and support ingrowth of the graft and recovery from muscle trauma. Based on the literature findings, some surgeons have the patients use collars for 6–12 weeks postoperatively, but there are no evidence-based background data for this [11, 14, 41, 52]. Due to the lack of evidence-based data, the use of postoperative immobilization techniques is based on the surgeons' own experience and patients' preexisting conditions.

Finally, surgeons usually arrange postoperative check-ups for the patients after 8 and 12 weeks. In most cases, CT scanning is then performed [14, 41, 52]. It is not clear from recent findings whether this radiological assessment forms part of standard care or represents the first imaging procedure following deterioration after the index procedure. CT scans should be performed early after surgery, usually before discharge, to provide baseline findings for follow-up examinations. In the present authors' experience, lateral and anteroposterior fluoroscopic imaging is sufficient during follow-up, unless the patient's clinical symptoms have deteriorated. If there is deterioration, CT scans should be carried out for comparison with the initial postoperative findings.

Limitations

As stated, the survey participants were acquired with the help of the members' registry of the societies mentioned (DWG, ASS, DGNC, and OEGNC), so that both neurosurgeons and orthopedic/trauma surgeons were reached and answered the online survey. However, a discipline-specific analysis could not be performed due to the data protection guidelines. The same is true for the different surgical qualifications and the years of surgical experience of the attended surgeons (resident vs. consultant).

The study presented is based on experts' opinion and should be interpreted as "level 5 evidence" (experts opinion), so that the results and conclusions should not replace prospective data on "cervical corpectomies". The online survey presented here is more to clarify the variety of planning and decision-making approaches used in connection with corpectomy procedures.

Conclusions

There is no substantial consensus among surgeons with regard to the management of multisegmental cervical disease and the use of cervical corpectomy. The number of resected levels at which additional dorsal support is thought to be appropriate is not clear from the present survey. The risk factors associated with an increased likelihood of implant failure are evident, but the preoperative strategy is not adapted, so that generally the use of cervical corpectomy depends on each surgeon's individual experience rather than on evidence-based medicine.

The online survey presented here is intended to clarify the variety of planning and decision-making approaches used in connection with corpectomy procedures. However, prospective data on this topic is essential.

Acknowledgments None of the authors has any conflicts of interest in connection with the study.

Compliance with ethical standards

Funding No funding was received for this research.

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval 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.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Acosta FL, Aryan HE, Chou D, Ames CP (2008) Long-term biomechanical stability and clinical improvement after extended multilevel corpectomy and circumferential reconstruction of the cervical spine using titanium mesh cages. J Spinal Disord Tech 21(3): 165–174
2. Andaluz N, Zuccarello M, Kuntz C (2012) Long-term follow-up of cervical radiographic sagittal spinal alignment after 1- and 2-level cervical corpectomy for the treatment of spondylosis of the subaxial cervical spine causing radiculomyelopathy or myelopathy: a retrospective study. J Neurosurg Spine 16(1):2–7
3. Arts MP, Peul WC (2008) Vertebral body replacement systems with expandable cages in the treatment of various spinal pathologies: a prospectively followed case series of 60 patients. Neurosurgery 63(3):537–544, discussion 544–5
4. Aryan HE, Sanchez-Mejia RO, Ben-Haim S, Ames CP (2007) Successful treatment of cervical myelopathy with minimal morbidity by circumferential decompression and fusion. Eur Spine J 16(9): 1401–1409
5. Boakye M, Patil CG, Ho C, Lad SP (2008) Cervical corpectomy: complications and outcomes. Neurosurgery 63(4 Suppl 2):295–301, discussion 301–2

