Adjacent segment disease after anterior cervical discectomy and fusion: Incidence and clinical outcomes of patients requiring anterior versus posterior repeat cervical fusion

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Abstract

Background: Adjacent segment disease (ASD) is a well-recognized long-term outcome in patients with degenerative disease of the spine. In this manuscript, we focus on the development in ASD in patients who have undergone a prior anterior cervical discectomy and fusion (ACDF).

Methods: Patient data were collected via clinical notes and patient interviews. Patients were followed for an average of 92.4 ± 72.6 months after the index ACDF.

Results: Of the 108 patients who underwent revision surgery due to symptomatic ASD, 77 patients underwent re-do ACDF, while 31 patients had posterior fusion surgery. Patients were more likely to be operated on posteriorly if they were older (P = 0.0115), male (P = 0.006), or had a higher number of cervical vertebral segments fused during the index ACDF (P = 0.013). These patients were statistically also more likely to exhibit myelopathic symptoms (P = 0.0053), and usually had worse neurologic function as assessed on the Nurick (P = 0.0005) and ASIA scales (P = 0.0020). Postoperatively, patients receiving anterior revision surgeries had higher rates of recurrent radiculopathy (P = 0.0425) and higher recurrence of ASD compared with patients fused posteriorly (P < 0.0001).

Conclusions: Patients undergoing an anterior revision surgery for ASD after ACDF have higher rates of postoperative radiculopathy and redevelopment of ASD when compared with posteriorly approached patients. Patients receiving posterior revision surgery had higher intraoperative blood loss, hospitalizations, and postoperative complications such as wound infections and discharge to rehabilitation, but had a statistically lower chance of redevelopment of ASD requiring secondary revision surgery. This may be due to the fact that posterior revision surgeries involved more levels fused. This study provides one of the longest and most comprehensive follow-ups of this challenging patient population. Prospective studies comparing surgical approaches and techniques are needed to corroborate our findings.
INTRODUCTION

Several authors have argued that adjacent segment disease (ASD) is part of the natural history of degenerative disease. However, ASD is a known complication of anterior cervical discectomy and fusion (ACDF) and often times requires reoperation. This revision surgery can be an additional ACDF or a posterior cervical fusion. However, the long-term outcomes of these two approaches for revision surgery after ASD development are relatively unknown. In order to further our understanding of the development and natural course of ASD, we present a single-institution series of 108 patients who required repeat cervical fusion due to symptomatic ASD after an initial ACDF. We compare the preoperative, perioperative, and postoperative outcomes of patients approached anteriorly versus posteriorly for their revision surgery.

MATERIALS AND METHODS

In this retrospective study, we reviewed data obtained for all neurosurgical patients undergoing ACDF at our institution over a 20-year period. We included patients who underwent ACDF for degenerative spinal disease and who subsequently developed ASD at least 6 months after index surgery. We excluded patients who received ACDF for traumatic, neoplastic, or infectious etiologies and patients who were reoperated for reasons other than ASD. We identified 108 patients who required repeat cervical fusion due to symptomatic ASD. All of the 108 patients who required repeat cervical fusion due to ASD had longer than 2 years follow-up. Symptomatic ASD was defined as radiographic evidence of ASD and associated clinical symptoms in patients with a history of ACDF at least 6 months prior. The 108 patients were divided into an anterior or posterior group based on surgical approach.

Intraoperative and perioperative data such as levels fused, blood loss, length of hospitalization, incidental durotomies, cerebrospinal fluid (CSF) leakage, deep venous thrombosis, pulmonary embolism, infection, hematoma, wound dehiscence, discharge to rehabilitation facilities, reoperations, and instrumentation failure were obtained from operative, discharge, and clinic notes. Our main outcome variables were symptoms at last follow-up, neurologic status (Nurick and Asia scale scores), ambulation status, patient satisfaction, and need for reoperation. These were ascertained from follow-up clinical notes and telephone calls.

Continuous variables were compared between the anterior and posterior cohorts via Student’s t-test and via \( \chi^2 \) test for noncontinuous variables. Data is presented as means ± standard deviation when applicable. Statistical analysis was performed with JMP 9 (SAS Institute Inc., Cary, NC). Statistical significance was set at \( P < 0.05 \).

