



Original Article

Safety and efficacy of cervical foraminotomy versus anterior cervical discectomy and fusion for 1–2 level radiculopathy

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ABSTRACT

Background: Cervical foraminotomy (CF) and anterior cervical discectomy and fusion (ACDF) are both used to treat 1–2 level cervical radiculopathy. We evaluated demographic and Patient-Reported Outcomes Measurement Information System (PROMIS) to match cohorts and compare the safety/efficacy of performing CF versus ACDF for 1–2 level unilateral radiculopathy.

Methods: This was a retrospective review of 64 patients with similar clinical and radiological data that underwent 1–2 level unilateral CF versus ACDF for cervical radiculopathy. Variables studied included operative revision rates, adverse events, surgical costs, postoperative imaging, PROMIS scores, numeric pain scores, incidence of dysphagia, frequency of vocal cord paralysis, and postoperative neurological status.

Results: We found no clinical or radiological differences between patients undergoing ACDF versus CF for unilateral 1–2 level cervical radiculopathy. Surgical differences were observed; ACDF patients demonstrated a 6.25% revision rate versus 0% for CF patients, 40% of ACDF patients reported mild dysphagia versus 0% for CF, 3% undergoing ACDF exhibited vocal cord paralysis versus 0% for CF, and ACDF incurred high implant costs (i.e., \$1,836.37 and \$2,773.44 for one- and two-level ACDFs) versus 0% for CF warranting no implants.

Conclusion: Patients undergoing CF versus ACDF for 1–2 level unilateral cervical radiculopathy required 3.70 fewer postoperative X-rays, 40 min less operative time, and 10.95-h shorter lengths of hospital stay ($P < 0.001$). Alternatively, ACDF patients had a 31.3% greater probability of achieving a minimum clinically important difference in PROMIS pain interference scores but incurred a 6.25% reoperation rate, a 40% incidence of dysphagia, and high implant costs versus 0% for CF.

Keywords: Anterior cervical discectomy and fusion, Cervical radiculopathy, Patient reported outcomes, Posterior cervical foraminotomy, Posterior keyhole foraminotomy

INTRODUCTION

Patient-Reported Outcomes Measurement Information System (PROMIS) is a National Institutes of Health (NIH) sponsored tool that utilizes standardized questionnaires to measure patient-based outcomes (i.e., pain, function, and depression).^[7,6] We utilized PROMIS scores to compare/ assess demographic, radiological, and surgical outcomes following cervical foraminotomy (CF) versus anterior cervical discectomy and fusion (ACDF). We are aware of the added unique risks of ACDF documented in the literature versus CF (i.e., vascular or esophageal injury, dysphagia,

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Table 1: Preoperative patient demographics.

Cohort	ACDF		CF		Total		P-value
Total, n (%)	32	50%	32	50%	64	100%	
Age, Mean (SD)	50.82	(9.07)	54.25	(8.34)	52.54	(8.81)	0.091
Gender, n (%)							0.790
Female	10	31%	11	34%	21	33%	
Male	22	69%	21	66%	43	67%	
Race, n (%)							0.440
Caucasian	24	75%	28	88%	52	81%	
African American	6	19%	3	9%	9	14%	
Other	2	6%	1	3%	3	5%	
Ethnicity, n (%)							1.000
Hispanic/Latino	1	3%	1	3%	2	3%	
NonHispanic/Latino	31	97%	31	97%	62	97%	
BMI, Mean (SD)	31.40	(5.99)	31.03	(6.72)	31.22	(6.32)	0.582
Spinal levels, n (%)							0.590
Single spinal level	23	72%	21	66%	44	69%	
Two spinal levels	9	28%	11	34%	20	31%	
Smoking status, n (%)							0.740
Current smoker	6	19%	5	16%	11	17%	
Never or Former smoker	26	81%	27	84%	53	83%	
Location of pain							0.818
Neck/back	22	69%	23	72%	45	70%	
Arm/shoulder	3	9%	3	9%	6	10%	
Generalized	7	22%	6	19%	13	20%	
ECI (SD)	1.63	(1.29)	1.44	(1.37)	1.53	(1.32)	0.511
PROMIS T-scores							
PF, Mean (SD)	39.04	(6.40)	39.73	(8.53)	39.38	(7.49)	0.840
PF, N Observed	32	100%	32	100%	64	100%	
PI, Mean (SD)	64.71	(6.22)	62.64	(7.39)	63.68	(6.86)	0.141
PI, N Observed	32	100%	32	100%	64	100%	
DE, Mean (SD)	52.07	(10.03)	51.74	(10.34)	51.90	(10.10)	0.657
DE, N Observed	31	97%	31	97%	62	97%	
Postoperative chart review (years)	6.15	(1.52)	5.99	(1.45)	6.07	(1.49)	0.662
Clinical followup (days)	399.59	(448.84)	181.72	(234.46)	290.66	(371.74)	0.019

