

Traumatic Cervical Unilateral and Bilateral Facet Dislocations Treated With Anterior Cervical Discectomy and Fusion Has a Low Failure Rate

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Abstract

Study Design: Retrospective radiographic and chart review.

Objective: To define the rate and associated risk factors of treatment failure of anterior cervical fusion for treatment of cervical facet dislocations.

Methods: Between 2004 and 2014, a retrospective review at a single level I trauma center identified 38 patients with unilateral or bilateral dislocated facet(s) treated with anterior cervical discectomy and fusion (ACDF). Two patients were eliminated due to less than 30-day follow-up. Demographic data, initial neurological exams, surgical data, radiographic findings, and follow-up records were reviewed.

Results: Of the 36 patients with facet dislocations treated with ACDF using a fixed locking plate, 16 were unilateral and 20 were bilateral. The mean age was 35 years (range 13-58). Mean follow-up was 323 days (range 30-1998). There were 3 treatment failures (8%). Three of 7 (43%) endplate fractures failed ($P < .01$), and 1/28 (4%) facet fractures failed ($P = .13$). The mean time to failure was 4 weeks (1-7 weeks). One treatment failure had a facet fracture, and all 3 failures had an associated endplate fracture.

Conclusion: Treatment failure occurred in 3 out of 36 (8%) patients with facet fracture dislocations treated with anterior cervical discectomy, fusion, and plating. Rates of failure are lower than has been previously reported. Endplate fractures of the inferior level in jumped facets appears to be a major risk factor of biomechanical failure. However, a facet fracture may not be a risk factor for failure. In the absence of an endplate fracture, ACDF is a reasonable treatment option in patients with single-level cervical facet dislocation.

Keywords

jumped facets, facet dislocation, cervical dislocation, ACDF, facet fracture, facet, perched

Introduction

Approximately two thirds of cervical spine injuries occur within the subaxial cervical spine, with fractures occurring most often at C6 and C7 and dislocations occurring most commonly between C5-C6 and C6-C7.¹ Facet dislocations are part of a spectrum of cervical spine flexion/distraction-type injuries. Flexion distraction injuries are described as anterior displacement of the vertebral body due to tensile or shear failure of the posterior elements coupled with facet fractures or dislocations. Facet fractures were classified by Allen et al² and later modified by Harris et al.³

It is agreed that bilateral facet dislocations (DF3) disrupt the posterior ligamentous complex and facet capsule⁴ and require

operative stabilization as the definitive treatment. The treatment of distractive flexion injuries with halo immobilization or external orthoses has been associated with a high rate of radiographic failure defined as re-dislocation, neurological deterioration, or failure of osseous or ligamentous healing.⁵ Cadaveric

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biomechanical studies that have simulated bilateral facet injuries report superior stabilization with lateral mass fixation posteriorly compared with anterior cervical plate fixation.⁶⁻⁸

Despite biomechanical advantages with posterior fixation, anterior cervical discectomy and fusion (ACDF) for the treatment of bilateral facet dislocations has also been reported as clinically successful.⁹⁻¹¹ Hundred percent fusion rates^{9,10} and low infection rates¹² have been reported with anterior fixation and fusion. The anterior approach enables the surgeon to decompress the spinal canal by removing the intervertebral disc and preventing potential neurological deterioration from disc sequestration.¹³⁻¹⁶

Several authors have reported poor outcomes with ACDF in the treatment of bilateral facet dislocations. Henriques et al reported 7 of 13 (54%) patients with bilateral facet injuries suffered re-displacement or loss of alignment with anterior plating alone.¹⁷ Conversely, in a review of 87 patients with facet (75% bilateral, 25% unilateral) dislocations, Johnson et al reported a 13% radiographic failure rate with single-segment ACDF in traumatic cervical flexion distraction injuries that correlated with the presence of endplate compression fracture and facet fractures on injury radiographs.¹¹ The optimal approach and treatment of cervical facet dislocations remains a controversial topic. We hypothesize that in select patients with a single-level unilateral or bilateral facet fracture-dislocation, a single-level ACDF has a low radiographic failure rate. The purpose of this case series is to examine the rate of reoperation due to treatment failure in patients treated with an ACDF in the setting of cervical facet dislocations.

