



Review Article

Short Review/Perspective on Adjacent Segment Disease (ASD) Following Cervical Fusion Versus Arthroplasty

Nancy E. Epstein, M.D., F.A.C.S.¹, Marc A. Agulnick, M.D., F.A.A.O.S.²

¹Department of Neurosurgery, School of Medicine, State University of New York at Stony Brook, and % Dr. Marc Agulnick 1122 Franklin Avenue Suite 106, Garden City, NY 11530, USA ²Department of Orthopedics, NYU Langone Hospital Long Island and St. Francis Hospital, 1122 Franklin Avenue Suite 106, Garden City, NY 11530, New York, United States.

E-mail: *Nancy E. Epstein - nancy.epsteinmd@gmail.com; Marc A. Agulnick - marc_agulnick@yahoo.com



***Corresponding author:**

Nancy E. Epstein, M.D., F.A.C.S.,
Clinical Professor of
Neurosurgery, School of
Medicine, State University of
NY at Stony Brook, NY and
% Dr. Marc Agulnick 1122
Franklin Avenue Suite 106,
Garden City, NY 11530, USA.
nancy.epsteinmd@gmail.com

Received : 13 June 2022

Accepted : 24 June 2022

Published : 22 July 2022

DOI

10.25259/SNI_541_2022

Quick Response Code:



ABSTRACT

Background: Although the incidence of radiographic Adjacent Segment Disease (ASD) following anterior cervical discectomy/fusion (ACDF) or cervical disc arthroplasty (CDA) typically ranges from 2-4%/year, reportedly fewer patients are symptomatic, and even fewer require secondary surgery.

Methods: Multiple studies have documented a 2-4% incidence of radiographic ASD following either ACDF or CDA per year. However, fewer are symptomatic from ASD, and even fewer require additional surgery/reoperations.

Results: In a meta-analysis (2016) involving 83 papers, the incidence of radiographic ASD per year was 2.79%, but symptomatic disease was present in just 1.43% of patients with only 0.24% requiring secondary surgery. In another study (2019) involving 38,149 patients undergoing ACDF, 2.9% (1092 patients; 0.62% per year) had radiographic ASD within an average of 4.66 postoperative years; the younger the patient at the index surgery, the higher the reoperation rate (i.e. < 40 years of age 4.56 X reoperations vs. <70 at 2.1 X reoperations). In a meta-analysis of 32 articles focusing on ASD 12-24 months following CDA, adjacent segment degeneration (ASDeg) occurred in 5.15% of patients, but adjacent segment disease (AS Dis) was noted in just 0.2%/year. Further, AS degeneration occurred in 7.4% of patients after 1-level vs. 15.6% following 2 level fusions, confirming that CDA's "motion-sparing" design did not produce the "anticipated" beneficial results.

Conclusion: The incidence of radiographic ASD ranges from 2-4% per year for ACDF and CDA. Additionally, both demonstrate lesser frequencies of symptomatic ASD, and the need for secondary surgery. Further, doubling the frequency of ASD following 2 vs. 1-level CDA, should prompt surgeons to limit surgery to only essential levels.

Keywords: Adjacent Segment Disease (ASD); Cervical Spine; Surgery: Cervical Disc Arthroplasty (CDA); Anterior Cervical Discectomy/Fusion (ACDF); Radiographic ASD; Symptomatic ASD: ASD Requiring Reoperations

INTRODUCTION

The incidence of radiographic Adjacent Segment Disease (ASD) following cervical spine surgery, whether following anterior discectomy/fusion (ACDF) or cervical disc arthroplasty (CDA), typically ranges from 2-4%/year [Table 1].^[1-12] However, the frequency of symptomatic ASD and the requirement for secondary surgery in these two populations is less well-defined [Table 1].^[1-12] In this short review/perspective, studies were carefully selected to include those that focused on the frequencies of ASD

This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, transform, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

©2022 Published by Scientific Scholar on behalf of Surgical Neurology International

Table 1: Summarizing Adjacent Segment Disease following Cervical Spine Surgery.

