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ABSTRACT

Background. Anterior cervical discectomy and fusion is accepted as the standard surgical treatment of cervical spondylotic myelopathy. Cervical disc arthroplasty has gained widespread acceptance as an alternate choice for ACDF. We intend to present the clinical and radiologic outcomes of patients who underwent ACDF in our department.

Methods. Designed as a retrospective study, the primary objective was to assess the nonunion in patients undergoing ACDF and Anterior cervical Corpectomy and fusion. The article discusses the outcome for the discectomy group. All patients who underwent ACDF for CSM from January 2014 to December 2018 were included. Patients who underwent posterior fusion in addition to anterior approach, revision surgery and congenital anomalies of the spine were excluded. Of the 230 eligible patients, 46 subjects were part of the study. They underwent neurologic and radiographic examination and their past records were examined. Neurologic outcome was assessed using Nurick grade and mJOA score. Dysphagia was assessed using the Bazaz score. Neck radiographs were analyzed for fusion, Adjacent segment Disease, subsidence, cervical and segmental lordosis.

Results. The overall response rate was 25.65%. The mean follow up duration was 4 years. The mean age of the population was 47.1 years. The most common operating level was C5/6. The neurologic status of patients improved from the baseline. There was mild transient dysphagia in 5(10.9%) patients. The overall rate of fusion was 91.3%. Subsidence was seen in 10.9%. Degenerative changes were noted in postop x rays of 67.4% of patients. There was no mortality.

Conclusion. ACDF achieves thorough decompression thereby resulting in neurologic improvement. It produces effective and sustained neurologic improvement. Preoperative adjacent segment degenerative changes were significantly associated with the development of ASD during follow up. This is can due to the progression of the disease. Though the procedure improves the lordosis, it tends to decrease with follow up.

Keywords

adjacent segment disease,
anterior cervical discectomy
and fusion,
cervical spondylotic
myelopathy,
standalone cage



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INTRODUCTION

Anterior cervical discectomy and fusion(ACDF) was pioneered by Cloward and Smith and Robinson separately in 1950s for the surgical treatment for patients with cervical spondylotic myelopathy(1,2,3). Thorough and direct decompression of the pathology and subsequent bony fusion of the involved levels , as advocated by the Cloward forms the fundamental principle of the surgery(2). Anterior approach have become the standard treatment for Cervical Spondylotic Myelopathy. Anterior Cervical Corpectomy and Fusion (ACCF) was introduced by Whitecloud and LaRocca to circumvent graft failure following discectomy following multilevel discectomy.(4)

Though anterior cervical discectomy and corpectomy are excellent in achieving the decompression of the spinal cord and restoring the lordosis ; they are not without complications. Various reported complications include graft subsidence, graft migration , graft collapse , nonunion, loss of lordosis and adjacent segment disease (ASD) (5,6,7,8). Injury to neurovascular structures and oesophagus though rare have been reported (5,7) .The design of the Anterior cervical plates introduced in 1980s to address the problem of graft migration and nonunion has evolved to the presently popular translational plates(9).The translational plates achieve graft loading by permitting controlled subsidence, a prerequisite for fusion (10). Adjacent segment degeneration a described complication of fusion surgeries , was further elaborated by Hilibrand et al as occurring at a rate of 2.5% per yr with cumulated rate of 25.9 % at 10 yrs (11) .

The hypothesis that fusion increases the stress at the adjacent levels and subsequently accelerates degenerative changes at those levels ,brought back motion preserving surgery in to surgeon's armamentarium. Originally introduced by Ulf Fernstorm in 1966, artificial cervical disc was a stainless steel ball bearing device ,which was discontinued due to high failure rate (12,13) . The next era in motion preserving implants happened with introduction of Frenchay (Prestige) and Bryan artificial disc .However both the devices were of different designs(14,15).First decade of 21 st century saw many arthroplasty devices completing trials and getting approval for use in Cervical Spondylotic Myelopathy concurrent with expanding indications

for their use(16). Accruing evidence from long term results of RCTs and multiple meta analyses suggested superiority of CDA(Cervical Disc Arthroplasty) over ACDF in overall outcome , adjacent segment degeneration and secondary surgery at the index and adjacent levels(17,18) . Dynamic Cervical Implant(DCI), developed by Dr G Matge et al is a U shaped single piece implant with teeth for fixation into adjacent endplates, with U - limb of the implant facilitating controlled flexion and extension, while preventing axial rotation and lateral bending ,thereby reducing the stress on facet joints. .Matge et al reported excellent short term neurologic outcome and motion preservation in majority of the patients (19).

