Dynamic Cervical Implant versus Anterior Cervical Diskectomy and Fusion: A Prospective Study of Clinical and Radiologic Outcome

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Abstract

Objective To evaluate clinical and radiologic outcome in patients treated with a dynamic cervical implant (DCI) or anterior cervical diskectomy and fusion (ACDF).

Study Design A prospective comparative cohort study.

Methods The study included 60 patients with one- or two-level cervical degenerative disk disease (DDD) undergoing treatment with either DCI ($n = 30$) or ACDF ($n = 30$). Clinical and radiologic outcomes were assessed 3 and 12 months after surgery. Clinical scoring systems included the Visual Analog Scale for Neck (VAS-N) and Arm pain (VAS-A), the Neck Pain and Disability Scale (NPAD), and the European Quality of Life Scale (EQ-5D).

Results Both the DCI and ACDF group showed significant clinical improvement 12 months after surgery using the VAS-N ($p = 0.034$ and $p < 0.001$, respectively), VAS-A ($p < 0.001$ and $p < 0.001$, respectively), NPAD ($p < 0.001$ and $p < 0.001$, respectively), and EQ-5D ($p < 0.001$ and $p < 0.001$, respectively). There were no significant differences in clinical outcome comparing both groups at the 3- and 12-month follow-up. The fusion rate at 12 months after surgery was 39.4% and 80.0% in the DCI and ACDF groups, respectively. Radiolucency was found in 90.9% in the DCI group at 12-month follow-up.

Conclusion The clinical results for DCI treatment are equivalent to those for ACDF in the treatment of one- and two-level cervical DDD at 12 months after surgery. Further studies are necessary to investigate the high rates of radiolucency and fusion associated with DCI treatment.

Keywords
- dynamic cervical implant
- anterior cervical diskectomy and fusion
- cervical spine
- adjacent segment disease
- cervical disk arthroplasty

Although anterior cervical diskectomy and fusion (ACDF) offers good results in the surgical treatment of cervical degenerative disk disease (DDD),[1,2] motion-preserving implants have been developed that restore or maintain the mobility of the involved segment. While cervical disk arthroplasty (CDA) has yielded clinical outcomes that are comparable to or slightly superior with those produced by ACDF,[3,4] the technique might not cover all pathologies, especially in patients with a physiologically reduced range of motion (ROM) or preexisting degeneration of the cervical spine.[5] In this situation, cervical disk arthroplasty may produce hypermobility with respect to the individual's ROM, exacerbating the stress on the facet joints.[6,7]

Anterior cervical diskectomy using a dynamic cervical implant (DCI) represents a new treatment strategy for cervical DDD, one that stabilizes the involved segment while maintaining a reduced ROM. The C-shaped titanium implant fits the concave surfaces of both adjacent end plates and has straight teeth on the upper and lower ends to prevent implant migration (►**Fig. 1**). Biomechanical testing after DCI

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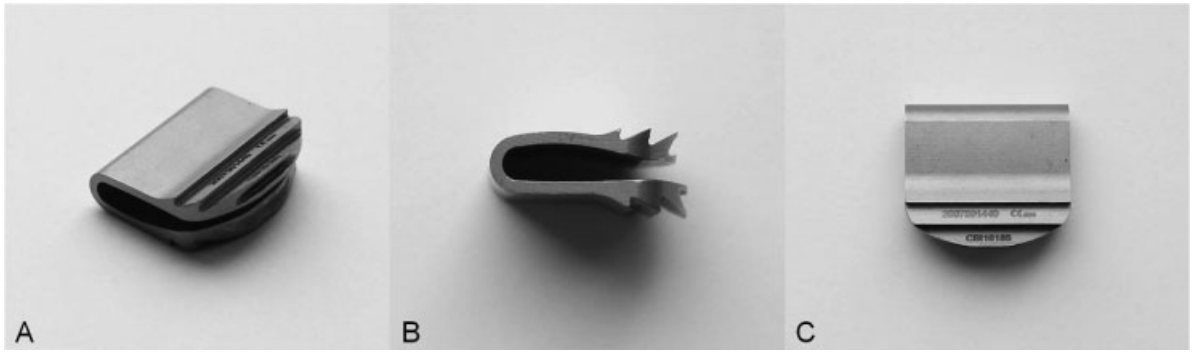

