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SYSTEMATIC REVIEW **Open Access**

Diagnosis and treatment of postoperative voice complications following anterior cervical discectomy and fusion: a systematic review

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Abstract

Background There is a wide discrepancy in the literature regarding the incidence of postoperative dysphonia following ACDF. How postoperative dysphonia is measured is also inconsistent, with many studies relying on patient-reported outcomes rather than diagnostic laryngoscopy. The purpose of this study was to consolidate information regarding dysphonia after ACDF to improve diagnosis and management.

Methods A comprehensive database search was performed using key terms. Inclusion criteria was as follows: published within 10 years, subjects > 18 years of age, ACDF for treatment of cervical radiculopathy and/or myelopathy, reports of postoperative changes in voice, and at least one postoperative follow-up between one week and six months. Works that included endoscopic surgical techniques and/or subjects with a history of cancer or trauma to the operated region were excluded. Reviews and meta-analyses were also removed from analysis.

Results Twenty-one eligible studies were analyzed. Evaluation methods varied, with incidence rates ranging from 0.3 to 27%. Symptoms typically arose within one week post-op, persisting up to one year. Treatment modalities included steroids, speech therapy, and laryngoplasty. Mechanisms included recurrent laryngeal nerve injury, endotracheal tube pressure, and postoperative edema.

Conclusions Postoperative voice complications following ACDF represent a clinically significant outcome that can impact a patient's quality of life. Patients should be counseled preoperatively about the potential risk, and managed postoperatively to mitigate long-term impairments. Involvement of otolaryngologists may help prevent these complications or allow for early detection and management, underscoring the importance of multidisciplinary care in optimizing surgical outcomes.

Keywords Dysphonia, ACDF, Laryngeal nerve, Vocal cord

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Background

Anterior cervical discectomy and fusion (ACDF) is one of the most common cervical spine procedures performed in the United States, with approximately 130,000-137,000 fusions carried out each year [1, 2]. ACDF results in markedly improved outcomes when performed for radicular or myelopathic complaints, with sustained improvements 10 years postoperatively [3–5].

While the surgical approach to the anterior cervical spine largely requires fascial splitting, without significant muscle dissection between the platysma and the longus colli, the location of this approach local to the esophagus and trachea in addition to neurologic structures such as the recurrent laryngeal nerve (RLN) makes postoperative complications common [6–9]. Reported morbidity rates following ACDF range from 13.2 to 19.3% [1, 10]. Complications related to the larynx are primarily vocal cord paralysis resulting from injury to RLN. There is a wide discrepancy in the literature regarding the incidence of dysphonia following ACDF, ranging from 1 to 70% [11]. This may be due to the myriad clinical presentations of dysphonia, which can range from transient voice changes to long term vocal deficits [12]. How postoperative dysphonia is measured is also inconsistent, with many studies relying on patient-reported outcomes rather than diagnostic laryngoscopy [13].

The purpose of this study was to consolidate and synthesize the existing research on dysphonia following ACDF. It is intended to present a clearer and more cohesive understanding of how we diagnose, describe, and report dysphonia after ACDF. The research question we hope to answer is whether or not current methods for diagnosing, describing, and reporting dysphonia after ACDF are consistent and effective across the literature. The findings of this work are intended to form the basis of higher quality prospective studies on this topic.

Materials and methods

A systematic literature search was performed using the PubMed and Google Scholar databases. Notable studies were identified using a search criteria developed in collaboration with our institution's library (**Appendix**), with selected citations uploaded into Covidence (Cochrane, London, UK). The reference lists of these studies were also evaluated to identify additional relevant papers for screening. Inclusion criteria were as follows: manuscripts published between 2013 and 2023, subjects > 18 years of age, ACDF performed to treat cervical radiculopathy and/or myelopathy, reports of postoperative voice changes, and at least one postoperative follow-up between one week and six months after surgery. Works that included endoscopic surgical techniques and/or subjects with a history of cancer or trauma to the operated region were excluded. Reviews and meta-analyses were also removed from analysis. Abstract screening, full-text review, and data extraction were then conducted in accordance with PRISMA guidelines (Fig. 1). Studies collected and included for this analysis were then reviewed for a risk of bias and study design using the Cochrane risk of bias assessment tool [14].

Results

A total of 937 studies were obtained from the initial search criteria after the removal of duplicate papers. After abstract screening and full-text review, 21 full-text articles were deemed suitable for data extraction and analysis. Table 1 highlights the differing ACDF approaches utilized by each study, as well as methods for evaluating postoperative voice complications.

Of the 13 studies that reported the specialties involved, only four listed an ENT head and neck surgeon as part of the operative team for initial dissection [18, 24, 32, 34]. The laterality of the surgical approach was reported in 13 studies, with seven using a right-sided approach and three using a left-sided approach. Three studies reported both left- and right-sided ACDF approaches based on either surgeon preference or a previous neck surgery [24, 32, 34]. Indications for study inclusion across all 21 studies were broadly single- or multi-level ACDF to treat cervical radiculopathy and/or myelopathy. Three studies specifically investigated the outcomes of patients who underwent a revision ACDF [18, 24, 32], while two studies evaluated different surgical constructs [32,36]. Panchal et al. specifically studied patients with minimal vocal symptoms based on Voice Handicap Index (VHI-10) scores obtained prior to surgery [27].

