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). 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. 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. Body mass index (BMI), gender, one- or two-level ACDF, and the use of postoperative collars have been nonuniformly advocated as predictive factors.
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.

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 (24.6) | 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
In our study, we found that the use of cervical collars after ACDF because of a lack of fusion from the review by Camara et al. advised against routine use of cervical collars after ACDF because of a lack of fusion improvement. 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. Veeravagu et al. reported that multilevel ACDF correlated with an increased rate of reoperation in a large retrospective study. 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 surgery due to spinal deformities. 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. 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.

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. 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.

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. Similar results were reported by Gruskay et al. Manoharan et al. described that male gender was associated with higher hospital readmission rates following orthopedic

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**Table 2: Logistic regression analysis**

|    | P     | OR    | 95% CI for OR |
|----|-------|-------|---------------|
| 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: Late Neck Disability Index (12-month follow-up). OR-Odds ratio, CI-Confidence interval, BMI-Body mass index

**Table 3: Logistic regression analysis**

|    | P     | OR    | 95% CI for OR |
|----|-------|-------|---------------|
| Sex| 0.009 | 0.461 | 0.257 0.826   |
| Age| 0.632 | 1.158 | 0.835 2.114   |
| BMI| 0.090 | 1.849 | 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 |
|----|-------|-------|---------------|
| 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 Neck Disability Index (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 |
|----|-------|-------|---------------|
| 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: Early Neck Disability (1-month follow-up). OR-Odds ratio, CI-Confidence interval, BMI-Body mass index
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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