Fig. 1 (A) Angular view of the dynamic cervical implant (Paradigm Spine GmbH, Wurmlingen, Germany). (B) Lateral view showing the C-shaped design that allows the implant to conform to concave end plates. (C) Plan view showing the rectangular shape of the implant that corresponds to the end-plate footprints of the cervical vertebra (photographs taken by H.R.).

implantation[8,9] suggested that the contribution to total cervical ROM in flexion/extension and in lateral bending is less than that of the intact cervical spine in ovine specimens. Finite element model analysis[10] revealed better maintenance of spinal kinematic motion than CDA when compared with the intact model. Recently published reports demonstrated the safety and efficiency of DCIs in the treatment of single-segment cervical DDD.[11,12]

The objective of this study was to compare clinical outcome from DCI surgery with that achieved with ACDF using a polyethylethylketone (PEEK) cage, and to evaluate the radiologic follow-up, particularly with regard to preservation of motion with DCIs.

Material and Methods

This prospective study was approved by the local ethics committee. From March 2009 to September 2010, 60 consecutive patients were enrolled for clinical and radiologic evaluation for surgical treatment of one- or two-level cervical DDD when they agreed to the study. All patients had radiculopathy with various types of neck pain. No cases of myelopathy were included. All patients were treated in the same manner via an anterior approach. After the anterior longitudinal ligament and annulus were incised, the disk was completely removed with special regard paid to cleaning the bony end plates of all disk material. The posterior osteophytes were resected using drills and Kerrison rongeurs, and the dorsal annulus and posterior longitudinal ligament were resected to reach and remove the disk herniation, achieving a sufficient decompression of the neural structures.[13,14] At the discretion of the surgeon, 30 patients each were given either a DCI (DCI, Paradigm Spine GmbH, Wurmlingen, Germany) or a PEEK cage (Cervios, ChronOS, Synthes, Switzerland). The size of the implant was determined by cage trials and lateral radiography with special attention to maximize the implant–end plate contact. The implant was inserted under slight distraction of the segment. Then compression was applied using Caspar pins to fixate the teeth of the implant into the bony end plates. Mobilization was performed on the first postoperative day without a collar. Patients with severe cervical facet joint arthrosis, instability, tumor, infection, and osteoporosis were not included in this study. The intent of surgery was to achieve solid fusion in the ACDF group and maintain motion in line with the implant's properties, with solid implant ingrowth in the DCI group, respectively.

Clinical Outcome Assessment

Baseline evaluation was performed the day before surgery. Clinical outcome was evaluated using the Visual Analog Scale for Neck (VAS-N) and Arm pain (VAS-A), the Neck Pain and Disability Scale (NPAD), and the European Quality of Life Scale (EQ-5D) at 3 and 12 months after surgery. The VAS is a commonly used instrument for patient self-assessment of pain perception ranging from 0 (best) to 10 (worst). Neck pain (VAS-N) and arm pain (VAS-A) were evaluated separately. The NPAD, a self-administered questionnaire with 20 items, was used for evaluating specific neck pain and its associated disability.[15] The total score ranged from 0 (best) to 100 (worst). The EQ-5D is an instrument for measuring patients' self-reported health-related quality of life and contains five dimensions with three description levels. It is validated with scores ranging from − 0.594 (worst) to 1.000 (best).[16–18]

Radiologic Outcome Assessment

Plain anteroposterior (ap) and lateral radiographs were obtained preoperatively and on the first postoperative day. Subsequent radiographs were supplemented by a flexion/extension view taken at 3 and 12 months after surgery. Radiologic outcome measures included the occurrence of implant migration, radiolucency (DCI), pseudoarthrosis (ACDF), implant subsidence, maintenance of lordosis, and fusion rate. Implant migration was defined as every ap or lateral position change compared with the baseline radiograph on the first postoperative day. Radiolucency of the DCI was defined as lucent zones between the surface of the implant and the end plates of the adjacent vertebral bodies. Pseudarthrosis following ACDF was defined as nonfusion at follow-up. Subsidence was determined by measuring the distances between both end plates of the index segment beside the implant. Lordosis was measured as the Cobb angle between the base plate of C2 and cover plate of C7 as shown in neutral lateral radiographs. Fusion was defined as motion

< 1 mm between the tips of the spinous processes in flexion-extension or the presence of bridging bony trabeculae.

