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Cervical Disc Arthroplasty vs. Anterior Cervical Discectomy and Fusion: A Narrative Review of Long-Term Outcomes

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Abstract

Anterior cervical discectomy and fusion (ACDF) has been the default surgical treatment for symptomatic cervical degenerative disc disease for decades, but concern about accelerated degeneration at the segments adjacent to a fused level has driven three decades of interest in motion-preserving alternatives. Cervical disc arthroplasty (CDA) was designed to address this concern by replacing, rather than fusing, the diseased disc. Early meta-analyses limited to two-year follow-up produced a mixed picture, but a growing body of long-term randomized controlled trial data — most recently synthesized in an August 2025 meta-analysis restricted to trials with at least four years of follow-up — now paints a more consistently favorable picture for CDA on pain, disability, neurological recovery, reoperation, and adjacent segment degeneration. This review walks through what the long-term evidence shows, why earlier short-term reviews were more equivocal, and where genuine uncertainty remains.

Keywords: Anterior cervical discectomy and fusion, Cervical disc arthroplasty, neurological recovery.

1. Introduction

1.1 Why an Alternative to Fusion Was Sought

ACDF removes the diseased disc, packs the resulting space with bone graft, and stabilizes the segment with a plate or cage-and-screw construct, eliminating motion at that level in exchange for decompressing the spinal cord or nerve root and restoring mechanical stability. It has a long track record of relieving radiculopathy and myelopathy, but the plate-and-cage construct has also been linked to swallowing difficulty, soft-tissue injury, and — most consequentially for long-term outcomes — adjacent segment degeneration, in which the vertebral levels above or below the fusion take on additional mechanical stress and degenerate faster than they otherwise would.

Cervical disc arthroplasty, conceptually borrowed from hip and knee joint replacement, was developed as a way to decompress the same neural structures while implanting an artificial disc that preserves motion at the operated segment. The theoretical appeal is straightforward: if the operated segment keeps moving roughly as it did before, the adjacent segments should be spared some of the extra mechanical load that follows a fusion, and mobility-related symptoms should hopefully be closer to normal. Whether that theory holds up when tested against real trial data — and whether it holds up over years rather than months — is the question this review addresses.

1.2. Why Long-Term Data Matter More Than Early Data Here

Early comparative studies were criticized for limiting their assessment to roughly two years of follow-up, which is not necessarily long enough for degenerative changes at adjacent segments to fully develop, nor for reoperation patterns to fully separate between fusion and arthroplasty groups. A 2020 meta-analysis of 13 randomized trials with a mean follow-up of about seven years illustrated the value of extending observation: it confirmed CDA's clinical benefits held up over time but was more circumspect about whether radiographic adjacent segment degeneration was clearly and consistently reduced, since that particular analysis found the difference in adjacent-level degeneration did not reach statistical significance.

The most recent and most rigorously restricted synthesis is a 2025 meta-analysis of 17 randomized controlled trials — all requiring a minimum of four years of follow-up, with some individual trials reporting data out to seven, ten, or even twenty years — covering 3,303 patients with single-segment cervical degenerative disc disease (1,741 receiving CDA, 1,562 receiving ACDF) across trials conducted mainly in the United States, along with sites in the Netherlands and China. Restricting inclusion to trials with genuinely long follow-up, rather than pooling everything regardless of duration, is what allows this review's conclusions to speak more directly to the durability question that shorter analyses could not fully answer.

1.3. What the Long-Term Data Show

Pain and disability. Across seven trials reporting Visual Analog Scale pain scores at final follow-up (1,262 patients), CDA patients had significantly lower neck and arm pain scores than ACDF patients. Eight trials reporting Neck Disability Index scores (1,359 patients) likewise favored CDA by a statistically significant margin. The review's authors suggested this may relate to preserved segmental motion producing a more physiological postoperative cervical spine configuration and better function of the surrounding musculature, though — as discussed below — these particular outcomes were flagged as less statistically robust on sensitivity testing.

Neurological recovery. Seven trials reported neurological success rates, and CDA showed significantly higher odds of neurological success than ACDF. The proposed mechanism is that disc replacement restores more normal intervertebral height and preserves the spinal functional unit, which may relieve pressure on adjacent structures more effectively than a fused, height-altered segment.

Range of motion. Four trials measuring range of motion at the operated segment (515 patients) found significantly greater preserved motion in the CDA group, as would be expected given that fusion is designed specifically to eliminate segmental motion while arthroplasty is designed to preserve it.