CF: Cervical foraminotomy, ACDF: Anterior cervical discectomy and fusion, PROMIS: Patient reported outcomes measurement information system, PI: Pain interference, BMI: Body mass index, SD: Standard deviation, ECI: Elixhauser comorbidity index, PF: Physical Function, DE: Depression

recurrent laryngeal nerve paralysis, and adjacent segment disease).^[5,9,10]

MATERIALS AND METHODS

Study design and setting

This is an IRB-approved retrospective cohort study of outcomes for 32 ACDF (CPT 22551) versus 32 CF (CPT 63020) patients matched by demographic and clinical characteristics

[2015–2021; Table 1]. Multiple inclusion and exclusion criteria were used to select patients for this study [Figure 1]. A major shortcoming of the study design was a patient selection for ACDF versus CF based on the surgeon or patient preferences. Major variables assessed included reoperations, adverse events, changes in numeric pain scores, preoperative and postoperative visits, surgery duration, hospital/implant costs, length of hospital stay, postoperative motor status, dysphagia, vocal cord paralysis, PROMIS outcomes, and other covariates [Table 1].

Table 2: Unadjusted PROMIS counts and improvements above preoperative levels.

Patient counts	ACDF		CF		Total		Pvalue
PROMIS physical function, <i>n</i> (%)							0.741
Preoperative	32	100%	32	100%	64	100%	
<4 Weeks	19	59%	14	44%	33	52%	
≥4, <10 Weeks	20	63%	18	56%	38	59%	
>10 Weeks	27	84%	18	56%	45	70%	
PROMIS pain interference, <i>n</i> (%)							0.699
Preoperative	32	100%	32	100%	64	100%	
<4 Weeks	19	59%	13	41%	32	50%	
≥4, <10 Weeks	20	63%	18	56%	38	59%	
>10 Weeks	27	84%	18	56%	45	70%	
PROMIS depression, <i>n</i> (%)							0.528
Preoperative	31	100%	31	100%	62	100%	
<4 Weeks	19	61%	11	35%	30	48%	
≥4, <10 Weeks	19	61%	17	55%	36	58%	
>10 Weeks	27	87%	17	55%	44	71%	
Improvement from preoperative score							
PROMIS physical function, <i>n</i> (%)							0.239
<4 Weeks	10	53%	3	21%	13	39%	
≥4, <10 Weeks	13	65%	11	61%	24	63%	
>10 Weeks	24	89%	9	50%	33	73%	
PROMIS pain interference, <i>n</i> (%)							0.630
<4 Weeks	14	74%	6	46%	20	63%	
≥4, <10 Weeks	17	85%	11	61%	28	74%	
>10 Weeks	23	85%	9	50%	32	71%	
PROMIS depression, <i>N</i> (%)							0.753
<4 Weeks	16	84%	6	55%	22	73%	
≥4, <10 Weeks	15	79%	9	53%	24	67%	
>10 Weeks	19	70%	10	59%	29	66%	
MCID improvement							
PROMIS physical function, <i>n</i> (%)							0.150
<4 Weeks	7	37%	1	7%	8	24%	
≥4, <10 Weeks	10	50%	10	56%	20	53%	
>10 Weeks	17	63%	8	44%	25	56%	
PROMIS pain interference, <i>n</i> (%)							0.528
<4 Weeks	10	53%	4	31%	14	44%	
≥4, <10 Weeks	14	70%	10	56%	24	63%	
>10 Weeks	17	63%	7	39%	24	53%	
PROMIS depression, <i>n</i> (%)							0.642
<4 Weeks	13	68%	7	50%	20	67%	
≥4, <10 Weeks	10	53%	8	73%	18	50%	
>10 Weeks	11	41%	7	41%	18	41%	