Statistical Analysis

The data are presented as means and standard deviations unless otherwise indicated. The Fisher exact test was used to compare categorical variables, and continuous variables were compared using the independent *t* test or Mann-Whitney *U* test. A paired *t* test was used for assessing clinical improvement from the preoperative assessment to the 3- and 12-month follow-up for each treatment group. A p value < 0.05 was considered statistically significant. Statistical analysis was done using R software v.2.14.1 (R Development Core Team, 2010, Vienna, Austria).

Results

A total of 53 of 60 patients included in the study completed both follow-up examinations at 3 and 12 months after surgery. ►**Table 1** summarizes the patient characteristics. Four patients in the DCI group and three patients in the ACDF group did not complete all follow-up for clinical evaluation. Radiologic follow-up could not be evaluated in a total of eight implants (five in the DCI group and three in the ACDF group) due to the lack of follow-up assessments as mentioned earlier and to raised shoulders on lateral radiographs in one DCI patient with a two-segment operation.

Table 1 Patient characteristics stratified by treatment (dynamic cervical implant versus anterior cervical diskectomy)

	DCI group ($n = 26$)	ACDF group ($n = 27$)	p value
Age, y; mean ± SD	44.1 ± 8.8	46.0 ± 7.3	0.420
Male/Female	16 / 10	11 / 16	0.173
No. of involved segments			
One segment, *n* (%)	19 (73%)	19 (70%)	1.000
Two segments, *n* (%)	7 (27%)	8 (30%)	
Involved segment			
C4–C5, *n*	1 (3%)	6 (17%)	0.107
C5–C6, *n*	15 (45%)	18 (51%)	0.666
C6–C7, *n*	17 (52%)	10 (29%)	0.082
C7–T1, *n*	0 (0%)	1 (3%)	1.000
Duration until follow-up			
3-mo follow-up	3.9 ± 1.0	5.0 ± 4.6	0.467
12-mo follow-up;	13.0 ± 1.8	12.8 ± 1.5	0.423

Abbreviations: ACDF, anterior cervical diskectomy and fusion; C, cervical segment; DCI, dynamic cervical implant; SD, standard deviation.

Dynamic Cervical Implant Group

►**Table 2** summarizes the mean values for clinical outcome measures. Both VAS-N and VAS-A improved after DCI surgery, and the mean differences between the preoperative assessment and the 3-month follow-up were 1.6 (95% confidence interval [CI], 0.28–2.95; $p = 0.019$) and 4.4 (95% CI, 3.30–5.64; $p < 0.001$), respectively. The improvement in VAS-N (95% CI, 0.12–3.09; $p = 0.034$) and VAS-A (95% CI, 2.22–5.01; $p < 0.001$) from the preoperative assessment to the 12-month follow-up remained significant. The NPAD score decreased after surgery, and the mean difference was 28.6 (95% CI, 18.58–38.62; $p < 0.001$) between the preoperative assessment and the 3-month follow-up, and 30.1 (95% CI, 19.72–40.41; $p < 0.001$) between the preoperative assessment and the 12-month follow-up. Compared with preoperative values, the EQ-5D improved significantly at 3 months (95% CI, − 0.23 to 0.05; $p < 0.004$) and at 12 months (95% CI, − 0.28 to − 0.08; $p < 0.001$).

The mean differences in VAS-N (95% CI, − 1.47 to 1.45; $p = 0.990$), VAS-A (95% CI, − 2.15 to 0.44; $p = 0.191$), NPAD (95% CI, − 10.92 to 13.83; $p = 0.814$), and EQ-5D (95% CI, − 0.15 to 0.07; $p = 0.461$) between the 3- and 12- month follow-ups were not statistically significant.