RESULTS

Patient population

A total of 888 patients underwent an ACDF at our institution for degenerative spinal disease between 1990 and 2010, and 108 (12.2%) developed ASD over an average of 92.4 ± 52.6 months. Of these patients, 77 were approached anteriorly for their re-do surgery, and 31 were approached posteriorly [Table 1]. The average time from the index ACDF to last follow-up was 92.4 ± 72.6 months. The average time from the

| Table 1: Preoperative characteristics of all patients undergoing repeat ACDF for symptomatic adjacent segment disease due to degenerative spinal disease |
|----------------------------------|----------------|----------------|----------------|---------|
| Number of cases                  | 108            | 77             | 31             |         |
| Age (mean)                       | 49.34±10.4     | 47.65±9.28     | 53.15±12.57    | 0.0115  |
| Sex (male %)                     | 49 (45.37)     | 28 (36.36)     | 21 (67.74)     | 0.0060  |
| Prior levels fused (mean)        | 1.73±0.80      | 1.61±0.81      | 2.03±0.71      | 0.0130  |
| Comorbidities (%)                |                |                |                |         |
| Diabetes                         | 13 (12.04)     | 8 (10.39)      | 5 (16.13)      | 0.6154  |
| COPD                             | 2 (1.85)       | 2 (2.60)       | 0 (0.0)        | 0.9070  |
| Coronary artery disease          | 5 (4.63)       | 4 (5.19)       | 1 (3.23)       | 0.6596  |
| Osteoporosis                     | 1 (0.93)       | 1 (1.30)       | 0 (0.0)        | 0.5238  |
| Obesity                          | 4 (3.70)       | 3 (3.90)       | 1 (3.23)       | 0.8675  |
| Smoking history                  | 15 (13.89)     | 11 (14.29)     | 4 (12.90)      | 0.8509  |
| Hypertension                     | 28 (25.93)     | 21 (27.27)     | 7 (22.58)      | 0.7943  |
| Depression                       | 10 (9.26)      | 8 (10.39)      | 2 (6.45)       | 0.7858  |
| Presenting symptoms (%)          |                |                |                |         |
| Neck pain                        | 105 (97.22)    | 77 (100.00)    | 28 (90.32)     | 0.0220  |
| Headaches                        | 25 (23.15)     | 19 (24.68)     | 6.00 (19.35)   | 0.6226  |
| Radiculopathy                    | 77 (71.30)     | 59 (76.62)     | 18 (58.06)     | 0.0632  |
| Myelopathy                       | 25 (23.15)     | 12 (15.58)     | 13 (41.94)     | 0.0053  |
| Motor weakness                   | 58 (53.70)     | 37 (48.05)     | 21 (67.74)     | 0.0877  |
| Sensory deficits                 | 62 (57.41)     | 44 (57.14)     | 18 (58.06)     | 1.0000  |
| Bowel/bladder dysfunction         | 10 (9.26)      | 6 (7.79)       | 4 (12.90)      | 0.6722  |

Nurick score (mean) 1.82±1.07 1.58±0.83 2.39±1.37 0.0005

COPD: Chronic obstructive pulmonary disease, ACDF: Anterior cervical discectomy and fusion
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index ACDF to symptomatic ASD requiring surgery was 46.4 ± 20.6 months. Patients approached posteriorly were more likely to be older compared with the anterior cohort (53.15 ± 12.57 vs 47.65 ± 9.28, P = 0.01); these patients were also more likely to be male [21 (67.7%) vs 28 (36.4%), P = 0.006]. Of note, patients approached posteriorly had a significantly higher number of spinal levels fused during the index ACDF (2.03 ± 0.71 vs 1.61 ± 0.81, P = 0.01).

Intraoperative and perioperative outcomes

An average of 1.54 ± 0.94 spinal levels were fused on revision surgery [Table 2]. Patients fused posteriorly had a significantly higher number of spinal levels fused compared with the anterior cohort (2.03 ± 1.30 vs 1.33 ± 0.63, P = 0.007). Thirty (96.8%) patients in the posterior group received autograft, compared with 20 (26.0%) in the anterior cohort (P < 0.0001). Conversely, 57 (74.0%) patients received allograft in the anterior cohort, compared with 12 (9.3%) patients in the posterior group. Patients in the posterior cohort lost significantly more blood compared with the anterior cohort (median blood loss 300 mL vs 25 mL, P < 0.0001).

