

# Long-term Outcomes and Complications of Multilevel ACDF, Compared with Single-level ACDF, A Retrospective Study

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## Abstract

**Objective:** To compare the clinical outcomes, radiological parameters, and complication incidence of patients who underwent anterior cervical discectomy and fusion (ACDF) to prove our hypothesis that multilevel ACDF did not have higher rate of complication than single level or 2-level ACDF.

**Methods:** We conducted a retrospective review of 82 consecutive patients who underwent ACDF for treatment of cervical spondylosis at Neurological Institute of Thailand in 10 years (2006 – 2015) by single surgeon. Patients were divided into 3 group (1-level, 2-level and 3 or 4 level ACDF). The clinical courses, fusion rate, postoperative complications, and radiographical adjacent-level changes regarding each group were evaluated.

**Results:** There is no statistical difference in restoration of cervical lordosis, and incidence of post-operative early and late complications between 1-level ACDF, 2-level ACDF and 3 or 4-level ACDF groups ( $P > 0.05$ ). The 3 or 4-level ACDF group had more bleeding ( $P = 0.000$ ) and longer length of stay in hospital ( $p = 0.002$ ), with no clinically significant. Subgroup analysis of 3-level ACDF and 4-level ACDF had no statistical differences in all categories.

**Conclusion:** This study showed that result of multilevel ACDF was not different from 1 or 2-level ACDF in all outcome parameters. Compared to previous systematic review of posterior approach, this study does not show different results and complications. Multilevel ACDF had no higher risk of surgery in comparison to 1 or 2-level ACDF.

**Key words:** ACDF, multilevel ACDF, single-level ACDF, anterior cervical discectomy and fusion, Long-term outcomes, complications

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## Introduction

Cervical spondylotic myelopathy (CSM) and radiculopathy are common causes of neurological dysfunction. These conditions are frequently presented in adult and old age groups. The onset of CSM is typically remarked by fine motor dysfunction and decreased hand dexterity, as well as worsening gait and balance.<sup>1,2</sup>

First introduced by Smith, Robinson, and Cloward in 1958<sup>3</sup>, anterior cervical discectomy and fusion (ACDF) is currently one of the most commonly performed procedure in the cervical spine. Usually, it is reserved for patients with myelopathy and/or intractable radiculopathy secondary to age-related degeneration.<sup>4</sup>

Anterior cervical fusion is shown to be a successful and often preferred treatment option in the surgical management of cervical radiculopathy and CSM.<sup>5</sup> ACDF most commonly addresses single- or two-level disease. Three-level and four-level ACDF, however, are less common and there are limited data regarding their clinical outcomes, particularly for 4-level ACDF.<sup>4</sup>

There is a concern about high rates of complications and pseudarthrosis with multilevel ACDF.<sup>6</sup> The purpose of this study is to compare surgical complications, short-term and long-term outcomes of patients with cervical spondylosis or herniated nucleus pulposus both single and multilevel who underwent ACDF at Neurological Institute of Thailand in 10 years (2006 – 2015).

## Methods

Following institutional review board approval,

a retrospective review of clinical and operative notes was performed to identify all neurosurgical patients who underwent an ACDF at a Neurological Institute of Thailand (NIT) by a single surgeon (T. Tangviriyapaiboon) between 2006 and 2015.

The patients older than 18 years underwent ACDF for treatment of cervical spondylosis were enrolled. Patients with a history of previous cervical spine surgery (n = 9), less than 6 months of follow-up (n = 5), patients underwent ACDF following trauma, tumor resection, or primary spinal infections as well as patients who experienced combined (anterior/posterior) approaches, were excluded from this study. Patient with incomplete document or imaging were also precluded. (n = 40) (Figure 1)

Patient data including age, sex, comorbidities, presenting symptoms and degree of neck pain measured by visual analog scale (VAS) pain score were collected from clinical notes. The intraoperative data, including discectomy levels, type of bone graft, and estimated blood loss, were gathered from the operative notes.

Outcomes consisted of perioperative complications, need for surgical revision due to pseudarthrosis or adjacent segment disease (ASD), symptoms and last follow up pain score were evaluated. Outcome variables were obtained from clinical documents at the last available follow-up.

