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Review Article

Cervical disc arthroplasty (CDA)/total disc replacement (TDR) vs. anterior cervical diskectomy/fusion (ACDF): A review

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ABSTRACT

Background: We performed a focused review to determine the "non-inferiority", potential superiority, and relative safety/efficacy for performing cervical disc arthroplasty (CDA)/total disc replacement (TDR) in carefully selected patients vs. anterior cervical diskectomy/fusion (ACDF). Notably, CDA/TDR were devised to preserve adjacent level range of motion (ROM), reduce the incidence of adjacent segment degeneration (ASD), and the need for secondary ASD surgery.

Methods: We compared the incidence of ASD, reoperations for ASD, safety/efficacy, and outcomes for cervical CDA/TDR vs. ACDF. Indications, based upon the North American Spine Society (NASS) Coverage Policy Recommendations (Cervical Artificial Disc Replacement Revised 11/2015 and other studies) included the presence of radiculopathy or myelopathy/myeloradiculopathy at 1-2 levels between C3-C7 with/without neck pain. Contraindications for CDA/TDR procedures as quoted from the NASS Recommendations (i.e. cited above) included the presence of; "Infection…", "Osteoporosis and Osteopenia", "Instability…", "Sensitivity or Allergy to Implant Materials", "Severe Spondylosis…", "Severe Facet Joint Arthropathy…", "Ankylosing Spondylitis" (AS), "Rheumatoid Arthritis (RA), Previous Fracture…", "Ossification of the Posterior Longitudinal Ligament (OPLL)", and "Malignancy…". Other sources also included spinal stenosis and scoliosis.

Results: Cervical CDA/TDR studies in the appropriately selected patient population showed no inferiority/occasionally superiority, reduced the incidence of ASD/need for secondary ASD surgery, and demonstrated comparable safety/efficacy vs. ACDF.

Conclusion: Cervical CDA/TDR studies performed in appropriately selected patients showed a "lack of inferiority", occasional superiority, a reduction in the incidence of ASD, and ASD reoperation rates, plus comparable safety/efficacy vs. ACDF.

Keywords: Adjacent segment disease, Adverse events, Anterior cervical diskectomy/fusion (ACDF), Cervical disc arthroplasty (CDA), Cervical surgery, Comparison, Outcomes, Safety/Efficacy, Secondary surgery/reoperations, Total disc replacement (TDR)

INTRODUCTION

Cervical disc arthroplasty (CDA)/total disc replacement (TDR) were primarily devised to preserve range of motion (ROM) and, thus, lower the incidence of adjacent segment

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Table 1: Summary of Findings for Cervical Disc Arthroplasty (CDA)/Total Disc Replacement (TDR) v Anterior Cervical Diskectomy/Fusion (ACDF).