Though present day neurosurgical literature is replete with high quality evidence from many RCTs which suggest better overall outcome of CDAs over ACDF all these trials however were nonblinded .Recent analysis from a single blind trial for CDA vs ACDF found comparable results for PROM(Patient Reported Outcome Measures) as well as clinical adjacent segment disease(20).Results of two double blinded trials comparing CDA with ACDF and ACD, NECK (NEtherlands Cervical Kinematics Trial)and PROCON trial reported no advantage of CDA over ACDF in either patient outcome variables or in ASD. Data from the same trials show the incidence of Heterotopic ossification(HO) in 68%-85% of patients ,with half of them being motion restricting severe HO (21). Above all CDA is the not the panacea for all patients needing anterior cervical fusion with only 47 % of all patients undergoing ACDF for various indications being candidates for CDA (22,24). Regarding DCI ,the outcomes reported by Matge et al were not replicated in other series(23) .

The present article discusses results of the subgroup analysis of the study conducted in the department to determine the rate of nonunion in patients undergoing anterior cervical fusion for spondylotic myelopathy including anterior cervical discectomy and corpectomy . The radiologic and clinical outcome of the discectomy and fusion subgroup is presented here.

MATERIALS AND METHODS

Patient population

The study was designed as a retrospective design and was approved by Institutional Ethics Committee. The primary objective was to determine the rate of

nonunion in patients undergoing anterior cervical fusion for cervical spondylotic myelopathy and included both discectomy and corpectomy subgroups. The patients operated between January 2014 to December 2018 in our Department and willing to be part of study were included. Those with history of previous cervical spine surgery, with congenital anomalies of spine and those who needed posterior approach in addition to anterior surgery were excluded. The patients underwent a detailed neurologic examination and radiographic examination with X rays of the Cervical Spine. Their hospital records, previous images, and records of the follow up visit were examined. Of the 256 eligible patients 59 patients who were willing to be part of the study and with complete data were included in the study. Of these 46 patients had undergone discectomy while 13 had received corpectomy. The baseline data of the patients are summarised in Table-1.

Table 1 Demographic details of patients

Age in years Mean \pm SD	47.1 \pm 10.7
Sex (M/F)	32/24
Presence of other comorbidities(%)	16 (34.8)
History of Smoking(%)	14 (30.4)
Single level affected (%)	31 (67.4)
Presence of MRI T2 hypertintensity (%)	19 (41.3)

Surgical procedure

The involved levels were approached using an oblique neck incision after identifying the level preoperatively with C arm. The Caspar retractor system was used to retract the great vessels of the neck and the tracheoesophageal complex. The longus colli was detached from anterior vertebral surface. Subsequent to reconfirming the level annulotomy and discectomy was done with microscopic assistance. The disc space spreader was used to widen the disc space during discectomy. After complete discectomy PLL(Posterior Longitudinal Ligament) was inspected for any defect and disc fragments posterior to the PLL was

removed. The osteophytes were thinned using drill and removed using Kerrison punches and was confirmed using C arm. After satisfactory decompression of the cord, the endplates were prepared and appropriately sized cages or standalone cages made of Titanium filled with locally harvested bone pieces were impacted in to the disc space while avoiding overdistraction. The standalone cages have a side flange with a screw hole which allowed placement of a single screw in to the adjacent vertebral bodies. For those with conventional plates, a contoured plate of appropriate length was placed over the adjacent segment and fixed using 4 screws, 2 each in to adjacent bodies. For patients undergoing Corpectomy, the upper and lower discs were removed followed by median corpectomy. Osteophytes were drilled thin and removed with punches. Once decompression was confirmed, adequately sized Titanium cages were impacted after filling them with bone harvested from the removed vertebra.