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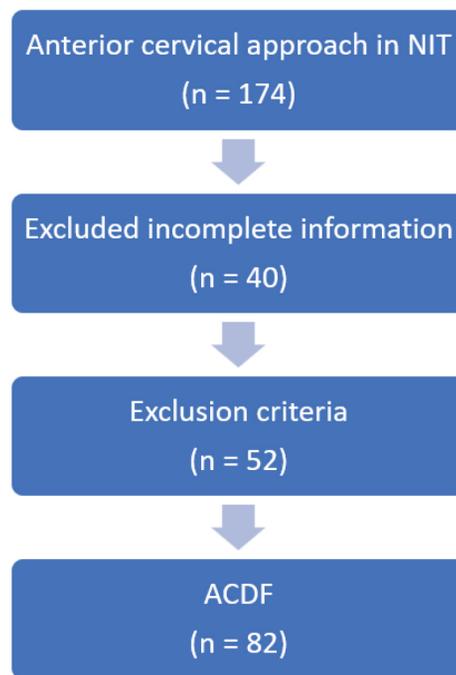


Figure 1 Patient selection flowchart showing the final cohort of 82 patients who underwent ACDF.

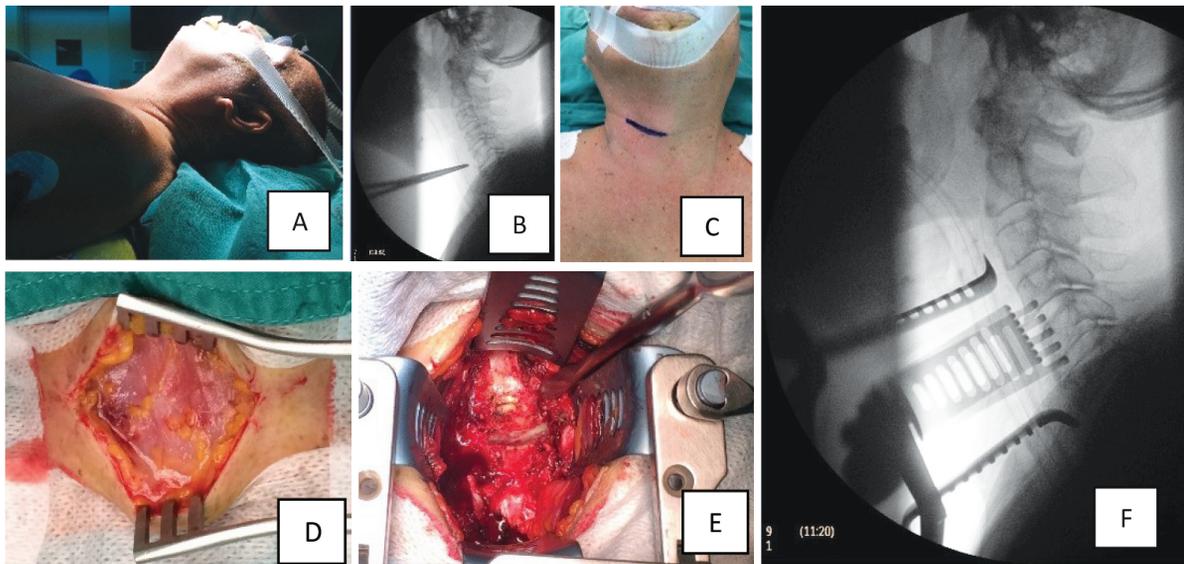


Figure 2 Intraoperative view of 3-level ACDF

### Operative technique

Patient was placed in supine position. Neck was hyperextended and shoulder was gently distracted down if lower cervical level was affected (Figure 2A). Skin incision was marked under fluoroscopic

guidance (Figure 2B). We preferred to operate on the right of the neck in all patients (Figure 2C). Skin incision is usually performed in transverse cervical fashion, except in patient who had multilevel disease or high vertebral height; incision was done

by longitudinal incision parallel to medial side of sternocleidomastoid muscle (SCM). Subcutaneous fat was undermined in all direction and bleeding was carefully checked. Platysma was opened in transverse fashion at midline to medial head of SCM (Figure 2D). Avascular plane was identified and dissected with Metzenbaum's scissor until prevertebral fascia was identified. Prevertebral fascia was sharply opened. Longus colli was dissected laterally to expose lateral cervical uncovertebral joint bilaterally. Cervical self-retraining retractors were applied (Figure 2E), then fluoroscope was used to identify level of surgery (Figure 2F). Discectomy was done under microscope until both uncovertebral