Author [Ref] Journal Years	Study Design	Date	Data	Data	Outcomes
Cho[2] Korean J Spine 2012	HO TDR (40 pts) vs. ACDF (47 pts) F/O>24 mos HO>Seen Any TDR ACDF Only HO with Cage	TDR (Bryan, ProDisc-C) ACDF Stand Alone Cage Fibula/ Allograft Plate/Screws HO Diagnosed Plain X-rays Last F/O	HO 27 TDR Bryan 8/18 ProDiscC 12/25 ACDF Cage 7/29 ACDF Plates Screw 0/25	ROM Not Correlate with HO Preop OPLL 22 Higher HO TDR 14 (Bryan 5/5 Prod Disc C 4/5) v ACDF Cage 5/7 No HO in ACDF Plate/Screw 0/5	Preop Osteophytes and OPLL Higher Rates OH with TDR v ACDF
Harrod[7] Spine 2012	ASD After CDA vs. Fusion RASP, CASP 14 Studies	Databases Medline Cochran Collaboration Library To 2012 RCT	Question if TDR Lower Risk RASP/ CASP v Fusion	CASP Same Reop Risks TDR (1.0%) v ACDF (4.8%) Risk RASP Similar TDR v ACDF	Low Quality Studies Need More Without Industry
Zhao[13] Eur Spine J 2015	MCDA v SCDA Medline, Embase PubMed Cochrane Library Central Register of Controlled Trials	Purpose CDA Maintain Motion Question: Safety, Outcomes-HO, Recovery, Reop	8 Cohorts: 4 Prosp 4 RR Same Results NDI, VAS, Reop, Morbidity HO, QOL	MCDA v SCDA at 1-2 Postop yrs Outcomes Equivalent	MCDA as Safe Effective as SCDA
NASS[9] 11/2015 NASS Coverage Com	NASS Coverage Policy Recommendations: Cervical Artificial Disc Replacement 11/2015 Defining Appropriate Coverage Positions Clinical Indications (NASS Coverage Committee)	Radiculopathy 1-2 Level Root Comp C3-C7 Failed Medical Rx+/- Neck Pain Myelopathy or Myeloradiculopathy Central Stenosis 1-2 Levels (Disc/ Spondylosis) C3-C7 +/- Neck Pain No Evidence for 3 or>Level CDA/TDR Not Appropriate for Treating ASD After Index Level Fusion	Contraindications "Infection-Active-Localized vs Systemic Osteoporosis Osteopenia Instability->3 mm Trans/ 11 Degrees Angulation Flex/Ext X-rays"	Contraindications "Sensitivity or Allergy to Implant Severe Spondylosis Defined as: >50% Disc Height Loss… Bridging Osteophytes Absence of Motion on Flex/Ext X-rays"	Contraindications "Severe Facet Joint Arthropathy AS, RA, Previous Fx- with Anatomic Deformity, OPLL, Malignancy Active. Cervical"
Zou[14] Eur Spine J 2017	Review Data 2 Level CDA (317 pts) v 1 Level ACDF (333 pts)	Review PubMed Cochrane Central Register Controlled Trials EBSCA, EMBASE Used 6 reports:	CDA Sig<EBL, <Reop, <ASD>>NDI	Same Results 2-TDR vs. ACDF Mean OR Time VAS (Neck/Arm) Rate Postop AE Sagittal ROM- Operated-Adjacent Levels, FSU	2-Level CDA Equivalent to ACDF 1-Level 2-Levels Some Better Outcomes vs. 2-level ACDF
Joaquim[8] Neurosurg Focus 2017	>2 Level CDA v ACDF 14 Articles Up to 7 Postop yr	Advantages CDA Motion Preservation<Reop	Multi CDA Safe as ACDF and:	Multi CDA Good Clinical+Radiological	Recommend Multi CDA

(Contd...)

Table 1: *(Continued).*

Author [Ref] Journal Years	Study Design	Date	Data	Data	Outcomes
	Medline Database	Multi CDA After Prior Cervical OR	>Preserved ROM<Potential Reop	Outcomes>HO Multi CDA v 1-Level CDA (No Clinical Impact)	Need RCT Independent of Industry
Findlay[4] Bone Joint J 2018	2 v 4-7 yr Outcomes TDR v ACDF GRADE Data 22 RCT-3160 Pts- 10 yrs	Medline, Embase Scopus Look at Neuro Success Reoperations ASD	TDR Superior to ACDF at 2 yr and 4-7 Postop yrs	Results 4-7 yrs Favor TDR NDI, SF-36 Physical Comp. Dysphagia Satisfaction	< ASD for TDR- 2+4 – 7 yrs TDR Mostly=ACDF-Better Select Results TDR<ASD
Chang[1] J Clin Neurosci 2018	TDR (30 pts) v ACDF (34 pts) ROM 1-Level	ROM 64 -X-rays Look at: ASD 1 yr F/O	>ROM TDR+5.67 Deg v ACDF–0.96 Deg	1-Level ACDF Multilevel Compensation for Loss of ROM	TDR: >ROM<Risk ASD
Xu[12] J Orthop Surg Res 2018	ASD After TDR Meta-analysis RCT-?TDR Reduce ASD Superiority to ACDF Not Documented	Meta-Analysis PubMed, Embase Cochrane Collaboration/Library, CBM Question Incidence ASD/ Reop Rates 11 Studies-2632 pts	ASD and Reop Rates Lower with TDR (Reop 0.58) vs ACDF (0.52)	Lower Rate ASD Irrespective of Postop Follow-Up Date	TDR Decreased Rates of ASD and Reoperation vs. ACDF Superiority Greater Over Time
Gornet[5] Int J Spine Surg 2019	Safety Efficacy 1-2 Level CDA v ADCF At 2-7 yrs postop Define I-IV Brooker's HO Classification	1-Level (545 pts) 2-Level (397 pts) CDA 1–280, 2–209 ACDF 1–265, 2–188 CDA+ACDF Similar 1–2 Level Success Same AE Same Implant-Related AE	7-yer Implant AE Higher 2 vs. 1-Level CDA ACDF>AE 2-Level 27.7% vs 1-Level 18.9%	Reop Similar 1-2 Level CDA v ACDF at Index or Adjacent Levels at 2+7 yrs Grade IV HO 7 yrs-4.6% 1-Level CDA-For 2-Level CDA Superior 8.65% Inferior 7.3%	1+2-Level CDA Same Safety/Efficacy CDJD 1-Level ACDF Similar Efficacy vs 1-Level ACDF 2-Level ACDF Higher AE
Gupta[6] Asian J Neurosurg 2021	30 Double Blind RCT 30 ACDF PEEK 30 vs. 30 CDA pts	1- Level CDDD 5 Year F/O 2010–2019	CDA Group: Sig. Better ROM Sig Sagittal ROM, FSU	PEEK Findings Sig Decrease ROM and FSU	CDA Superior ROM, FSU l Alignment Kept/Ht vs. ACDF/ PEEK
Turkov[11] Int J Spine Surg 2021	Review CDA vs. ACDF Databases PubMed Google Scholar	Clinical 1–2-Levels Efficacy, Safety, AE Multi CDA and ACDF	CDA=or>Clinical Outcomes v ACDF, >NDI>VAS scores	<CDA Rates v ACDF: Dysphagia ASD, Reop No>Reop for Multi CDA v ACDF	CDA v ACDF Safe with<Risk ASD-Safe Effective Low AE
Coric[3] J Neurosurg Spine 2022	Prosp 24 mos Non-Randomized FDA IDE Multicenter Trial	182 pts -2 Level PEEK TDR vs. 170 ACDF>Success TDR 86.7% v 77% ACDF	Reop 2.2% TDR vs. 8.8% ACDF Mean NDI Sig Better Both Groups	24 mos 15 Point Better NDI 92.9% TDR vs. 83.5% ACDF MR in TDR at	Conclusion Support TDR for 2-level CDDD Superior Outcomes vs. ACDF