The radiologic 12-month follow-up showed ventral migration of the DCI in 5 of 33 implants (15.2%). Of these, four cases (12.1%) were already present at the 3-month follow-up. The distance between the end plates (an indication of subsidence) decreased significantly from the first postoperative radiograph (5.6 ± 1.1 mm) to the 3-month (4.6 ± 1.0 mm; $p < 0.001$) and 12-month follow-ups (3.4 ± 1.0 mm; $p < 0.001$). Cervical lordosis increased from pre- to postoperative radiographs but was not significant (8.4 ± 14.6 degrees versus 10.6 ± 11.6 degrees; $p = 0.352$). Lordosis was found to have increased by the 3- and 12-month follow-ups and was measured as 12.6 ± 9.5 degrees ($p = 0.132$) and 11.4 ± 11.6 degrees ($p = 0.692$), respectively. The fusion rate was 23.7% (9 of 38 implants) at the 3-month follow-up and 39.4% (13 of 33 implants) at the 12-month follow-up (►**Fig. 2**). Radiolucency was found in 39.5% and 90.9% at the 3- and 12-month follow-ups, respectively (►**Fig. 3**).

Reoperation of the index segment was performed on two patients. One of these patients presented with new neck pain due to late ventral migration of the implant (►**Fig. 4**). The other presented with new radicular pain and new foraminal stenosis.

Anterior Cervical Diskectomy and Fusion Group

Both VAS-N and VAS-A improved after ACDF surgery, and the mean differences between the preoperative assessment and the 3-month follow-up were 2.9 (95% CI, 1.58–4.36; $p < 0.001$) and 5.2 (95% CI, 3.89–6.59; $p < 0.001$), respectively (►**Table 2**). The improvement in VAS-N (95% CI, 2.31–4.92; $p < 0.001$) and VAS-A (95% CI, 3.08–5.94; $p < 0.001$) from the preoperative assessment to the 12-month follow-up remained significant. The NPAD decreased after surgery, and the mean difference was 34.4 (95% CI, 23.60–45.45; $p < 0.001$) between the preoperative assessment and the

Table 2 Clinical outcome at the 3- and 12-month follow-ups

	DCI group ($n = 26$)	ACDF group ($n = 27$)	p value	95% confidence interval
Preoperative assessment				
VAS-N	5.7 ± 2.6	6.9 ± 2.4	0.058	−2.53 to 0.04
VAS-A	6.1 ± 2.4	7.2 ± 2.5	0.105	−2.35 to 0.23
NPAD	59.1 ± 13.6	65.6 ± 15.9	0.099	−14.18 to 1.25
EQ-5D	0.63 ± 0.14	0.53 ± 0.25	0.077	−0.01 to 0.20
3-mo follow-up				
VAS-N	4.1 ± 2.4	4.0 ± 2.7	0.874	−1.32 to 1.55
VAS-A	1.7 ± 1.9	2.0 ± 2.5	0.636	−1.53 to 0.95
NPAD	30.5 ± 21.8	31.4 (± 22.8)	0.932	−13.11 to 12.03
EQ-5D	0.77 (± 0.19)	0.74 (± 0.24)	0.710	−0.10 to 0.15
12-mo follow-up				
VAS-N	4.1 (± 2.6)	3.3 (± 2.6)	0.312	−0.74 to 2.26
VAS-A	2.5 (± 2.5)	2.7 (± 2.9)	0.826	−1.69 to 1.35
NPAD	29.0 (± 21.7)	29.1 (± 24.8)	0.997	−12.87 to 12.81
EQ-5D	0.81 (± 0.20)	0.82 (± 0.17)	0.753	−0.12 to 0.09

Abbreviations: ACDF, anterior cervical diskectomy and fusion; DCI, dynamic cervical implant; EQ-5D, European Quality of Life Scale; NPAD, Neck Pain and Disability Scale; VAS-N/-A, Visual Analog Scale for Neck and Arm pain.
Note: Values are expressed as mean and standard deviation.

3-month follow-up and 36.5 (95% CI, 25.54–47.45; $p < 0.001$) between the preoperative assessment and the 12-month follow-up. The improvement in EQ-5D was 0.21 (95% CI, − 0.34 to − 0.08; $p < 0.002$) from the preoperative assessment to the 3-month follow-up and 0.29 (95% CI, − 0.40 to − 0.18; $p < 0.001$) from the preoperative assessment to the 12-month follow-up.