Table 2 summarizes the clinical characteristics of postoperative voice complications observed following ACDF across the 21 studies. Complication terminology varied, with the most commonly used terms including "dysphonia" (9/21), "hoarseness" (10/21), "vocal cord paresis" (2/21), "vocal cord paralysis" (7/21), and "recurrent laryngeal nerve palsy" (6/21). Choy et al. utilized the term "superior laryngeal nerve palsy", while Mehra et al. used "loss of high pitch", and Strohl et al. used "vocal fold motion impairment" [16, 24, 32]. Six studies reported multiple diagnoses, with patients experiencing a combination of dysphonia or hoarseness with subsequently identified vocal cord paralysis, paresis, or recurrent laryngeal nerve palsy. The most common method used to evaluate postoperative voice changes was patient-reported symptoms, which was utilized in 10 of the 21 studies. Six studies used some variation of endoscopic laryngoscopy, while two utilized the Voice Handicap Index (VHI-10).

The incidence of voice complications following ACDF ranged from 0.3 to 27%. Four studies examined differences in the incidence of voice complications between

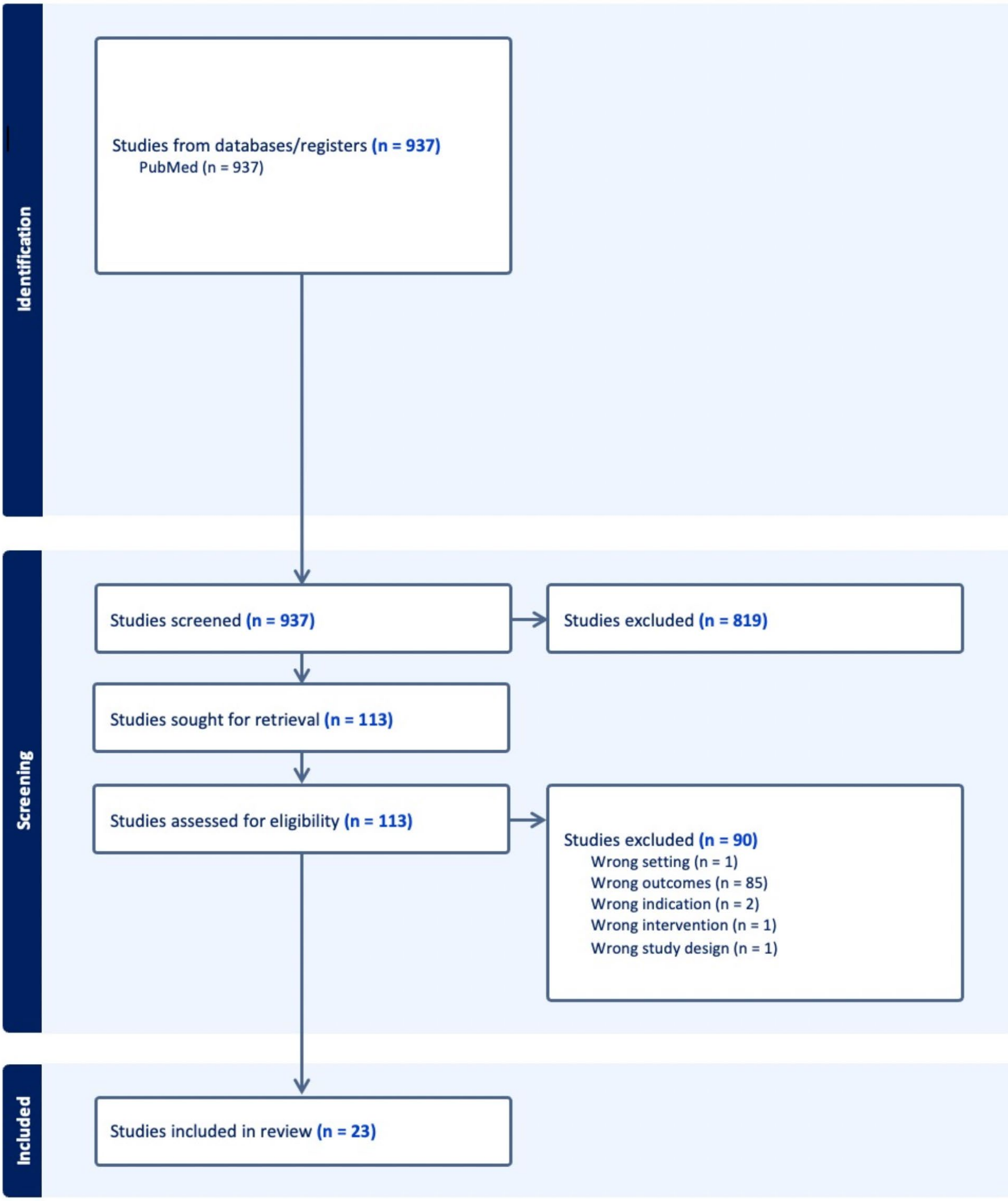

Fig. 1 PRISMA flow diagram illustrating systematic review process

different surgical constructs or materials, including zero-profile implants, stand-alone anchored spacers, and the use of rhBMP-2. However, no significant differences were found. Jenkins et al. examined the incidence of postoperative voice changes following local vs. IV steroid administration during ACDF, with higher rates of dysphonia reported in the control and IV steroid groups [22]. Two studies examined differences in the incidence of dysphonia based on external surgical variables such as location and timing. Kamalpathy et al. studied the

