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# A comprehensive study on cervical foraminal stenosis severity: Clinical implications and postoperative outcomes

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## ABSTRACT

**Aim**: To assess the clinical implications of cervical foraminal stenosis severity and evaluate the impact of surgical intervention on postoperative outcomes.

**Methods:** A retrospective analysis was conducted on 557 patients who underwent anterior cervical discectomy and fusion (ACDF) surgery for cervical disc herniation between 2020 and 2023. Cervical foraminal stenosis severity was graded using a classification system based on axial T2-weighted magnetic resonance imaging (MRI) images. Preoperative and postoperative visual analog scale (VAS) and Neck Disability Index (NDI) scores were recorded to evaluate pain and disability levels.

**Results:** The majority of patients (79.5%) exhibited severe stenosis (grade 2), with significant improvements in VAS and NDI scores observed postoperatively. Patients with grade 2 stenosis demonstrated the most pronounced reduction in VAS scores, indicating greater pain relief following surgery. However, patients with grade 0 and grade 1 stenosis also experienced improvements in pain and disability scores postoperatively.

**Conclusions:** Cervical foraminal stenosis severity significantly influences postoperative outcomes, with surgical intervention leading to substantial improvements in pain and disability levels, particularly in cases of severe stenosis. These findings underscore the importance of accurately grading stenosis severity and considering surgical intervention as an effective treatment option for symptomatic patients.

**Key words:** Cervical neuroforaminal stenosis, anterior cervical discectomy and fusion (ACDF), VAS, NDI, outcomes.

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## 1. Introduction

Cervical neuroforaminal stenosis is the narrowing of the space in the neck through which the nerves and spinal cord pass. Narrowing of the cervical vertebrae joints can be caused by three different factors. One of these is superior articular process hypertrophy, which is the enlargement of the small bony protrusions in the joints of the cervical vertebrae. This growth can cause stenosis by narrowing the space through which the nerves pass. Another cause is ligamentum flavum hypertrophy, which is the thickening and hardening of the yellow ligaments between the vertebrae. Thickening can cause stenosis by narrowing the space through which

the nerves pass. Intervertebral Disc Herniation can cause the discs between the cervical vertebrae to dislocate due to aging or trauma, which can narrow the space through which the nerves pass and lead to cervical neuroforaminal stenosis [1]. Mild stenosis cases can often remain asymptomatic, while radiologically advanced moderate to severe stenosis can cause radiculopathy and motor deficits. Treatment is determined based on the severity and duration of symptoms. In mildly symptomatic, short-term patients who respond to conservative treatment, surgical treatment is not considered a priority. However, in more advanced cases, surgical treatments can be performed to improve the quality of life [2]. Anterior cervical discectomy and fusion (ACDF) surgery is the current gold standard treatment for cervical disc herniation that causes stenosis [3].

Magnetic resonance imaging (MRI) can reveal stenosis and its severity [4]. However, there are few conclusive studies on measuring and classifying the severity of this stenosis. The imaging classification established by Kim et al. can be used to determine the degree of canal stenosis preoperatively [5]; however, there is limited research on the clinical implications of this classification and its impact on quality of life and symptoms post-surgery. This study aims to assess the impact of canal diameter severity on post-surgery pain and quality of life, as observed through MRI.

## 2. Materials and metods

### *2.1. Patient data*

The study protocol was approved by the Istanbul Medipol University ethical board numbered 432/2024. All patients provided written informed consent for the procedures. We retrospectively analyzed 557 patients who underwent ACDF surgery for cervical disc herniation between 2020 and 2023. We included patients over 18 years of age who underwent elective one level ACDF for cervical radiculopathy or myelopathy. Exclusion criteria for the study were patients without preoperative and postoperative MRI images, revision surgery, reoperation, surgery for any malignant tumor, infection, or trauma. Demographic data, including age, gender, and clinical follow-up time, were collected through file review. Clinical evaluation was conducted using the Visual Analogue Scale (VAS) and Neck Disability Index (NDI) preoperatively and 12 months postoperatively.

