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Micromotion after anterior cervical discectomy and fusion with anterior plating

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ABSTRACT

Background: Anterior cervical discectomy and fusion (ACDF) is one of the most beneficial surgical procedures to treat herniated discs. Micromotion is a small motion between the fused adjacent cervical segments. This study compares the micromotion in different cervical movements following ACDF with anterior plating. The data can further enhance cervical stabilization and provide safer long-term results of ACDF. This study examines the degree of micromotion after the ACDF procedure with anterior plating.

Methods: This was a retrospective descriptive study. The study subjects were patients who underwent ACDF with anterior plating at National Brain Center Hospital, Indonesia between February 2019 and January 2022. All patients who were treated with ACDF were included in the study.

Results: There was a total of 41 patients who underwent ACDF surgery from February 2019 to January 2022 meeting the criteria. The shift of the cervical intervertebral disc angles in the flexion position was in the approximate range of 5.25° – 6.83°. In the extension position, the angle shift was in the approximate range of 2.75° – 4.79°. The cervical vertebrae level with the least alteration was C3 – C4 and with the most alteration was C6 – C7 for flexion and C4 – C5 for extension.

Conclusion: C5 – C6 is the most common site for disc herniation. The stabilization of ACDF could still be increased further. The findings of our evaluation of C5 – C6 are in line with previous studies calculating the flexion-extension range. Micromotion of the adjacent cervical vertebral segment still occurred even after the ACDF procedure and anterior plating. Other stabilization techniques could potentially improve structural outcomes.

Keywords: Anterior cervical approach, anterior cervical discectomy and fusion, cervical range of motion, cervical spine, herniated disc.

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INTRODUCTION

Herniated disc is the most common disorder of the spine that can affect people of varying ages. It can be caused by sudden mechanical trauma or degenerative changes throughout the years.[1] Herniated disc occurs annually in 5 – 20 of 1000 adults, mostly male sex and in the age between 30 – 60 years old.[2] While disrupting the portion of the spine which assists movement and sensations of the head and upper limbs to the autonomic nervous system such as the respiratory function, cervical disc herniation is an important disease that can endanger patients.[1]

Spontaneous regression of disc herniation is very rare. It usually requires management such as physiotherapy or surgery.[3] One of the most common surgical procedures to treat herniated discs is anterior cervical discectomy and fusion (ACDF). The anterior cervical approach gives surgeons easier access to the vertebral column. It results in higher efficiency in managing the pathology. ACDF itself is known for having a lower complication rate compared to its close alternative, anterior cervical corpectomy and fusion (ACCF).[4,5] ACDF procedure is usually completed by fusing the cervical spine and adding it with rigid or dynamic plates. The stability then can be improved further using lateral mass screws, trans articular screws, unilateral pedicle screws, or bilateral pedicle screws. Additional stabilization is usually needed for ACDF procedure in long multilevel disc herniation.[6–8]

ACDF provides a good outcome in reducing clinical symptoms. In a study by Elsayed *et al.*, 36.8% of patients of stand-alone cage ACDF and 42.9% of patients of ACDF with anterior plating obtained relief of all perioperative symptoms and improvement of abnormal findings.[9] The improvement accounts for the high fusion rate achieved with the ACDF procedure. ACDF without anterior plating had fusion rates of 92.1% for single-level and 79.9% for two-disc-level disease. Anterior plating increased the fusion rate to 97.1% for single-level and 94.6% for two disc-level diseases. The average fusion time of ACDF is 3 – 12 months.[10,11] However, ACDF with and without anterior plating had a range of complications such as dysphagia, laryngeal nerve palsy, infection, adjacent segment disease, and pseudoarthrosis.[12] Several previous studies indicated that ACDF with stand-alone cages had lower long-term outcomes and a higher risk of end plate nonunion, cage subsidence, and cervical kyphosis compared to ACDF with anterior plating. In one study by Han *et al.*, anterior plating decreased the risk of cage subsidence from 36.1% to 15.6% and cervical kyphosis from 15.8% to 7.6%.[13,14]

