

# Hybrid implants in anterior cervical decompressive surgery for degenerative disease

## ABSTRACT

**Background:** Anterior cervical discectomy and fusion (ACDF) still represent the mainstream surgical approach in the treatment of degenerative cervical Degenerative Disc Disease (DDD), being a loss of mobility at the treated segment and adjacent segment diseases well-known complications. To overcome those complications, hybrid surgery (HS) incorporating ACDF and cervical disk arthroplasty is increasingly performed for DDD.

**Methods:** We retrospectively reviewed the clinical, surgical, and outcome data of 62 consecutive patients (male/female, 29/37) harboring cervical disk herniation with or without osteophytes, with radiculopathy with or without myelopathy, who underwent a cervical discectomy on two or more levels with the anterior approach with at least one disk prosthesis along with cage and plate or O Profile screwed plate.

**Results:** All the patients improved regardless of the cervical construct used. No significant relationship between different kind of prostheses as well as their surgical level, the number and the site of the cages (screwed and/or plated) was found out concerning immediate stability, dynamic prosthesis effectiveness, and clinical improvement in all the patients up to the maximum follow-up.

**Conclusions:** Although the optimal surgical technique for cervical DDD remains controversial, HS represents a safe and effective procedure in selected patients with multilevel cervical DDD, as demonstrated by biomechanical and clinical studies and the present series. Some technical aspects should be considered when dealing with this procedure, like the drilling of the endplate, and some radiological findings have to be detected because potentially predictive of future misplacement.

**Keywords:** Anterior cervical discectomy and fusion, degenerative disc diseases, hybrid surgery, myelopathy, spinal surgery

## INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) still represent the mainstream surgical approach in the treatment of degenerative cervical disc disease (DDD).<sup>[1,2]</sup> However, despite technical refinements and excellent results reported in terms of neural decompression, segmental stabilization and clinical outcomes, the ensuing fusion results in a loss of mobility at the treated segment and increases the stress on adjacent segments, which may cause more rapid disc degeneration and lead to adjacent segment diseases (ASDs).<sup>[3,4]</sup> Other important complications are associated with this procedure, as demonstrated by biomechanical and clinical studies, including bone graft nonunion, implant migration, subsidence, and bone donor site pain, overall accounting for a reoperation rate of 10%.<sup>[5,6]</sup> These concerns overall


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led to the introduction, in recent years, of cervical disc arthroplasty (CDA) as an alternative option conceived to preserve segmental motion and normal disc height, thereby preventing, at least theoretically, adjacent segment degeneration.<sup>[7,8]</sup>

Although CDA has recently gained wide attention, a clear predominance over ACDF is still matter of discussion, some authors not reporting a clear predominance of a technique over another in terms of ASD, some others reporting superiority in terms of clinical outcomes and ASD incidence.<sup>[2,9-11]</sup>

CDA can be burdened by other complications such as subsidence, vertebral body fracture, migration, bearing surface wear, and heterotopic ossification, which could be attributed to the biomechanical changes after CDA.<sup>[8,12,13]</sup>

To overcome the limits and drawbacks of both, hybrid surgery (HS) incorporating ACDF and CDA is increasingly performed for DDD. HS has the advantage to help surgeons in tailoring disc replacement or fusion to the selected levels according to the different degrees of degeneration at each level. HS, avoiding long-level fusion, preserves segmental motion of the cervical spine, thereby preventing further ASD.

Several authors have reported clinical series of ACDF and CDA, but few experiences of cervical HS with sufficient follow-up (FU) have been published.

Herein, we present a retrospective institutional analysis of patients harboring cervical degenerative disc diseases operated on using hybrid implants, with the aim of identifying biomechanical mechanisms, clinical features, and radiological findings underlying the success rate and the failure of the implants.

## METHODS

We retrospectively reviewed the clinical, surgical, and outcome data of 62 consecutive patients (male/female, 30/32) harboring cervical disk herniation with or without osteophytes, with radiculopathy with or without myelopathy, who underwent a cervical discectomy on two or more levels with the anterior approach between April 2011 and March 2018 at the Department of Neurosurgery of Fondazione Policlinico Gemelli IRCCS, Catholic University, Rome. All patients provided informed consent for the analysis of clinical data.