CF: Cervical foraminotomy, ACDF: Anterior cervical discectomy and fusion, PROMIS: Patient reported outcomes measurement information system, MCID: Minimum clinically important difference, PI: Pain interference.

Table 3: Postoperative regression for achieving MCID measured by PROMIS function (PF), pain (PI), and depression (DE) scores.

	PROMIS PF MCID				PROMIS PI MCID				PROMIS DE MCID			
	Odds Ratio	Lower CI	Upper CI	P-value	Odds Ratio	Lower CI	Upper CI	P-value	Odds Ratio	Lower CI	Upper CI	P-value
Surgery												
ACDF	Reference				Reference				Reference			
CF	0.46	0.16	1.33	0.15	0.15	0.05	0.52	0.003	0.51	0.06	4.42	0.538
Time												
Weeks 0-4	Reference				Reference				Reference			
Weeks 4-10	4.85	1.30	18.13	0.019	4.05	1.09	15.09	0.037	0.27	0.05	1.49	0.134
Weeks >10	5.40	1.58	18.40	0.007	1.92	0.60	6.14	0.273	0.18	0.03	1.04	0.056
	Prob ability	Lower CI	Upper CI	P-value*	Prob ability	Lower CI	Upper CI	P-value*	Prob ability	Lower CI	Upper CI	P-value*
Adjusted Probability of Achieving MCID												
ACDF	51.44	39.28	63.61	--	67.13	56.65	77.61	--	46.69	31.76	61.62	--
CF	37.40	23.96	50.84	--	35.85	24.31	47.39	--	39.34	22.44	56.24	--
Difference in Adjusted Probability of Achieving MCID												
CF vs. ACDF	-14.04	-32.57	4.48	0.137	-31.28	-47.17	-15.38	0.000	-7.35	-30.42	15.72	-0.532
Observations	116				115				109			

$\alpha = 0.05$ for confidence intervals; see Appendix 1 for full regression with covariates
 *P values for margin analysis (adjusted probabilities) are not included since the null hypothesis test is non-informative, CF: Cervical foraminotomy, ACDF: Anterior cervical discectomy and fusion, PROMIS: Patient reported outcomes measurement information system, MCID: Minimum clinically important difference, PF: Physical function, DE: Depression, CI: Confidence interval, PI: Pain interference

RESULTS

Adverse events

For ACDFs performed over 6.15 years, two patients required revisions (i.e., 1 for pseudoarthrosis and the other for recurrent axial pain), 13 had mild dysphagia, and there was one case of vocal cord paralysis but no infections. A 5.99-year record review following CF showed no patients required operative revisions, and there were no adverse events (i.e., no dysphagia, no vocal cord paralysis, and no infections).

PROMIS evaluations

Ten weeks postoperatively, 89%/85% of ACDF and 50%/50% of CF patients reported improvement versus their preoperative PROMIS function/pain status [Table 2]. Notably, 51% of ACDF and 37% of CF patients achieved minimum clinically important difference (MCID) for physical function, and 67% and 36%, respectively, achieved MCID for pain, but ACDF patients reported 4.44 greater PROMIS pain interference (PI) t-score values [Appendix 1 and Table 3]. Further, 63% of ACDF versus 56% of CF patients reported complete pain resolution, 34% versus 47% reported full return of strength, and 47% versus 56% reported resolution of neurological symptoms [Table 4]. However, there were no significant differences

