



Cervical disc arthroplasty: What we know in 2020 and a literature review

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Abstract

Cervical disc arthroplasty (CDA) is a safe and effective option to improve clinical outcomes (e.g., NDI, VAS, and JOA) in degenerative cervical disc disease and compressive myelopathy. CDA's two main purported benefits have been that it maintains physiologic motion and thereby minimizes the biomechanical stresses placed on adjacent segments as compared to an ACDF. CDA might reduce the degeneration of adjacent segments, and the need for adjacent-level surgery. Reoperation rates of CDA have been reported to range from 1.8% to 5.4%, with a minimum 5-year follow-up. As the number of CDA procedures performed continues to increase, the need for revision surgery is also likely to increase. When performed skillfully in appropriate patients, CDA is an effective surgical technique to optimize clinical outcomes and radiological results. This review may assist surgical decision-making and enable a more effective and safer implementation of cervical arthroplasty for cervical degenerative disease.

Keywords

artificial disc replacement, cervical disc arthroplasty, cervical disc replacement, degenerative cervical disc disease

Date received: 20 February 2021; Received revised 20 February 2021; accepted: 9 March 2021

Introduction

A substantial portion of patients develop recurrent symptoms after fusion surgery, usually at a level adjacent to the initially operated segment. Revision cervical spine surgery may then be needed. For anterior cervical arthrodesis, the reported 2-year revision rate ranges from 2.1% to 9.13% for single-level surgery and from 4.4% to 10.7% for multilevel cervical arthrodesis.¹ The most common reason for revision surgery is adjacent segment disease (ASD), which has an average incidence of new symptoms between 1.6% and 4.2% per year.² Symptomatic adjacent-level degeneration has been reported to develop in 25.6% of patients who underwent anterior cervical arthrodesis during 10 years of follow-up, of whom 72% required surgical treatment.²

Alternative techniques have been sought to preserve cervical mobility in order to address this problem and to avoid adjacent segment degeneration. The advantages of cervical disc arthroplasty (CDA) over fusion include

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maintaining normal neck motion and reducing degeneration of adjacent segments of the cervical spine.³ In the literature, CDA results are at least similar or even superior to clinical outcomes after anterior cervical arthrodesis at short- and medium-term follow-up.^{4,5} The implantation of CDA was reported to be a safe procedure, with a surgical complication rate of 1.5%.⁶ The reoperation rates of CDA ranged between 1.8% and 5.4%, with a minimum 5-year follow-up.⁷ However, despite the low revision rates, favorable outcomes, feasibility, and ability to perform explanation of artificial disc prostheses,^{8,9} many surgeons still have negative perceptions of cervical arthroplasty. No study that we are aware of has compared the adjacent-level reoperation rates for CDA versus the natural history of the disease. Furthermore, we believe that other significant factors limiting the more widespread use of CDA include the technical difficulty of the procedure compared to ACDF, complications such as spontaneous fusion and loosening, postoperative hematoma, heterotopic ossification (HO) and, in some countries, decreased reimbursement compared to ACDF.^{10,11}

This paper is a review of the current literature, to determine the radiological and clinical outcomes of patients who underwent CDA for cervical degenerative disease in order to help inform preoperative decision-making and discussions with patients. We hope that more successful implantation can be achieved and that the revision rate can be reduced by reviewing the literature and sharing our preferred technique for cervical disc arthroplasty.

History of artificial discs

Cervical disc replacement was developed and the first implantation of a cervical artificial disc was performed in the 1960s.¹² More than 15 different artificial discs are actively used globally as an alternative to anterior cervical arthrodesis.¹³ Nine CDAs have currently received US FDA approval: Prestige ST (Medtronic Inc., Minneapolis, MN, USA), Prodisc-C (DePuy Synthes; Johnson and Johnson, New Brunswick, NJ, USA), Bryan (Medtronic Inc.), Secure-C (Globus Medical Inc., Audubon, PA, USA), PCM (NuVasive, Medtronic Inc.), Mobi-C (Zimmer Biomet, Warsaw, IN, USA), Prestige LP (Medtronic Inc.), M6-C (Orthofix Medical, Spinal Kinetics LLC, Sunnyvale, CA, USA), and Simplify (Simplify Medical, Sunnyvale, CA, USA).

Artificial disc design and biomaterials

Several types of discs have been fabricated using different materials, designs, and techniques. Common materials used to create artificial cervical discs include polyethylene, titanium, cobalt-chrome, and stainless steel. Less common are polyurethane, PEEK and ceramics. To encourage bony ingrowth, the endplate surface is coated with various materials, including calcium phosphate, hydroxyapatite, and

porous titanium. The material used can also affect the ability to image both the prosthesis and the adjacent neural tissues postoperatively.¹⁴ There are also concerns that the metal contained in metal implants might increase serum titanium concentrations; however, the concentrations remain lower than those in patients who undergo the long-accepted posterior spinal instrumentation procedure. Thus, metal-on-metal CDAs appear unlikely to pose an increased risk in vivo.¹⁵