All the patients underwent complete preoperative radiologic workup using magnetic resonance (MR), computerized tomography (CT) scan, standard and dynamic X-ray.

neurophysiology was studied with electromyography at both arms and somatosensory evoked potentials and motor evoked potentials in all the cases with myelopathy.

All the patients were operated on by anterior approach, through horizontal or vertical incision according to the number of levels to be operated, with Caspar distractor with at least one disk prosthesis along with cage and plate or O profile screwed plate.

The indication for cage plating was myelopathy with osteophytes, the indication for disk prosthesis placement was soft herniated disk without radiological and clinical signs of myelopathy and osteophytes.

Cages and plates were evaluated and compared with Screwed cages (plates O-profile), as well as disk prosthesis according to different mechanical structures.

Postoperative radiologic FU included dynamic cervical X-ray before discharge and after 1 month, CT scan and MR at the 3<sup>rd</sup> postoperative month. Then, the patients were examined in the outpatient clinic every 6 months with dynamic X-ray.

Preoperatively and at FU, they were clinically evaluated according to the modified Japanese Orthopaedic Association (mJOA) scoring system and Nurick grade to assess the myelopathic status and Visual Analog Scale (VAS) to evaluate the neck pain intensity.

Radiographic assessments included cervical lordosis and range of motion (ROM) of the cervical spine.

## Statistical analysis

Continuous data are presented as mean  $\pm$  standard deviation, frequency data as counts and percentages. Paired *t*-test was used for continuous variables and the Chi-squared test for frequency variables. Analysis of variance for repeated measures was used to assess time differences in mJOA scores across time points, while paired *t*-test was used to compare score means between two adjacent time points.  $P < 0.05$  were considered statistically significant. Quantitative variables at each FU time points between the two groups were analyzed using the Mann–Whitney *U*-test. Data were analyzed using StatView version 5 software (SAS Institute Inc., USA).

## RESULTS

### Demographic and surgical data

Data of patients are summarized in Table 1. The mean age was  $55.57 \pm 12.05$  years and the mean FU was  $37.15 \pm 29$  months. Mean operative time was  $170.4 \pm 36.3$  min.

Forty-five patients (72.5%) underwent cervical discectomy on two levels; sixteen patients (25.8%) underwent cervical discectomy on three levels; one patient (1.6%) underwent cervical discectomy on four levels.

In sixteen out of the 45 patients operated on two levels, the prosthesis was placed at the superior level. In the remaining 29, the cage was implanted at the superior level.

Among the patient's group treated on more than two levels, eleven patients (17.7%) underwent two cervical cages implantation and one cervical prosthesis; four patients (6.4%) underwent one cage and two prosthesis; one patient (1.6%) underwent 2 cages and 2 prosthesis [Table 1].

No statistically significant ( $P > 0.05$ ) relationship between different kind of prosthesis as well as their surgical level, the number and the site of the cages (screwed and/or plated) was found out concerning immediate stability, dynamic prosthesis effectiveness, and clinical improvement in all the patients up to the maximum FU.

The subgroup analysis among different levels treated and position of cage or prosthesis did not reveal a significant difference ( $P > 0.05$ ) in terms of outcome.

All the patients improved postoperatively and no junctional segmental secondary herniated disk or dislocation were reported at the maximum FU. In particular, both mJOA scores

and Nurick grades improved significantly at last FU. Average preoperative Nurick's grade was  $1.32 \pm 0.71$  and improved to  $1 \pm 0.64$  at final FU ( $P < 0.0095$ ) [Figure 1]. Preoperative mJOA score was  $9.27 \pm 1.57$  and improved to  $12.88 \pm 1.24$  at final FU ( $P < 0.00001$ ) [Figure 1 and Table 2]. Subgroup analyses between myelopathic and nonmyelopathic patients revealed statistically significant differences in terms of pre- and post-operative VAS, mJOA and Nurick scores, as shown in Table 3.