(Contd...)

Table 1: *(Continued).*

Author [Ref] Journal Years	Study Design	Date	Data	Data	Outcomes
Ng[10] Global Spine J 2022	Outcomes Multi 2012–2019 ACDF CDA, PCF ANOVA Medical AE, Surgical AE, Healthcare	ACS-NSQUIP Utilization 684 Pts Each Group Score Matching PCF 1.67±1.61 d ACDF 1.5±1.32d CDA 1.27±1.05 d	Multi PCF; Longer LOS PCF 1.67±1.61 d ACDF 1.5±1.32d CDA 1.27±1.05 d	Higher Reop Rates PCF 3.2%, ACDF 1.0%, CDA 04% Multi PCF Superficial Inf PCDF 1.3%, ACDF 0.3%, CDA 0.1% Deep Inf-PCF 1.2%, ACDF 0% CDA 0%	Same Outcomes Multi ACDF vs CDA Multi PCF>LOS, >Reop>Inf v ACDF v CDA

SA: Stand alone, VAS: Visual analog scale, HRQL: Health-related quality of life, EuroQOL: Quality of life ACDF: anterior diskectomy/fusion, ASD: Adjacent segment disease, yr: Year, Eval: Evaluation, Preop: Preoperative, Postop: Postoperative, NDI: Neck Disability index questionnaire, Sig: Significantly, Multi: Multilevel, F/O: Follow-up , Avg: Average, MR: Magnetic resonance imaging, CT: Computed tomography, AE: Adverse events, Pts: Patients, AutoG: Autograft, HO: Heterotopic ossification, CDA: Cervical disc arthroplasty, CDDD: Cervical degenerative disc disease, ROM: Range of motion, FSU: Functional spinal unit, TDR: Total disc replacement, IDE: Investigational device exemption trial, FDA: Food and drug administration, RR: Retrospective review, Sx: Symptoms/symptomatic, GRADE Criteria: grading of recommendations assessment development and evaluation, SF-36: Short form health survey physical component scores, MCDA: Multilevel CDA, SCDA: Single CDA, QOL: Quality of life, RCT: Randomized controlled trials, PCF: Posterior cervical foraminotomy, ACS-NSQUIP: American college of surgeons national surgical quality improvement project, d: Days, v: Versus, OR: Operation, RASP: Radiographical adjacent segment pathology, CASP: Clinical adjacent segment pathology, Ref: References, Prosp: Prospective, Deg: Degrees, Sup: Superficial, Inf: Infection, Reop: Reoperation, NASS: North american spine society, Com: Committee, Rx: Treatment, Comp: Compression, Flex/Ext: Flexion/Extension, Deg: Degeneration, AS: Ankylosing spondylitis, RA: Rheumatoid arthritis, Fx: Fracture, Def: Deformity, OPLL: Ossification posterior longitudinal ligament, Trans: Translation