Patients were usually discharged on 5th postoperative day. Patients were given a cervical collar for 6 weeks. The follow ups were at 6 weeks, 3 months, 6 months and 1 year and annually thereafter. At 3 months, 6 months and at 1 year f/u, they undergo C Spine x rays.

Clinical and radiologic outcome assessment

Nurick grade and mJOA (modified Japanese Orthopaedic Association) score were used to assess the neurologic outcome. Radiologic assessment was done using plain and dynamic x rays. Bazaz criteria was used for assessing dysphagia. The criteria used for fusion was absence of movement of >2 mm between spinous processes of the fused segment and absence of radiolucency between the implant and the bony surface and absence of bridging bone between the fused vertebrae. Subsidence was interpreted as migration of the cage more than 2mm in to the adjacent bodies(25). The criteria proposed by Chung et al was used to assess ASD (26). The implant complications included - screw pullout, screw breakage, plate loosening and plate breakage. Global Cervical Lordosis was measured using Cobb Angle between inferior endplate of C2 and inferior endplate of C7(27). Segmental angle was defined as the angle between the superior endplate of superior

vertebra and inferior endplate of inferior vertebra (28)

Statistical methods

Categorical and quantitative variables were expressed as frequency (percentage) and mean \pm SD respectively. Chi-square test and Fisher's exact test were used to find association between categorical variables. Mann-Whitney U Test was used to compare selected quantitative parameters between type of surgery. For all statistical interpretations, $p < 0.05$ was considered the threshold for statistical significance. Statistical analyses was performed by using a statistical software package SPSS, version 20.0

RESULTS

The discectomy subgroup included 46 patients. The demographic data of the patients is given in Table 1. Mean duration of follow up was 4 years. 31 (67.4%) % of patients had pathology affecting one level while 32.6% had pathologies at multiple levels. The details of the levels is given in Table 2. Cord signal changes ie, T2 hyperintensity were present in 41.3 %. Plate extending in to adjacent disc space was present in 30.4 % patients in postop x ray . Among patients with plate overlap majority of the overlap was at the cranial level (90.5%) and in 9.5% of subjects overlap was at the inferior level. Degenerative changes at adjacent levels were present in preop x rays in 43.5 % of patients. Regarding the height of cage most commonly used was 6 mm cages in 47.8% of patients, 7 mm in 34.8 %, 8 mm in 10.9% and 5 mm in 6.5% patients.

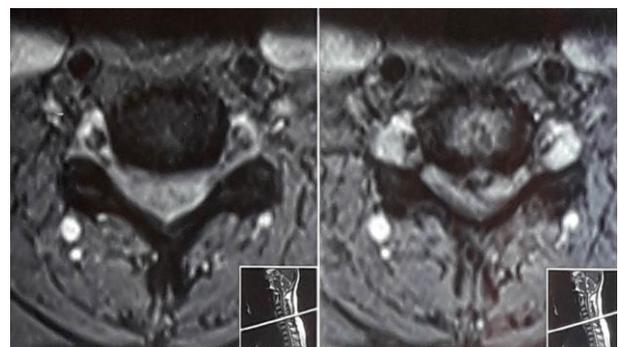
Table 2. Level Affected

Primary level	Count
C3/4	8 (17.4)*
C4/5	11 (23.9)*
C5/6	19 (41.3)*
C6/7	8 (17.4)*

()* - in Percentages

Neurologic status of patients improved after surgery as reflected by the improvement in Nurick grade and mJOA score (Table 2) and this improvement was sustained till final follow up. Mild transient dysphagia occurred in 5 (10.9%) patients which improved in all during the postop period. Regarding radiologic outcome ,the overall fusion rate was 91.3%(Figure 1).