Table 1 ACDF surgical approach and evaluation of postoperative dysphonia

Author	Study Design	Specialties involved in ACDF Procedure	Laterality of ACDF Approach	Indications for Study Inclusion	Method of Evaluation for Post-Op Voice Complications
Chen et al. 2014 [15]	Case control study	N/A	Right	Four-Level Primary ACDF	Endoscopic laryngoscopy
Choy et al. 2022 [16]	Case report	N/A	N/A	C3/4, C4/5 ACDF for cervical myelopathy	Endoscopic laryngoscopy, electromyogram of bilateral thyroarytenoid and cricothyroid muscles
Elder et al. 2016 [17]	Case control study	N/A	N/A	ACDF with intraoperative durotomy and/or CSF leak	Patient-reported symptoms
Erwood et al. 2018 [18]	Non-randomized experimental study	Neuro, ENT	Right	1 or more ACDF surgery	Videolaryngostroboscopy
He et al. 2018 [19]	Randomized controlled trial	N/A	N/A	Cervical spondylotic myelopathy w/ multilevel ACDF	Patient-reported symptoms
Helseth et al. 2019 [20]	Case control study	Neuro	Right	ACDF for radiculopathy, cervical myelopathy	Patient-reported symptoms
Huschbeck et al. 2020 [21]	Case control study	Neuro	Right	C2-C7 ACDF	Endoscopic laryngoscopy
Jenkins et al. 2018 [22]	Randomized controlled trial	Ortho	N/A	ACDF for radiculopathy or myelopathy	Voice Handicap Index (VHI-10)
Kamalpathy et al. 2021 [23]	Case control study	N/A	N/A	Single-level vs. multi-level ACDF	Patient-reported symptoms
Mehra et al. 2014 [24]	Case control study	Ortho, ENT	Left, Right	Multilevel, revision high-cervical (above C4), and/or low-cervical (below C6) ACDF	Patient-reported symptoms
Nanda et al. 2014 [25]	Case control study	Neuro	Right	ACDF for radiculopathy, myelopathy	Endoscopic laryngoscopy
Njoku Jr. et al. 2014 [26]	Case control study	Neuro	Right	C3-4 and C7-T1 ACDF w/ Zero-P implant	Patient-reported symptoms
Panchal et al. 2017 [27]	Randomized controlled trial	N/A	Left	C3-C7 ACDF with VHI < 1.1	Voice Handicap Index (VHI-10)
Reisener et al. 2021 [28]	Case control study	Ortho	N/A	ACDF for degenerative cervical spine pathologies	Hospital for Special Surgery Dysphagia and Dysphonia Inventory (HSS-DDI)
Riederman et al. 2017 [29]	Case control study	N/A	N/A	Primary ACDF	Patient-reported symptoms
Shi et al. 2018 [30]	Case control study	Ortho	Right	ACDF with either plate-cage construct (PCC) or stand-alone anchored spacer (SAAS)	Patient-reported symptoms
Siemionow et al. 2014 [31]	Case control study	Ortho, Neuro	N/A	ACDF followed by PSIF crossing cervicothoracic junction	N/A
Strohl et al. 2020 [32]	Case control study	Ortho/Neuro, ENT	Left, Right	Revision ACDF	Endoscopic laryngoscopy
Wang et al. 2015 [33]	Case control study	Ortho	Left	ACDF for cervical spondylotic myelopathy	Patient-reported symptoms
Winkler et al. 2016 [34]	Case control study	Neuro, ENT	Left, Right	Revision ACDF using tunneled subcricoid approach at C5 and below	Endoscopic laryngoscopy
Yemeni et al. 2019 [35]	Case report	N/A	Left	ACDF for myeloradiculopathy	Patient-reported symptoms, nasolaryngoscopy

influence of single- vs. multi-level ACDF as well as inpatient vs. outpatient ACDF, Siemionow et al. examined differences in dysphagia between same-day vs. staged ACDF with posterior spinal fusion (PSF) [23, 31]. Again, no significant differences were noted between the examined groups.

Dysphonia symptom onset occurred within the first week of surgery as per 14 of the 21 studies. Choy et al. was the only study to report a delayed time of symptom onset, with superior laryngeal nerve palsy occurring three months after surgery [16]. Time until symptom resolution ranged between six weeks and one-year after surgery, with symptoms resolving either transiently or after treatment. Mehra et al. found that most patients experiencing postoperative voice changes reported symptom relief between six-months and one-year postoperatively [24]. However, eight studies reported cases of persistent symptoms as far as two years postoperatively, with no improvement or resolution despite treatment.

There were multiple proposed mechanisms of action for postoperative voice changes following ACDF. The most commonly described mechanism was recurrent laryngeal nerve palsy due to manual retraction (13 of 21 studies). Other recognized possible causes included endotracheal tube and cuff pressure (4/21), postoperative edema or hematoma (6/21), fibrous tissue formation (4/21), and compression from spacers and/or implants (3/21).

Multiple studies disagreed as to areas of the cervical spine at a higher risk of postoperative dysphonia. Both Chen et al. and Strohl et al. identified lower cervical regions below C5 as high risk regions based on their reported incidence of postoperative voice changes [15, 32]. However, Mehra et al. found that patients undergoing ACDF at cervical levels above C4 were more likely to develop postoperative vocal dysfunction [24]. Winkler et al. reported a cervical exposure > four levels as a risk factor for the development of vocal symptoms following ACDF [34]. Other notable surgical risk factors included anterior cervical plating, one or two-level fusions, and revision ACDF surgeries. Non-surgical risk factors included diabetes, infection, worker's comp status, and psychosocial factors. Erwood et al. found a correlation between a postoperative objective swallowing abnormality and subsequent vocal cord paralysis development [18]. Reisener et al. found a relationship between pre-op NDI scores and postoperative dysphonia in patients undergoing ACDF [28]. Notable non-surgical risk factors included diabetes, infection, and psychosocial factors.

