Original Article

Factors affecting functional outcome after anterior cervical discectomy and fusion: A multicenter study

ABSTRACT

Background: Although anterior cervical discectomy and fusion (ACDF) represents a standardized procedure for surgical treatment of a cervical herniated disc, several variables could affect patients' clinical and radiological outcome. We evaluated the impact of sex, age, body mass index (BMI), myelopathy, one- or two-level ACDF, and the use of postoperative collars on functional and radiological outcomes in a large series of patients operated for ACDF.

Materials and Methods: Databases of three institutions were searched, resulting in the enrollment of 234 patients submitted to one- or two-level ACDF from January 2013 to December 2017 and followed as outpatients at 6- and 12-month follow-up. The impact of variables on functional and radiological outcomes was evaluated using univariate and multivariate logistic regression analysis.

Results: At univariate analysis, female sex, higher BMI, two-level ACDF, and postoperative collar correlated with a significantly worse early and late Neck Disability Index (NDI). Multivariate analysis showed that male patients had a lower risk of worse early ($P = 0.01$) and late NDIs ($P = 0.009$). Patients with myelopathy showed better early NDI ($P = 0.004$). Cervical collar negatively influenced both early and late NDIs ($P < 0.0001$), with a higher risk of early nonfusion ($P = 0.001$) but a lower risk of late nonfusion ($P = 0.01$). Patients operated for two-level ACDF have a worse early NDI ($P = 0.005$), a worse late NDI ($P = 0.01$), and a higher risk of early nonfusion ($P = 0.048$). BMI and age did not influence outcome.

Conclusions: Female sex, two-level surgery, and the use of postoperative collars significantly correlate with worse functional outcomes after one- or two-level ACDF.

Keywords: Anterior cervical discectomy and fusion, functional outcome, herniated disc

INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) represents the standard procedure performed for focal anterior compression of nerve roots and/or spinal cord. Results of ACDF are effective on both clinical and neurological symptoms, with low complication rates.[1,2] However, to date, early and long-term results are still variable, and the impact of the individual variables on surgical outcome is still debated.

Different studies highlighted the role of patient age, American Society of Anesthesiologists score, and myelopathy as the risk factor affecting the outcome.[3] Body mass index (BMI),[4,5] gender,[6,7] one- or two-level ACDF,[2] and the use of postoperative collars have been nonuniformly advocated as predictive factors.[8,9]

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We performed a multicenter retrospective study comparing radiological and functional outcomes of patients operated on for one- or two-level ACDF and analyzed the effect of different variables including age, sex, BMI, presence of myelopathy, and the use of postoperative cervical orthoses on final outcomes.

MATERIALS AND METHODS

We retrospectively collected clinical and radiological data from January 2013 to December 2017 from patients operated on by ACDF with polyetheretherketone (PEEK) cages for cervical herniated disc in three neurosurgical departments.

Indications for surgery, surgical technique, and follow-up strategies were comparable among the three centers.

Surgery was indicated in cases of cervical radiculopathy and root compression due to cervical disc herniation that had failed conservative treatment for at least 6 weeks or in patients with cervical cord compression or myelopathy secondary to cervical disk herniation/spondylosis. In all cases, cervical magnetic resonance confirmed the diagnosis.

Surgical treatment consisted of standard anterior microsurgical discectomy and fusion (ACDF) with PEEK cages in all cases. Implanted cages were similar through centers of shape (Rabea-Peek, Medizintechnik; ACIF Spine Vision; LorX-BBraun). No graft, plates, or dynamic systems were used.

Follow-up included clinical examinations at 1, 6, and 12 months from surgery and radiological evaluations by cervical X-ray at 6 and 12 months. No patients were lost to follow-up. Clinical follow-up consisted of standard neurological examination and assessment of the Neck Disability Index (NDI) score. During the radiological follow-up, static cervical radiographs were investigated for fusion which was defined as an increased opacification and bridging trabecular bone at the margins of the graft, as reported by Gruskay *et al*. X-rays were independently reviewed by two senior radiologists.[10]

The electronic databases of the three participating institutions were searched using the ICD9 diagnosis codes 722.0 (cervical herniated disc without myelopathy), 721.0 (cervical spondylosis without myelopathy), and 721.1 (cervical spondylosis with myelopathy) as well as the ICD9 treatment codes 81.02 (other cervical fusion of the anterior column) and 80.51 (excision of intervertebral disc). After patients were identified, clinical information was retrieved from patients' medical records and outpatient follow-up visits, while radiological data were obtained from the picture archiving and communication system archives. Informed consent was obtained from all participants included in the study.