Author [Ref] Year Journal	Study Design	Surgical Data ACDF CDA Other	Data Review	Data Review	Conclusion
Seo and Choi ^[7] 2008 Br J Neurosurg	ASD After Fusion Treat RAD Myelopathy	CDA Rationale - Prevent or Limit ASD	Is ASD Part of the Natural History of Degeneration	Short-Term CDA Data for Younger Patients-Aware Not Long-Term Data	Discussion ASD After Fusion vs. CDA
Kepler and Hilibrand ^[4] 2012 Orthop Clin North Am	ASD After Fusion Rad and Myelopathy 2-3%/year	ASD Defined Motion Segment Adjacent to Prior Fusion	ASD May Be Due to Altered BIO after Fusion	ASD Prompted Development of CDA	Literature Shows No Reduced Rate ASD after CDA
Cho and Riew ^[3] 2013 JAAOS	ASD Cervical Fusion ACDF vs. No Fusion AD/FOR	No Fusion	ASD with Fusion: Is 3% per year or 25% at 10 Years	No Fusion Same Rate ASD vs. Fusion	CDA Similar Incidence ASD
Virk <i>et al.</i> ^[11] 2014 Orthopedics	ASD in Cervical Spine Surgery	ASD Seen on X-ray Due to BIO Risk Factors	Complications of Fusion Listhesis Instability HNP	Complication of Fusion Stenosis HFA, Scoli VCF	Post Fusion Increased Load Adjacent Level
Shriver <i>et al.</i> ^[9] 2016 Spine J	ASD after CDA MA 32 articles AS-Deg 8.3% AS Dis 0.9%	FO 12-24 Mos CDA AS Deg 5.1% AS Dis 0.2%	FO>24 Mos CDA AS Deg 16.6% AS Dis 2.6%	2 Level Procedures: Higher ASD (15.6) vs. 1 Level (7.4%)	AS Disease 1 Level CDA 0.8%
Shiban <i>et al.</i> ^[8] 2016 Acta Neurochir (Wein)	ASD/Fusion Rates 1, 2, 3 Level ACDF Using Stand Alone Empty PEEK Cages	Consecutive Review 265 Cases Followed Minimum 1 yr 2007-2010	Mean Age 55 52% Males 127-1 Level 125-2-Levels 13-3 Levels CSM (49%) Rad (50%)	83 Studies 85% 1-Level 95% 2-Level 94% 3-Level	X-ray ASD 10% 1-level 29% 2-Level 15% 3-Level Reop ASD 6% (16 Patients)
Kong <i>et al.</i> ^[5] 2016 Medicine (Baltimore)	Prevalence ASD PRISMA Rev/MA	XR ASD Symp ASD Reop ASD	83 Studies	Per Year ASD 2.79% X-ray 1.43% Symptomatic 0.24% Reoperation	Heterogenous Studies
Tobert <i>et al.</i> ^[10] 2017 Clin Spine Surg	ASD Cervical and Lumbar Spine 2-4% Per Year	ASD Leads to Reop	Prior Adjacent Level Spondylosis Altered Biomechanics Adjacent to Fusion	Asymptomatic Patients Option for Non-Operative Treatment	Etiologies ASD Different Approaches
Alhashash <i>et al.</i> ^[11] 2018 Spine	ASD After ACDF 2005-2012	70 patients Long-Term Follow-up 3-10 Years After Reop	Reop for ASD Mean 32 Mos After 1 st ACDF	ASD in 54% at 32 Mos-Most at C56 (28%) Next C45	Risk ASD Deg Changes Preop at 2 nd Level or Poor Postop Lordosis
Wu <i>et al.</i> ^[12] 2019 Int J Surg	Risk Factors Reop for ASD After ACDF	16-year Cohort Study (Near Perfect Follow-up)	38,149 Pts 1 st ACDF 2.9% (1092) 2 nd Surgery Mean 4.66 yrs Later	Risk Reop for ASD Higher Younger Patients<40 4.56 X<50 4.09 X<60 3.09 X<70 2.17 X>70 Higher	Reop Rate Higher with Depression 1.42 X and Psychosis 1.45 X

(Contd...)