6. Burkett CJ, Baaj AA, Dakwar E, Uribe JS (2012) Use of titanium expandable vertebral cages in cervical corpectomy. J Clin Neurosci 19(3):402–405
7. Cabraja M, Abbushi A, Kroppenstedt S, Woiciechowsky C (2010) Cages with fixation wings versus cages plus plating for cervical reconstruction after corpectomy—is there any difference? Cen Eur Neurosurg 71(2):59–63
8. Castellvi AE, Castellvi A, Clabeaux DH (2012) Corpectomy with titanium cage reconstruction in the cervical spine. J Clin Neurosci 19(4):517–521
9. Conrad BP, Cordista AG, Horodyski M, Rechtine GR (2005) Biomechanical evaluation of the pullout strength of cervical screws. J Spinal Disord Tech 18(6):506–510
10. Daniels AH, Riew KD, Yoo JU, Ching A, Birchard KR, Kranenburg AJ, Hart RA (2008) Adverse events associated with anterior cervical spine surgery. J Am Acad Orthop Surg 16(12): 729–738
11. Daubs MD (2005) Early failures following cervical corpectomy reconstruction with titanium mesh cages and anterior plating. Spine (Phila Pa 1976) 30(12):1402–1406
12. Edwards CC, Karpitskaya Y, Cha C, Heller JG, Lauryssen C, Yoon ST, Riew KD (2004) Accurate identification of adverse outcomes after cervical spine surgery. J Bone Joint Surg Am 86-A(2):251–256
13. Einsiedel T, Schmelz A, Arand M, Wilke HJ, Gebhard F, Hartwig E, Kramer M, Neugebauer R, Kinzl L, Schultheiss M (2006) Injuries of the cervical spine in patients with ankylosing spondylitis: experience at two trauma centers. J Neurosurg Spine 5(1):33–45
14. Eleraky MA, Llanos C, Sonntag VK (1999) Cervical corpectomy: report of 185 cases and review of the literature. J Neurosurg 90(1 Suppl):35–41
15. Epstein NE (2000) The value of anterior cervical plating in preventing vertebral fracture and graft extrusion after multilevel anterior cervical corpectomy with posterior wiring and fusion: Indications, results, and complications. J Spinal Disord 13(1):9–15
16. Frempong-Boadu A, Houten JK, Osborn B, Opulencia J, Kells L, Guida DD, Le Roux PD (2002) Swallowing and speech dysfunction in patients undergoing anterior cervical discectomy and fusion: a prospective, objective preoperative and postoperative assessment. J Spinal Disord Tech 15(5):362–368
17. Hartmann S, Thomé C, Keiler A, Fritsch H, Hegewald AA, Schmölz W (2015) Biomechanical testing of circumferential instrumentation after cervical multilevel corpectomy. Eur Spine J 24(12): 2788–2798
18. Hee HT, Majd ME, Holt RT, Whitecloud TS, Pienkowski D (2003) Complications of multilevel cervical corpectomies and reconstruction with titanium cages and anterior plating. J Spinal Disord Tech 16(1):1–8, discussion 8–9
19. Herman JM, Sonntag VK (1994) Cervical corpectomy and plate fixation for postlaminectomy kyphosis. J Neurosurg 80(6):963–970
20. Hilibrand AS, Carlson GD, Palumbo MA, Jones PK, Bohlman HH (1999) Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. J Bone Joint Surg Am 81(4):519–528
21. Hitchon PW, Brenton MD, Coppes JK, From AM, Torner JC (2003) Factors affecting the pullout strength of self-drilling and self-tapping anterior cervical screws. Spine (Phila Pa 1976) 28(1): 9–13
22. Kasliwal MK, O'Toole JE (2014) Clinical experience using polyetheretherketone (PEEK) intervertebral structural cage for anterior cervical corpectomy and fusion. J Clin Neurosci 21(2):217–220
23. Koller H, Hempfing A, Ferraris L, Maier O, Hitzl W, Metz-Stavenhagen P (2007) 4- and 5-level anterior fusions of the cervical spine: review of literature and clinical results. Eur Spine J 16(12): 2055–2071