Patients were hospitalized for an average of 3.56 ± 3.77 days [Table 3]. Patients approached posteriorly had a significantly longer length of stay (5.71 ± 4.13 days vs 2.69 ± 3.26, P = 0.0007). Seven (6.48%) patients had perioperative wound infections, and all occurred in the posterior cohort (22.58%, P < 0.0001). Thirty (96.8%) patients experienced dysphagia, with a statistically significant proportion in the anterior cohort [28 (10.4%) vs 2 (6.45%), P = 0.0037]. Patients did not statistically differ in the rates of pneumonia, hematoma, wound dehiscence, infarction, death, or paraplegia between the two operative cohorts. Patients undergoing posterior surgery for ASD were more likely to be discharged to rehabilitation rather than home [7 (22.6%) vs 0 (0.0%), P < 0.0001].

Long-term outcomes

Patients were followed for an average of 92.4 ± 76.5 months from the date of the index ACDF. Last follow-ups were ascertained via a combination of clinical notes and telephone interviews [Table 4]. Of the 108 patients with ASD after ACDF, 8 were lost to follow-up. Postoperatively, 86 (86.0%) patients had neck pain, and 59 (59%) had radiculopathy. Although patients approached anteriorly had a significantly higher rate of neck pain preoperatively, the postoperative rates of neck pain between the two cohorts were statistically similar. Of note, patients approached anteriorly had a significantly higher chance of recurrent or continued radiculopathy [28 (65.8%) vs 11 (40.7%), P = 0.0425]. We coded patients’ responses to motor strength and ambulatory ability into mean postoperative Nurick scores, which was 1.55 ± 0.85 for the anterior cohort, and 2.00 ± 1.28 for the posterior cohort. This was not statistically different, P = 0.13. We also asked patients regarding their sensory status and converted this into a mean ASIA score, 4.24 ± 0.62 and 3.95 ± 0.80 for the

| Table 2: Intraoperative characteristics of patients undergoing repeat ACDF for symptomatic adjacent segment disease due to degenerative spinal disease |
|-----------------------------------------------|
| Patient number | Anterior (%) | Posterior (%) | P value |
|----------------|--------------|---------------|---------|
| Levels fused (mean) | 1.54±0.94 | 1.33±0.63 | 2.03±1.30 | 0.0070 |
| Autograft (%) | 50 (46.30) | 20 (25.97) | 30 (96.77) | <0.0001 |
| Allograft (%) | 61 (56.48) | 57 (74.03) | 4 (12.90) | <0.0001 |
| Blood loss (%) | 50 (21.5,150) | 25 (18.75,50) | 300 (262.5,550) | <0.0001 |

ACDF: Anterior cervical discectomy and fusion, ASD: Adjacent segment disease

| Table 3: Perioperative characteristics of patients undergoing repeat ACDF for symptomatic adjacent segment disease due to degenerative spinal disease |
|-----------------------------------------------|
| Patient number | Anterior (%) | Posterior (%) | P value |
|----------------|--------------|---------------|---------|
| Length of stay (mean) | 3.56±3.77 | 2.69±3.26 | 5.71±4.13 | 0.0007 |
| DVT (%) | 0 (0.00) | 0 (0.00) | 0 (0.00) | 1.0000 |
| PE (%) | 0 (0.00) | 0 (0.00) | 0 (0.00) | 1.0000 |
| Infection (%) | 7 (6.48) | 0 (0.00) | 7 (22.58) | <0.0001 |
| Pneumonia (%) | 1 (0.93) | 0 (0.00) | 1 (3.23) | 0.6362 |
| Hematoma (%) | 1 (0.93) | 0 (0.00) | 1 (3.23) | 0.6362 |
| Wound dehiscence (%) | 1 (0.93) | 0 (0.00) | 1 (3.23) | 0.6362 |
| C5 palsy (%) | 0 (0.00) | 0 (0.00) | 0 (0.00) | 1.0000 |
| Dysphagia (%) | 30 (27.78) | 28 (10.39) | 2 (6.45) | 0.0037 |
| Infarction (%) | 1 (0.93) | 0 (0.00) | 1 (3.23) | 0.6362 |
| Death (%) | 1 (0.93) | 0 (0.00) | 1 (3.23) | 0.6362 |
| Paraplegia (%) | 2 (1.85) | 1 (1.30) | 1 (3.23) | 0.6362 |
| Rehab discharge (%) | 7 (6.48) | 0 (0.00) | 7 (22.58) | <0.0001 |