Treatment options for postoperative voice changes and vocal dysfunction following ACDF included a combination of conservative and surgical therapies. Five studies reported symptom resolution following a course of short-term steroids. Jenkins et al. found that local steroid application was more effective than IV steroids immediately following ACDF at preventing postoperative dysphonia [22]. Four studies reported improved dysphonia following a course of speech therapy. Five studies included patients who required a laryngoplasty with vocal cord medialization to alleviate postoperative vocal dysfunction. Regarding preventative measures, two studies concluded that ENT involvement with either initial surgical exposure or postoperative care reduced the incidence of postoperative voice changes. Other alleviating factors included the use of stand-alone spacers and postoperative reintubation to prevent either airway edema or vocal cord paralysis.

Discussion

This systematic review focused on dysphonia following ACDF. Our review identified several disagreements within the existing body of literature regarding the prevalence rate, clinical presentation, and measurement of dysphonia after ACDF. It is hoped that this study can contribute to future research and interventions for postoperative dysphonia following ACDF, ultimately leading to improved patient outcomes.

There was a significant variability in the reported incidence of dysphonia after ACDF, with percentages ranging from 0.3 to 27% [19, 24]. This variability may be the result of the use of different outcome measures used to define dysphonia. While a majority of the included studies used perceived symptoms of hoarseness as their primary outcome, others looked specifically for evidence of recurrent laryngeal nerve injury and vocal cord paralysis. Another factor that could impact complication rates is the use of different tools to measure vocal outcomes. While 10 studies used patient-reported symptoms such as hoarseness to evaluate postoperative vocal complications, six used endoscopic laryngoscopy and two the Voice Handicap Index (VHI-10). Given that patients may have dysphonia without vocal cord changes noted during laryngoscopy, it is likely that studies that required a positive laryngoscopy rather than patient-reported symptoms alone would underreport postoperative vocal complications.

Most of the cases of postoperative dysphonia resolved within 6 months, requiring observation or conservative treatments such as short-term steroids and speech therapy. Vocal fold injection and medialization was also successfully utilized in patients with vocal fold motion abnormalities. While most patients with postoperative dysphonia recovered without lasting complications, there were several reports of patients with persistent dysphonia as far as two years postoperatively without any resolution. Mehra et al. reported that 9% who underwent an anterior approach to the cervical spine had subjective voice complaints that persisted beyond one year [24]. However, it is unclear what treatment options were offered to patients

Table 2 Postoperative vocal complication clinical characteristics

Author	Complication Terminology	Incidence Rate	Time of Onset	Time of Resolution	Proposed Mechanism of Action	Risk Factors	Treatment/ Alleviating Factors
Chen et al. 2014 [15]	Vocal cord paralysis, Hoarseness	9/1895 (0.48%)	N/A	4 months post-op (3/9)	Indirect stretch or focal pressure on recurrent laryngeal nerve due to retraction, endotracheal tube + cuff pressure on RLN	Surgical field involving C6/7	Short-term steroids, speech therapy, laryngoplasty
Choy et al. 2022 [16]	Superior laryngeal nerve palsy	N/A	3 months post-op	N/A	Direct injury, excessive traction by retractor blades resulting in stretch injury, or postoperative edema	N/A	Voice therapy, vocal cord injection, right medialization laryngoplasty
Elder et al. 2016 [17]	Hoarseness	2/14 (14%)	Immediately post-op	2–60 days post-op	Recurrent laryngeal nerve palsy	N/A	N/A
Erwood et al. 2018 [18]	Vocal cord paralysis	5/67 (7.5%)	Immediately post-op	2 months post-op	Sectioning or retraction injury to recurrent laryngeal nerve, retraction of esophagus w/ reduced perfusion, direct pharyngeal or esophageal pressure, hypoglossal nerve injury, alteration in C2-7 angle, reoperative scar tissue	Post-op objective abnormality of swallowing	2-team surgical approach using ENT surgeon
He et al. 2018 [19]	Hoarseness	Zero-profile cohort: 0/52 (0%) Anterior cervical plate cohort: 1/52 (2%)	N/A	Present at 2 years post-op	Injury to recurrent laryngeal nerve	Anterior cervical plating	N/A
Helseth et al. 2019 [20]	Vocal cord paresis, Hoarseness	3/1083 (0.3%) 2 w/ unilateral vocal cord paresis	Immediately post-op	Persistent > 3 months post-op	Permanent injury to the recurrent laryngeal nerve	N/A	N/A
Huschbeck et al. 2020 [21]	Recurrent laryngeal nerve palsy	19/211 (9%)	N/A	N/A	Laterality of recurrent laryngeal nerve palsy	N/A	N/A
Jenkins et al. 2018 [22]	Dysphonia	Control: 10% IV steroid: 20%	1 day post-op	Persistent > 3 months post-op	N/A	N/A	Local steroid application
Kamalpathy et al. 2021 [23]	Hoarseness	Outpatient single-level ACDF: 74/18,230 (0.4%) Inpatient single-level ACDF: 90/18,230 (0.5%) Outpatient multi-level ACDF: 60/15,577 (0.4%) Inpatient multi-level ACDF: 69/15,577 (0.4%)	1 day post-op	Persistent > 90 days post-op	N/A	None	N/A
Mehra et al. 2014 [24]	Dysphonia, Vocal cord paralysis, Recurrent laryngeal nerve palsy, Hoarseness, Vocal cord paresis, Loss of high pitch	35/129 (27%) 1 patient w/ vocal cord paresis 1 patient w/ vocal cord paralysis	Immediately post-op	29% at 1 month post-op, 54% at 3 months post-op, 60% at 6 months post-op, 66% at 1 year post-op, 9% persistent > 1 year post-op	Stretch injury to the RLN or SLN, denervation of the pharyngeal plexus followed by disorganized reinnervation, prolonged endolaryngeal pressure on the terminal branches of RLN from the ETT cuff, infection, hematoma, edema, fibrosis, bone graft dislodgement, adhesions between the cervical esophagus and the plate, delayed osteophyte formation, retropharyngeal cerebrospinal fluid collection, and pharyngoesophageal diverticulum	Levels above C4	Steroid medications, voice and swallow therapy, vocal cord medialization