Materials and Methods

We retrospectively identified patients through billing data and radiology records from January 2004 to September 2014 at Harborview Medical Center, Seattle, Washington, USA. This is a retrospective cohort study of consecutive patients with Allen and Ferguson Classification, unilateral (DF2) and bilateral (DF3, DF4) facet dislocations from Harborview Medical Center, Seattle, Washington, USA treated with ACDF.

All patients under 70 years of age at the time of admission, treated for unilateral and bilateral facet dislocations with ACDF, were included. All patients were placed in a Miami-J collar for a minimum of 6 weeks postoperatively. Those with a pathologic fracture due to neoplasm, or infection, and those with less than 30-day follow-up were excluded.

Using electronic medical records, we reviewed all identified patients' charts for age, sex, mechanism of injury, and level of neurologic compromise as determined by their American Spinal Injury Association (ASIA) impairment scale on admission and on last obtainable follow-up examination. We analyzed radiographs to assess patterns, fixation, angles, and presence of disc herniation, and pseudoarthrosis. The initial injury computed tomography (CT) scan and reformatted images were reviewed. The presence or absence of a facet fracture and/or a fracture of the endplate was recorded. The postoperative distance of translation (in mm) and degree of

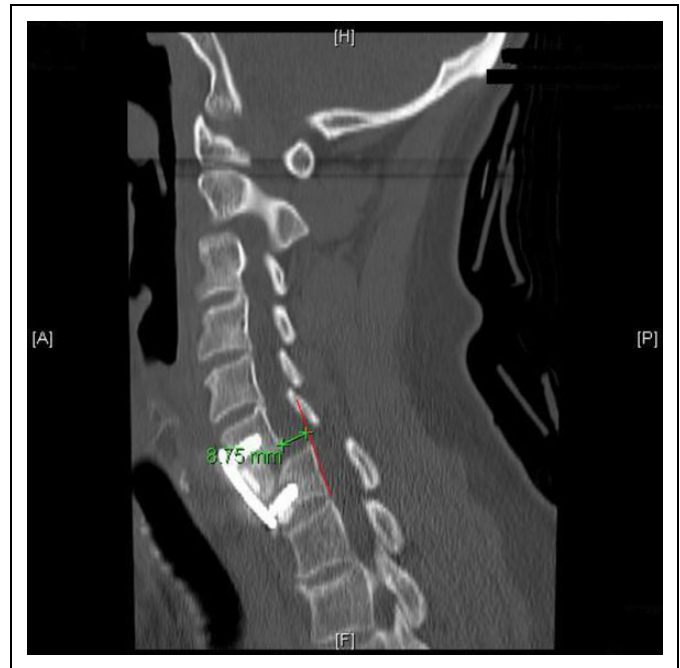


Figure 1. Measurement taken to record translation. (Note that the screws in this failure are relatively short and did not measure to be within 2 mm of the posterior cortex of the vertebral body.)

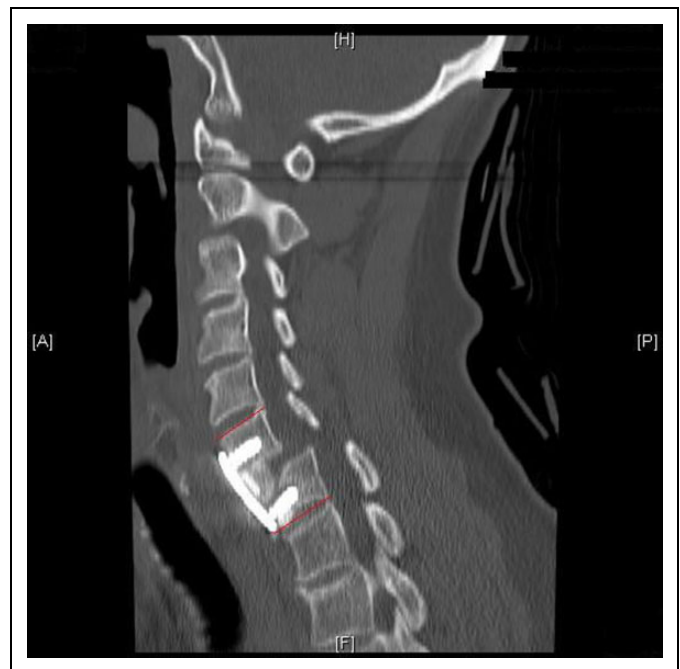


Figure 2. Measurement taken to record kyphosis.

kyphosis was measured. The translation was measured from the posterior inferior edge of the cephalic vertebrae to a tangential line of the posterior body of the subjacent vertebrae (Figure 1). The degree of kyphosis was recorded as the angle between the superior endplate of the injured vertebrae and the inferior endplate of the subjacent intact vertebrae (Figure 2).