joints was seen and dura was freely identified level by level (Figure 3G). In term of fusion, either iliac bone graft or PEEK (Polyetheretherketone) was used (Figure 3H). Anterior plate fixation was performed in all cases with more than 2 level ACDF, but in 1 or 2 level ACDF, stand-alone PEEK maybe used in patients who not required reduction. After plate-screw system was placed, fluoroscope was used for instrumental adjustment (Figure 3I-J). Bleeding was checked and stopped. Vacuum drain was not inserted in all cases. Platysma and subcutaneous tissue were sutured with Vicryl 3-0. Skin was closed by subcuticular stitches and sterile strip was placed.

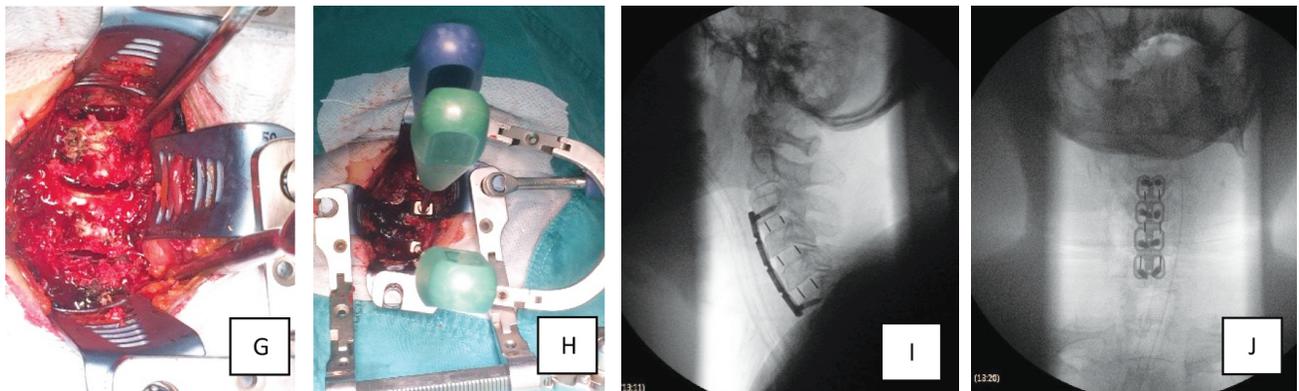


Figure 3 Intra operative view of 3-level ACDF (cont.)

Table 1 Demographic data

| Data                            | 1-level: N = 35 | 2-level: N=27 | > 2-level: N=20 | p Value |
|---------------------------------|-----------------|---------------|-----------------|---------|
| Age (Median)                    | 54 (26-75)      | 53 (35-75)    | 56 (40-76)      | 0.286   |
| Sex                             |                 |               |                 |         |
| Male (%)                        | 19 (54.3)       | 9 (33.3)      | 6 (30.0)        | 0.123   |
| Underlying disease (%)          |                 |               |                 |         |
| DM                              | 6 (17.1)        | 5 (18.5)      | 5 (25.0)        | 0.769   |
| HT                              | 15 (42.9)       | 8 (29.6)      | 14 (70.)        | 0.021   |
| AF                              | 0 (0)           | 1 (3.7)       | 1 (5.0)         | 0.326   |
| Asthma                          | 2 (5.7)         | 2 (7.4)       | 3 (15.0)        | 0.530   |
| Anxiety                         | 1 (2.9)         | 1 (3.7)       | 0 (0)           | 1.000   |
| Old CVA                         | 1 (2.9)         | 1 (3.7)       | 2 (10.0)        | 0.556   |
| Other                           | 11 (31.4)       | 4 (14.8)      | 8 (40.0)        | 0.138   |
| Level                           |                 |               |                 |         |
| C2-3 (%)                        | 0               | 0             | 0               |         |
| C3-4 (%)                        | 11.40           | 18.50         | 60.00           | 0.000   |
| C4-5 (%)                        | 2.90            | 55.60         | 100             | 0.000   |
| C5-6 (%)                        | 57.10           | 81.50         | 100             | 0.001   |
| C6-7 (%)                        | 28.60           | 44.40         | 70              | 0.012   |
| C7-T1 (%)                       | 0               | 0             | 0               |         |
| Current Smoking (%)             | 5 (14.3)        | 3 (11.1)      | 2 (10.0)        | 0.738   |
| Drug Abuse (%)                  | 0               | 0             | 0               |         |
| Current Alcohol user (%)        | 5 (14.3)        | 5 (18.5)      | 2 (10.0)        | 0.791   |
| Main clinical (%)               |                 |               |                 | 0.193   |
| Myelopathy                      | 15 (42.9)       | 17 (63)       | 14 (70)         |         |
| Radiculopathy                   | 19 (54.3)       | 9 (33.3)      | 6 (30)          |         |
| Neck pain                       | 1/2.9%          | 1 (3.7)       | 0 (0)           |         |
| Follow up time (years) (Median) | 4 (2-6)         | 3 (1-5)       | 3 (1-5)         | 0.635   |