Reoperation. Across fourteen trials and 2,533 patients, CDA carried significantly lower odds of reoperation at the index level than ACDF — a finding that has been broadly consistent across multiple independent meta-analyses over the past decade, including this review, an earlier two-level-disease-specific meta-analysis, and large administrative-database studies. Common reasons for CDA reoperation include worsening neurological symptoms, persistent pain, and device subsidence or displacement, whereas ACDF reoperations more often relate to nonunion, implant migration, or adjacent segment disease.

Adjacent segment degeneration. Three trials with adjacent segment degeneration data (567 patients) found significantly lower rates in the CDA group compared with ACDF. This is arguably the most clinically important — and historically most contested — finding, since reducing adjacent segment disease was the entire rationale for developing motion-preserving technology in the first place.

Safety, operative time, and blood loss. Adverse event rates did not differ significantly between the two procedures across nine trials, and operative time was similar in the two studies that reported it. CDA was associated with modestly greater intraoperative blood loss across two trials, plausibly related to the additional bone preparation required for prosthesis placement, though the review's authors judged this difference of limited clinical significance.

1.4. Why Earlier Reviews Were More Equivocal

Not every prior meta-analysis reached the same confident conclusion on adjacent segment degeneration. An 11-trial, 3,505-patient meta-analysis of randomized trials found CDA achieved better overall success, functional outcome success, neurological success, and patient satisfaction than ACDF, but specifically found no statistically significant difference in radiological adjacent segment degeneration between the two groups. Individual trial data have echoed this uncertainty: some investigators found the incidence of adjacent segment disease after arthroplasty was not clearly lower than after fusion, and in patients with osteoporosis or more diffuse degenerative disease, arthroplasty's adjacent-segment advantage appeared to shrink or disappear. Even within the most recent long-term review, the authors were explicit that current evidence cannot fully distinguish whether adjacent segment changes after ACDF represent an acceleration of degeneration caused by fusion, or simply the natural aging trajectory of a degenerative cervical spine occurring on a similar timeline regardless of the index procedure.

This pattern — consistent superiority on pain, disability, neurological outcomes, and reoperation, but historically less consistent superiority on the specific radiographic question of adjacent segment degeneration — is a useful way to think about the overall evidence landscape. The clinical outcome advantages for CDA are fairly well replicated across multiple independent meta-analyses spanning more than a decade; the mechanistic claim that preserving motion specifically prevents adjacent segment degeneration is more recently and less uniformly supported, and remains an area of live scientific debate.

1. 5. Two-Level Disease: A Separate but Related Question

Most of the foundational CDA trials, including those feeding the 2025 long-term meta-analysis, focused on single-level disease. A separate 2024 meta-analysis focused specifically on two-level cervical degenerative disc disease, pooling eight studies (two RCTs, four retrospective, and two prospective) totaling 1,155 patients. It found CDA associated with a significantly higher overall surgical success rate and a significantly lower secondary surgery rate compared with ACDF at two contiguous levels, broadly consistent with the single-level literature, suggesting the clinical case for arthroplasty is not confined to single-segment disease, though the evidence base for multi-level procedures remains considerably smaller and more heterogeneous than for single-level surgery.

1. 6. How Confident Should We Be? Reading the Fine Print

The 2025 long-term meta-analysis is notable for transparently flagging its own fragility. Its authors performed a leave-one-out sensitivity analysis — recalculating the pooled result after removing each individual trial in turn — and found that results for operative time, neck and arm pain scores, Neck Disability Index, and adjacent segment degeneration rate changed meaningfully depending on which single trial was excluded. This means those particular findings, while statistically significant in the full pooled analysis, should be read with some caution rather than treated as settled fact. By contrast, findings for neurological success, range of motion, reoperation rate, and adverse events were described as more stable across the sensitivity analysis, lending them somewhat more confidence.

Other limitations are worth noting. The trials used a range of different disc prostheses (ActivC, Bryan, Discover, ProDisc-C, Kineflex|C, Mobi-C, SECURE-C, Prestige, and PCM among them), and outcomes plausibly differ across implant designs in ways a pooled analysis cannot fully separate out. Cost-effectiveness could not be assessed because individual patient-level data were unavailable, and only English-language publications were included, introducing a possible language bias. Finally, the trials themselves — like nearly all surgical RCTs — could not blind patients or surgeons to which procedure was performed, introducing a structural risk of performance and detection bias that no amount of long follow-up can fully correct.