Table 2 (continued)

Author	Complication Terminology	Incidence Rate	Time of Onset	Time of Resolution	Proposed Mechanism of Action	Risk Factors	Treatment/ Alleviating Factors
Nanda et al. 2014 [25]	Vocal cord paralysis, Recurrent laryngeal nerve palsy, Hoarseness	19/1576 (1.2%) 2 patients w/ unilateral vocal cord palsy	Immediately post-op	6 weeks-3 months post-op	Recurrent laryngeal nerve palsy	One-level fusion (11 patients), two-level fusion (7 patients)	Conservative management with steroids
Njoku Jr. et al. 2014 [26]	Hoarseness	5/41 (12%)	Immediately post-op	3 months post-op	Esophageal irritation or ischemia, recurrent laryngeal nerve palsy, adhesions, and screw or plate migration in a small fraction of cases	N/A	N/A
Panchal et al. 2017 [27]	Dysphonia	N/A	Immediately post-op	1 month post-op, persistent > 1 year post-op	Recurrent laryngeal nerve injury due to stretching during retraction	N/A	Stand-alone spacer
Reisener et al. 2021 [28]	Dysphonia	N/A	N/A	N/A	N/A	Pre-op NDI score, WC status, psychosocial factors (depression, victimization)	N/A
Riederman et al. 2017 [29]	Dysphonia	rhBMP-2: 5/200 (2.5%) ICBG: 9/200 (4.5%)	Immediately post-op	N/A	N/A	Revision ACDF	N/A
Shi et al. 2018 [30]	Hoarseness	SAAS: 3/34 (8.8%) PCC: 3/31 (9.7%)	N/A	N/A	Acute soft-tissue edema, esophageal injury from retraction, hematoma, nerve injury, duration of intubation, and endotracheal tube cuff pressure, etc.	N/A	N/A
Siemionow et al. 2014 [31]	Dysphonia, Vocal cord paralysis	Same-day ACDF and PSIF: 2/35 (5.7%) Staged ACDF and PSIF: 4/35 (11.4%) Vocal cord paralysis: 1/35 (2.8%)	N/A	N/A	N/A	Diabetes (3/7 patients)	Post-operative re-intubation for airway edema or vocal cord paralysis
Strohl et al. 2020 [32]	Dysphonia, Vocal fold motion impairment (VFMI)	Dysphonia: 25% Immediate VFMI: 15/72 (21%)	Immediately post-op	4 months post-op, persistent > 14 months post-op	Recurrent laryngeal nerve injury + trauma from intubation, vocal cord edema or hemorrhage, or injury to the superior laryngeal nerve	Infection, operative exposure of levels C7/T1	Temporary vocal fold augmentation
Wang et al. 2015 [33]	Dysphonia, Hoarseness	Zero-P: 0/27 (0%) PCB: 2/30 (6.7%)	Immediately post-op	1 month post-op	Recurrent laryngeal nerve injury caused by the overstretch of prevertebral soft tissue in order to place plate cage benezech implant well in operation	N/A	N/A
Winkler et al. 2016 [34]	Dysphonia, Recurrent laryngeal nerve palsy, Vocal cord paralysis	Dysphonia: 5/48 (10.4%) Permanent recurrent laryngeal nerve injury: 3/48 (6.2%)	Immediately post-op	Persistent > 3 months post-op	Extensive scarring increasing risk for inadvertent injury to recurrent laryngeal nerve.	Exposures involving > 4 disc levels w/ extension to upper thoracic spine	N/A

Table 2 (continued)

Author	Complication Terminology	Incidence Rate	Time of Onset	Time of Resolution	Proposed Mechanism of Action	Risk Factors	Treatment/ Alleviating Factors
Yemeni et al. 2019 [35]	Vocal cord paralysis, Recurrent laryngeal nerve palsy	N/A	3 days post-op	6 months post-op	Wound healing-induced mechanical damage, post-operative inflammatory remodeling of the affected region, arterial vasospasm, venous congestion, and edema or hematoma-induced pressure, progression of postoperative prevertebral soft tissue swelling	N/A	Course of steroids, speech therapy, ENT f/u

with persistent dysphonia. Further investigations into optimal treatments for patients with prolonged dysphonia following ACDF are warranted.

Several mechanisms have been proposed to explain postoperative dysphonia following ACDF, though its etiology is likely multifactorial. A majority of the included studies (13/21) attributed dysphonia to recurrent laryngeal nerve injury during the operation. It has been proposed that excessive retraction leads to indirect stretch or increased pressure on the nerve, resulting in injury. Interestingly, some studies hypothesized that injury to the recurrent laryngeal nerve was less likely to occur during a left sided anterior approach to the cervical spine due to the anatomic course of the left RLN. The left RLN has a longer loop than the right-sided nerve and is thus better protected within the groove at the junction of the esophagus and trachea [12]. However, a relationship between ACDF approach laterality and postoperative dysphonia was not found in our review. Despite this anatomic difference, however, our review of the literature found no studies that found a statistical difference in the incidence of dysphonia following a left vs. right-sided ACDF approach.