Degenerative changes were noted in postop x rays of 67.4% patients , 3 patients had implant related complications 2 had screw breakage and one suffered loosening of the screw. There was no mortality in the group. One patient had deteriorated neurologically in immediate postop period due to haematoma and required evacuation , following which patient improved gradually .



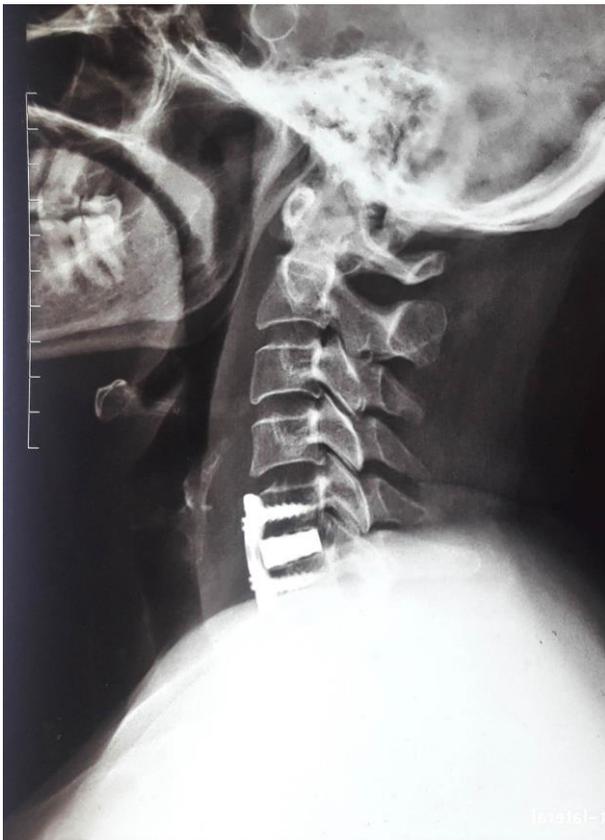


Figure 1. A - Sagittal T2 image showing cord compression due to the disc. B -Axial Image .C ,D and E - Lateral radiographs - preop ,Postop and at 2 years f/u respectively . 2 yr radiograph shows solid fusion of the operated level.

The lordosis both cervical and segmental angle improved after surgery , but there was partial loss of this improvement over the follow up period (Table 3). Subsidence occurred in 5 patients .All of them had undergone fusion with standalone cage (p = 0.026)

The degenerative changes on X rays had increased from 43.5% in preop x rays to 67.4% in post op xrays. The affected level, no of operated levels, plate extending to the adjacent disc space , height of cage were not associated with postop degenerative changes .However preop degenerative changes had a significant association with postop X ray changes (p=0.025).

Table 3 Cervical Lordosis and Segmental Angle comparison

		Mean ± SD	Median (IQR)	Pair	p
Cervical lordosi	Pre Op	18.2 ± 6.5	18 (15 - 23)	-	-
	Post Op	22.6 ± 7.5	23 (18 - 26)	Pre Vs Post	p<0.01
	Follow up	19.8 ± 6.5	20 (15 - 23)	Pre Vs Follow up	0.007
Segmental angle	Pre Op	3.5 ± 2.3	3 (2 - 5)	-	-
	Post Op	4.7 ± 2.2	5 (3 - 6)	Pre Vs Post	p<0.01
	Follow up	3.5 ± 2.2	3 (2 - 5)	Pre Vs Follow up	0.351

Table 4.

		Mean ± SD	Media n (IQR)	Pair	p
Nurick grade	Pre Op	3.1 ± 1.1	3 (2 - 4)	-	-
	Post Op	2.4 ± 1.4	2 (1 - 4)	Pre Vs Post	p<0.01
	Follow up	1.4 ± 0.9	1 (1 - 1)	Pre Vs Follow up	p<0.01
MJOA	Pre Op	12.2 ± 3.2	13 (11 - 14)	-	-
	Post Op	12.8 ± 3.5	13 (11 - 15)	Pre Vs Post	p<0.01
	Follow up	15.7 ± 3.1	17 (15 - 18)	Pre Vs Follow up	p<0.01

DISCUSSION

The participation rate in the study was (25.65%). The travel restrictions imparted due to COVID and the patient reluctance to attend the hospital OPD which was a dedicated COVID treatment centre might have contributed to low participation rate.