Figure 3. (A) Preoperative mid-sagittal CT reformat showing kyphosis and translation at C5-C6 with subtle endplate fracture at C6 in 36-year-old male alcoholic who fell down the stairs. (B) Preoperative para-sagittal CT reformat showing perched facet on left. (C) Immediate postoperative lateral cervical spine radiograph. (D) Four-week postoperative radiograph showing increased kyphosis. (E) Six-month follow-up lateral radiograph after posterior lateral mass screws placed bilaterally at C5-C6.

We also recorded the presence or absence of a neurologic (spinal cord or root level) injury. If magnetic resonance imaging was completed prior to reduction, the presence of a disc herniation was recorded.

The follow-up assessment included a medical chart review looking at complications including re-dislocation, neurologic change, and need for further operative stabilization after discharge. Imaging was reviewed for final alignment and translation. Results from the last follow-up studies were used for analysis.

The postoperative CT scan was taken on the operative or first postoperative day. The latest follow-up radiograph post-surgery was the one used for analysis, except in the case of early radiographic failure. Neurologic recovery was assessed

by chart review. Our primary outcome was a treatment failure necessitating a reoperation. One or more of the following defined a biomechanical failure:

1. Dislodgement of the interbody graft
2. Breakage of the plate or screws
3. Recurrent facet dislocation
4. Increase in kyphosis greater than 11°
5. Increase in anterolisthesis greater than 3.5 mm

Bivariate analyses were performed to examine the relationships between treatment failure and qualitative and quantitative variables relating to the patient. The presence of a facet or endplate fracture was examined using the Fisher exact test (Table 5).

Table 1. Patient Demographics.

	n (%)
Gender	
Male	27 (75)
Female	9 (25)
Age (years)	
<18	2 (5.6)
18-40	27 (75)
41-59	7 (19.4)
Injury level	
C3-4	4 (11.1)
C4-5	8 (22.2)
C5-6	14 (38.9)
C6-7	10 (27.8)
Injury characteristics	
Unilateral dislocation	16 (44.4)
Bilateral dislocation	20 (55.6)
Facet fracture	16 (44.4)
Disc herniation	13 (36.1)
Vertebral endplate fracture	7 (19.4)
Mechanism of injury	
Motor vehicle accident	20 (55.6)
Ground level fall	7 (19.4)
Dive into water	3 (8.3)
Assault	2 (5.6)
Fall from height	4 (11.1)

This study was approved by the University of Washington institutional review board.

Results

We identified 38 patients that were treated for unilateral or bilateral facet dislocations between January 2004 and September 2014. Of the 38 patients, 2 (5%) had less than 90-day follow-up and were excluded. Thirty-six patients (95%) met the inclusion criteria. All patients underwent an attempt at an emergent closed reduction prior to surgery. These were all done within 24 hours of injury and as soon as possible within admission to the emergency room. Only one patient's attempted reduction was unsuccessful. This patient was subsequently reduced intraoperatively after a discectomy with the use of Caspar pin assisted distraction. ACDF was performed due to surgeon preference. All patients had a single-level injury, and they lacked clear radiographic features of osteoporosis and/or diffuse idiopathic skeletal hyperostosis/ankylosing spondylitis.

The mean follow-up was 323 days. Sixteen patients with unilateral and 20 with bilateral facet dislocations who underwent ACDF were identified (male-female ratio 27:9; average age 35 years; age range 13-58 years). Endplate fractures were present in 7 patients (19%). Mechanisms of injury included 20 motor vehicle accidents, 7 ground-level falls, 3 dives into water, 2 assaults, and 4 falls from height. The most common level of dislocation was C5-C6 (n = 14; Table 1).