24. Koller H, Schmidt R, Mayer M, Hitzl W, Zenner J, Midderhoff S, Middendorf S, Graf N, Gräf N et al (2010) The stabilizing potential of anterior, posterior and combined techniques for the reconstruction of a 2-level cervical corpectomy model: biomechanical study and first results of ATPS prototyping. Eur Spine J 19(12):2137–2148
25. Koller H, Schmoelz W, Zenner J, Auffarth A, Resch H, Hitzl W, Malekzadeh D, Ernstbrunner L, Blocher M, Mayer M (2015) Construct stability of an instrumented 2-level cervical corpectomy model following fatigue testing: biomechanical comparison of circumferential antero-posterior instrumentation versus a novel anterior-only transpedicular screw-plate fixation technique. Eur Spine J 24(12):2848–2856
26. König SA, Spetzger U (2014) Distractable titanium cages versus PEEK cages versus iliac crest bone grafts for the replacement of cervical vertebrae. Minim Invasive Ther Allied Technol 23(2):102–105
27. Liu Y, Qi M, Chen H, Yang L, Wang X, Shi G, Gao R, Wang C, Yuan W (2012) Comparative analysis of complications of different reconstructive techniques following anterior decompression for multilevel cervical spondylotic myelopathy. Eur Spine J 21(12): 2428–2435
28. Omeis I, Bekelis K, Gregory A, McGirt M, Sciubba D, Bydon A, Wolinsky JP, Gokaslan Z, Witham T (2010) The use of expandable cages in patients undergoing multilevel corpectomies for metastatic tumors in the cervical spine. Orthopedics 33(2):87–92
29. Ozgen S, Naderi S, Ozek MM, Pamir MN (2004) A retrospective review of cervical corpectomy: indications, complications and outcome. Acta Neurochir (Wien) 146(10):1099–1105, discussion 1105
30. Pitzen T, Barbier D, Tintinger F, Steudel WI, Strowitzki M (2002) Screw fixation to the posterior cortical shell does not influence peak torque and pullout in anterior cervical plating. Eur Spine J 11(5): 494–499
31. Pitzen TR, Drumm J, Bruchmann B, Barbier DD, Steudel WI (2006) Effectiveness of cemented rescue screws for anterior cervical plate fixation. J Neurosurg Spine 4(1):60–63
32. Pitzen T, Franta F, Barbier D, Steudel WI (2004) Insertion torque and pullout force of rescue screws for anterior cervical plate fixation in a fatigued initial pilot hole. J Neurosurg Spine 1(2):198–201
33. Prieto-Alhambra D, Muñoz-Ortego J, De Vries F, Vosse D, Arden NK, Bowness P, Cooper C, Diez-Perez A, Vestergaard P (2015) Ankylosing spondylitis confers substantially increased risk of clinical spine fractures: a nationwide case–control study. Osteoporos Int 26(1):85–91
34. Raslan F, Koehler S, Berg F, Rueckriegel S, Ernestus RI, Meinhardt M, Westermaier T (2014) Vertebral body replacement with peek-cages after anterior corpectomy in multilevel cervical spinal stenosis: a clinical and radiological evaluation. Arch Orthop Trauma Surg 134(5):611–618
35. Reinhold M, Schwieger K, Goldhahn J, Linke B, Knop C, Blauth M (2006) Influence of screw positioning in a new anterior spine fixator on implant loosening in osteoporotic vertebrae. Spine (Phila Pa 1976) 31(4):406–413
36. Riley LH, Vaccaro AR, Dettori JR, Hashimoto R (2010) Postoperative dysphagia in anterior cervical spine surgery. Spine (Phila Pa 1976) 35(9 Suppl):S76–S85
37. Sasso RC, Ruggiero RA, Reilly TM, Hall PV (2003) Early reconstruction failures after multilevel cervical corpectomy. Spine (Phila Pa 1976) 28(2):140–142
38. Schmidt R, Wilke HJ, Claes L, Puhl W, Richter M (2003) Pedicle screws enhance primary stability in multilevel cervical corpectomies: biomechanical in vitro comparison of different implants including constrained and nonconstrained posterior instrumentations. Spine (Phila Pa 1976) 28(16):1821–1828
39. Sembrano JN, Mehbod AA, Garvey TA, Denis F, Perra JH, Schwender JD, Transfeldt EE, Winter RB, Wroblewski JM