We collected preoperative clinical data including sex, age (cutoff: median value – 50 years), BMI (cutoff: median value – 25.67), presence of myelopathy, as well as postoperative and outcome data including one- versus two-level ACDF, presence of postoperative collar (Schanz collar), and functional outcome (early – 1-month NDI and late – 6/12-month NDI). The only collected measure of radiological outcome was the evidence of radiological fusion at the cervical X-rays (early – 1 month and late – 6/12 months) according to the abovementioned definition.

Sample size and statistical analysis

The statistical analyses were carried out using IBM SPSS for Mac (version 23.0.0).

We estimated the required sample size assuming a 9.5% mean NDI in the control group (ACDF with collar, standard deviation [SD]: 11%), an alpha error of 0.05, and an 80% power to detect a 5.3% mean NDI in the treatment group (ACDF without collar). To detect that difference, 216 patients with 108 in each group were needed.

Fisher's exact test was used for comparing clinical variables. Logistic regression analysis was used for defining the impact of variables on dichotomized functional (clinical and radiological) outcome measures, i.e., early radiological fusion versus no fusion/partial fusion, late radiological fusion versus no fusion/partial fusion, early NDI (cutoff: median value: 6.8%), and late NDI (cutoff: median value: 2%). Results presenting $P \leq 0.05$ were considered statistically significant.

RESULTS

Cohort characteristics

A total of 234 patients (120 females and 114 males) were enrolled in the current study. The mean age at surgery was 51.3 years (SD: 11.6, age range: 24–78), and the median age was 50.

The BMI ranged from 17.24 to 43.15 (mean value: 26.65, SD: 4.82, median value: 25.67). Myelopathy was present in 96 patients (41%), while 138 patients (59%) had radiculopathy without myelopathy. Surgery was performed at one level in 142 cases (60.7%) and at two levels in 92 cases (39.3%). One hundred and eleven patients did not use any cervical collar after surgery (47.4%) and 123 used it (52.6%). No complications occurred after surgery. Postoperative and

follow-up X-rays showed no cases of cage subsidence or dislocation requiring re-operation.

Early postoperative NDI ranged from 0% to 78% (mean value: 11.74%, SD: 14.4, median: 6.8%). Late postoperative NDI ranged from 0% to 42% (mean value: 0.92%, SD: 4.06, median value: 2%). At 1-month X-rays, 57 patients (24.4%) presented fusion, 56 (23.9%) had partial fusion, and 121 patients had no fusion (51.7%). At 12-month follow-up, 166 patients presented fusion (70.9%), 67 had partial fusions (28.6%), and one case had no fusion (0.4%).

Univariate analysis

At univariate analysis, female sex, higher BMI, two-level ACDF, and the use of postoperative collar correlated with worse early and late NDIs [Table 1]. Patients with myelopathy had a better early NDI and an earlier tendency to fusion. Patients with postoperative collar had a lower rate of early fusion and a higher rate of late fusion.

Multivariate analysis

Multivariate logistic regression analysis showed that male patients had a lower risk of worse early NDI [odds ratio (OR): 0.46, 95% confidence interval (CI): 0.26–0.83, $P = 0.01$; Table 2] and a lower risk of a worse late NDI [OR: 0.46, 95% CI: 0.26–0.83, $P = 0.009$; Table 3]. Patients with myelopathy had a lower risk of a worse early NDI [OR: 0.39, 95% CI: 0.2–0.7, $P = 0.004$; Table 2]. Patients with collar had a higher risk of a worse early NDI [OR: 4.58, 95% CI: 2.5–8.2, $P < 0.0001$; Table 2], a higher risk of a worse late NDI [OR: 3.78, 95% CI: 2–6.8, $P < 0.0001$; Table 3], a higher risk of early nonfusion [OR: 2.9, 95% CI: 1.5–5.7, $P = 0.001$; Table 4], but a lower risk of late nonfusion [OR: 0.46, 95% CI: 0.26–0.8, $P = 0.01$; Table 5]. Patients operated for two-level ACDF had a worse early NDI [OR: 2.4, 95% CI: 1.3–4.4, $P = 0.005$; Table 2], a worse late NDI [OR: 2.1, 95% CI: 1.1–3.8, $P = 0.01$; Table 3], and a higher risk of early nonfusion [OR: 1.99, 95% CI: 1–3.9, $P = 0.048$; Table 4]. BMI and age did not influence outcome.