There were no statistically significant changes in VAS-N (95% CI, − 0.83 to 2.11; $p = 0.387$), VAS-A (95% CI, − 2.20 to 0.74; $p = 0.325$), NPAD (95% CI, − 11.05 to 14.99; $p = 0.763$), and EQ-5D (95% CI, − 0.20 to 0.04; $p = 0.174$) between the 3-month and 12-month follow-ups.

There were no cases of cage dislocation at the radiologic follow-up 12 months after surgery. Subsidence increased significantly from postoperative radiographs to the 3-month follow-up, as indicated by end-plate distances (5.7 ± 1.1 mm versus 4.8 ± 0.9 mm; $p < 0.001$), and further increased at the 12-month follow-up (4.4 ± 1.0 mm; $p < 0.001$). Lordosis, as measured by the Cobb angle, was 8.1 ± 13.6 degrees at the preoperative assessment, 11.5 ± 12.5 degrees

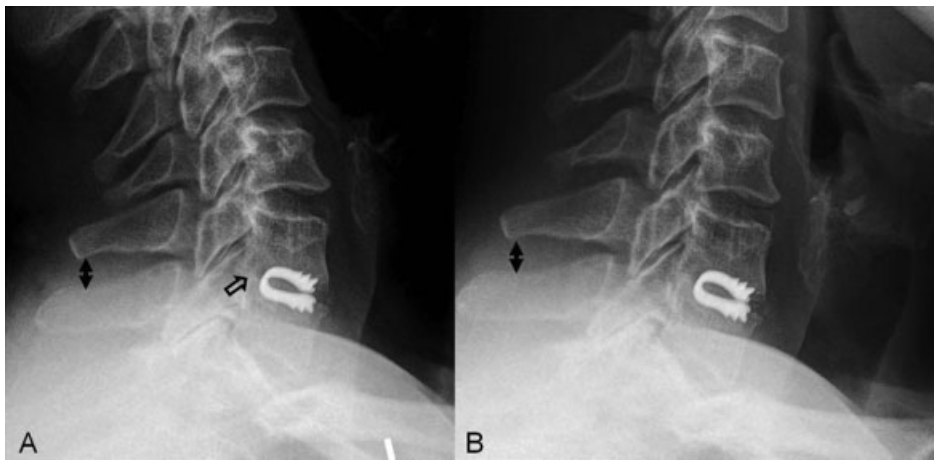

Fig. 2 Fusion after dynamic cervical implant surgery on the C6–C7 segment at the 12-month follow-up. Lateral radiographs in (A) extension and (B) flexion revealed constant distances between the C6 and C7 spinous processes (black arrows) and the bony trabeculae behind the implant (open arrow).

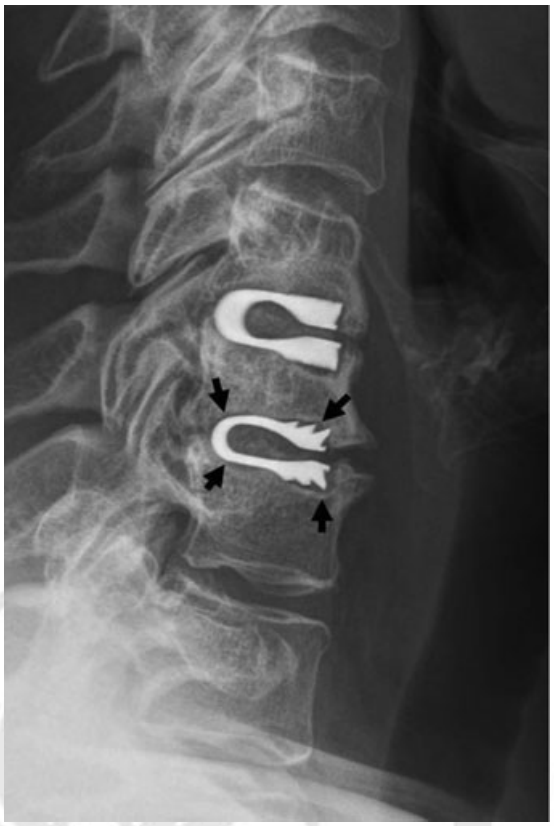

Fig. 3 Radiolucency after dynamic cervical implant (DCI) surgery on segments C5–C6 and C6–C7 at the 12-month follow-up. Lateral radiograph showing nonintegration of the DCI with lucent zones along the surface of the implant as well as around the teeth at segments C5–C6 and C6–C7 (indicated by black arrows at segment C6–C7).

on the first postoperative radiograph, 15.3 ± 11.6 degrees at the 3-month follow-up, and 15.7 ± 12.3 degrees at the 12-month follow-up. The differences between radiologic evaluations were not statistically significant. The fusion rate was 44.1% (15 of 34 implants) at 3 months and 80.0% (28 of 35 implants) at the 12-month follow-up.