degeneration (ASD), and the requirement for secondary ASD surgery [Table 1].[1-14] Further, for carefully selected patients (i.e. without direct contraindications for placing these devices), our literature review focused on whether CDA/TDR showed a "lack of inferiority"/occasional superiority, comparable safety/efficacy, and outcomes vs. anterior cervical diskectomy/fusion (ACDF) [Table 1].[1-14]

Multiple Direct Indications and Contraindications to Performing Cervical CDA/TDR

The indications for performing cervical CDA/TDR taken from the North American Spine Society (NASS) Coverage Policy Recommendations: Artificial Cervical Disc Replacement (i.e. revised 11/2015) included; "Radiculopathy related to nerve root compression from 1-2 level degenerative disease (either herniated disc or spondylotic osteophyte) from C3-C4 to C6-C7 refractory to…non-operative management", or "Myelopathy or myeloradiculopathy related to central spinal stenosis from 1-2 level degenerative disease (either herniated disc or spondylotic osteophyte) from C3-C4- C6-C7 with or without neck pain" [Table 1].[9] NASS Coverage Policy Recommendations for performing cervical CDA/TDR included; "Infection…," "Osteoporosis or osteopenia", "Instability…", Sensitivity or allergy to implant materials", "Severe spondylosis …. (i.e. >50% disc heigh loss…, bridging osteophytes, …absence of motion on flexion extension…", "Severe facet arthropathy…", "Ankylosing Spondylitis (AS)", "Rheumatoid Arthritis (RA)", "Previous fracture with…deformity", "Ossification of the Posterior Longitudinal Ligament (OPLL)", and "Malignancy active in cervical spine" [Table 1].[9] Additonal studies included stenosis and scoliosis amongst other factors [Table 1].[1-8,10-14]

Postoperative Dynamic X-rays Confirm Increased Postoperative ROM Following CDA/TDR v ACDF

Several studies documented an increased ROM following CDA/TDR vs. ACDF [Table 1].[1,6] Utilizing 1-year postoperative dynamic X-rays, Chang *et al*. (2018) documented the greater preservation of ROM following 1-level TDR (30 patients: index level postoperative ROM + 5.67 degrees) vs. 1-level ACDF (34 patients: index level postoperative ROM -0.96 degrees) [Table 1].[1] They thought this increase would reduce the risk for ASD, and the requirement for secondary ASD surgery. Over a 5 year period, Gupta *et al*. (2021) performed a double blind randomized controlled study (RCT) that compared the outcomes for 30 1-level CDA/TDR vs. 30 1-level Polyetheretherketone (PEEK) ACDF addressing cervical degenerative disease (CDD) [Table 1].[6] CDA/TDR patients exhibited greater improvement in their range of motion (ROM) and sagittal alignment, and better

maintained postoperative disc height, and overall improvement in their functional spinal units (FSU).

Improvement in Different Variables But Often Comparable Postoperative Outcomes for Single or Multilevel CDA/TDR v ACDF

Various studies showed differences in critical variables (i.e. ASD, reoperation rates for ASD), but comparable outcomes for cervical single or multilevel CDA/TDR vs. 1 level ACDF [Table 1].[5,7,8,14] In 14 studies comparing the incidence of ASD after cervical CDA/TDR vs. ACDF, Harrod *et al*. (2012) found similar frequencies of RASP (i.e. Radiographical Adjacent Segment Pathology) in both series along with no significant differences in the risk for reoperations for CDA/TDR (1.0%) vs. ACDF (4.8%) [Table 1].[7] For cervical 2-level CDA vs. 1-level ACDF, Zou *et al*. (2017) found equivalent outcomes, but somewhat better results after 2-level CDA vs. 2-level ACDF procedures [Table 1].[14] They noted comparable; average operative times, Visual Analog Scale (VAS) outcomes (neck/arm), and the incidence of adverse events (AE). Notably, CDA correlated with significantly reduced estimated blood loss (EBL), lower reoperation rates, a lower incidence of ASD, and better outcomes as documented utilizing NDI (i.e. Neck Disability Index Questionnaire). When Joaquim *et al*. (2017) used to compare results for more than 2-level CDA vs. ACDF (i.e. 14 articles with a 7 year follow-up duration); they found that multilevel CDA preserved ROM at the index surgical levels, lowered the incidence of ASD and need for ASD reoperations, and resulted in both good radiological and clinical outcomes [Table 1].[8] Gornet *et al*. (2019) found similar safety/efficacy, comparable rates of adverse events, and similar frequencies of implant-related complications 2-7 years following 1-2 level cervical CDA/TDR vs. ACDF [Table 1].[5] As anticipated the 7-year incidence of implant-related adverse events was higher for 2-level vs. 1-level CDA, while for ACDF, there were more complications for 2 vs. 1-level procedures.