DISCUSSION

Although ACDF represents a widely and diffuse surgical option in the neurosurgical community for the treatment of patients affected by focal anterior compression of the spinal cord and nerve roots in the cervical spine, the impacts of different variables were rarely assessed in the pertinent literature and need to be addressed in detail. Moreover, in an era when patients look for the best possible outcome, the role of preoperative patients' variables needs to be assessed and described in detail.

In the present study, we have evaluated the effect of age, sex, BMI, myelopathy, and the use of postoperative cervical orthoses on radiological and clinical outcomes in patients undergoing one- or two-level ACDF, respectively, in three Italian neurosurgical centers who adopted a similar approach. Results of this study show that female sex, two-level surgery, and the use of postoperative collar significantly correlate with worse functional outcome after one- or two-level ACDF, whereas BMI showed no significant impact on functional outcome in the multivariate logistic regression analysis.

Table 1: Univariate analysis

	Early NDI<6.8%	Early NDI≥6.8%	*P*	Late NDI<2%	Late NDI≥2%	*P*	Early fusion yes	Early fusion no	*P*	Late fusion yes	Late fusion no	*P*
Sex (%)												
Female	53 (22.6)	67 (28.6)	0.01	62 (26.5)	58 (24.8)	0.01	23 (9.8)	97 (41.5)	0.08	87 (37.2)	33 (14.1)	0.5
Male	69 (29.5)	45 (19.2)		78 (33.3)	36 (15.4)		34 (14.5)	80 (34.2)		79 (33.8)	35 (15)	
Age (%)												
<50	59 (25.2)	56 (23.9)	0.89	68 (29.1)	47 (20.1)	0.89	27 (11.5)	88 (37.6)	0.8	87 (37.2)	28 (11.9)	0.15
≥50	63 (26.9)	56 (23.9)		72 (30.8)	47 (20.1)		30 (12.8)	89 (38)		79 (33.8)	40 (17.1)	
BMI (%)												
<25.67	70 (29.9)	49 (20.9)	0.049	80 (34.2)	39 (16.7)	0.02	33 (14.1)	86 (36.8)	0.4	86 (36.8)	33 (14.1)	0.5
≥25.67	52 (22.2)	63 (26.9)		60 (25.6)	55 (23.5)		24 (10.3)	91 (38.9)		80 (34.2)	35 (15)	
No myelopathy (%)	63 (26.9)	75 (32.1)	0.02	77 (32.9)	61 (26.1)	0.08	30 (12.8)	108 (46.1)	0.03	103 (44)	35 (15)	0.18
Myelopathy (%)	59 (25.5)	37 (15.8)		63 (26.9)	33 (14.1)		27 (11.5)	69 (29.5		63 (26.9)	33 (14.1)	
One level ACDF (%)	84 (35.9)	58 (24.8)	0.01	94 (40.2)	48 (20.5)	0.01	41 (17.5)	101 (43.2)	0.055	102 (43.6)	40 (17.1)	0.65
Two-level ACDF (%)	38 (16.2)	54 (23.1)		46 (19.7)	46 (19.7		16 (6.8)	76 (32.4)		64 (27.4)	28 (12)	
No collar (%)	79 (33.8)	32 (13.7)	<0.0001	85 (36.3)	26 (11.1)	<0.0001	39 (16.7)	72 (30.8)	<0.0001	70 (29.9)	41 (17.5)	0.03
Collar (%)	43 (18.4)	80 (34.2)		55 (23.5)	68 (29.1)		18 (7.7)	105 (44.8)		96 (41)	27 (11.5)	

ACDF-Anterior cervical discectomy and fusion, BMI-Body mass index, NDI-Neck Disability Index

Table 2: Logistic regression analysis

	P	OR	95% CI for OR	
			Inferior	Superior
Sex	0.010	0.463	0.258	0.831
Age	0.450	1.264	0.688	2.319
BMI	0.196	1.467	0.820	2.625
Myelopathy	0.004	0.389	0.206	0.735
Collar	0.000	4.576	2.536	8.257
Level	0.005	2.401	1.304	4.422

Outcome variable: Early Neck Disability Index (1-month follow-up). OR-Odds ratio, CI-Confidence interval, BMI-Body mass index