1. 7. Clinical Interpretation

Taken together, the accumulated randomized trial evidence — now extending in some individual trials out to ten and twenty years — supports cervical disc arthroplasty as at least as effective as, and on several measures more effective than, ACDF for appropriately selected patients with single- or two-level symptomatic cervical degenerative disc disease, with a consistently lower reoperation rate being perhaps the most robust and clinically meaningful finding across the literature. The claim that arthroplasty meaningfully reduces adjacent segment degeneration specifically is better supported in the most recent long-term synthesis than in some earlier reviews, but it remains a less settled question than the broader clinical-outcome advantages, and patient-specific factors such as osteoporosis or diffuse multilevel degenerative disease may blunt this particular benefit. None of this displaces ACDF as an excellent and durable option — particularly where a patient's anatomy, bone quality, or degree of instability makes fusion the more appropriate or only reasonable choice — but it does support the trend, visible in recent large administrative-database studies, toward more selective use of arthroplasty rather than treating fusion as the default across all candidates.

1.8. Future Directions

The field would benefit from more randomized trials specifically addressing two-level and multi-level disease with long follow-up, from head-to-head comparisons between different disc prostheses rather than only device-versus-fusion comparisons, and from formal cost-effectiveness analyses using individual patient-level data. Continued long-term follow-up of the existing trial cohorts — several of which have already published outcomes out to a decade or two — will also help settle whether the adjacent segment degeneration advantage seen in the most recent long-term meta-analysis holds up, grows, or narrows as patients age further beyond the follow-up windows captured so far.

Conclusion

Extending the evidence base to trials with a minimum of four years of follow-up has sharpened, rather than overturned, the case for cervical disc arthroplasty as a durable, effective alternative to fusion in appropriately selected patients: better pain and disability scores, higher neurological success, preserved segmental motion, and a consistently lower reoperation rate across more than a decade of independent meta-analyses. The specific question of whether arthroplasty meaningfully reduces adjacent segment degeneration is better supported now than in some earlier reviews but remains less consistently replicated than the clinical outcome advantages, and several of the newest long-term findings are statistically less robust than they first appear once individual-trial sensitivity is accounted for. Cervical disc arthroplasty is best described, on the current evidence, as an increasingly well-supported and durable alternative to fusion for suitable candidates — not yet a universal replacement for ACDF, which remains the necessary choice for many patients, but a technology whose long-term track record has moved meaningfully past "promising" toward "established."

References

1. Zhang Y, Ju J, Wu J. Comparison of cervical disc arthroplasty versus anterior cervical discectomy and fusion for the treatment of single-segment cervical degenerative disc disease with a minimum of 4-year follow-up: a systematic review and meta-analysis of randomized controlled trials. *J Orthop Surg Res*. 2025;20:758.
2. Wang QL, Tu ZM, Hu P, et al. Long-term Results Comparing Cervical Disc Arthroplasty to Anterior Cervical Discectomy and Fusion: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Orthop Surg*. 2020;12(1):16–30.
3. Comparison of cervical disc arthroplasty and anterior cervical discectomy and fusion for the treatment of cervical disc degenerative diseases on the basis of more than 60 months of follow-up: a systematic review and meta-analysis. *BMC Neurology*. 2020.
4. Chen CM, Yang JJ, Wu CC. Cervical Disc Arthroplasty (CDA) versus Anterior Cervical Discectomy and Fusion (ACDF) for Two-Level Cervical Disc Degenerative Disease: An Updated Systematic Review and Meta-Analysis. *J Clin Med*. 2024;13(11):3203.
5. Singh M, Balmaceno-Criss M, Anderson G, et al. Anterior cervical discectomy and fusion versus cervical disc arthroplasty: an epidemiological review of 433,660 surgical patients from 2011 to 2021. *Spine J*. 2024;24(8):1342–51.
6. Jawahar A, Cavanaugh DA, Kerr EJ, Birdsong EM, Nunley PD. Total disc arthroplasty does not affect the incidence of adjacent segment degeneration in cervical spine: results of 93 patients in three prospective randomized clinical trials. *Spine J*. 2010;10(12):1043–8.

This narrative review is a paraphrased synthesis of published systematic reviews, meta-analyses, and primary trials identified through literature search current to September 2026. It is intended as an educational overview and does not substitute for reading the primary sources in full or for individualized clinical judgment.