Several Studies Documented Superiority of Postoperative Variables, Including Outcomes, Along with Reduced Dysphagia Rates for Cervical CDA/TDR vs. ACDF

Several studies documented select superior postoperative variables and outcomes along with reduced dysphagia rates following CDA/TDR vs. ACDF [Table 1].[3,4,11,12] Utilizing multiple databases, Findlay *et al*. (2018) evaluated 22 RCT (Randomized Controlled Studies) including 3160 patients studied over a 10 year period who underwent CDA/TDR vs. ACDF [Table 1].[4] When CDA/TDR were compared with ACDF at both 2 and 4-7 postoperative years, although outcomes were similar for many variables, CDA/TDR patients selectively showed superior outcomes based on NDI's (Neck Disability Index Questionnaire) and SF-36 (Short Form 36 Physical Component) scales, and a reduced incidence of postoperative dysphagia. In Xu *et al*. (2018) meta-analysis they evaluated 11 RCT that included 2632 patients and compared CDA/TDR with ACDF; they saw a reduced incidence of ASD and reoperation rates for CDA/TDR, and concluded this reduction in rate would further decrease (i.e. confirming CDA/TDR "superiority") "over time" [Table 1].[12] Turkov *et al*. (2021) compared single vs. multilevel CDA/TDR vs. ACDF and found "equivalent or improved clinical outcomes" for the former along with improved NDI and VAS scores [Table 1].[11] Further, CDA/TDR were safe/effective, exhibited lower rates of postoperative dysphagia, less ASD, fewer ASD-related reoperations, and a lower incidence of postoperative complications that did not increase for multilevel vs. single-level CDA/TDR. Over a 24 month period, Coric *et al*. (2022) performed a non-randomized FDA (Food and Drug Administration) IDE (Investigational Device) multicenter study involving 182 patients undergoing 2-level PEEK CDA/TDR vs. historical data from 170 "routine" ACDF (allograft/plates) [Table 1].[3] Success rates were higher and the reoperation rates lower for CDA/TDR (i.e. 86.7% and 2.2%) vs. ACDF (i.e. 77% and 8.8%) leading to their conclusion that CDA/TDR resulted in "superior outcomes" vs. "routine" ACDF techniques.

Comparable Safety/Efficacy of Multilevel Cervical CDA (MCDA)/TDR vs. Single-Level CDA (SCDA)/TDR

At 1 and 2 postoperative years, Zhao *et al*. (2015) concluded that single (SCDA) vs. multilevel (MCDA) procedures were equally safe/effective with relatively comparable preservation of ROM, reoperation rates, and outcomes [Table 1].[13]

Comparison of Multiple Variables Including Outcomes for Posterior Cervical Foraminotomy (PCF) vs. CDA/TDR vs. ACDF (ACS-NSQUIP Study)

In a NSQUIP study (ACS-NSQUIP study (American College of Surgeons National Surgical Quality Improvement Project) from 2012-2019, Ng *et al*. (2022) looked at multiple variables including outcomes for 684 patients undergoing PCF vs. CDSA (684 patients) vs. ACDF (684 patients) [Table 1].[10] PCF patients respectively demonstrated longer lengths of stay (LOS), higher reoperation rates, more superficial and deep infections, but no differences in outcomes vs. ACDF and TDR.