### *2.2. Surgical Technique of ACDF*

Following intraoperative fluoroscopic distance determination from the anterior cervical region, a longitudinal incision of approximately 2 cm was made to open the platysma. The sternocleidomastoid muscle was then lateralized, and the anterior cervical corpus was reached in the midline. After the corpus was exposed by peanut dissection, the distance was confirmed by fluoroscopy. A discectomy was performed, which included the endplates. Posterior osteophytes were removed using a high-speed drill and Kerrison rongeur in some areas. The fragments in the foramen were controlled with a nerve hook. After adequate decompression, the posterior longitudinal ligament was opened, and a cervical PEEK cage was placed in the disc space.

### *2.3. Cervical foraminal stenosis grading system*

A grading system for cervical foraminal stenosis was used to evaluate the condition at the symptomatic cervical level. A grading system for cervical foraminal stenosis was used to evaluate the condition at the symptomatic cervical level. Axial T2-weighted MR images were employed for this purpose. The grading system used was the one described by Kim et al [5], which scores

the stenosis based on the distance of the affected intravertebral disc. The evaluation of cervical stenosis is based on the difference between the width of the narrowest part of the foramen and the width of the extraforaminal nerve root at the anterior margin of the superior articular process. A grade of 0 indicates a wide neural foramen with no stenosis, while a grade of 1 indicates moderate stenosis where the narrowest width of the neural foramen is between 51-100% of the width of the extraforaminal nerve root. Grade 2 refers to severe cervical stenosis where the width of the neural foramen is equal to or less than 50% of the width of the extraforaminal nerve roots.

### *2.4. Clinical outcome measures*

We assessed patients' pain and quality of life preoperatively (approximately 7 days before surgery) and postoperatively (at least 1 year after surgery) using the following clinical outcome measures: VAS and NDI [6,7]. Questionnaires assessing postoperative clinical outcomes were administered during the patient's 12th month follow-up visit. NDI scores were categorized as 0-4 as no disability, 5-14 as mild disability, 15-24 as moderate disability, 25-30 as severe disability, and 35-50 as severe disability.

### *2.5. Statistical analysis*

The data was analyzed using statistical tests to identify significant relationships between variables. For continuous data, such as age or pain scores, the researchers used the Mann-Whitney U-test to compare groups. For categorical data, such as the presence or absence of a particular condition, the chi-square test was employed. However, it is important to note that this test requires a minimum number of respondents in each category. Fisher's exact test was used when the aforementioned condition was not met. Statistical analyses were conducted using IBM SPSS Statistics version 23. A finding was deemed statistically significant if the probability of its occurrence by chance was less than 5% ($p$-value < 0.05). This threshold ensures that observed differences are not due to chance and reflect a real relationship between variables.

## 3. Results

A series of demographic characteristics and clinical measurements were evaluated. The total number of participants was 557, with 49.2% (274) being female and 50.8% (283) being male. The mean age was 48.2 years, with a range of 25 to 72 years. The distribution of stenosis grades was as follows: grade 0 (9.9%, 55 individuals), grade 1 (10.6%, 59 individuals), and grade 2 (79.5%, 443 individuals). With regard to the distribution according to spine level, 0.7% were classified as level 2-3 (four patients), 30.3% as level 3-4 (169 patients), 34.5% as level 4-5 (192 patients), 23.5% as level 5-6 (131 patients), and 11.0% as level 6-7 (61 patients). The mean preoperative VAS score was 7.24 (minimum 5, maximum 9), while the mean postoperative VAS score was 3.21 (minimum 1, maximum 7). Additionally, the preoperative NDI was calculated as 18.7 (minimum 5, maximum 30) and postoperative NDI was calculated as 5.94 (minimum 0, maximum 13) (Table 1).

The preoperative and postoperative VAS scores and the changes in these scores according to the degree of stenosis are presented, along with the related statistical $p$-values. The findings indicate that the mean preoperative VAS score in patients with stenosis grade 0 was 5.5, while the mean postoperative VAS score was 1.5. In this case, a mean decrease of 4.56 in VAS scores was observed, and the $p$-value obtained was 0.052, which is within the statistically significant range. A similar trend was observed for stenosis grade 1, with the preoperative VAS score averaging 5.5 and the postoperative VAS score averaging 1.5, resulting in a mean decrease in VAS scores of 4.27.