ACDF: Anterior cervical discectomy and fusion, DVT: Deep vein thrombosis, PE: Pulmonary embolism

| Table 4: Postoperative characteristics of patients undergoing repeat ACDF for symptomatic adjacent segment disease due to degenerative spinal disease |
|-----------------------------------------------|
| Number of cases | Anterior (%) | Posterior (%) | P value |
|----------------|--------------|---------------|---------|
| Neck pain (%) | 86 (86.00) | 65 (89.04) | 21 (77.78) | 0.2642 |
| Radiculopathy (%) | 59 (59.00) | 48 (65.75) | 11 (40.74) | 0.0425 |
| Nurick score (mean) | 1.65±0.99 | 1.55±0.85 | 2.00±1.28 | 0.1267 |
| Asian scale (mean) | 4.17±0.67 | 4.24±0.62 | 3.95±0.80 | 0.1431 |
| Ambulatory (%) | 90 (90.00) | 68 (93.15) | 22 (81.48) | 0.1765 |
| Now better? (%) | 44 (44.00) | 32 (43.84) | 12 (44.44) | 0.9566 |
| Reoperation for ASD (%) | 30 (27.78) | 25 (32.47) | 5 (16.13) | 0.1478 |

ACDF: Anterior cervical discectomy and fusion, ASD: Adjacent segment disease
Thus, whereas Hilibrand’s study, presumably these studies In a series of 120 patients, Carreon described the combined results from fusion surgeries in one of the largest cohorts of patients had a longer length of hospitalization compared with those who received a second ACDF (P = 0.0425) at last follow-up. Additionally, during this follow-up period, 30 patients (27.78%) required a second revision surgery due to recurrent ASD. Compared with the rate of ASD after the index ACDF (108 out of 888 patients, 12.2%), the rate of ASD after re-do fusion (30 out of 108 patients, 27.78%) was significantly higher (P < 0.0001). Of these patients requiring two revision surgeries, 25 (32.5%) occurred in the anterior cohort and only 5 (16.1%) in the posterior cohort. Of note, this increase in the rate of ASD after revision surgery only held true for patients in the anterior cohort (25 out of 73 patients, 32.5%, P < 0.0001), but not patients in the posterior cohort (5 out of 27 patients, 16.1%, P = 0.3656). This may be explained by the fact that posterior revision surgeries fused more levels and thus left the patient at less risk of developing further ASD.

As with all retrospective studies, limitations exist in the amount of information that can be discerned from clinic notes. Variables such as Visual Analog Scale, Oswestry Disability Index, and Short Form-36 scores could not be reconstructed in a retrospective fashion. Thus, a more complete picture may be afforded by a prospective study.

CONCLUSIONS

ACDF is a common and long-standing surgical treatment for degenerative cervical spinal disease. In
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this manuscript, we describe 108 patients undergoing revision surgery after ACDF due to development of symptomatic ASD, accomplished via anterior re-do ACDF or posterior instrumented fusion. Patients approached posteriorly tended to be older and exhibited more myelopathic symptoms. They had more perioperative and postoperative complications; however, they had a lower rate of redeveloping ASD necessitating secondary revision surgery. ASD remains a significant cause of morbidity after ACDF. Further studies are necessary in order to advance our understanding of ASD and its optimal treatment.

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Commentary

This study constitutes an interesting validation of what many spinal surgeons would gestalt to be true about adjacent segment disease (ASD) in the cervical spine. This article evaluates 108 patients undergoing revision surgery for ASD following anterior cervical discectomy and fusion (ACDF). They found that 77 patients having repeated ACDF exhibited more frequent recurrent radiculopathy and repeated ASD versus the 31 undergoing posterior fusions. Furthermore, the posterior fusion group tended to be older, had more vertebral levels fused, more infections, and were more severely myelopathic and neurologically compromised.

Certainly, regarding the incidence of infection, it is well known that posterior cervical surgery carries approximately a 4-5% risk of infection vs the usual <1% for ACDF percentage. Also, older patients better tolerate posterior versus anterior cervical surgery, for several reasons. Certainly, many of the older patients will have osteoporosis, whether male or female, and will better tolerate a multilevel posterior versus anterior approach. They will not have to deal with the increased risk of ACDF regarding osteoporosis-related graft/plate extrusions, graft subsidence/pistoning, or fractures and will avoid the potential complications of stroke/ischemia associated with inadvertent carotid retraction/manipulation. Furthermore respiratory decompensation is less likely, as there is only the more routine problems regarding intubation to deal with rather than those associated with anterior retraction/dysphagia attributed to retraction/dynamic segments, etc., In short, it is no surprise that the older male patients (and this is also true for females) will better tolerate a posterior approach as either a primary procedure (if feasible and appropriate) or second procedure, and dealing with their greater myelopathic preoperative deficits with more multilevel decompressions/initial fusions may in some cases (not necessarily directly related to this study) avoid the need for secondary surgery.

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