Definition and Higher Incidence of Heterotopic Ossification (HO) for Cervical CDA/TDR and ACDF Using Stand Alone Cages vs. None for ACDF Performed with Allograft/Screws/Plates but None with Clinical Impact

Definition of HO

Spinal heterotopic ossification (HO) is typically defined by ossification/calcification occurring within the ligaments/soft tissues of the spine. If HO occurs at the index level following cervical surgery utilizing CDA/TDR devices, it can both limit/eliminate the motion-sparing design of these implants, and potentially contribute to recurrent and/or clinically significant spinal cord/nerve root compression. Gornet referenced the Brooker Classification (I-IV) for HO typically applied to total hip arthroplasties (THA) (i.e. I-islands of bone within soft tissues, II->1 cm between bone spurs, III- <1 cm between bone spurs, IV-bony fusion between spurs) [Table 1].[5]

Different Rates but No Clinical Impact of HO for Cervical CDA/TDR vs. ACDF with Stand Alone Cages

Although several studies documented a higher incidence of HO for cervical CDA/TDR vs. ACDF with stand-alone cages vs. a 0% incidence for ACDF employing allograft/screws/plates, they typically observed that HO did not negatively impact outcomes for any surgical group [Table 1].[2,5,8] In 2012, Cho *et al*. performed dynamic X-rays over 24 postoperative months to evaluate the incidence of HO following 40 TDR (Bryan and ProDisc-C) vs. 47 ACDF (i.e. using either stand-alone cages vs. fibula allograft/plates/screws) [Table 1].[2] They found a higher incidence of HO for both CDA/TDR designs vs. a lower incidence when utilizing ACDF cages vs. none for ACDF performed with allograft/screws/plates. Interestingly, the development of postoperative HO highly correlated with the preoperative presence of significant osteophyte formation and/or calcification/ossification of the posterior longitudinal ligament (OPLL). Comparing multilevel cervical CDA/DTR vs. ACDF, Joaquim *et al*. (2017) observed a higher incidence of HO for multilevel cervical CDA/TDR procedures versus 1-level CDA, but HO had "no clinical impact" on outcomes [Table 1].[8] Gornet *et al*. (2019) also found the incidence of Grade IV HO (i.e. Brooker Classification IV (i.e. typically applied to complete bony HO fusion following total hip arthroplasty (THA)) at 7 postoperative years was 4.6% for 1-level CDA/TDR, but further increased for 2-level CDA (i.e. 8.65% at the superior level vs. 7.3% at the inferior level) [Table 1].[5]

CONCLUSION

Although some studies showed the select superiority for specific variables concerning CDA/TDR (i.e. preservation of ROM, reductions in ASD, lower ASD reoperation rates, and postoperative dysphagia), most concluded CDA/TDR exhibited comparable overall outcomes to ACDF [Table 1].[1-14]

Declaration of patient consent

No patients involved in the study other than those discussed in the literature.

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Conflicts of interest

There are no conflicts of interest

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Commentary

Cervical Disc Arthroplasty (CDA) vs Anterior Cervical Discectomy and Fusion (ACDF)

Multiple non-inferiority studies have shown that CDA maintains range of motion and potentially may decrease adjacent segment disease (ASD). But the fact that the surgery is done for radiculopathy in a degenerative condition makes it difficult to measure the true effect on adjacent segment degeneration. Since multiple CDA's are now approved for 2 level implantation and many are used off-label, it complicates the picture even more. Should some of the earlier CDA's have had 2 level implants initially but were restricted due to the early FDA indications? The use of finite element models can help us better understand the biomechanics behind ACDF and CDA, and the effects of different biomaterials and CDA designs. With more 2 level CDA implants being performed, time will tell if CDA's are actually making a significant impact on ASD. However, current data is not conclusive. As we increase the index level range of motion with CDA, we shift the increased stress posteriorly to increase the index level facet forces, and simultaneously decrease the cephalad and caudal adjacent level intradiscal pressures. This tradeoff of increased facet forces may potentially be a source of chronic neck pain or persistent neck pain despite a clinically improved radiculopathy postoperatively.

The issue of heterotopic ossification is frequently overlooked and not documented as the overall spinal range of motion is maintained with CDA's and spinal segmental motion coupling. Heterotopic ossification occurs in other disease processes (SCI) and with other types of prosthetic joints (hips and elbows etc.). Since the early CDA implants, the perioperative technique has been modified and more surgeons are using NSAIDS postoperatively to try to minimize early HO formation. Many of the CDA studies are not followed long enough, or fail to document HO formation.

As the biomaterials that make up the CDA's are varied and CDA designs change over time with increasing amounts of translation capabilities added, it will be interesting to see if the CDA will become too mobile, and will anterior migration and anterior osteolysis increase with the newer designs?

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