Table 1: (Continued).

Author [Ref] Year Journal	Study Design	Surgical Data ACDF CDA Other	Data Review	Data Review	Conclusion
Butler <i>et al.</i> ^[2] 2019 Clin Spine Surg	CDA: Waysto Prevent Cervical ASD After ACDF	CDA Preserve Motion Delay/ Avoid ASD	Most Cases of ASD are: Multifactorial/ Unavoidable Need Study 1000's of patients to Answer Question	Alternatives Non-Fusion Limit OR Levels Restore Lordosis Five year FO required	Develop CDA Algorithm to Treat ASD Need Larger Studies MA
JAAOS: J Am Acad Orthop Surg, ACDF: Anterior Cervical Discectomy/Fusion, CDA: Cervical Disc Arthroplasty, AD: Anterior Discectomy No Fusion, FOR: Foraminotomy, MA: Meta Analysis, Rev: Review, PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses, FO: Follow-Up, Pt: Patient, Mos: Months, Deg: Degenerative, Prof: Profile, Q: Question, BIO: Biomechanics. Comp: Complications, ST: Stenosis, HNP: Herniated Nucleus Pulposus, HFA: Hypertrophic Facet Arthrosis, Scol: Scoliosis, VCF: Vertebral Compression Fractures, RAD: Radiculopathy, Deg: Degeneration, Dis: Disease, PEEK: Polyetheretherketone Cages, CSM: Cervical Spondylotic Myelopathy, Rad-Radiculopathy, Reop: Reoperations, X: Times, OR: Operated					

following predominantly ACDF and CDA, while also looking at different rates of postoperative symptomatic ASD (0.62-1.43%), and the need for reoperations (0.2–0.24%).

DEFINITION OF ASD

Virk *et al.* (2014) defined the various degenerative, radiographic, and/or biomechanical factors predisposing patients to the development of ASD [Table 1].^[12] These factors included; disc disease, stenosis, spondylosis, spondylolisthesis, arthrotic changes of facet/uncovertebral joints, or fractures. Although ASD was typically initially described as due to greater stress at adjacent levels following a fusion, subsequent literature showed it also occurs with comparable frequencies following CDA.^[6,11]

INCIDENCE OF ASD AFTER CERVICAL SURGERY

Several studies cited 2–4% frequencies of ASD following ACDF, with some also citing comparable rates with non-fusion techniques [Table 1].^[2,5,10,12] Kepler and Hilibrand (2012) observed a 2–3% per year incidence of ASD following cervical fusion [Table 1].^[4] They recommended that ASD frequencies could be mitigated utilizing improved surgical fusion techniques, while also questioning the future potential efficacy of CDA through “motion preserving surgery.” Cho and Riew (2013) found a 3% overall incidence of ASD/year typically following ACDF, noting that this frequency would rise to 25% over a 10 year period.^[3] They also showed that the frequency of ASD remained relatively unchanged for non-fusion procedures (anterior discectomy without fusion or

laminoforaminotomy) including CDA. Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis 2009) guidelines, Kong *et al.* (2016) evaluated 83 cervical surgical studies utilizing multiple databases, and found that ASD occurred in 2.79% of patients/year; however, only 1.43% were symptomatic/year, while just 0.24% required secondary surgery/year.^[5]