One patient underwent reoperation due to a new disk herniation within the follow-up period of 12 months. The herniation occurred at an adjacent segment that had previously degenerated.

Outcome Comparison between the DCI and ACDF Group

There were no significant differences in baseline patient characteristics comparing the DCI and ACDF group (►**Table 1**). All clinical baseline parameters showed a trend of inferior values in the ACDF group, especially for VAS-N and EQ-5D, but the differences were not statistically significant (►**Table 2**). There were no significant differences in clinical outcome at 3 and 12 months after surgery comparing both groups with regard to VAS-N, VAS-A, NPAD, and EQ-5D.

►**Table 3** summarizes the radiologic outcome at the 12-month follow-up. The difference in the number of implant dislocations between the DCI and ACDF group was statistically significant ($p = 0.023$). Subsidence was greater in the DCI group than it was in the ACDF group ($p < 0.001$). As expected, the fusion rate in the ACDF group was higher than that of the DCI group ($p = 0.001$).

Overall, 3 of 53 patients (5.7%) had to undergo reoperation within a follow-up period of 12 months. In the DCI group, both reoperations were performed on the index segment, but only one of these was implant related (due to ventral implant migration); the second patient had developed new foraminal stenosis causing new arm pain. In the ACDF group, one patient

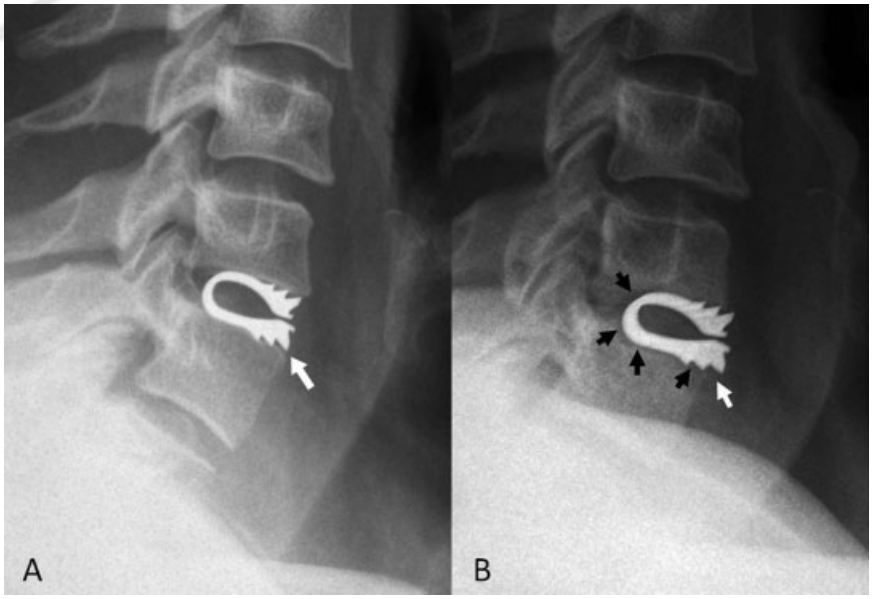

Fig. 4 (A) Radiograph shows the postoperative placement of a dynamic cervical implant (DCI) at C6–C7. After 10 months, the patient experienced a sudden onset of new neck pain. (B) The radiograph revealed anterior migration of the implant (white arrow). Note the small lucent zone surrounding the DCI (black arrows) indicating non ingrowth. This patient is to undergo reoperation and segment fixation.