Another important mechanism of injury proposed in the literature is prolonged pressure on the branches of the RLN from the endotracheal tube cuff. This has been reported to account for between 7.5 and 11.2% of RLN injuries, specifically RLN palsy (RLNP). Given the reported relationship between endotracheal cuff pressure and RLNP, intraoperative adjustment of cuff pressure has been proposed as a method to avoid RLN injury. Other mechanisms of postoperative dysphonia include postoperative edema and hematoma as well as vocal cord hemorrhage.

While postoperative dysphonia following ACDF is clinically significant, there is paucity of literature that details how to prevent or manage this complication. Mehra et al. and Strohl et al. emphasized the importance of early otolaryngologist involvement, suggesting that head and neck surgeons would be able to best manage patient expectations regarding vocal function following ACDF and help counsel patients with complications [24, 32]. Preoperative vocal documentation and/or screening can be used to aid postoperative diagnosis if dysphagia arises. These screenings can be performed by orthopedic spine surgeons as well as head and neck surgeons. Erwood et al. further highlighted the importance of otolaryngologists, arguing that although otolaryngologists are not formally trained in ACDF procedures, they may nevertheless help provide safe access to the cervical spine given their experience operating in the anterior neck [18]. By operating alongside the spine surgeon, otolaryngologists may help to prevent injury to the vocal cords.

This systematic review has several limitations. First, there is inherent variability across the 21 studies regarding study design, sample patient populations, interventions, and outcome measurements. Reported outcomes varied from paper to paper, and some studies did not include onset/resolution timepoints or risk factors. There are also limitations to our study's search strategy, as potentially relevant studies could have been excluded due to the omission of certain terms in our preliminary search. Lastly, only studies published from 2013 to 2023 were included in our analysis. Any earlier findings or associations between ACDF and post-operative dysphonia were not included.

Overall, the results of our systematic review show that there is a large degree of inconsistency across reported incidence rates, mechanisms of action, and management options for postoperative dysphonia following ACDF. From a clinical perspective, this can create confusion regarding the significance of this complication and, if it does arise in patients, how to best treat and manage relevant symptoms. Future studies should seek to quantify incidence rates within a large patient cohort along with significantly associated pre-operative variables. Furthermore, prospective studies investigating the effects of various treatment options on alleviating or resolving postoperative dysphonia would be beneficial in providing clinical direction for providers.

Conclusions

Postoperative vocal complications following ACDF can be a notable source of postoperative morbidity. While most patients recover within 6 months, some may have persistent vocal complications that impair quality of life. Patients should be counseled and potentially screened preoperatively, as well as managed postoperatively to avoid long term impairments from postoperative dysphonia. Early Otolaryngologist involvement may help to prevent this complication and allow for early detection and symptom management. Additional prospective studies to firmly establish the incidence of postoperative dysphonia and identify ideal treatment strategies are warranted.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-025-05464-1.

Supplementary Material 1

Author contributions

G.J. and J.X conceived the original study idea, performed the systematic review with subsequent data analysis, prepared Table 1, and 2, and wrote the main manuscript.S.W. assisted with the systematic review with subsequent data analysis, prepared Fig. 1, and assisted with writing the main manuscript.R.S. helped provide the search criteria for the systematic review.R.K. and M.S.F. oversaw the project as senior authors and reviewed progress and findings when relevant.All authors reviewed manuscript prior to submission.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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References