Artificial discs can be classified according to their structure as articulating or non-articulating. Articulating implants are composed of two or three solid discrete components combined in a ball-in-socket or ball-in-trough configuration. Ball-in-trough designs are more capable of allowing physiologic translational motion, which ball-in-socket devices do not.¹⁶ However, articulating devices generally lack a compressible component that mimics the shock absorbance of the nucleus pulposus in the natural disc. Another classification of artificial implants is based on their range of motion (ROM). The spectrum includes constrained, semi-constrained, and unconstrained; these ROMs are less than, equal to, or greater than physiologic ROM, respectively.¹⁶ Seven different prostheses have been used in Korea, as follows: Prestige (semi-constrained; two-piece design), ROTAIO (unconstrained; SIGNUS Medizintechnik GmbH, Alzenau, Germany), Mobi-C (unconstrained, three-piece design; LDR Zimmer Biomet), Prodisc-C (semi-constrained, two-piece design; DePuy Synthes Johnson & Johnson), Activ C (semi-constrained, ball-and-socket design; B. Braun, Sheffield, UK), Discover (unconstrained, titanium endplates with a center ultra-high molecular-weight-polyethylene core; Alphatec Spine, Carlsbad, CA, USA), Baguera C (semi-constrained; Spineart SA, Geneva, Switzerland). Recently, prosthesis design has involved changes in the center of rotation (COR), as a constrained or semi-constrained prosthesis (two-piece implant, ball-and-socket or ball-in-trough design) tends to shift the COR anteriorly and/or superiorly. In contrast, an unconstrained prosthesis (three-piece implant, mobile nucleus design) tends to maintain the preoperative COR location.¹⁷ Even if a new design is developed, further study is needed to evaluate the selection of surgical prostheses and the standardization of surgical techniques.

Artificial disc replacement: Surgical technique

Meticulous pre-incision patient positioning is critical to avoid placing the CDA in malalignment. The patient must be positioned with the head in neutral rotation, the neck in physiologic lordosis (not hyperlordotic or kyphotic) and without scoliosis in the coronal plane. We then check AP and lateral C-arm images to ensure that the patient is positioned properly. On a true lateral view, with the C-arm orthogonal to the table, the left and right facets at the operative level should appear perfectly superimposed so

that only one facet is visible at each level and the joint is perfectly delineated. This ensures that the neck is not rotated or tilted to the left or right. Finally, on the AP view, the spinous processes should be centered between the pedicles, the shoulders should be level and each disc should be perfectly horizontal. Any deviation from this ideal position will result in malalignment of the prosthesis. If the patient has scoliosis of the cervical spine preoperatively, then it is preferable to position the patient in the same alignment as their preoperative standing alignment. Even if great care is taken to maintain the ideal position throughout the procedure, it is quite easy to inadvertently move the neck during the procedure such that the prosthesis is placed in a sub-optimal position. For example, the head can rotate away from the side of the incision, creating a rotational malalignment. If the retraction on the trachea and esophagus is too vigorous, it can pull the spine along, creating a scoliosis. This malalignment can be worsened if a table-mounted retractor is used, as it can further push the spine away from the table-mounted side as the retractor is widened. For all of the above reasons, once we have placed the patient in the ideal position, we tape the head at the forehead, under the nose and over the chin to prevent any inadvertent displacement from the ideal position. We also place the self-retaining retractors in the wound and open them before we attach it to the table.

Adequate C-arm visualization of the operative level is critical throughout the procedure. For the lower cervical levels, one can often use collimation to narrow the field of view to improve visualization. One can also tape the shoulders down further during positioning, but care must be taken to avoid a stretch injury to the brachial plexus. Spinal cord monitoring can usually detect if the plexus is being overstretched. If despite all of the above measures the operative level is still not visible on fluoroscopy, it is advisable to proceed with an ACDF instead.

The surgical approach is performed as described by Smith and Robinson.¹⁸ We confirm the operative level, elevate the medial border of the longus colli muscles, and then place the retractor underneath the longus colli. Next, we place Caspar pins. It cannot be overemphasized how important pin placement is. Both pins must be in the exact midline and parallel to each other, or the prosthesis will be malpositioned. They must be as far from the operative disc space as possible, without violating the adjacent discs, in order to provide enough working room for all of the jigs used during end plate preparation. We find the exact midline by exposing both uncinates and marking the midpoint between the two sides. If one is not comfortable with this technique for identifying the midline, an AP view should be checked at this time. Once the midline has been identified, the pins can be placed as far away from the disc as possible by using lateral C-arm guidance.

Once the Caspar pins are in place, the discectomy is performed. Then parallel distraction of the disc space is performed by opening the posterior disc space such that

the posterior and anterior disc spaces are equally distracted. Most arthroplasty devices have an intradiscal distractor for this purpose. It may occasionally be necessary to first release the PLL, as well as the lateral annulus in the unconvertible joint to achieve parallel distraction. If parallel distraction is not achieved, the anterior disc will open up more than the posterior and the disc space will be made hyperlordotic.

After a thorough discectomy, all bone spurs are removed under microscope visualization. We then remove the PLL, which, if left behind, can encourage the growth of traction spurs behind the prosthesis. During endplate preparation, care must be taken to avoid excessive bone removal, as removal of the cortical endplate can result in subsidence of the prosthesis. Next, the implant is trialed under direct visualization and fluoroscopic confirmation to ensure fit. Lateral fluoroscopic images are obtained to verify that the facets are not over- or under-distracted and that they are parallel. They should be identical to the preoperative height and alignment and comparable to the adjacent facets, assuming that the adjacent levels are normal. The largest size prosthesis that is completely contained within the margins of the disc space should be utilized.