Table 3 Radiologic outcome at 12 months after surgery

	DCI group 33 implants	ACDF group 35 implants	*p* value
Ventral migration, *n* (%)	5 (15)	0 (0)	0.023
Change in subsidence in millimeter; mean ± SD	2.3 ± 1.0	1.3 ± 0.8	<0.001
Fusion rate, *n* (%)	13 (39)	28 (80)	0.001
Pseudarthrosis, *n* (%)		7 (20)	
Radiolucency, *n* (%)	30 (91)		

Abbreviations: ACDF, anterior cervical diskectomy and fusion; DCI, dynamic cervical implant; SD, standard deviation.

with preexisting DDD of the adjacent segment developed symptomatic disk herniation, also requiring reoperation within the follow-up period. There was no significant difference between the two groups in terms of the reoperations performed on the index segment.

Discussion

Situated between ACDF and CDA, DCI represents a completely new kind of cervical implant philosophy.[19–21] The goal of DCI implants is to provide increased stability while preserving reduced ROM of the involved segment (►**Fig. 5**). By contrast, it has been suggested that CDA preserves motion within the total physiologic ROM[22] and, moreover, extends the ROM of the involved segment.[5,10] This may exacerbate the stress on the index facet joints,[5,6,10] particularly in patients with preexisting cervical DDD.[23] The long-term effects of facet joint degeneration after CDA remain to be established, which may have a great impact on the physiologic decrease in ROM with aging.[24] The biomechanical characteristics of DCIs[10] may be better suited to this situation.

The current results showed a significant improvement in clinical outcome in both the DCI and the ACDF group at the 3- and 12-month follow-up. After 3-month follow-up, no further improvement was observed. In both groups, relief from arm pain was greater than that from neck pain. These findings correspond to known data from the literature for ACDF and CDA 1 year after surgery,[25] suggesting that treatment with DCIs seems to be as effective as ACDF in terms of the clinical outcome at the 12-month follow-up for patients with one- or two-segment cervical DDD.

The radiologic outcome at the last follow-up in the ACDF group showed a slight cage subsidence of ~ 1 mm and a fusion rate of 80.0%.[2] Subsidence in segments undergoing DCI surgery was significantly greater. A high percentage of segments treated with DCIs exhibited lucent zones between implant surfaces and bony end plates, implying no ingrowth. We found this phenomenon of radiolucency in 39.5% of all segments with DCIs at the 3-month follow-up and in 90.9% at the 1-year mark. These findings underscore the observation that ventral dislocation is more frequent in DCIs (15.2%). In addition, the high percentage of radiolucency in the DCI group may be why neck pain did not improve as much as it

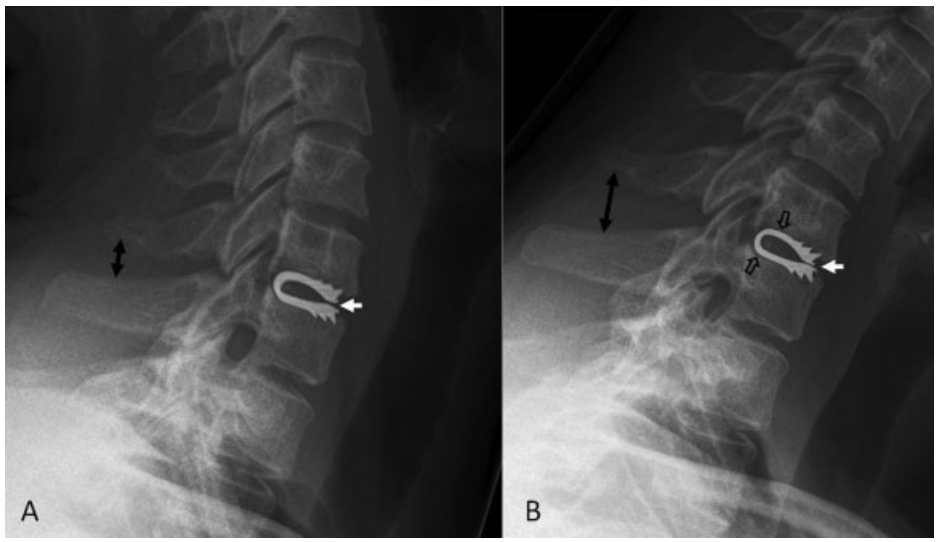

Fig. 5 Lateral radiographs from the 12-month follow-up showing (A) extension and (B) flexion after dynamic cervical implant surgery on the C6–C7 segment. The changing distances between the limbs of the implant (white arrows) and the C6–C7 spinous processes (black arrows) indicate preserved motion in the index segment. However, lucent lines (open arrows) indicate nonintegration of the implant into the bony end plates.

did in the ACDF group. With regard to the two revision operations in the DCI group, the implants were easy to remove, with only fibrous tissue located between the implant surface and bony end plates. We see this as a significant drawback of the DCI and as a source of more potential dislocations and increasing neck pain at later follow-ups.