Anterior Cervical Discectomy and fusion remains as a standard surgical option for patients with Spondylotic myelopathy despite the popularity of cervical disc arthroplasty. Evidence from control arm of CDA -IDE(Cervical Disc Arthroplasty – Investigational Drug Exemption) trials provide high quality evidence about the outcome and complications of ACDF (29). The fusion rate 97% -98% along with excellent clinical outcome in 94% reported by Cloward in his series of more than 2000 patients, operated for various pathologies underscores safety and efficacy of the procedure as well as the sound scientific basis of this procedure(3). The ability to achieve thorough decompression of the offending pathology and restoration of lordosis are the inherent advantages of the procedure. This is reflected in the neurologic outcome after fusion surgeries, which shows a sustained improvement in neurologic function on long term follow up (30,31,32). A recent study by Karim *et al* concluded that the neurologic improvement in all groups ie, mild, moderate and severe myelopathy, though the improvement was more pronounced in severe group (33). In our study population the mean mJOA score improved from the 12.8 (SD 2.5) to 16.5 (SD 1.9) at final follow up which is similar to the result from the

past studies. All these results point to the efficacy of the procedure.

Postop dysphagia is a frequent complication reported after anterior cervical fusion with reported incidence ranging from 12% -35% (34). This subsides in majority of the patients though it can be troublesome for a minor group of patients. Various proposed etiological factors for dysphagia include design of the plate, female sex, number of levels operated and use of conventional plate (35,36,37). Mild Dysphagia for solid food present in 10.9% of our patients during immediate postop period resolved in follow up.

Cloward in his article stressed the role of fusion in ACDF as equally important as decompression. He had used variously shaped allografts in his patients with an excellent fusion rates of up to 97% (3). Though studies variously use absence of relative motion between the spinous processes of fused segments, the presence of bridging bone and absence of radiolucency between the endplate and implant as the criteria for fusion there is no uniformity in the definition for fusion. Fraser *et al* in a metaanalysis reported an overall fusion rate of 89.2% for anterior fusion surgeries which also included noninstrumented fusion and corpectomies(38). For instrumented ACDF, the fusion rate varied from 82.5% for multilevel to 97.1% for single level(38). However information on fusion rates stratified according to the implant type was not available. Noordhoek *et al* reported comparable fusion rates of >90% for Titanium and PEEK cages (38,39). Our study population using Titanium cages had a fusion rate of 91.3%. The cohort of patients who didn't achieve radiologic fusion in our group were neurologically stable and were free of symptoms. (Figure 2).

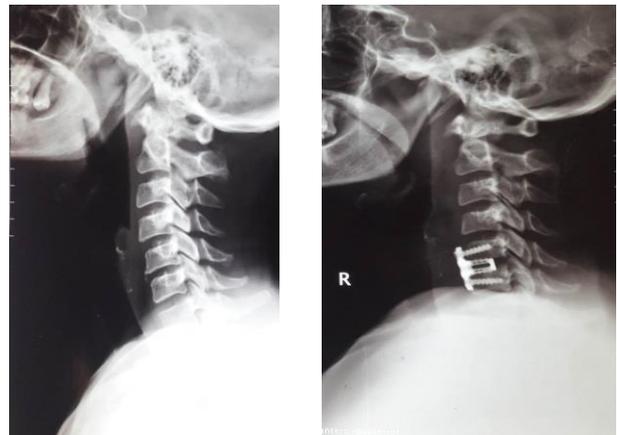




Figure 2. A – Nonunion after C5/6 fusion- Lateral Radiographs (A) preop, (B) Postop,(C) at 2 yrs,(D) Extension and (E) Flexion images .Flexion pronounces defect in the bridging bone and radiolucency around the implant.