Prior to prosthesis implantation, we irrigate with copious amounts of antibiotic irrigation to remove all bone dust. This is a critical step to avoid heterotopic ossification. We also place bone wax on all bony surfaces that will not come in contact with the prosthesis. This helps to inhibit peri-prosthetic spur formation. Care must be taken to avoid placing any bone wax where the prosthesis comes into contact with the bony endplate, since bone wax acts as an inhibitory barrier to osteointegration.

Next, the prosthesis is inserted and A/P and lateral radiographs or fluoroscopy is used to verify that it is the correct size and in correct position. Meticulous hemostasis and thorough irrigation is performed throughout the procedure and prior to closure to avoid HO formation, auto-fusion of the prosthesis and infection. We also remove the periosteum with the electrocautery 1 cm above and below the prosthesis and bone wax the exposed vertebrae to inhibit anterior peri-prosthetic HO.

Artificial disc replacement: ROM, outcomes, and indications

The advantages of CDA over ACDF are that arthroplasty maintains the normal intervertebral motion, does not promote adjacent segment degeneration, avoids cervical immobilization in an orthosis and eliminates the very rare potential infective risks associated with allograft bone.^{14,19}

Cervical arthroplasty has been shown to preserve segmental cervical motion.²⁰⁻²² Cervical ROM at the upper and lower adjacent segments are also well-preserved after cervical arthroplasty.²³ Biomechanical studies suggest that preserving cervical ROM with a prosthesis might help to prevent accelerated adjacent segment degeneration

compared to a fusion.²⁴ Laxer et al. reported that the adjacent segment disc experienced substantially lower pressures with cervical arthroplasty than with a simulated anterior cervical fusion at two levels.²⁵ Recently, several studies have presented evidence that radiological changes at the adjacent levels were statistically significantly superior to those observed after ACDF.^{21,26,27}

According to prospective randomized clinical trials comparing cervical arthroplasty with anterior cervical fusion, the CDA group had statistical superiority over ACDF for overall success (observed rate 78.6% in CDA vs. 62.7% in ACDF), Neck Disability Index (NDI) success (87.0% in CDA vs. 75.6% in ACDF), and neurological success (91.6% in CDA vs. 82.1% in ACDF).^{28,29} Substantial and significant differences were found between anterior cervical fusion and cervical arthroplasty in one- to two-level cervical degenerative disease concerning improvement in the neck and arm pain visual analog scale (VAS) scores and NDI scores.³⁰ Furthermore, in a meta-analysis of prospective randomized clinical trials with long-term (>5 years) follow-up, cervical arthroplasty achieved a higher rate of clinical success and better functional outcome measurements, with statistical significance compared to ACDF.³¹

Indications

The ideal patient for cervical arthroplasty has a soft disc herniation causing neurological symptoms or signs, physiologic motion without instability, hypermobility, kyphosis or scoliosis, osteoporosis, infection, inflammatory disease or facet arthritis. C3–4 to C6–7 can be replaced, and the operative level must be radiographically visible using lateral fluoroscopy. Cervical arthroplasty is highly desirable for patients with cervical radiculopathy and/or myelopathy at one or two contiguous levels who otherwise meet the inclusion criteria. Cervical arthroplasty has been reported to improve the clinical outcomes in well-selected patients with traumatic cervical disc herniation without spinal cord injury, fracture, or instability.³² However, deformity correction or revision of earlier fusion are not considered to be reasonable indications for disc replacement at the present time.

Adjacent segment degeneration and revision surgery

Adjacent-level degeneration can often result in the need for additional surgery. The prevalence of radiographic ASD (4.74–28.28%),^{14,20} symptomatic ASD (0–13.34%),²³ and ASD requiring reoperation (0–16.9%)^{23,33} varies in the literature for both CDAs and ACDFs. Meta-analyses suggest that cervical arthroplasty is associated with a significantly lower incidence of ASD and reoperation.^{31,34}

Increased attention has been focused on the secondary surgery rate due to adjacent segment degeneration. According to previous reports, anterior cervical arthrodesis had

higher reoperation rates than cervical arthroplasty.¹³ Chang et al. reported that the reoperation rate due to ASD was 6.0% for anterior cervical arthrodesis and 3.1% for cervical arthroplasty, based on a review of the literature.³⁵ In another literature review, the reported revision rates for cervical arthroplasty was between 0 and 0.4% at 5-year follow-up.⁷ In contrast, the revision rate was between 9.13% and 15% after anterior cervical arthrodesis to treat degenerative cervical disease.^{1,23,33,36} According to a recent study on anterior cervical fusion, the revision rate following anterior cervical fusion was reported to be 3.94% with a minimum 2 year follow-up.³⁷ In our experience, there was a 2.48% (3/121) revision rate following CDA due to improper indications, osteolysis, and implant subsidence.