1. Epstein NE. A review of Complication Rates for Anterior Cervical Diskectomy and Fusion (ACDF). Surg Neurol Int. 2019;10:100. https://doi.org/10.25259/SNI-191-2019.
2. Saifi C, Fein AW, Cazzulino A, Lehman RA, Phillips FM, An HS, Riew KD. Trends in resource utilization and rate of cervical disc arthroplasty and anterior cervical discectomy and fusion throughout the United States from 2006 to 2013. Spine Journal: Official J North Am Spine Soc. 2018;18(6):1022–9. https://doi.org/10.1016/j.spinee.2017.10.072.
3. Buttermann GR. Anterior cervical discectomy and Fusion outcomes over 10 years: a prospective study. Spine. 2018;43(3):207–14. https://doi.org/10.1097/BRS.0000000000002273.
4. Burkhardt BW, Brielmaier M, Schwerdtfeger K, Oertel JM. Clinical outcome following anterior cervical discectomy and fusion with and without anterior cervical plating for the treatment of cervical disc herniation-a 25-year follow-up study. Neurosurg Rev. 2018;41(2):473–82. https://doi.org/10.1007/s10143-017-0872-6.
5. Stull JD, Goyal DKC, Mangan JJ, Divi SN, McKenzie JC, Casper DS, Okroj K, Kepler CK, Vaccaro AR, Schroeder GD, Hilibrand AS. The outcomes of patients with Neck Pain following ACDF: a comparison of patients with Radiculopathy, Myelopathy, or mixed symptomatology. Spine. 2020;45(21):1485–90. https://doi.org/10.1097/BRS.0000000000003613.
6. Wang P, Kong C, Teng Z, Zhang S, Cui P, Wang S, Zhao G, Lu S. Enhanced recovery after surgery (ERAS) program for Anterior Cervical Discectomy and Fusion (ACDF) in patients over 60 Years Old. Clin Interv Aging. 2023;18:1619–27. https://doi.org/10.2147/CIA.S422418.
7. Joo PY, Zhu JR, Kammien AJ, Gouzoulis MJ, Arnold PM, Grauer JN. Clinical outcomes following one-, two-, three-, and four-level anterior cervical discectomy and fusion: a national database study. Spine Journal: Official J North Am Spine Soc. 2022;22(4):542–8. https://doi.org/10.1016/j.spinee.2021.11.002.
8. Yeshoua BJ, Singh S, Liu H, Assad N, Dominy CL, Pasik SD, Tang JE, Patel A, Shah KC, Ranson W, Kim JS, Cho SK. Association between Age-stratified cohorts and Perioperative complications and 30-day and 90-day readmission in patients undergoing single-level Anterior Cervical Discectomy and Fusion. Clin Spine Surg. 2024;37(1):E9–17. https://doi.org/10.1097/BSD.0000000000001509.
9. Buerba RA, Giles E, Webb ML, Fu MC, Gvozdyev B, Grauer JN. Increased risk of complications after anterior cervical discectomy and fusion in the elderly: an analysis of 6253 patients in the American College of Surgeons National Surgical Quality Improvement Program database. Spine. 2014;39(25):2062–9. https://doi.org/10.1097/BRS.0000000000000606.
10. Tasiou A, Giannis T, Brotis AG, Siasios I, Georgiadis I, Gatos H, Tsianaka E, Vagkopoulos K, Paterakis K, Fountas KN. Anterior cervical spine surgery-associated complications in a retrospective case-control study. J Spine Surg (Hong Kong). 2017;3(3):444–59. https://doi.org/10.21037/jss.2017.08.03.
11. Erwood MS, Hadley MN, Gordon AS, Carroll WR, Agee BS, Walters BC. Recurrent laryngeal nerve injury following reoperative anterior cervical discectomy and fusion: a meta-analysis. J Neurosurg Spine. 2016;25(2):198–204. https://doi.org/10.3171/2015.9.SPINE15187.
12. Gowd AK, Vahidi NA, Magdycz WP, Zollinger PL, Carmouche JJ. Correlation of Voice Hoarseness and vocal cord Palsy: a prospective Assessment of recurrent laryngeal nerve Injury following anterior cervical discectomy and Fusion. Int J Spine Surg. 2021;15(1):12–7. https://doi.org/10.14444/8001.
13. Stachler RJ, Francis DO, Schwartz SR, Damask CC, Digoy GP, Krouse HJ, McCoy SJ, Ouellette DR, Patel RR, Reavis C, Charlie W, Smith LJ, Smith M, Strode SW,