Adjacent segment degeneration after anterior cervical fusion was noticed by several authors as the the procedure gained widespread popularity(40,41,42).Hilibrand et al in a series of 409 patients followed up to 21 years reported the annual incidence of adjacent segment degeneration of 2.5% per year . Using a survivorship analysis they estimated cumulative incidence of 25.9 % at 10 years. Authors however had distinguished between adjacent segment disease and symptomatic adjacent segment disease which occurred in 14.2 %.They recognized single operated level and C5/6 or C6/7 as risk factors for development of ASD(11) .The etiology of the adjacent segment disease is the subject of a hitherto unsettled discussion. Hilibrand et al after comparing the occurrence of ASD in anterior and posterior surgery groups concluded ASD as outcome of natural history of disease rather

than an outcome precipitated by treatment(43). Other risk factors emerged from further studies includes Plate extending to the adjacent disc space - plate to disc distance < 5 mm (44) , kyphotic postop sagittal alignment in patients with ASD (45) ,preop needle localization at wrong level (46). 0.5 to 1 fold distraction on the other hand has been found to be protective against ASD(47) .In our patient population the number of levels operated, plate overlap in to adjacent disc space and height of the cage were not associated with development of degenerative changes in postop x rays .However degenerative changes in pre op x rays(43%) was significantly associated with development of further changes in post op x rays(67%)(p = .025).This finding supports the argument that the ASD is an outcome of the natural history of the disease rather than a complication of the treatment. The height of the cage , an indirect marker of distraction had no association with the ASD in our study .

Subsidence of the cage in to the adjacent vertebral body is not an infrequent phenomenon with the use of metal cages .There have been contrasting reports of subsidence unfavourably affecting clinical outcome(48,49) and having no impact on clinical outcome(50,51). Various authors have reported patient related, technique related a and implant related factors associated with subsidence.The risk factors include age, sex ,preop cervical alignment ,bone mineral density (52,53,54). Truumees et al reported overdistracted and damage to endplates positively correlated with occurrence of subsidence(55).Cage height and Titanium cages , standalone cages were also reported to be significantly associated with subsidence (56).In our patients five developed subsidence ,all of them had undergone fusion with standalone cage compared to conventional cage and plate ,which was significant (p=.026).However all the patients with subsided cages eventually attained fusion. Both group had similar clinical outcome despite the subsidence. The finding in our patients possible might be due to 2 factors – Titanium cages and greater graft loading with standalone cages compared to conventional cages. Titanium cages have greater modulus of elasticity compared to PEEK and bone , with the resultant modulus mismatch playing a role in subsidence (57).

Restoration of lordosis is one of the advantages of the ACDF over posterior procedures. The improvement in lordosis is reported to be associated

with improvement NDI scores and JOA recovery rate .The impact of the correction of lordosis on improvement of JOA score is less clear as to whether this being a result of decompression or directly related to restoration of lordosis (58). Katsuura et al reported the occurrence of local kyphosis in 43% of patients undergoing multilevel discectomy which was a predisposing factor for ASD(59). Reports differ on the long term maintenance of the postop lordosis (60,61).Multilevel procedures tend to lose the lordosis compared to fewer operated segments. In our study the post op cervical lordosis(22.6 degrees) and the segmental angle (4.7 degrees) increased significantly compared to preop levels (18.2 and 3.5) .Though the gain in the lordosis was partially lost over the follow up duration ,the final cervical lordosis(19.8) was higher compared to preop levels and was significant for cervical lordosis ,though not segmental angle at final follow up. We attribute this to the progression of the degenerative disease which was present in 67% of our patients radiologically at final follow up. Thus the occurrence of ASD and loss of lordosis is closely related. However whether this loss of lordosis was due to the progression of the degenerative pathology couldn't be conclusively verified from our study.

CONCLUSION

Anterior Cervical Discectomy and Fusion is an effective option for the treatment for Cervical Spondylotic Myelopathy . It produces a sustained neurologic improvement .Preoperative adjacent segment degenerative changes was significantly associated with development of ASD during follow up. This is can due to the progression of the disease rather being precipitated by the procedure. Though the procedure improves the lordosis, it tends to decrease with follow up.

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