Surgical considerations and case illustration

Artificial discs are available in various sizes, shapes, and heights to achieve these goals and provide good surgical outcomes. It is vital to choose the appropriate prosthesis size and height. Prostheses with a height of ≥ 2 mm more than normal can lead to marked changes in the cervical biomechanics and bone-implant interface stress, which may induce ASD and subsidence.³⁸ We believe that a prosthesis that is ≥ 2 mm taller than the disc it is replacing can lead to increased stresses on the disc, potentially shortening its lifespan. On the other hand, too short a prosthesis can result in kyphosis and reduced flexion motion. The CDA should also maximally fill the disc space without intruding into the spinal canal or extending past the anterior margin of the disc space. Too small a disc can result in early subsidence, as well as early wear due to concentration of forces across a smaller surface area (Figure 1). In our experience, the most common prosthesis size was 6 mm in height and 16 mm in depth, consistent with a previous report.³⁹ It should be kept in mind that the vertebral body tends to be smaller in the Asian population than in the West.

CDA is currently approved as a treatment for cervical spondylotic myelopathy.^{22,40} Long-term outcomes (7 years) were reported in a clinical trial analyzing two-level cervical arthroplasty versus ACDF in 287 patients with radiculopathy alone and 110 patients with myelopathy alone or associated with radiculopathy.¹⁵ There were no statistically significant differences between the groups in NDI, neck pain, or arm pain. The researchers concluded that CDA was a safe and effective treatment for patients with myelopathy. The caveat is that CDA was only be used for one- and two-level retrodiscal cord compression, since retrovertebral disease cannot be treated with a disc-based decompression. This limits the utility of CDA to a small subset of patients with myelopathy. It is not appropriate for patients with severe congenital stenosis, ossifying diseases such as OPLL or DISH, or for any segment with instability.⁴¹ Preoperative instability due to previous surgery or degenerative disease, poor bone quality, and kyphotic deformity

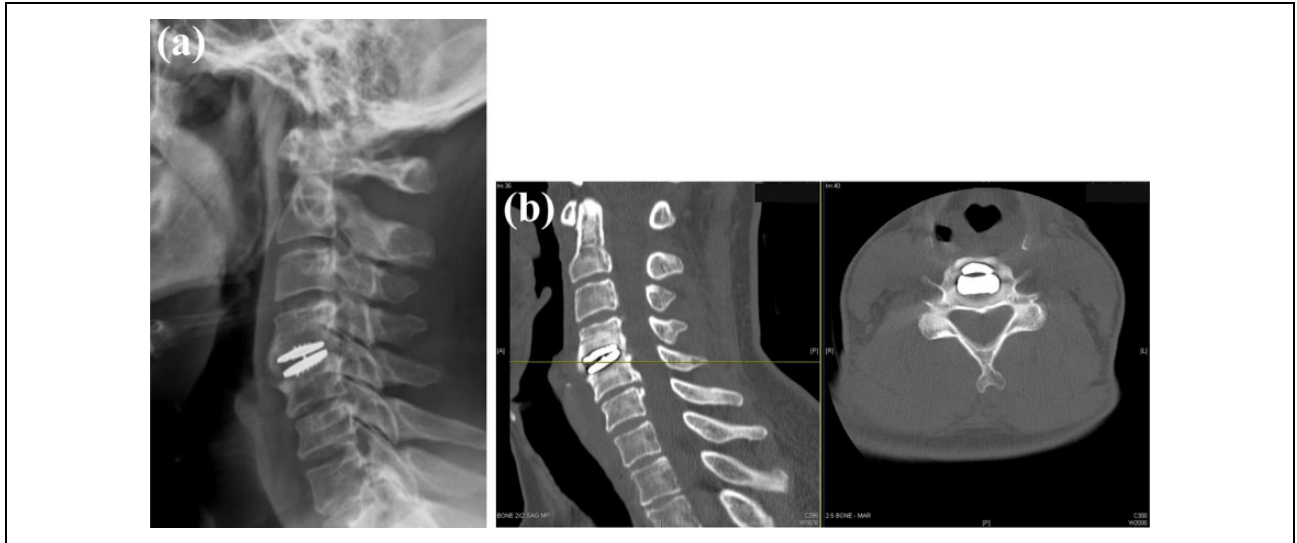


Figure 1. HO developed after cervical arthroplasty. Plain radiograph (a) and CT (b) demonstrating a CDA done by another surgeon. The CDA is too small and has subsided into the cranial endplate. HO has developed anterior to the disc space. CDA, cervical disc arthroplasty; HO, heterotrophic ossification. (Courtesy of Prof. K. Daniel Riew.)

all contribute to device failure, and arthroplasty should not be performed when these pathologies are encountered.⁴²

Case illustration: A 40 y.o. male had undergone a C6–7 CDA by another surgeon but had persistent left C7 radiculopathy. A myelo-CT demonstrated a left posterior-lateral osteophyte. Inadequate decompression is the most common reason for revision following CDA. He underwent revision surgery with removal of the osteophyte and ACDF (Figure 2).

Case illustration: A 44-year-old man had a CDA at C5–6 3 years ago by another surgeon complicated by a retropharyngeal hematoma. The arthroplasty is too anterior. Because of persistent C6 distribution numbness and weakness and new onset C7 symptoms, he underwent revision surgery at C5–6 with an ACDF and a new CDA at C6–7 (Figure 3).

Case illustration: A 51-year-old male underwent a CDA by another surgeon at C5–6 and C6–7. Because of persistent symptoms, the same surgeon performed a posterior fusion. However, he developed a pseudoarthrosis and recurrent symptoms due to persistent anterior neural impingement. We revised him anteriorly with removal of the two CDAs and an ACDF at both levels (Figure 4).