Even with a better outcome, ACDF with anterior plating could still not achieve optimum correction if structural complications occurred. The immediate structural complications include plate-fixing malposition and false measurement, while the progressive ones include moving, loosening, and breaking of the plate or screw. Most of the immediate complications are user-related "failure to construct", while most of the progressive complications are naturally occurring "construct failure." In order from the most common, the structural complications are plate loosening (3.2%), oblique plate positioning (2.5%), screw moving to penetrate the endplate (1.9%), and screw loosening (1.7%).[15,16]

Three out of the four most common structural complications are caused by the biomechanics of the spine.[15] A potential inducing factor to these progressive complications is a little movement between consecutive segments which are fused. We define this movement as micromotion. It is a movement of less than 2 mm which is influenced mostly by the movement of the neck, particularly flexion and extension which moves the cervical spine within the same axis as the fusion plate and screws. Micromotion can decrease the stability of the cervical spine even after ACDF with the anterior plating procedure, which can slow down the fusion and healing process. It will negatively affect the clinical outcome for patients months or years after the procedure.[17,18]

The purpose of this study is to compare the micromotion in fused cervical spine segments that is achieved by different cervical movements in patients following ACDF surgery. The study data can be used further to enhance cervical stabilization and provide safer results of ACDF in the long term.

METHODS

This study was conducted as a retrospective descriptive study. The study subjects were patients who underwent ACDF with anterior plating at National Brain Center Hospital, Indonesia between February 2019 and January 2022. We followed the subjects for up to one year.

All patients who had herniated nucleus pulposus at the cervical level and were treated with ACDF and anterior plating were included in the study. The exclusion criteria were patients who did not comply with post-operative radiographic follow-up. Additionally, the data will also be excluded if the obtained data from lateral cervical spine plain radiographs did not comprise the position of erect, flexion, and extension.

RESULTS

There was a total of 96 patients who underwent ACDF with anterior plating surgery from February 2019 to December 2022. The inclusion criteria were met in 41 cases (42.71%). The other 55 cases were excluded from the study because of incomplete radiographs. The patient selection can be seen in Fig. 1.

The demographic characteristic of the sample can be seen in Table 1. There were 25 male (60.98%) and 16 female (39.02%) patients. The age range of the patients was six cases in 30 – 39 years old (14.63%), 16 cases in 40 – 49 years old (39.02%), 11 cases in 50 – 59 years old (26.83%), and eight cases in 60 – 69 years old (19.51%). We found the 40 – 49 years old as the group with the highest number of cases. From the radiographic study, we found 20 single-level disc herniation (48.78%), 20 two-level disc herniation (48.78%), and one three-level disc herniation (2.44%). The locations of the disc herniation varied between four cases on the C3 – C4 level (9.76%), 19 cases on the C4 – C5 level (46.34%), 34 cases on the C5 – C6 level (82.93%) and six cases on the C6 – C7 level (14.63%). The highest number of cases occurred on the C5 – C6 level of cervical vertebrae.

We further calculated the intervertebral disc angle created between the midplanes of two consecutive vertebral bodies in the position of erect, flexion, and extension. With the ventral side facing left and the dorsal side facing right, the intervertebral disc angle shift in the flexion position was in the counter-clockwise direction, whereas in the extension position was in the clockwise direction (Fig. 2).

The angle shift in flexion and extension of cervical vertebrae can be seen in Table 2. Intervertebral disc angle alterations are found by the motion of flexing and extending cervical vertebrae in all patients. The shift of the intervertebral disc angles in flexion position were 5.25° ± 3.95° on the C3 – C4, 5.84° ± 3.04° on the C4 – C5, 5.79° ± 4.04° on the C5 – C6 and 6.83° ± 3.97° on the C6 – C7. In the extension position, the angles shift were 2.75° ± 1.5° on the C3 – C4, 4.79° (0° – 19°) on the C4 – C5, 3.42° (0° – 9°) on the C5 – C6 and 3.5° ± 2.58° on the C6 – C7. The cervical vertebrae level with the least alteration in flexion and extension position was C3 – C4. We also found C6 – C7 and C4 – C5 as the cervical vertebrae levels with the most angle alteration in flexion and extension