Woo P, Nnacheta LC. Clinical practice Guideline: Hoarseness (Dysphonia) (update). Otolaryngology–Head Neck Surg. 2018;158(S1). https://doi.org/10.1177/0194599817751030.
14. Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, Savović J, Schulz KF, Weeks L, Sterne JAC, et al. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343:d5928. https://doi.org/10.1136/bmj.d5928.
15. Chen CC, Huang YC, Lee ST, Chen JF, Wu CT, Tu PH. Long-term result of vocal cord paralysis after anterior cervical disectomy. Eur Spine Journal: Official Publication Eur Spine Soc Eur Spinal Deformity Soc Eur Sect Cerv Spine Res Soc. 2014;23(3):622–6. https://doi.org/10.1007/s00586-013-3084-y.
16. Choy W, Garcia J, Safaee MM, Rubio RR, Loftus PA, Clark AJ. Superior Laryngeal nerve Palsy after Anterior Cervical Diskectomy and Fusion: a Case Report and Cadaveric description. Operative Neurosurg (Hagerstown Md). 2022;23(2):e152–5. https://doi.org/10.1227/ons.0000000000000276.
17. Elder BD, Theodros D, Sankey EW, Bydon M, Goodwin CR, Wolinsky JP, Sciubba DM, Gokaslan ZL, Bydon A, Witham TF. Management of Cerebrospinal Fluid Leakage during Anterior Cervical Discectomy and Fusion and its effect on spinal Fusion. World Neurosurg. 2016;89:636–40. https://doi.org/10.1016/j.wneu.2015.11.033.
18. Erwood MS, Walters BC, Connolly TM, Gordon AS, Carroll WR, Agee BS, Carn BR, Hadley MN. Voice and swallowing outcomes following reoperative anterior cervical discectomy and fusion with a 2-team surgical approach. J Neurosurg Spine. 2018;28(2):140–8. https://doi.org/10.3171/2017.5.SPINE161104.
19. Helseth Ø, Lied B, Heskestad B, Ekseth K, Helseth E. Retrospective single-centre series of 1300 consecutive cases of outpatient cervical spine surgery: complications, hospital readmissions, and reoperations. Br J Neurosurg. 2019;33(6):613–9. https://doi.org/10.1080/02688697.2019.1675587.
20. He S, Feng H, Lan Z, Lai J, Sun Z, Wang Y, Wang J, Ren Z, Huang F, Xu F. A randomized trial comparing clinical outcomes between Zero-Profile and Traditional Multilevel Anterior Cervical Discectomy and Fusion surgery for cervical myelopathy. Spine. 2018;43(5):E259–66. https://doi.org/10.1097/BRS.0000000000002323.
21. Huschbeck A, Knoop M, Gahleitner A, Koch S, Schrom T, Stoffel M, Alfieri A, Dengler J. Recurrent laryngeal nerve Palsy after Anterior Cervical Discectomy and Fusion - Prevalence and Risk factors. J Neurol Surg Part Cent Eur Neurosurg. 2020;81(6):508–12. https://doi.org/10.1055/s-0040-1710351.
22. Jenkins TJ, Nair R, Bhatt S, Rosenthal BD, Savage JW, Hsu WK, Patel AA. The effect of local Versus Intravenous corticosteroids on the Likelihood of Dysphagia and Dysphonia following anterior cervical discectomy and Fusion: a Single-Blinded, prospective, randomized controlled trial. J Bone Joint Surg Am Vol. 2018;100(17):1461–72. https://doi.org/10.2106/JBJS.17.01540.
23. Kamalapathy PN, Puvanesarajah V, Sequeria S, Bell J, Hassanzadeh H. Safety profile of outpatient vs inpatient ACDF: an analysis of 33,807 outpatient ACDFs. Clin Neurol Neurosurg. 2021;207:106743. https://doi.org/10.1016/j.clineuro.2021.106743.
24. Mehra S, Heineman TE, Cammisa FP, Jr, Girardi FP, Sama AA, Kutler DI. Factors predictive of voice and swallowing outcomes after anterior approaches to the cervical spine. Otolaryngology–head neck Surgery: Official J Am Acad Otolaryngology-Head Neck Surg. 2014;150(2):259–65. https://doi.org/10.1177/0194599813515414.
25. Nanda A, Sharma M, Sonig A, Ambekar S, Bollam P. Surgical complications of anterior cervical diskectomy and fusion for cervical degenerative disk disease: a single surgeon's experience of 1,576 patients. World Neurosurg. 2014;82(6):1380–7. https://doi.org/10.1016/j.wneu.2013.09.022.
26. Njoku I, Jr, Alimi M, Leng LZ, Shin BJ, James AR, Bhangoo S, Tsiouris AJ, Härtl R. Anterior cervical discectomy and fusion with a zero-profile integrated plate and spacer device: a clinical and radiological study: clinical article. J Neurosurg Spine. 2014;21(4):529–37. https://doi.org/10.3171/2014.6.SPINE12951.
27. Panchal RR, Kim KD, Eastlack R, Lopez J, Clavenna A, Brooks DM, Joshua G. A clinical comparison of anterior cervical plates Versus stand-alone intervertebral Fusion devices for single-level Anterior Cervical Discectomy and Fusion procedures. World Neurosurg. 2017;99:630–7. https://doi.org/10.1016/j.wneu.2016.12.060.
28. Reisener MJ, Okano I, Zhu J, Salzmann SN, Miller CO, Shue J, Sama AA, Cammisa FP, Girardi FP, Hughes AP. Workers' Compensation Status in Association with a high NDI score negatively impacts post-operative Dysphagia and Dysphonia following Anterior Cervical Fusion. World Neurosurg. 2021;154:e39–45. https://doi.org/10.1016/j.wneu.2021.06.100.
29. Riederman BD, Butler BA, Lawton CD, Rosenthal BD, Balderama ES, Bernstein AJ. Recombinant human bone morphogenetic protein-2 versus iliac crest bone graft in anterior cervical discectomy and fusion: Dysphagia and dysphonia rates in the early postoperative period with review of the literature. J Clin Neuroscience: Official J Neurosurgical Soc Australasia. 2017;44:180–3. https://doi.org/10.1016/j.jocn.2017.06.034.
30. Shi S, Zheng S, Li XF, Yang LL, Liu ZD, Yuan W. Comparison of a stand-alone anchored spacer Versus plate-cage construct in the treatment of two noncontiguous levels of cervical spondylosis: a preliminary investigation. World Neurosurg. 2016;89:285–92. https://doi.org/10.1016/j.wneu.2016.02.009.
31. Siemionow K, Tyrakowski M, Patel K, Neckrysh S. Comparison of perioperative complications following staged versus one-day anterior and posterior cervical decompression and fusion crossing the cervico-thoracic junction. Neurol Neurochir Pol. 2014;48(6):403–9. https://doi.org/10.1016/j.pjnns.2014.10.001.
32. Strohl MP, Choy W, Clark AJ, Mummaneni PV, Dhall SS, Tay BK, Loftus PA, El-Sayed IH, Russell MS. Immediate Voice and swallowing complaints following revision anterior cervical spine surgery. Otolaryngology–head neck Surgery: Official J Am Acad Otolaryngology-Head Neck Surg. 2020;163(4):778–84. https://doi.org/10.1177/0194599820926133.
33. Wang Z, Zhu R, Yang H, Shen M, Wang G, Chen K, Gan M, Li M. Zero-profile implant (Zero-p) versus plate cage benezech implant (PCB) in the treatment of single-level cervical spondylotic myelopathy. BMC Musculoskelet Disord. 2015;16:290. https://doi.org/10.1186/s12891-015-0746-4.
34. Winkler EA, Rowland NC, Yue JK, Birk H, Ozpinar A, Tay B, Ames CP, Mummaneni PV, El-Sayed IH. A Tunneled Subcricoid Approach for Anterior cervical spine reoperation: Technical and Safety results. World Neurosurg. 2016;86:328–35. https://doi.org/10.1016/j.wneu.2015.09.028.
35. Yerneni K, Burke JF, Nichols N, Tan LA. Delayed recurrent laryngeal nerve Palsy following anterior cervical discectomy and Fusion. World Neurosurg. 2019;122:380–3. https://doi.org/10.1016/j.wneu.2018.11.066.

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