Complications

Postoperative complications include cerebrospinal fluid leak, nerve root injury, esophageal injury, dysphagia, prevertebral hematoma, prosthesis migration, implant subsidence, postoperative C5 palsy, and hoarseness.⁴³ Another complication of cervical disc arthroplasty is fusion of the

operated levels. To prevent anterior bone spur formation, Riew et al. reported that meticulous hemostasis and minimizing the risk of hematoma also helped to decrease the levels of circulating growth factors promoting fusion.⁴² They recommended continuing to perform irrigation until every little speck of bone dust is gone.⁴² In addition, they recommend denuding the periosteum 1 cm above and below the prosthesis with monopolar electrocautery and placing bone wax on the bone.

HO is a frequent postoperative complication of cervical arthroplasty that runs contrary to the fundamental goal of an artificial disc (Figure 1). The reported prevalence of HO after arthroplasty ranges from 16.1% to 85.7%.^{11,44} In our experience, HO prevalence was 30.58%. We showed that the prevalence and severity of HO did not vary significantly across various types of CDA devices, including the mechanical design (semi-constrained, unconstrained, or constrained), metal type or brand. Risk factors for HO have been hypothesized, including lack of peri-operative nonsteroidal anti-inflammatory drug use, sex, age, surgical level, number of treated levels, preoperative degeneration, and surgical technique.^{11,44,45} Riew et al. demonstrated that a well-fitting prosthesis that covers the majority of the endplate diameter can help to prevent HO.^{42,46}

Osteolysis is another frequent but not-well recognized complication of CDA (Figure 5). A recent systematic review article found that the reported incidence of asymptomatic osteolysis was as high as 64%, with the majority of papers showing an incidence between 44% and 64%.⁴⁷ Fortunately, it appears that most cases of osteolysis are asymptomatic. As the systematic review notes, symptomatic osteolysis has only been reported in three cases among four case reports.⁴⁷ The etiology of osteolysis is not