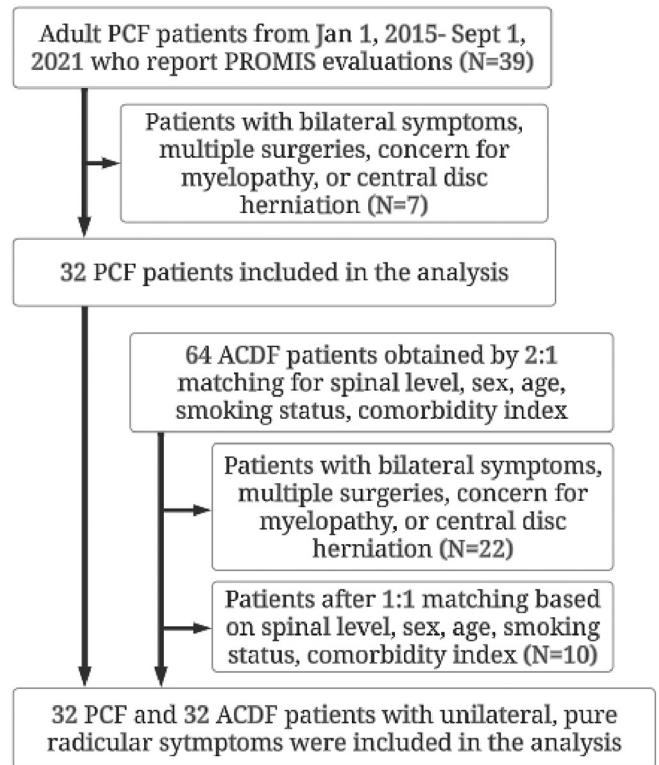


Figure 1: The exclusion criteria displaying which patients were included in the analysis. ACDF: Anterior cervical discectomy and fusion, PCF: Posterior cervical foraminotomy

Table 4: Unadjusted postoperative results for resolution of pain, weakness, and paresthesia.

Cohort	ACDF		CF		Total		P-value
Total, n (%)	32	50%	32	50%	64	100%	
Weakness resolution, n (%)							0.348
No	1	3%	4	13%	5	8%	
Yes	11	34%	15	47%	26	41%	
No initial weakness	20	63%	13	41%	33	52%	
DTR weakness, Mean (SD)	58.09	(136.21)	30.27	(23.31)	42.04	(89.00)	0.213
DTR weakness, n Observed	11	34%	15	46.88	26	40.63	
Paresthesia resolution, n (%)							0.149
No	2	6%	8	25%	10	16%	
Yes	15	47%	18	56%	33	52%	
No initial neurologic symptoms	15	47%	6	19%	21	33%	
DTR paresthesia, Mean (SD)	47.47	(116.54)	25.78	(20.83)	35.64	(79.33)	0.515
DTR paresthesia, n Observed	15	47%	18	56.25	33	51.56	
Pain resolution, n (%)							0.306
No	9	28%	14	44%	23	36%	
Yes	20	63%	18	56%	38	59%	
No initial pain symptoms	3	9%	0	0%	3	5%	
DTR pain, Mean (SD)	77.42	(135.22)	65.33	(88.72)	71.38	(112.02)	0.248
DTR pain, n Observed	12	38%	12	38%	24	75%	
Complications							
Revisions	2	6.3%	0	0.0%	2	6.3%	
Dysphagia	13	40.6%	0	0.0%	13	40.6%	
Vocal cord paralysis	1	3.1%	0	0.0%	1	3.1%	

DTR: Days to resolve, For full regression with covariates, see Appendix 1. CF: Cervical foraminotomy, ACDF: Anterior cervical discectomy and fusion, SD: Standard deviation.

between the two groups in average improvement for PROMIS Physical Function (PF), DE t-scores, and time to achieve MCID for PF, PI, or DE PROMIS scores [Appendices 1 and 2].

Symptom resolution

Sixty-three percentages of ACDF versus 56% of CF patients reported complete pain resolution, 34% versus 47% reported full return of strength, and 47% versus 56% reported resolution of neurological symptoms [Table 4].