(2009) A concomitant posterior approach improves fusion rates but not overall reoperation rates in multilevel cervical fusion for spondylosis. J Spinal Disord Tech 22(3):162–169
40. Setzer M, Eleraky M, Johnson WM, Aghayev K, Tran ND, Vrionis FD (2012) Biomechanical comparison of anterior cervical spine instrumentation techniques with and without supplemental posterior fusion after different corpectomy and discectomy combinations: laboratory investigation. J Neurosurg Spine 16(6):579–584
41. Sevki K, Mehmet T, Ufuk T, Azmi H, Mercan S, Erkal B (2004) Results of surgical treatment for degenerative cervical myelopathy: anterior cervical corpectomy and stabilization. Spine (Phila Pa 1976) 29(22):2493–2500
42. Shamji MF, Cook C, Pietrobon R, Tackett S, Brown C, Isaacs RE (2009) Impact of surgical approach on complications and resource utilization of cervical spine fusion: a nationwide perspective to the surgical treatment of diffuse cervical spondylosis. Spine J 9(1):31–38
43. Singh K, Vaccaro AR, Kim J, Lorenz EP, Lim TH, An HS (2003) Biomechanical comparison of cervical spine reconstructive techniques after a multilevel corpectomy of the cervical spine. Spine (Phila Pa 1976) 28(20):2352–2358, discussion 2358
44. Siska PA, Ponnappan RK, Hohl JB, Lee JY, Kang JD, Donaldson WF (2011) Dysphagia after anterior cervical spine surgery: a prospective study using the swallowing-quality of life questionnaire and analysis of patient comorbidities. Spine (Phila Pa 1976) 36(17):1387–1391
45. Skeppholm M, Ingebro C, Engström T, Olerud C (2012) The dysphagia short questionnaire: an instrument for evaluation of dysphagia: a validation study with 12 months' follow-up after anterior cervical spine surgery. Spine (Phila Pa 1976) 37(11):996–1002
46. Smith-Hammond CA, New KC, Pietrobon R, Curtis DJ, Scharver CH, Turner DA (2004) Prospective analysis of incidence and risk factors of dysphagia in spine surgery patients: comparison of anterior cervical, posterior cervical, and lumbar procedures. Spine (Phila Pa 1976) 29(13):1441–1446
47. Thalgott JS, Xiongsheng C, Giuffre JM (2003) Single stage anterior cervical reconstruction with titanium mesh cages, local bone graft, and anterior plating. Spine J 3(4):294–300
48. Uribe JS, Sangala JR, Duckworth EA, Vale FL (2009) Comparison between anterior cervical discectomy fusion and cervical corpectomy fusion using titanium cages for reconstruction: analysis of outcome and long-term follow-up. Eur Spine J 18(5):654–662
49. Vaccaro AR, Falatyn SP, Scuderi GJ, Eismont FJ, McGuire RA, Singh K, Garfin SR (1998) Early failure of long segment anterior cervical plate fixation. J Spinal Disord 11(5):410–415
50. Vosse D, Landewé R, van der Heijde D, van der Linden S, van Staa TP, Geusens P (2009) Ankylosing spondylitis and the risk of fracture: results from a large primary care-based nested case–control study. Ann Rheum Dis 68(12):1839–1842
51. Wang M, Gourab K, McGrady LM, Rao RD (2008) Alteration of load sharing of anterior cervical implants with change in cervical sagittal alignment. Med Eng Phys 30(6):768–773
52. Wang JC, Hart RA, Emery SE, Bohlman HH (2003) Graft migration or displacement after multilevel cervical corpectomy and strut grafting. Spine (Phila Pa 1976) 28(10):1016–1021, discussion 1021–2
53. Yan D, Wang Z, Deng S, Li J, Soo C (2011) Anterior corpectomy and reconstruction with titanium mesh cage and dynamic cervical plate for cervical spondylotic myelopathy in elderly osteoporosis patients. Arch Orthop Trauma Surg 131(10):1369–1374
54. Zaïri F, Aboukais R, Thines L, Allaoui M, Assaker R (2012) Relevance of expandable titanium cage for the treatment of cervical spondylotic myelopathy. Eur Spine J 21(8):1545–1550

Comments

This is a well-written manuscript on a survey providing information on peoples' practice of cervical corpectomy. There are several controversies and some of these have been addressed by this survey. As is expected in such a study, there are inevitable limitations, including regional bias, as per the countries assessed, and the response rate was not very high but acceptable

Overall, the information is useful and clearly proves the lack of consensus on several matters. This may form the basis for a similar survey in other settings/countries and for prospective studies.

Andreas K. Demetriades
Edinburgh, UK