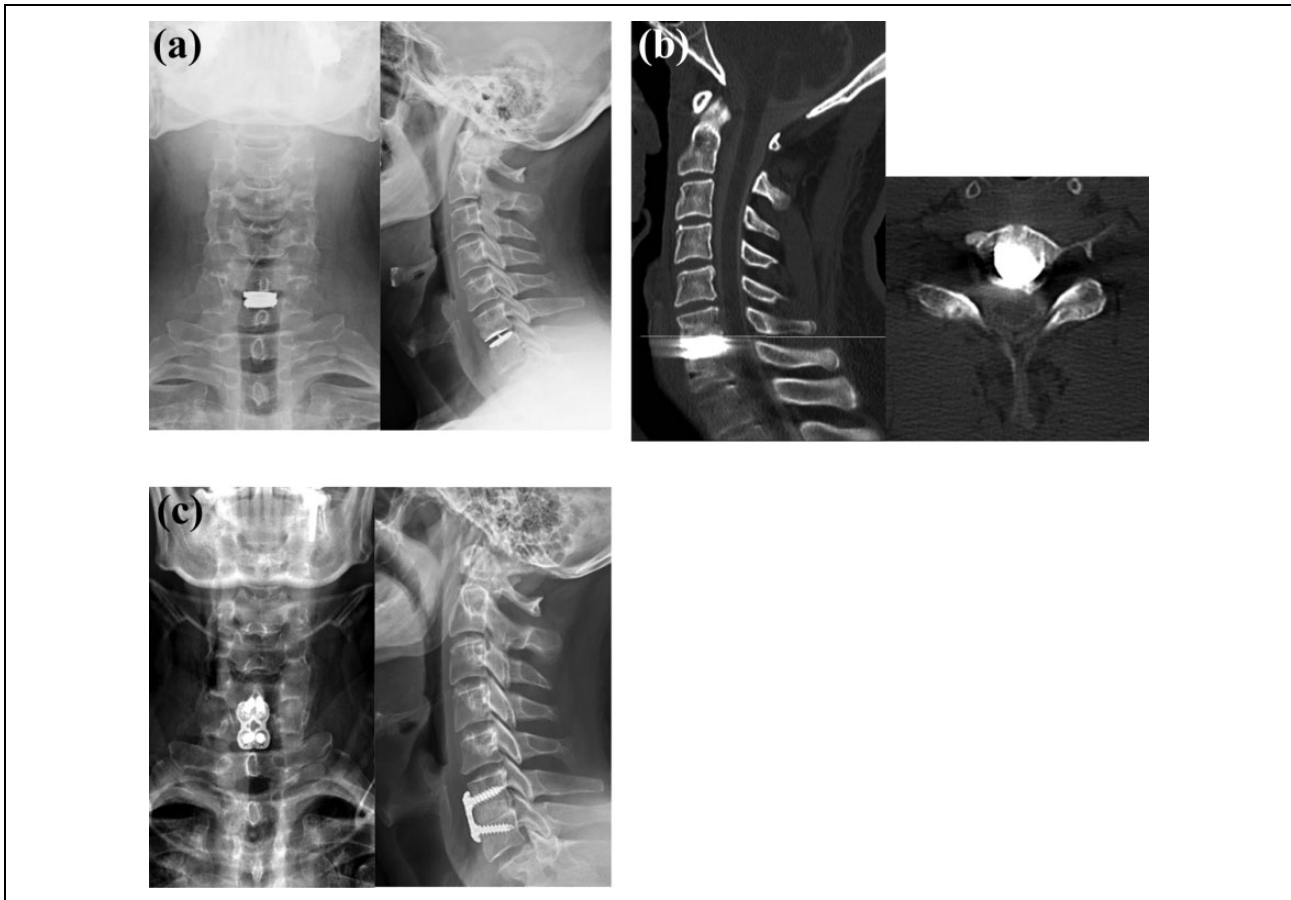


Figure 2. CDA with inadequate decompression. This is a 40 years old male who had undergone a C6–7 CDA by another surgeon but had persistent left C7 radiculopathy. Plain radiograph anteroposterior and lateral view (a). (b) Myelo-CT shows a left posterior-lateral osteophyte. Inadequate decompression is the most common reason for revision following CDA. (c) Plain radiograph anteroposterior and lateral images following revision ACDF. CDA, cervical disc arthroplasty; ACDF, anterior cervical discectomy and fusion. (Courtesy of Prof. K. Daniel Riew.)

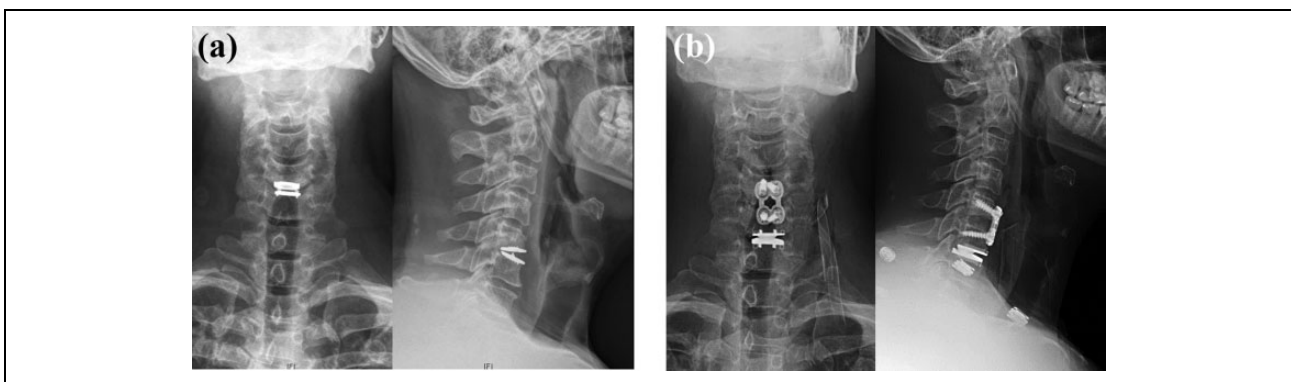


Figure 3. Poorly placed CDA revised to ACDF and new arthroplasty at the caudal adjacent level. (a) Plain anteroposterior and lateral radiographs of a 44-year-old male who had a CDA done elsewhere. (b) Anteroposterior and lateral radiographs following revision surgery, explanting the CDA at C5–6 and placing a new CDA at C6–7. See text for details. CDA, cervical disc arthroplasty; ACDF, anterior cervical discectomy and fusion. (Courtesy of Prof. K. Daniel Riew.)

known but may be multifactorial, including indolent infection, stress shielding, and an immune reaction to wear debris.

Health economics

The cost and benefits of both anterior cervical fusion and cervical arthroplasty have been studied in the