DM = Diabetes mellitus type II

AF = Atrial fibrillation

HT = Hypertension

CVA = Cerebrovascular accident

### Statistical Analysis

Patient variables are presented as the median where applicable. Binary outcomes were compared using chi-square tests while continuous variables were compared using Fisher’s exact test and paired samples test. Statistical analyses were performed using Microsoft access and SPSS. A p value < 0.05 was defined as statistically significant.

### Results

#### Demographics

A total of 174 ACDF were performed in our institution during 2006-2015. Eighty-two cases met our inclusion and exclusion criteria, with 35 cases underwent single level ACDF, 27 cases underwent 2-level ACDF and 20 cases underwent more than

2-level ACDF (Figure 1). There is no difference in patient's demographic data, except hypertension that was found to be a significant comorbid in > 2-level ACDF group compared with other groups. Cervical myelopathy was the main presenting symptom in multilevel ACDF patients, while radiculopathy was the major presenting symptom in single level group, but there was no statistical difference among these groups.

This study found that C5-6 (100% in > 2-level, 81.5% in 2-level, 57.1% in 1-level) was the most affected segment followed by C4-5, C6-7 and C3-4 in orderly (Table 1). A significantly higher proportion of patient in > 2-level group (100%,70%,60%) required surgery at C4-5, C6-7 and C3-4 respectively. Neither C 2-3 nor C7-T1 segment was involved in any group.

**Table 2** Operative data

| Group                      | 1-level      | 2-level       | > 2-level     | p Value |
|----------------------------|--------------|---------------|---------------|---------|
| Graft                      |              |               |               |         |
| Autologous bone (%)        | 8 (22.9)     | 9 (33.3)      | 9 (45.0)      | 0.231   |
| Operative time (Minute)*   | 120 (70-240) | 165 (100-300) | 226 (151-325) | 0.000   |
| EBL (ml)*                  | 20 (5-150)   | 40 (10-160)   | 125 (30-700)  | 0.000   |
| LOS (day)*                 | 4 (2-16)     | 4 (2-19)      | 5.5 (4-26)    | 0.002   |
| Delta Cobb angle (degree)* | -3.37        | -4.148        | -2.65         | 0.646   |

\* = Median

Delta Cobb angle = Immediate post-operative Cobb angle – Pre-operative Cobb angle

### Early Complications

There is no patient in our study had neurological decline, surgical revision, or deep venous thrombosis (Table 3). Dysphagia was the most frequent complication in all groups (25.7%,33.3%,40% respectively), but no statistically significant among

### Comparison of Perioperative outcomes

In the study, the bony fusion was usually performed using PEEK (Polyetheretherketone) with or without anterior plate fixation. Autologous bone grafts harvested from anterior iliac crest were used as much as 22.9%, 33.3% and 45% in 1-level, 2-level and >2-level group, respectively. Operative time was increased according to increased number of operative levels (Table 2). Blood loss was increased significantly in > 2-level ACDF but any of patient in all groups have an anemic symptom or need for blood transfusion. Length of stay in > 2-level ACDF group (5.5 days) was longer than other groups (4 days). Delta Cobb angle in all group was not significantly changed.

them. Dysphonia was detected mostly in single level group (17.1%) but there was no statistical significance comparing with other groups. One patient in single level ACDF group was re-admitted due to urinary tract infection and was treated with antibiotics for 1 week. Wound complication was

found in 3 patients, all of them were a superficial wound dehiscence and were treated with wound dressing until primary closure as out-patient cases.