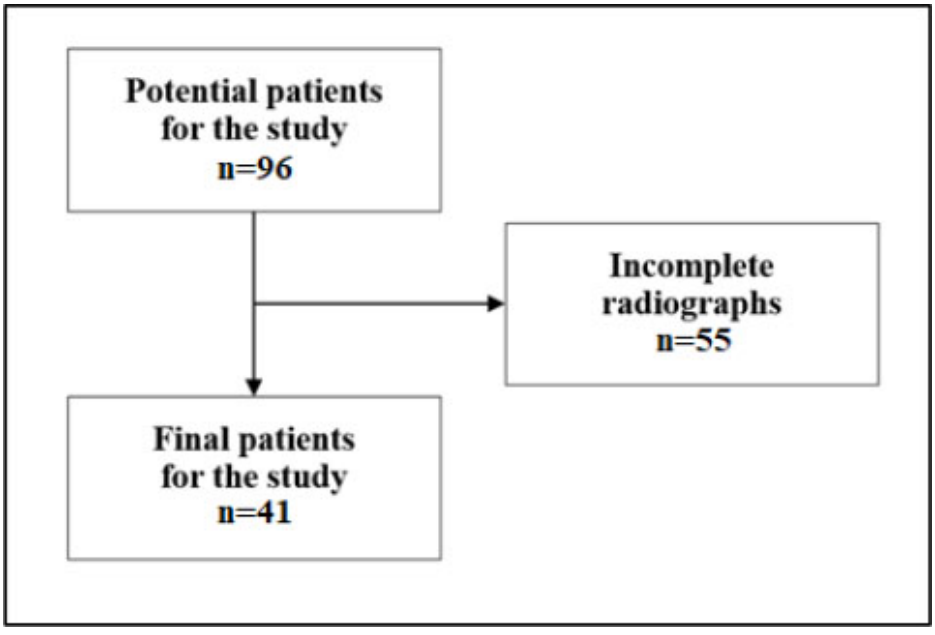

Figure 1. Patient selection.

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position consecutively.

DISCUSSION

This descriptive study presented the micromotion that occurred in different levels of the cervical spine. The individualized data showed the effect of the ACDF procedure on the respective vertebral segment structure and stabilization better than the levels of plating involved when being compared to each other.

From the demographics, we found higher cases of herniated nucleus pulposus in the male gender and in the age range from 40 to 59 years old. Many possible factors are associated with this prevalent finding.[19] One of them is a mechanical insult from dynamic work which has a higher correlation with the said gender and age range.[20,21] The C5 – C6 as the vertebral level with the highest cases of disc herniation is also consistent with previous studies. The C5 – C6 level of vertebrae is the most mobile segment of the whole cervical spine. The wider mobilization comes with a cost of heavier stress than the rest of the cervical vertebrae, making it the most prone site of injury and degeneration.[22,23]

ACDF procedure helps to stabilize the cervical segment in disc herniation cases with a good 10-year clinical outcome prognosis, even with the chance of dizziness and balance problems as a daily outcome.[24,25] While the procedure has many advantages such as the wider surgical view of the anterior approach, many studies concluded that the stabilization given by ACDF is not yet perfect. In a study by Li *et al.*, a 3-dimensional Finite Element Model (FEM) was used to simulate biomechanical changes in three planes caused by the movement of flexion-extension, axial rotation, and lateral bending. It was concluded that ACDF impairs normal cervical biomechanics, especially at adjacent segments, generating hypermobility and higher stress.[26] Limanówka *et al.* demonstrated an increase in segmental range of motion occurring within three months for single-level ACDF and 6 – 12 months for two-level ACDF.[18] Fluoroscopic and computer study by Mourning *et al.* showed that significant plating motion was detected in 29 out of 48 fusion cervical segments after two weeks postoperative period.[27]

Motion in flexion and extension in the form of a flexion-extension range of motion has been calculated by several studies with no standard or identical results. As the most common site of disc herniation, C5 – C6 levels became the widely researched vertebral levels. A few studies of C5 – C6 showed various ranges of degrees in flexion-extension movement. Tsitsopoulos *et al.* calculated 2.8° ± 1.4° changes in the flexion-extension movement of two-level ACDF with a locking plate. Hart *et al.* calculated 9.1° ± 3.7° changes of one-level ACDF. Scholz *et al.* calculated 5.1° ± 1.7° in flexion and 3.7° ± 1.7° in extension of one-level ACDF.[28–30] The slight degree of changes is in line with