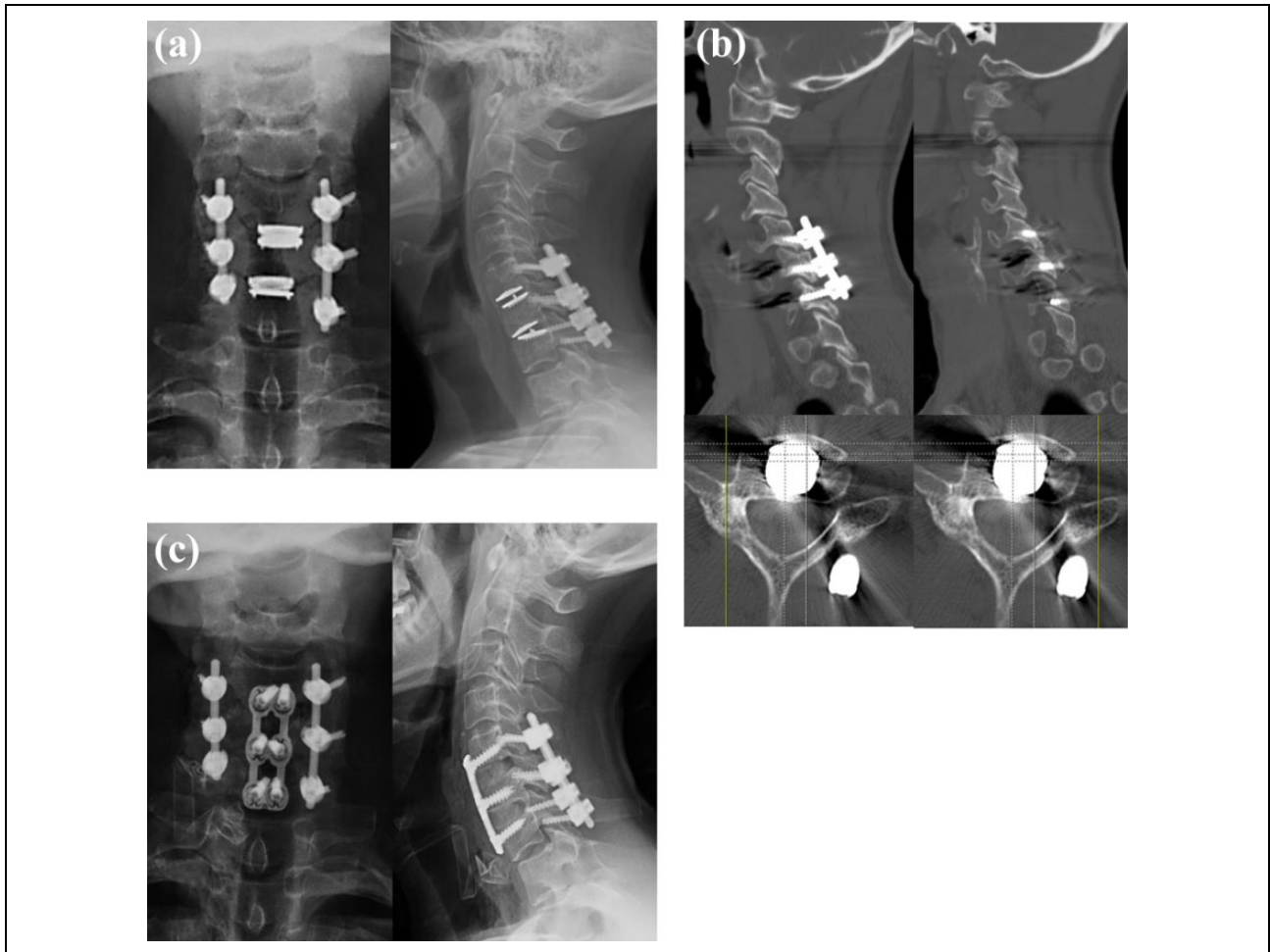


Figure 4. A patient who underwent revision surgery after cervical arthroplasty and posterior fusion. (a) Plain anteroposterior and lateral radiographs of a 51-year-old male underwent CDA by another surgeon at C5–6–7 and revision surgery with posterior fusion. (b) CT scans show pseudoarthrosis on posterior fusion. (c) We revised him anteriorly with the removal of the two CDAs and an ACDF at both levels. See text for details. CDA, cervical disc arthroplasty; ACDF, anterior cervical discectomy and fusion. (Courtesy of Prof. K. Daniel Riew.)

United States. Because of its inclusion in the diagnosis-related group (DRG), the cost of medical care for CDA is lower than that for ACDF. CDA has been reported to be more cost-effective than ACDF.⁴⁸ However, in Korea, the cost of surgery and materials used for CDA are higher than those of ACDF (Health Insurance Review and Evaluation Center, 2016). Lee et al. analyzed the costs and benefits (in terms of quality-adjusted life-years [QALY]) of cervical anterior interbody fusion and CDA to treat degenerative cervical disc disease.⁴⁹ They stated that patients who underwent anterior cervical fusion had a total cost of USD 2357 over 5 years and obtained a utility of 3.72 QALY. Patients who underwent CDA received 4.18 QALY for a total of USD 3473 over 5 years.⁴⁹ CDA is an effective option to that provides additional benefits, although it incurs additional costs in Korea. However, there are various ethical considerations and dilemmas in performing cervical arthroplasty with inappropriate indications and recommendations to gain economic

benefits, especially for non-life-threatening indications of cervical disc diseases.

Our experience

The radiological and clinical outcomes of a total of 121 patients treated with CDA from June 2006 to June 2019 were evaluated (Table 1). Radiological measurements and clinical outcomes included VAS, NDI, and the JOA myelopathy score, and were assessed preoperatively and at ≥ 2 years of follow-up. The mean follow-up period was 38 months (range, 25–114 months). Radiographic data demonstrated mobility at the treated levels and adjacent levels, with no hypermobility signs at the adjacent level. There was a non-significant loss of global cervical motion, and ROM of a functional spinal unit at the operating level and the upper and lower adjacent disc level, compared to the preoperative findings (Table 2). The cervical global and segmental angles

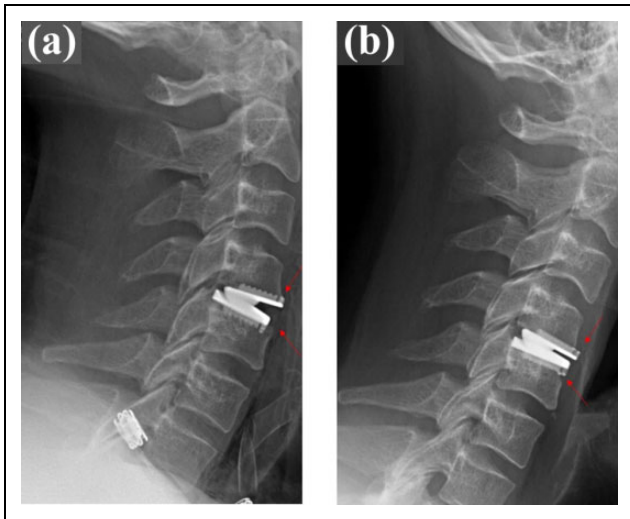


Figure 5. Osteolysis after cervical arthroplasty. Radiographs demonstrating osteolysis over time. (a) The prosthesis fills the entire disc space on December 11, the day of surgery. (b) Six months later, there has been resorption of the anterior bone and the prosthesis is minimally exposed. The patient has neck pain and is being observed for now. (Courtesy of Prof K Daniel Riew.)