REDUCING THE RISKS AND/OR PREVENTION OF ASD FOLLOWING CERVICAL SURGERY

Several cervical spine studies, mostly involving ACDF, identified risk factors predisposing patients to developing radiographic ASD, symptomatic ASD, and the need to reoperate on ASD [Table 1].^[1,2,6,10,12] Tobert *et al.* (2017) observed a 2-4% frequency of ASD following both cervical and lumbar surgery, largely attributed to; pre-existing spondylotic disease at the adjacent level, degenerative changes at those levels, and/or altered adjacent level “biomechanics” following the index surgical procedures.^[10] Looking at the incidence of ASD after 70 ACDF (2005–2012) followed between 3-10 years, Alhashash *et al.* (2018) showed reoperations for ASD (i.e., based upon X-rays/MR studies) were warranted an average of 32 months after the index ACDF surgery (i.e. 54% single level procedures).^[11] Two major factors predisposing to secondary surgery included preoperative “degenerative changes” (74%), or postoperative sagittal malalignment (i.e. lack of adequate lordosis). Butler *et al.* (2019), similarly noted a 3% incidence of ASD following ACDF per years; ways to avoid ASD included “consider non fusion alternatives,” improve patient selection, pay more attention to preserving lordosis during ACDF (i.e.

sagittal alignment), and considering CDA's for their "motion sparing" design.^[2] Most notably, in Wu *et al.* (2019) series of 38,149 patients undergoing ACDF, 2.9% had radiographic evidence of postoperative ASD observed an average of 4.66 years postoperatively (1092 patients: 0.62%/per year) [Table 1].^[11] Of interest, younger patients were more susceptible to ASD and required more frequent reoperations vs. older patients (i.e. < 40 years of age 4.56 fold incidence of reoperations vs. < 70 at 2.17 fold incidence). Further, patients exhibiting depression or psychoses also exhibited higher frequencies (1.42 and 1.45 fold respectively) of warranting additional surgery.

ACDF Data Largely Excluded ASD Results with Polyetheretherketone (PEEK) Cages

Notably, we did not specifically focus on the results for ACDF performed with stand-alone polyetheretherketone (PEEK) cages. In Shiban *et al.* (2016), one year following 265 PEEK cage fusions, 16 (6%) warranted reoperation to address radiographic ASD [Table 1].^[8]

CDA'S "BIOMECHANICAL MOTION SPARING" DESIGN FAILED TO REDUCE ASD

CDA's, by maintaining "motion" at operated levels, were devised to "theoretically" reduce stress transmitted to adjacent segments [Table 1].^[4,6,7] In 2008, Seo and Choi evaluated the frequency of ASD after cervical fusion vs. CDA, focusing on the potential pros and cons of each technique.^[7] They questioned whether ASD in part reflected the "natural history" of progressive degeneration rather than simply representing the response to a "fusion." They further emphasized that CDA were recommended for younger patients without significant spondylosis who clearly demonstrated adequately preserved range of motion. Although Kepler and Hilibrand (2012) also emphasized CDA's potential "motion-sparing" capabilities that might limit the risk of ASD, they nevertheless found that so far, the literature did not; "...distinguish a difference in the rate of ASD between fusion and disc replacement."^[4]

CDA'S COMPARABLE ADJACENT SEGMENT DEGENERATION (AS-DEG) VS. ADJACENT SEGMENT DISEASE (AS-DIS) VS. ANTERIOR CERVICAL FUSIONS

Two studies emphasized that CDA's failed to limit or eliminate ASD when compared with largely anterior cervical fusions [Table 1].^[6,9] In their meta-analysis of 32 studies, Shriver *et al.* (2016) found that at 1-2 postoperative years, there was a 5.1% frequency of AS-Deg, and a 0.2% incidence of AS-DIS.^[9] Long-term follow-up data over 24 postoperative

months showed that the incidence of both AS-DEG and AS-DIS further increased to 16.6% and 2.6% respectively. Additionally, higher frequencies of ASD occurred after 1-level (7.4%) vs. 2-level CDA procedures (15.6%). Parrish *et al.* (2021) also noted CDA's comparable 1-2% frequencies of radiographic ASD vs. anterior cervical fusions.^[6]