In term of post-operative pain, when patient

was fully conscious, was evaluated and recorded in VAS score. In all groups, there was no difference in post-operative pain at early period and before patients were discharged from hospital.

**Table 3** Early post-Operative complications

| Group                  | 1-level | 2-level  | > 2-level | p Value   |       |
|------------------------|---------|----------|-----------|-----------|-------|
| Dysphagia (%)          |         | 9 (25.7) | 9 (33.3)  | 8 (40.0)  | 0.536 |
| Dysphonia (%)          |         | 6 (17.1) | 4 (14.8)  | 2 (10.0)  | 0.922 |
| Wound complication (%) |         | 2 (5.7)  | 0 (0.0)   | 1 (5.0)   | 0.466 |
| Neurological decline   |         | 0        | 0         | 0         |       |
| Revision               |         | 0        | 0         | 0         |       |
| Readmission (%)        |         | 1 (2.9)  | 0         | 0         | 1.000 |
| DVT                    |         | 0        | 0         | 0         |       |
| VAS immediate          |         | 4 (1-8)  | 4 (2-8)   | 4.5 (2-8) | 0.862 |
| VAS at DC date         |         | 2 (1-2)  | 2 (0-5)   | 2 (0-4)   | 0.169 |

DVT = Deep vein thrombosis

VAS = Visual analog scale

**Table 4** Late postoperative complications

| Group              | 1-level | 2-level  | > 2-level | p Value  |       |
|--------------------|---------|----------|-----------|----------|-------|
| Dysphagia          |         | 0        | 0         | 0        |       |
| Dysphonia (%)      |         | 2 (5.7)  | 1 (3.7)   | 0 (0)    | 0.787 |
| Pseudarthrosis (%) |         | 1 (2.9)  | 1 (3.7)   | 0 (0)    | 1.000 |
| Instrument failure |         | 0        | 0         | 0        |       |
| Adjacent level     |         | 4 (11.4) | 2 (7.4)   | 2 (10.0) | 0.898 |
| VAS Neck pain      |         | 1 (0-5)  | 1 (0-3)   | 1 (0-3)  | 0.489 |
| VAS Radicular pain |         | 1 (0-4)  | 0 (0-5)   | 0 (0-3)  | 0.155 |
| Delta cobb angle   |         | -5.371   | -1.815    | 4.45     | 0.131 |

Delta Cobb angle = Last follow up Cobb angle – Pre-operative Cobb angle

## Late Complications

The median follow-up time was 4 years in single level group, 3 years in 2-level group and 3 years in > 2 group, respectively ( $p$ -value = 0.635) (Table 1). There was no long-term complications of dysphagia or instrumental failure. Prolonged dysphonia was found in 3 patients, 2 in single level ACDF group and 1 in 2-level ACDF group (Table 4). Pseudarthrosis was seen 1 in single level group and 1 in 2-level group. Adjacent segment disease was found in all groups; 4, 2 and 2 patients in each group, respectively, without statistical significance ( $p$  = 0.898), Extended ACDF procedures were performed in 2 patients with adjacent segment disease in single level group at 2 years after first surgery and 1 patient in 2-level group at 3 years after first surgery. The others were improved by conservative management.

There was no statistical significance in both long-term post-operative axial neck pain and radicular pain among 3 groups. Nearly all patients reported no pain (VAS = 0) or minimal intermittent pain (VAS = 1). Postoperative follow-up dynamic imaging was performed in all cases. The Cobb angle of latest follow-up imaging was compared with immediate postoperative imaging. Progressive kyphosis was found in group of > 2-level ACDF (4.45 degree in 3 year follow up) more than other group, but without statistical significance ( $p$  = 0.131).