Table 1. Patients’ demographic characteristics.

	Artificial disc replacement (121)
Age (years)	42.68 ± 9.69
Sex (M:F)	57:64
Underlying problem, n (%)	
Radiculopathy	97 (80.17 %)
Myelopathy	6 (4.95 %)
Mixed	18 (14.88 %)
BMD (T-score)	-0.03 ± 1.44
Symptom duration (weeks)	6.74 ± 8.41
Follow-up (months)	37.75 ± 24.52
Operation level, n (%)	
C3/4	4 (3.31 %)
C4/5	23 (19.01 %)
C5/6	53 (43.80 %)
C6/7	33 (27.27 %)
C3/4/5	2 (1.65 %)
C4/5/6	2 (1.65 %)
C5/6/7	4 (3.31 %)
Artificial prosthesis, n (%)	
Semi-constrained	77 (63.64 %)
Unconstrained	44 (36.36 %)

M, male; F, female; BMD, bone mineral density.

All data are expressed as mean ± standard deviation unless otherwise noted.

significantly increased. Postoperative neck VAS, NDI, and JOA scores showed greater improvement after one- and two-level CDA. We experienced a 30.58% rate of HO and a 2.48% reoperation rate due to cervical instability, implant subsidence, or osteolysis. In our institute’s experience, cervical arthroplasty with a semi-constrained prosthesis was most widely used

Table 2. Radiological findings before and after cervical artificial disc replacement.

C2-7 Cobb angle (°)	C2-7 ROM (°)		Segmental angle (°)		USROM (°)		LSROM (°)		
	Last Follow-up (P)	Preop	Last Follow-up (P)	Preop	Last Follow-up (P)	Preop	Last Follow-up (P)		
7.71 ± 12.54	12.40 ± 10.81 (<0.0001*)	43.45 ± 15.63	45.37 ± 14.98 (0.2956)	1.55 ± 5.09	4.33 ± 6.36 (0.0004*)	8.46 ± 3.07	9.11 ± 3.91 (0.3394)	5.43 ± 3.83	5.73 ± 3.10 (0.6392)

Preop, preoperative phase; ROM, range of motion; USROM, upper segmental range of motion; LSROM, lower segmental range of motion. All data are expressed as mean ± standard deviation unless otherwise noted. * P < 0.05.

because it was the most extensively researched type of prosthesis. Although there is no significant difference between prosthesis types, it is recommended that a generous exposure be utilized during cervical arthroplasty with keel devices. When operating on patients with cervical myelopathy, it is necessary to consider whether the main cause of cervical myelopathy is cord compression (by a disc or bony spur) or instability. CDA should be avoided in anyone with cervical myelopathy associated with instability. Device dislodgement might be prevented through a careful choice of implant size and preservation of the integrity of the endplate during preparation.⁴⁸

How to improve the clinical results of cervical disc arthroplasty

It is essential to perform CDA in well-selected patients with a soft disc herniation causing radiculopathy and/or myelopathy at one or two contiguous levels, physiologic motion without osteoporosis, hypermobility, kyphosis, or scoliosis. It should be kept in mind to choose the well-fitting prosthesis size covering the majority of the endplate diameter and height within 1–2 mm of the original vertebral body. Further prospective or randomized controlled multicenter studies are needed to evaluate clinical and radiological outcomes, such as range of motion (ROM) and the center of rotation (COR) in patients who have undergone CDA according to various prosthesis designs.

Conclusion

There are numerous benefits to CDAs. Cervical arthroplasty can mitigate pain and neck disability in appropriate patients with degenerative cervical disc disease causing radiculopathy or myelopathy. CDAs has been demonstrated to preserve segmental motion at long-term follow-up and to decrease the incidence of adjacent-level surgery, as compared to ACDF. Cervical global alignment and the segmental angle at rest improves after cervical arthroplasty. On the other hand, there are also some negatives associated with CDA. It is not appropriate for anyone with osteoporosis, ossifying diseases, instability, collapsed disc, facet arthrosis, inflammatory diseases, spinal infections and retrovertebral disease. It is also technically demanding to implant a perfectly sized, perfectly placed prosthesis and there are numerous pitfalls that can result in poor outcomes. Despite the challenges, when performed technically well in appropriate patients, we believe that cervical arthroplasty is a safe and effective alternative to anterior cervical arthrodesis with several potential benefits.

Acknowledgments

The authors wish to thank Prof. Sang Hyun Han for his contributions in drafting the manuscript and revising it for important

intellectual content. The authors thank all of the subjects who participated in the study, the support staff, and the research coordinator staff.

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Declaration of conflicting interests


The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: KD Riew has invested in Axiomed and Spinal Kinetics and received royalties from Zimmer Biomet for an anterior cervical plate. The other authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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