Only one failure was present in our series, consisting of a displacement of a C5–C6 prosthesis in the patient who underwent a four levels surgery with two cages at level C3–C4 and C4–C5 and two prosthesis at level C5–C6 and C6–C7 1 month before. The patient, a 62-year-old modern dancer who started to dance soon after a couple of weeks after surgery, surprisingly asymptomatic, underwent “redo surgery” at level C5–C6 and, after removal of CDA a screwed cage (0 Profile) was implanted [Figures 2-5].

In this case, a critic, *post hoc* re-evaluation of the immediate postoperative X-ray and CT scansagittal reconstruction, allowed to recognize a divergent aspect of the involved prosthesis, due to an asymmetrical drilling of the endplates, which mimic the shape of a *chalix*, comparing to the parallel, *rail* sign, that a symmetrical drilling normally give [Figure 6].

**Table 1: Patient's characteristics**

	TOT	II levels	III levels	IV levels	Radiculopathy	Myelopathy
Number of patients	62	45	16	1		
Age (years)	55.57 ± 12.05	54.5	59	62		
Sex (male/female)	30/32	20/25	10/6	0/1		
Levels						
2 (C3-C4)		8			6	4
2 (C4-C5)		9			7	3
2 (C5-C6)		29			25	12
3 (C3-C5)			4 (2C+1P)		3	2
3 (C4-C6)			7 (2C+1P); 4 (2P+1C)		9	7
4 (C3-C6)				1 (2C+2P)	1	1
Blood loss, mL						
Operative time (min)	170.4 ± 36.3	157 ± 23.7	210 ± 7.7	248		
Follow-up	37.15 ± 29	38.3 ± 30.3	33.5 ± 24.9			

C-Cage, P-Prosthesis, TOT-Total

**Table 2: Overall clinical outcomes**

	Preoperative	1 month follow-up	6 months follow-up	1 year follow-up	Last follow-up	P
VAS scores	5.96 ± 1.55	4.76 ± 1.22	3.1 ± 1.18	2.95 ± 1.23	2.85 ± 1.21	<0.0001*
mJOA scores	9.27 ± 1.77	11.8 ± 1.09	12.83 ± 1.16	12.89 ± 1.17	12.88 ± 1.57	<0.0001*
Nurick scores	1.32 ± 0.71	1.13 ± 0.65	1.06 ± 0.69	1.06 ± 0.69	1 ± 0.64	0.0095*

\*Significant changes ( $P < 0.05$ ). VAS-Visual analog scale, mJOA-Modified Japanese Orthopedic Association