## Subgroup Analysis

In subgroup analysis of > 2 level ACDF group, 14 patients underwent 3-level ACDF and 6 patients in 4-level ACDF. In term of complications of surgery, both early and late complications in all categories were not significantly different. (Table 5)

**Table 5** Early and Late post-Operative complications in 3-level and 4-level ACDF

| Group                      | 3-level (14) | 4-level (6) | $p$ -Value |
|----------------------------|--------------|-------------|------------|
| <b>Early complications</b> |              |             |            |
| Dysphagia (%)              | 4 (28.6)     | 4 (66.7)    | 0.161      |
| Dysphonia (%)              | 2 (14.3)     | 0 (0)       | 1.000      |
| Wound complication (%)     | 1 (7.1)      | 0 (0)       | 1.000      |
| Neurological decline       | 0            | 0           |            |
| Revision                   | 0            | 0           |            |
| Readmission                | 0            | 0           |            |
| DVT                        | 0            | 0           |            |
| VAS immediate              | 4 (2-8)      | 5 (2-8)     | 0.673      |
| VAS at DC date             | 2 (1-3)      | 2 (1-3)     | 0.760      |
| <b>Late complications</b>  |              |             |            |
| Late Dysphagia             | 0            | 0           |            |
| Late Dysphonia             | 0            | 0           |            |
| Pseudarthrosis             | 0            | 0           |            |
| Instrument failure         | 0            | 0           |            |
| Adjacent level (%)         | 2 (14.3)     | 0 (0)       | 1.000      |
| Late VAS Neck pain         | 1 (0-3)      | 1.5 (0-2)   | 0.794      |
| Late VAS Radicular pain    | 0 (0-3)      | 0 (0-3)     | 0.507      |

## Discussion

ACDF is a common procedure in neurosurgery and is the gold standard treatment for single level cervical HNP, but in multilevel disease, it has controversy whether anterior or posterior approach has better result and less complications. At Neurological Institute of Thailand, ACDF is the procedure of choice in multilevel HNP with both myelopathy and radiculopathy. This research is retrospective study of patients underwent ACDF and followed up by our senior author (T. Tangviriyapaiboon), during 2006 - 2015.

This study was focus on both early and late post-operative complications between single level ACDF, 2-level ACDF and > 2-level ACDF groups. To the best of our knowledge, this study is the very first article in Thailand that focus on clinical result among these groups of patients.

There was no statistically significant difference in demographic data among 3 groups except underlying hypertension, which was higher in > 2-level ACDF. C5-6 disc was the most affected level in all groups, followed by C6-7, C4-5 and C3-4 level respectively.

Intraoperative blood loss and operative time were significantly increased correlated with number of operative levels. However, the clinical was similar in the aspect of blood transfusion and anemic symptom after surgery. Length of hospital stay was extended in multilevel ACDF for additional 1.5 day compared with single level or 2-level ACDF.

All groups have no difference in early and late complications, implied that number of levels was not associated with early or late complications in this study (Dysphagia, Dysphonia, Pseudarthrosis and adjacent level spondylosis). Instrument failure and re-operation were not seen in all groups.

In Yang Liu's<sup>7</sup> study of surgical management of multilevel CSM, dysphagia was presented in ACDF 11.6%, Anterior cervical corpectomy and fusion (ACCF) 10.3% and Anterior cervical corpectomy/discectomy and fusion (hybrid) 9.7%, which was significantly higher comparing with our study. Hoarseness was found in 4.3% in ACDF group of Yang Liu's study and 1.8 – 3.8% in Craig Kilburg's study<sup>8</sup> compare with 0% of this study. In a systematic review of CSM published in 2013 by Lawrence et al<sup>1</sup>, pseudarthrosis was higher in multilevel ACDF group than posterior approach (4-17%). However, pseudarthrosis was not seen in all groups in our study. In term of neurological decline, especially C5 palsy was not found in our study but commonly found in posterior approach (3.7%)<sup>9</sup> (7.1 – 10.2%)<sup>1</sup>.

In subgroup analysis of > 2-level ACDF showed that 3-level and 4-level ACDF was not difference in both results and complications.

Limitations of this retrospective study were incomplete patient information leading to small number of collected data and all surgical procedures performed by only one spine surgeon that has experience in this type of surgery more than 10 years.

## Conclusion

Multilevel cervical spondylosis has variety in choice of treatment include ACDF, ACCF, hybrid and posterior approach. This study was shown that result of multilevel ACDF was not difference to 1 or 2 level ACDF in all outcome parameters. Compared with systematic review of posterior approach, this study was not difference to all results. Multilevel ACDF had no higher risk of surgery in terms of neurological complications and instrument failure, compared with 1 or 2-level ACDF.

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