**Table 1**. Characteristic features of the patients included in the study.

| **Variables** | | **Value (n (%) / M ± SD [min - max])** |
|---|---|---|
| Sex | Female | 274 (49.2%) |
| | Male | 283 (50.8%) |
| Age | | 48.2 ± 11.2 [25 - 72] |
| Stenosis Grade | 0 | 55 (9.9%) |
| | 1 | 59 (10.6%) |
| | 2 | 443 (79.5%) |
| Level | 2-3 | 4 (0.7%) |
| | 3-4 | 169 (30.3%) |
| | 4-5 | 192 (34.5%) |
| | 5-6 | 131 (23.5%) |
| | 6-7 | 61 (11.0%) |
| Preoperative VAS | | 7.24 ± 1.05 [5 - 9] |
| Postoperative VAS | | 3.21 ± 1.89 [1 - 7] |
| Preoperative NDI | | 18.7 ± 5.02 [5 - 30] |
| Postoperative NDI | | 5.94 ± 2.72 [0 - 13] |
| Follow-up time (month) | | 12.1 ± 1.24 [10 - 14] |

*VAS: Visual Analogue Scale, NDI: Neck Disability Index, SD: Standard Deviation, M: mean, min: minimum, max: maximum, p<0.05*: Statistically significant.*

However, the *p*-value obtained in this case was 0.207, which is statistically insignificant. In patients with stenosis grade 2, the mean preoperative VAS score was 7.5, while the mean postoperative VAS score was 4. In this case, an average decrease of 3.93 in VAS scores was observed, and the *p*-value obtained was 0.006, which is statistically significant (Table 2).

The data presented in Table 3 was analyzed to determine the impact of degree of stenosis on preoperative and postoperative NDI scores. In patients with stenosis grade 0, the preoperative NDI score was 11.98 on average, while the postoperative NDI score was 2.0 on average. In this case, a mean decrease of 9.98 in NDI scores was observed, and the *p*-value obtained was 0.006, which is statistically significant. For stenosis grade 1, the mean preoperative NDI score was 13.95, while the mean postoperative NDI score was 1.80. In this instance, a mean decrease of 12.15 in NDI scores was observed, and the *p*-value obtained was 0.103, which is statistically insignificant. In patients with stenosis grade 2, the mean preoperative NDI score was 20.20, while the mean postoperative NDI score was 6.98. In this instance, an average decrease of 13.22 in NDI scores was observed, with a *p*-value of <0.001, which is statistically significant. The results demonstrate that preoperative NDI scores increase with increasing stenosis grade, while postoperative NDI scores

**Table 2.** Showing preoperative VAS and postoperative VAS scores according to stenosis levels.

| **Stenosis** | **Preoperative VAS** | **Postoperative VAS** | **VAS Change (Postoperative VAS- Preoperative VAS)** | ***p*-value** |
|---|---|---|---|---|
| | **Value (n (%) / M ± SD [min - max])** | | | |
| **0** | 5.64 ± 0.48 [5 - 6] | 1.07 ± 0.26 [1 - 2] | 4,56 | Stenosis 0-1 *p* = 0.052 |
| **1** | 5.86 ± 0.34 [5 - 6] | 1.59 ± 0.49 [1 - 2] | 4,27 | Stenosis 1-2 *p* = 0.207 |
| **2** | 7.62 ± 0.78 [6 - 9] | 3.69 ± 1.82 [1 - 7] | 3,93 | Stenosis 0-2 *p* = 0.006* |

*VAS: Visual Analogue Scale, SD: Standard Deviation, M: mean, min: minimum, max: maximum, p<0.05*: Statistically significant.*

decrease. In particular, patients with stenosis grade 2 exhibited the most pronounced postoperative NDI score decrease, which was statistically significant. (Table 3).