CONCLUSION

This short review/perspective of select studies emphasizes how to limit the risk of adjacent segment degeneration (i.e. radiographic, symptomatic, and/or requiring reoperations). This requires; carefully selecting "symptomatic" patients for either ACDF or CDA (i.e., for CDA, younger patients with preserved range of motion without spondylosis), stringently limiting the number of operated levels, and optimizing the surgical "technique" to preserve lordosis.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Alhashash M, Shousha M, Boehm H. Adjacent segment disease after cervical spine fusion: evaluation of a 70 patient long-term follow-up. *Spine* 2018;43:605-9.
2. Butler JS, Morrissey PB, Wagner SC, Kaye ID, Sebastian AS, Schroeder GD, *et al.* Surgical strategies to prevent adjacent segment disease in the cervical spine. *Clin Spine Surg* 2019;32:91-7.
3. Cho SK, Riew DK. Adjacent segment disease following cervical spine surgery. *J Am Acad Orthop Surg* 2013;21:3-11.
4. Kepler CK, Hilibrand AS. Management of adjacent segment disease after cervical spinal fusion. *Orthop Clin North Am* 2012;43:53-62.
5. Kong L, Cao J, Wang L, Shen Y. Prevalence of adjacent segment disease following cervical spine surgery: A PRISMA-compliant systematic review and meta-analysis. *Medicine (Baltimore)* 2016;95:e4171.
6. Parish JM, Asher AM, Coric D. Adjacent-segment disease following spinal arthroplasty. *Neurosurg Clin N Am* 2021;32:505-10.
7. Seo M, Choi D. Adjacent segment disease after fusion for cervical spondylosis; myth or reality *J Neurosurg* 2008;22:195-9.
8. Shiban E, Gapon K, Wostrack M, Meyer B, Lehmborg J. Clinical

- and radiological outcome after anterior cervical discectomy and fusion with stand-alone empty polyetheretherketone (PEEK) cages. *Acta Neurochir (Wien)* 2016;158:349-55.
9. Shriver MF, Lubelski D, Sharma AM, Steinmetz MP, Benzel EC, Mroz TE. Adjacent segment degeneration and disease following cervical arthroplasty: A systematic review and meta-analysis. *Spine J* 2016;16:168-81.
 10. Tobert DG, Antoci V, Patel SP, Saadat E, Bono CM. Adjacent segment disease in the cervical and lumbar spine. *Clin Spine Surg* 2017;30:94-101.
 11. Wu JC, Chang HK, Huang WC, Chen YC. Risk factors of second surgery for adjacent segment disease following anterior cervical discectomy and fusion: A 16-year cohort study. *Int J Surg* 2019;68:48-55.
 12. Virk SS, Niedermeier S, Yu E, Khan SN. Adjacent segment disease. *Orthopedics* 2014;37:547-55.

How to cite this article: Epstein NE, Agulnick MA. Short review/perspective on Adjacent Segment Disease (ASD) following Cervical Fusion versus Arthroplasty. *Surg Neurol Int* 2022;13:313.

Comment: Jamie S. Baisden, M.D.

Professor Department of Neurosurgery, Medical College of Wisconsin, Milwaukee, WI

The FEM stuff we have been doing goes well with this report showing adjacent level stresses throughout the spine with both ACDF and CDA. The Metal on Polymer CDA such as Prestige are stiffer and would be predicted to increase ASD more than a metal on Polymer (Secure- C, Prodisc-C, Mobi-C). These more mobile disc arthroplasties shift the stresses to the index level along the facets. The newer discs like Simplify with different core biomaterials will hopefully “soften” the construct and produce less ASD.

I agree with the “natural history of ASD” and often think of the A as standing for accelerated- both ACDF and CDA - accelerating a natural history. Seems like it boils down to whether you are treating radiculopathy or myelopathy and what is the least procedure a surgeon can do to achieve symptomatic relief without triggering the degenerative cascade. The posterior minimally invasive foraminotomy will be making a comeback in the near future.