Table 1. Demographic characteristics of the sample

Variables	n	Percentage
Gender		
Male	25	60.98%
Female	16	39.02%
Age (years)		
30 – 39	6	14.63%
40 – 49	16	39.02%
50 – 59	11	26.83%
60 – 69	8	19.51%
Disc herniation level		
Single	20	48.78%
Two	20	48.78%
Three	1	2.44%
Disc herniation locations		
C3 – C4	4	9.76%
C4 – C5	19	46.34%
C5 – C6	34	82.93%
C6 – C7	6	14.63%

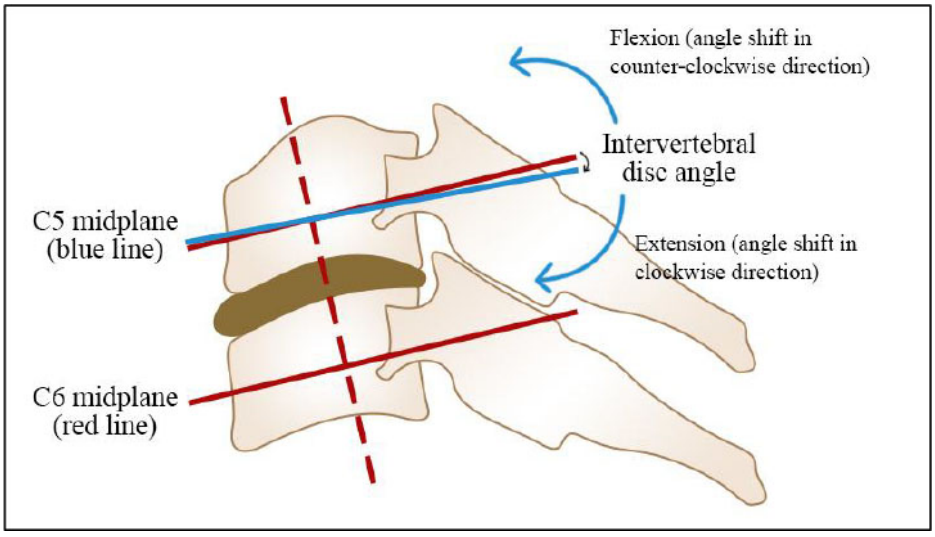

Figure 2. Intervertebral disc angle.

Table 2. Angle shift in flexion and extension of cervical vertebrae

Cervical Levels	n	Angle Shift in Flexion (°)	Angle Shift in Extension (°)
C3 – C4	4	5.25 ± 3.95	2.75 ± 1.5
C4 – C5	19	5.84 ± 3.04	4.79 (0 – 19)
C5 – C6	34	5.79 ± 4.04	3.42 (0 – 9)
C6 – C7	6	6.83 ± 3.97	3.5 ± 2.58

Normally distributed data were presented as mean ± standard deviation, whereas non-normally distributed data were presented as median (minimum-maximum).

the amount of our micromotion finding, approximately 5.79° in flexion and 3.42° in extension position. Unfortunately, not much is discussed about the borderline in which the motions are considered significant to result in worsening clinical outcomes. In the future, comparison with the preoperative micromotion and in a wider population would help significantly for further studies. Evaluation of new models such as elastically deformable implants could also contribute to stronger stabilization.[31]

Micromotion is an important aspect to monitor as it could cause an increase in intradiscal pressure which could lead to a worse regeneration process. The increase is found greater at the extension position compared to the flexion position. Besides the stabilization of the plate-affected vertebral segments, many studies have also reported disc degeneration at the levels adjacent to the fusion.[32]

The present study came with several limitations. The major limitation of our study is the finite data that we could optimize. The study used only postoperative radiographic results without comparing them with the preoperative ones. We also only included follow-up for a short duration while it would take years for further destabilization could take place.

CONCLUSION

This study provided knowledge on how ACDF procedure and anterior plating affect the structural motion of adjacent cervical vertebral segments. While the micromotion still occurred, other additional stabilization techniques could potentially be used to improve the structural outcomes. Further research can be done to maximize the results of this study, especially to fully understand the wide range of influencing factors and ultimately to improve the stabilization of ACDF in the future.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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This study received no specific funding from any funding agency.

ETHICAL APPROVAL

The study has been approved ethically by the Research Ethics Committee of the National Brain Center Hospital.

AUTHOR CONTRIBUTIONS

All authors contributed evenly and significantly through all steps of the research.

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