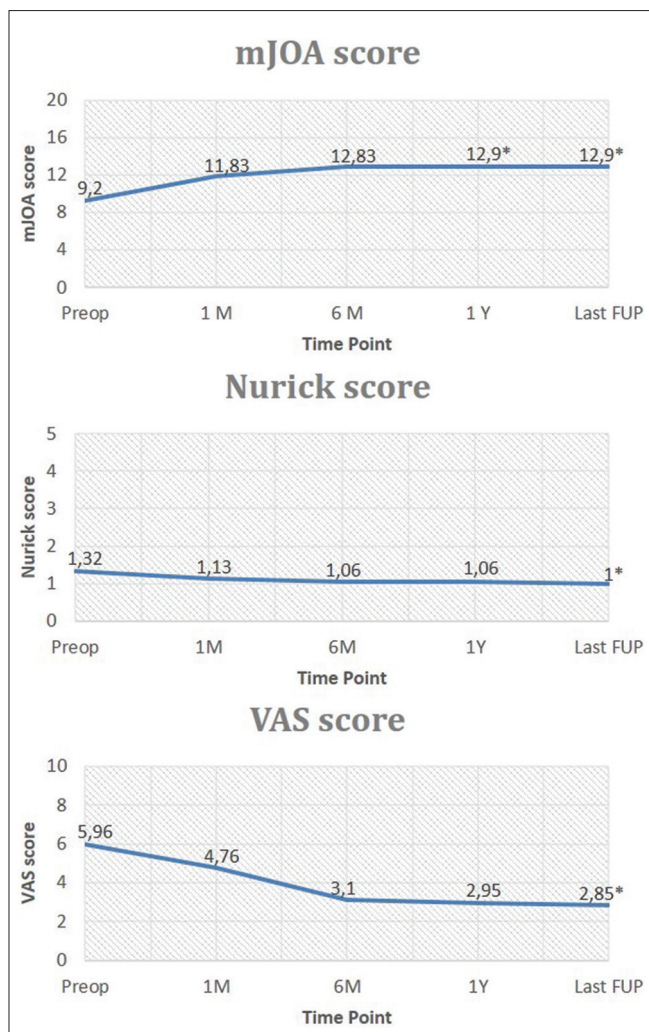


Figure 1: Modified Japanese Orthopaedic Association, Nurick and Visual Analog Scale scores at different time points. Significant changes ( $P < 0.05$ ) are marked with an asterisk in the graph

## DISCUSSION

The optimal surgical technique for cervical DDD remains controversial. ACDF is still widely performed for cervical degenerative disc diseases, mainly associated with myelopathy.<sup>[14-16]</sup>

Current complications described in the literature are ranging 13.2%–19.3%. These included dysphagia (1.7%–9.5%), postoperative hematoma (0.4%–5.6%) (surgery required in 2.4% of 5.6%), exacerbation of myelopathy (0.2%–3.3%), symptomatic recurrent laryngeal nerve palsy (0.9%–3.1%), cerebrospinal fluid leak (0.5%–1.7%), wound infection (0.1%–0.9%–1.6%), increased radiculopathy (1.3%), Horner’s syndrome (0.06%–1.1%), respiratory insufficiency (1.1%), esophageal perforation (0.3%–0.9%, with a mortality rate of 0.1%), and instrument failure (0.1%–0.9%).<sup>[17,18]</sup>

Furthermore, ACDF is also proven to alter the normal biomechanics of the cervical spine, to decrease mobility at

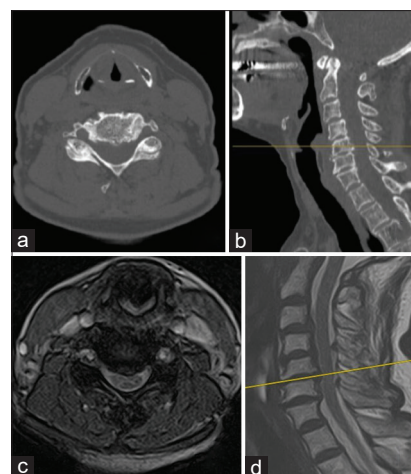


Figure 2: Axial (a) and sagittal (b) computed tomography scan before the first surgery, showing cervical osteophytes C5–C6. Axial (c) and Sagittal (d) preoperative T2-weighted magnetic resonance imaging

Table 3: Clinical outcomes

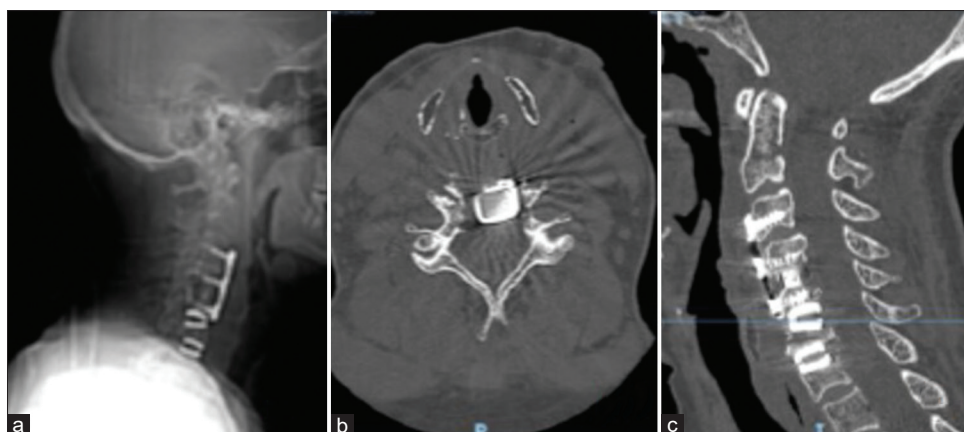
VAS scores	Myelopathy (n=29)	Nonmyelopathy (n=33)	P°
Preoperative	6.20±1.73	5.75±1.34	0.4593
Last follow-up	3.34±1.12	2.42±1.13	0.0057*
P§	<0.0001*	<0.0001*	
mJOA scores			
Preoperative	7.89±0.96	13.48±1.39	<0.0001*
Last follow-up	11.75±1.04	15.87±1.27	<0.0001*
P§	<0.0001*	<0.0001*	
Nurick scores			
Preoperative	1.83±0.70	0.87±0.32	<0.0001*
Last follow-up	1.44±0.49	0.61±0.49	<0.0001*
P§	0.0171*	0.0131*	