Ten patients (28%) had complete tetraplegia (ASIA A) and 10 patients (28%) had an incomplete spinal cord injury (ASIA B, C, D) on admission. Of the 10 patients with complete

Table 2. Neurological Status of Patients on Presentation and at Final Follow-up.

Neurological Injury (ASIA)	Preoperatively, n (%)	Final Follow-up, n (%)
ASIA A	10 (27.8)	5 (13.9)
ASIA B	1 (2.8)	5 (13.9)
ASIA C	1 (2.8)	0 (0)
ASIA D	8 (22.2)	6 (16.7)
ASIA E	16 (44.4)	20 (55.6)

Abbreviation: ASIA, American Spinal Injury Association.

Table 3. Change in Radiographic Measurements at Final Follow-up.

	Minimum	Maximum	Mean	SD
Change in translation (mm)	-1.6	9.5	0.86	2.24
Change in kyphosis (°)	-7.80	16.00	2.59	5.36

tetraplegia, 5 (50%) had an improvement in their ASIA score postoperatively. Of the 10 patients with incomplete spinal cord injury, 5 (50%) had an improvement in their ASIA score postoperatively (Table 2). There was no association of neurological injury with treatment failure.

Immediately postoperatively, the mean anterolisthesis measured 0.1 mm (range -2.5 mm to 1.9 mm), the kyphosis averaged 0.5° (range -15° to 16°). At final follow-up, the mean change in translation measured 0.9 mm (range -1.6 to 9.5 mm, SD 2.24 mm) and change in kyphosis measured 2.6° (range -7.8° to 16°, SD 5.4°; Table 3).

Three of 36 patients (8%) had a treatment failure resulting in a second operation, which entailed a posterior fusion for enhanced stability. Two of 3 patients had a recurrent dislocation associated with pullout of the screws from the inferior vertebral body. The third patient developed graft subsidence and focal kyphosis of 16° as well as facet subluxation without dislocation (Figure 3A-D). On postoperative day 30, the surgeon elected to return to the operating room to perform posterior fixation and fusion. None of the 3 failures had a permanent change in neurologic status. All 3 of these patients had associated endplate fractures at the time of injury. Change in angulation greater than 11° and anterolisthesis greater than 3.5 mm were both present in all 3 patients (Table 4). One patient had a pseudoarthrosis, which was fixed with posterior fixation and fusion.

There were 3 treatment failures (8%). Three of 7 (43%) endplate fractures failed ($P < .01$) and 1/28 (4%) facet fractures failed ($P = .13$). The mean time to failure was 4 weeks (1-7 weeks; Table 5).

Discussion

Cervical flexion distraction injuries are potentially devastating injuries that involve a predominant flexion force with disruption of the posterior tensile elements of the spine. Despite several biomechanical studies demonstrating the superiority

Table 4. Characteristics of Treatment Failures.

	Patient 1	Patient 2	Patient 3
Age (years)	35	36	56
Mechanism of injury	MVA	GLF	MVA
Unilateral or bilateral dislocation	Unilateral	Unilateral	Unilateral
Facet fracture present	No	No	Yes
Neurological injury (ASIA)	E	D	E
Disc herniation	Yes	No	Yes
Vertebral endplate fracture	Yes	Yes	Yes
Re-dislocation	Yes	No	Yes
Change in translation (mm)	9.5	4	13.6
Change in kyphosis (°)	13.6	16	16
Time until failure (weeks)	7	4	1

Abbreviations: MVA, motor vehicle accident; GLF, ground-level fall; ASIA, American Spinal Injury Association.

Table 5. Bivariate Analysis of the Relationship Between Treatment Failure and Endplate Fracture and Facet Fractures.

	Treatment Failure (n = 3)	No Treatment Failure (n = 33)	P
Facet fracture	1	26	.134
No facet fracture	2	7	
Endplate fracture	3	4	.004
No endplate fracture	0	29	

of combined anterior-posterior approach, compared to posterior spinal instrumented fusion (PSIF) or ACDF alone, there remains proponents of fixation with ACDF.⁶ Anterior fixation is associated with shorter operation room time, less blood loss, permits discectomy, and obviates the need to place patients in the prone position with unstable spinal injuries.