Lower hospital costs, operating room time, and length of stay for CF versus ACDF

The average implant cost for one-level ACDF was \$1,836.37, and for two-level ACDF was \$2,773.44; CF incurred no implant costs [Table 5]. Additional benefits of CF operations included statistically less operating time (137 vs. 177 min) and a shorter length of stay [22.7 vs. 33.7 h; Table 5].

Fewer postoperative radiographs for CF versus ACDF patients

CF patients required fewer postoperative cervical radiographs (i.e., average 0.4) versus ACDF patients [i.e., average 4.10; Table 5]. Three cervical CTs were performed for CF versus 5 for ACDF patients, while MR scans were performed in 7 CF versus 10 ACDF patients, respectively [Table 5]. The frequency of adjacent segment degeneration was 44% for 2.23 years after CF versus a slightly higher 50% for ACDF patients, followed by an average of 1.88 years.^[4]

DISCUSSION

Although ACDF is more commonly performed to treat cervical radiculopathy without myelopathy, CF appears to provide comparable results but with fewer adverse events/morbidity and costs.^[10] Although we found that ACDF patients had greater likelihood of achieving MCID measured with PROMIS PI, they required a 6.25% revision rate versus

Table 5: Hospital costs and postoperative imaging.

	ACDF	CF	P-value
Avg Hospital LOS (hours)	33.68 (29.62, 37.73)	22.73 (19.98, 25.46)	<0.001
Avg Hospital LOS (days)	1.41 (0.98, 1.84)	0.95 (0.61, 1.28)	0.099
Avg OR Time (minutes)	176.97 (156.88, 197.07)	136.92 (121.44, 152.40)	0.002
Avg Imaging Studies			
X-rays	4.10 (3.37, 4.84)	0.40 (0.18, 0.62)	<0.001
Computed tomography	0.22 (-0.01, 0.44)	0.08 (-0.01, 0.16)	0.204
Magnetic resonance	0.33 (0.11, 0.55)	0.21 (0.05, 0.37)	0.386
Adjacent segment degeneration	16 (50%)	14 (44%)	0.624
Disc space narrowing	5 (16%)	5 (16%)	1.000
Spinal canal narrowing	6 (19%)	8 (25%)	0.572
Neuroforaminal narrowing	11 (34%)	10 (31%)	0.801
Implant costs	One spinal level	Two spinal levels	
Mean	\$1,836	\$2,773	NA
Median	\$1,369	\$2,179	NA
Min	\$1,041	\$1,460	NA
Max	\$3,150	\$5,015	NA

Avg: Average per patient, LOS: Length of stay in days, OR time: Operating room time in minutes, CF: Cervical foraminotomy, ACDF: Anterior cervical discectomy and fusion. Confidence intervals assume alpha=0.05, NA: Not applicable

0% for CF, more postoperative X-rays (i.e., 4.1 vs. 0.4 studies), longer operations, longer lengths of hospital stay, high implant costs versus 0% for CF, a 41% risk of dysphagia versus 0% for CF, and a 3% risk of vocal cord paralysis versus 0% for CF.^[8,12]

ACDF and CF revision rates range between 5% and 10%^[1-3,9,11,12], with large retrospective studies often reporting fewer revisions for ACDF^[5], while randomized trials show lower CF reoperation rates.^[10] Baseline cohort health differences could explain this variation as studies with low CF revisions, including our study, document low comorbidities, and studies favoring ACDF report high comorbidities. Differences in reoperation rates may also be attributable to more surgeons performing ACDF in medically complex patients, given its familiarity and popularity, whereas few may be adequately trained in or technically adept at performing CF.

CONCLUSION

Advantages for CF versus ACDF for one- or two-level unilateral cervical radiculopathy included 3.70 fewer postoperative X-rays, 40 min less operative time, a 10.95-h shorter length of hospital stay, a 0% reoperation rate versus 6.5% for ACDF, no implant costs, no postoperative dysphagia (41% for ACDF), and no vocal cord paralysis (3% for ACDF).

Ethical approval: The research/study was approved by the Institutional Review Board at the University of Rochester research subjects review board (RSRB), number STUDY00000982, approved the study dated March 02, 2023.

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