\*Significant changes ( $P < 0.05$ ). §Paired t-test, °Mann-Whitney U-tests. VAS-Visual analog scale, mJOA-Modified Japanese Orthopedic association

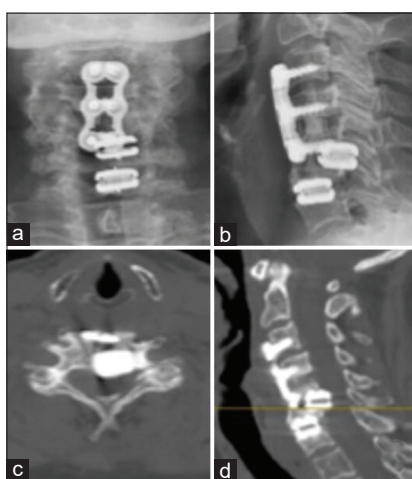
the fused segments and to overload the adjacent levels; it can result in acceleration of ASD and the need for further surgery in the long term.<sup>[3,4,19]</sup> CDA, introduced with the aim to preserve the motion of the treated level and to prevent an overload of the adjacent discs, is currently limited by strict indications, hypermobility of the operative levels, higher medical cost and the lack of long-term FU.<sup>[4,8,9,12,13,20]</sup> Nevertheless, progressive development of heterotopic ossification in CDA, with gradual reduction of ROM can occur as well.<sup>[21]</sup>

The aim of HS for multilevel cervical DDD<sup>[8,13]</sup> is based on the assumption that the most suitable treatment should be utilized at each cervical disc.<sup>[22]</sup> This technique aims to tailor ACDF or CDA to the selected levels for preserving segmental motion of the cervical spine, avoiding long-level fusion and preventing further ASD.<sup>[23,24]</sup>

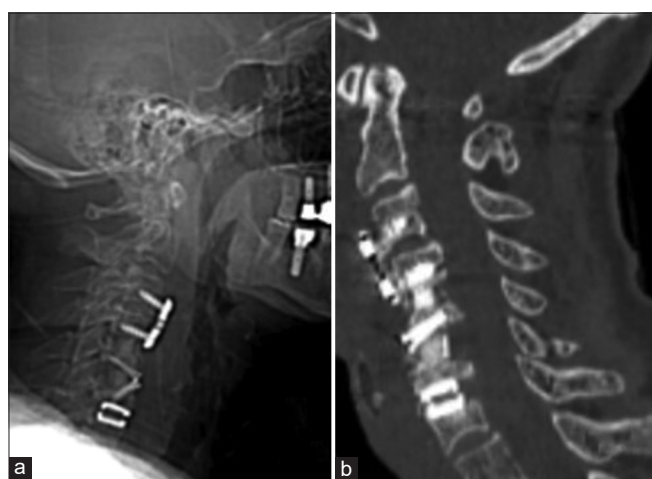
Several biomechanical and clinical studies investigated the potential benefits of HS over ACDF and CDA alone.<sup>[24]</sup>



**Figure 3:** Cervical X-ray (a) and axial (b) and sagittal (c) cervical computed tomography scans after the first surgery showing two cages at level C3–C4 and C4–C5 and two prosthesis at level C5–C6 and C6–C7



**Figure 4:** Anterior posterior and LL cervical X-ray (a and b), axial and sagittal computed tomography scan (c and d) showing dislocation of C5–C6 prosthesis 1 month after first surgery