Table 3: Logistic regression analysis (12-month follow-up)

	P	OR	95% CI for OR	
			Inferior	Superior
Sex	0.009	0.461	0.257	0.826
Age	0.632	1.158	0.635	2.114
BMI	0.090	1.649	0.924	2.943
Myelopathy	0.058	0.547	0.292	1.022
Collar	0.000	3.780	2.094	6.826
Level	0.015	2.107	1.158	3.836

Outcome variable: Late Neck Disability Index. OR-Odds ratio, CI-Confidence interval, BMI-Body mass index

Table 4: Logistic regression analysis

	P	OR	95% CI for OR	
			Inferior	Superior
Sex	0.059	0.542	0.287	1.024
Age	0.838	1.071	0.554	2.070
BMI	0.506	1.242	0.656	2.349
Myelopathy	0.190	0.640	0.329	1.247
Collar	0.001	2.964	1.545	5.689
Level	0.048	1.991	1.005	3.943

Outcome variable: Early Rx fusion (1-month follow-up). OR-Odds ratio, CI-Confidence interval, BMI-Body mass index

Table 5: Logistic regression analysis

	P	OR	95% CI for OR	
			Inferior	Superior
Sex	0.709	1.117	0.625	1.995
Age	0.320	1.359	0.743	2.486
BMI	0.380	1.301	0.723	2.343
Myelopathy	0.254	1.423	0.776	2.609
Collar	0.012	0.466	0.257	0.843
Level	0.736	1.108	0.610	2.014

Outcome variable: Late Rx fusion (12-month follow-up). OR-Odds ratio, CI-Confidence interval, BMI-Body mass index

In contrast to our results, in the literature, others have reported different conclusions in which the male gender appeared to be a negative predictive factor of surgical outcome. Basques *et al*. in their retrospective study reported that male gender was associated with a higher risk of adverse events following ACDF.[7] Similar results were reported by Gruskay *et al*.[10] Manoharan *et al*. described that male gender was associated with higher hospital readmission rates following orthopedic surgery due to spinal deformities.[11] However, these studies reported results regarding medical or anesthesiological complications and hospital length of stay, without assessing the functional, clinical, or radiological parameters. It has to be emphasized that the rate of complications, which clearly remains a fundamental parameter, represents a different topic in ACDF patients that needs to be evaluated separately from the functional outcome after ACDF.

Narain *et al*. retrospectively reviewed 302 patients who underwent ACDF grouped on the basis of the BMI and found no difference in the risk of surgical complications.[12] However, in this study, the functional status was assessed using only the Visual Analog Scale, and their postoperative follow-up was limited only to 6 months. Results of our study are in line with those reported by Auffinger *et al*. in both ACDF and posterior cervical fusion in 88 patients, including NDI score.[1]

Cervical collar is routinely used following ACDF surgery; however, the clinical evidence supporting this practice is limited. The highest level of evidence available so far comes from the review by Camara *et al*. advised against routine use of cervical collars after ACDF because of a lack of fusion improvement.[8] In our study, we found that the use of cervical collars was associated with a higher risk of both worse early and late NDIs at outpatient follow-up.

Different cohorts of patients undergoing one or multilevel ACDF have been already compared in the literature, focusing on the different risk of surgical complications and the risk of reintervention.[13,14] Veeravagu *et al*. reported that multilevel ACDF correlated with an increased rate of reoperation in a large retrospective study.[14] Therefore, even if different other studies have reported higher rates of surgical complications following multilevel ACDF, at the best of our knowledge, this is the first study specifically designed to compare the functional outcomes of patients undergoing cervical fusion based on fused levels.

Limitations

Limitations of this study are represented by its retrospective nature and by the fact that the coding system prevents to accurately acquire data regarding eventual hospital readmission after follow-up. Further randomized clinical trials are needed to better evaluate the weight of the assessed variables on surgical outcome.

CONCLUSIONS

We evaluated the effect of several variables on the functional and radiological outcomes of patients undergoing ACDF in

a large multicenter study. We found that female sex, the use of postoperative cervical collar, and two-level surgery are significantly associated with a higher risk of worse functional outcome. However, further prospective case–control studies are needed, since a deeper analysis and knowledge of these, often unnoticed, clinical variables could lead to improved care in ACDF patients.

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Conflicts of interest

There are no conflicts of interest.

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