**Table 3.** Showing preoperative NDI and postoperative NDI scores according to stenosis levels.

| Stenosis | Preoperative NDI | Postoperative NDI | NDI Change (Postoperative NDI- Preoperative NDI) | *p*-value |
|---|---|---|---|---|
| | Value (n (%) / M ± SD [min - max]) | | | |
| **0** | 11.98 ± 3.57 [5 - 17] | 2.00 ± 1.43 [0 - 4] | 9.98 ± 3.94 [2 - 16] | Stenosis 0-1 $p = 0.006$* |
| **1** | 13.95 ± 2.81 [5 - 17] | 1.80 ± 1.42 [0 - 4] | 12.15 ± 2.97 [5 - 17] | Stenosis 1-2 $p = 0.103$ |
| **2** | 20.20 ± 4.27 [12 - 30] | 6.98 ± 1.86 [4 - 13] | 132.23 ± 3.87 [4 - 24] | Stenosis 0-2 $p < 0.001$* |

*NDI: Neck Disability Index, SD: Standard Deviation, M: mean, min: minimum, max: maximum, p<0.05*: Statistically significant.*

## 4. Discussion

Cervical neuroforaminal stenosis presents a complex scenario where radiological findings from advanced imaging modalities like MRI play a crucial role in understanding the anatomical changes associated with foraminal stenosis [8]. These imaging techniques aid in diagnosing cervical neural foraminal stenosis accurately, excluding other conditions like peripheral neuropathy, predicting prognosis, and determining appropriate treatment strategies [8]. Studies have shown that angled sagittal MRI provides increased specificity and accuracy in diagnosing foraminal stenosis by offering a clearer view of anatomical structures, especially laterally [9].

The relationship between disc degeneration and morphological changes in the intervertebral foramen is essential for diagnosing foraminal stenosis in patients with cervical spondylosis and radiculopathy [10]. The grading systems developed for cervical neural foraminal stenosis through MRI assessments contribute to standardizing the evaluation of this condition [11]. It has been highlighted that the correct diagnosis of cervical stenosis is crucial as it can lead to painless compressive cervical motor radiculopathy, emphasizing the importance of long-term evaluation in such cases [12].

In clinical practice, the challenges lie in translating these detailed radiological findings into effective treatment strategies. For instance, the incidence of cervical stenosis can be reduced by carefully placing cerclages and utilizing anti-stenosis tools [13]. Moreover, the prevention of graft subsidence following anterior cervical reconstruction is crucial to avoid sagittal balance loss and recurring foraminal stenosis [14]. Understanding the histopathological findings associated with cervical stenosis, especially in postmenopausal women, can provide insights into the progression of this condition [15].

The study on the impact of cervical foraminal stenosis on clinical outcomes utilized an imaging-based classification system to objectively assess stenosis severity. The majority of participants were found to have grade 2 stenosis, indicating severe narrowing and symptomatic presentation that may necessitate surgical intervention. The research also evaluated the effect of surgical intervention on clinical outcomes, showing significant improvements in VAS and NDI scores postoperatively, particularly in cases of grade 2 stenosis.

We also evaluated the impact of surgical intervention on clinical outcomes. The findings suggest that surgical treatment plays a crucial role in symptom relief for patients with severe stenosis, highlighting the positive impact of surgery on clinical outcomes.

The differences between preoperative and postoperative VAS and NDI scores suggest that surgery plays an important role in symptom improvement. In particular, in patients with grade 2 stenosis, surgical intervention significantly contributed to symptom relief. This suggests that surgical treatment has a positive impact on clinical outcomes, especially in cases of severe stenosis.

### *4.1. Limitations*

Despite the comprehensive nature of this study, several limitations should be acknowledged. Firstly, the retrospective design of the study may introduce selection bias and limit the generalizability of the findings. Additionally, the reliance on patient-reported outcome measures such as the VAS and NDI may be subject to reporting bias. Furthermore, the study focused exclusively on patients who underwent ACDF surgery, limiting the generalizability of the results to other surgical interventions or conservative treatments. Moreover, the relatively short follow-up period of 12 months may not capture long-term outcomes or complications associated with cervical foraminal stenosis and surgical intervention. Finally, the study did not assess factors such as comorbidities, smoking status, or occupational factors, which may influence postoperative outcomes and should be considered in future research. Despite these limitations, this study provides valuable insights into the clinical implications of cervical foraminal stenosis severity and the impact of surgical intervention on patient outcomes.

### *4.2. Conclusions*

This research has enhanced our comprehension of the seriousness of cervical foraminal stenosis and how surgical intervention affects clinical results. The results of the clinical VAS and NDI tests are significantly affected, particularly in patients with grade 2 stenosis. Consequently, the grading of foraminal stenosis should be regarded as a crucial indicator of the clinical outcome.

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