The reported results of ACDF in patients with unilateral and bilateral cervical facet dislocations and fracture-dislocations have varied considerably. Review of published literature reveals fixation failure ranging from 5% to 54%.^{10,11,17,18} This variability in results could be explained by studies with small numbers of patients, variability in techniques, and instrumentation. To our knowledge, there have been few publications over the past 10 years investigating the efficacy of ACDF for flexion-distraction injuries with jumped facets.

We hypothesize that in single-level jumped facets, ACDF is associated with low rates of radiographic and clinical failure as reflected by reoperation rates. Three of 36 patients had radiographic evidence of fixation failure and required reoperation. All 3 failures had endplate fractures. One of the failures also had a facet fracture at the involved level. Our results are consistent with those reported by Johnson et al that ACDF in the setting of an endplate fracture is associated with treatment failure. However, Johnson et al also reported that facet fractures are associated with treatment failure. Of the 28 patients with facet fractures, only one had a treatment failure and that

patient also had an endplate fracture. It is possible that our results differ because of a smaller number of patients in our study. Nonetheless, according to our series, a facet fracture does not appear to be a predictor of treatment failure. There are few studies examining the clinical outcomes of ACDF for single-level flexion-distraction injuries. Henriques et al reported the fusion results of a cohort of 36 patients with flexion-distraction injuries. They identified severity of flexion distraction injuries as a potential risk factor for ACDF failure as 4/5 failures had DF grade 3 injuries. They also noted that severity of neurologic injury was a predictor of failure. They concluded that ACDF was clinically appropriate for patient with DF grade 1-2 without neurologic deficits. In contrast to that report, we did not find a correlation between our fixation failures as 2 of 3 failures had DF grade 2 injuries and 1 failure grade 3 injury. Furthermore, 2 of our failures had ASIA E scores and one ASIA D.

Endplate and facet fractures have been reported as risk factors for ACDF failure.¹¹ Johnson et al followed a cohort of patients after ACDF for flexion distraction injuries and found that 65% of their failures were associated with end plate fractures. There were 7 patients in our cohort with associated endplate fractures, of which 3 patients had a failure of fixation. However, fractures involving the facets do not appear to be correlated with treatment failure. Of the 28 patients with facet fractures, only one had a treatment failure. Although facet fractures are a harbinger of less intrinsic stability, it appears that ACDF provides sufficient fixation leading to low failure rates.

The authors feel the several technical pearls may contribute to a low rate of treatment failure. All patients treated with ACDF had locking plates. Screw loosening afflicted early anterior plate designs.¹⁹⁻²¹ Modern designs of anterior cervical plates with locking screw plate interfaces have led to greater application of anterior fixation to cervical trauma.^{10,22} The authors also stress the importance of long screw fixation. We feel that positioning screws within 2 mm of the posterior vertebral cortex will optimize fixation and could decrease failure rates. Also, it is important to accentuate the lordosis in order to optimize intrinsic stability. Finally, in the setting of posterior facet injuries, we aim to place small interbody grafts in order to prevent facet distraction and subluxation.

We recognized several limitations to our study. First, data collection was collected retrospectively, which may have introduced bias. However, independent researchers were not involved in patient care and should not have influenced the results performed data collection. A potential for selection bias could influence surgeon preference, particularly in cases of highly unstable injuries or comminuted facet fractures, which may have led surgeons to opt for posterior fixation. Second, the collection of data and treatment are not standardized and controlled in the manner of a prospective study. Finally, patients' subjective outcomes were not assessed and were not inclusive of our definition of treatment failure. It is beyond the scope of this study to report clinical outcomes data.

Conclusion

Treatment failure occurred in 8% of facet fracture dislocations treated with anterior cervical discectomy, fusion, and plating. Rates of failure are lower than has been previously reported. As suggested by Johnson et al, endplate fractures of the inferior level in jumped facets appears to be a major risk factor of biomechanical failure. However, our series suggests that a facet fracture may not be a risk factor for failure. Concern regarding mechanical failure of flexion distraction injuries should be high when they are associated with fractures of the endplate. In the absence of an endplate fracture, ACDF is a reasonable treatment option in this sample of patients with single-level cervical facet dislocation.

Authors' Note

This study was reviewed and approved by the institutional review board of the University of Washington, Seattle, WA, where this study was performed.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Richard J. Bransford reports personal fees from AOSpine North America, personal fees from Globus, grants from Depuy-Synthes, outside the submitted work.

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