**Figure 5:** X-ray (a) sagittal computed tomography scan (b) after “redo surgery.” Dislocated prosthesis was removed, and a cage was implanted

Current biomechanical evidence indicates that HS preserves the cervical spinal kinematics, interdiscal pressure (IDP) in

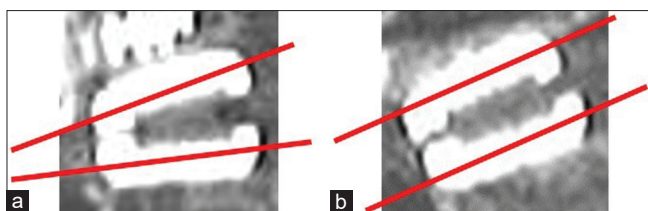
adjacent segments, and facet joint force.<sup>[2,25]</sup> Conversely, 2-level fusion largely constrains ROM of operative levels and induced compensatory increase of motion at adjacent levels that may adversely increase the IDP.<sup>[25-27]</sup>

Other biomechanical studies demonstrate that fusion induces hypermobility and increased stress at adjacent segments,<sup>[28,29]</sup> while CDA maintains physiological motion and pressure at these segments.<sup>[30,31]</sup> Nevertheless, a recent meta-analysis indicated no statistically significant difference in the rate of ASD between CDA and ACDF, so there is still no clear evidence that less decrease in motion results in less ASD,<sup>[32,33]</sup> which has been attributed by several authors to the fusion-induced increasing IDP.<sup>[30,34]</sup>

A biomechanical study by Singh *et al.* revealed that hybrid decompression can avoid the long fused segments and maintain better stability and cervical alignment of the operated levels and less occurrence of plate migration by segmental plate fixation compared to end-construct plate fixation.<sup>[35]</sup>

In our series, including both two and three levels treated and one case of four levels, no ASD nor cervical instability or cage dislocation have occurred at maximum FU but in only one case associated with overloading of posterior endplates drilling. The dynamic power of the prosthesis was unchanged at the maximum FU in all the cases.

Regarding clinical aspects, several authors report that HS could reach a similar<sup>[12,23,24,36,37]</sup> and even better outcomes in selected patients compared to ACDF.<sup>[36]</sup> In particular, the immediate restoration of normal activities due to the self-stabilizing constructs, without the need to wear a cervical collar, was particularly appreciated by all the patients. Considering radiological outcomes, other studies demonstrate an equivalent or better recovery in the HS group comparing with ACDF or CDA in terms of ROM of the cervical spine.<sup>[12,24,36-38]</sup>



**Figure 6: Chalix sign (a) and rail sign (b) as showed by divergent (a) and parallel (b) red lines**

Complication rates differ among the reported series, overall ranging from 0% to 28.6%.<sup>[12,23,24,35,36]</sup> In particular, HS shows no higher complication rates in the comparative studies.<sup>[12,24,36]</sup>

In our series, the only complication that occurred could have been prevented by immediately recognizing the chalix sagittal fluoroscopic sign to perform an intra-operative correction before the dislocation occurred.

In our series, in which all patients have been operated on by the experienced senior author, this surgical complication occurred only in one out of 62 patients (1.6% of patients) and the patient did not worsen after that. Nevertheless, it is the result of a technical and, therefore, modifiable factor, suggesting the need to perform parallel drilling of the endplate in the prosthesis site more than in screwed cages due to the residual mobility of the construct.

### Study limitations

Our study could be prone to the biases associated with a retrospective research method. In addition, the results herein presented are not compared with patients operated on by different techniques.

### CONCLUSIONS

Although the optimal surgical technique for cervical DDD remains controversial, HS represents a safe and efficacious procedure in selected patients with multilevel cervical DDD, as demonstrated by biomechanical and clinical studies and the present series. Some technical aspects should be considered when dealing with this procedure, like the drilling of the endplate, and some radiological findings have to be detected because potentially predictive of future misplacement. Further prospective, randomized controlled studies are needed to reach more reliable conclusions.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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