Because DCI is a motion-preserving implant, the rate of fusion is crucial. When implanting DCIs we paid special attention to maximizing the footprint of the implant, thus providing maximum coverage of the end plates. The height of the implant was selected by gently distracting the segment. Nevertheless, at 3 months we found unintended fusion in 23.7% of the segments and in 39.4% at the 1-year follow-up. This high rate of fusion may represent the physiologic response to the high rate of radiolucency we found. Perhaps this problem could be solved by modifying the implant design.[26] Coating the DCI surface could be a particularly effective way to improve bony ingrowth.

Although there have been some conference and industrial reports,[19–21,27] only three peer-reviewed reports have been recently published regarding the biomechanical properties[10] and clinical and radiologic results[11,12] of the DCI.

Mo et al compared the DCI implanted at the segment C5–C6 with the Prodsic-C, ACDF (plate), and the intact spine in a finite element model.[10] ROM in flexion/extension increased by only 7% after DCI implantation but decreased by 30% and 20% in axial rotation and lateral bending, respectively. ACDF decreased ROM by 90% in all motions. During flexion/extension the facet joint contact force and capsular ligament strain increased in the DCI models compared with the intact condition. In the DCI model the superior adjacent segment was more on stress then the inferior one, but with a smaller extent than in the ACDF model. The authors conclude that DCI could better maintain the spinal kinematics than ACDF.

Li et al reported clinical and radiologic outcomes after ACDF ($n = 42$) and DCI ($n = 39$) single-segment operations for DDD with a maximum of 2-year follow-up.[11] They found the same significant improvements in clinical outcome measurements for ACDF and DCI surgery, with no significant differences between both groups. For the radiologic outcome, Li et al reported a significant increase in overall and treated-segment ROM in the DCI group, but not at the adjacent segments. Disk height (DHI) increased significantly in both groups after surgery. The overall fusion rate was 94.9%, probably in the ACDF group. Fusion rate in the DCI group was not mentioned. One anterior implant migration of 2 mm in the DCI group appeared with no need for revision surgery. In each group, two cases of cage subsidence occurred.

In our study, we found the same clinical improvements. Furthermore, we had five cases of DCI dislocations with one implant-related revision surgery. The difference could result from the stricter criteria we used that dictated that every case of implant migration was mentioned as dislocation, whereas Li et al used 2-mm dislocation as criteria. Moreover, they had only two cases of subsidence in the DCI group (no criteria were noted) and a significant increase in DHI, whereas we measured a significant decrease in the end-plate distances from 5.6 mm to 3.4 mm when comparing postoperative and 1-year follow-up radiographs. The difference is probably due to the use of different kinds of measurements. Li et al take their measurements of DHI from the middle of the implant, whereas we do it from the side. Because the configuration and height of the DCI do not change over time, a measurement taken from the middle will only register the implant height itself, irrespective of the subsidence of the implant. Thus in our opinion, DHI and subsidence are not correctly reflected by Li et al.[11]

In our DCI group, we found a high rate of radiolucency (90.9%) and fusion (39.4%) at 1-year follow-up. Both issues were not mentioned in the report by Li et al. They only report two cases of pseudarthrosis, but no criteria were noted. Moreover, fusion in the DCI group is not mentioned at all in their results.[11]

Wang et al present the prospective results of 30 patients with single-segment DDD operated with DCI.[12] As we did, they found significant improvements in all clinical parameters. They report no implant dislocation, no resorption at the bony end plate, and no spontaneous fusion confirmed by computed tomography (CT) scans. In lateral radiographs in flexion/extension, all DCIs provided similar ROM pre- and postoperatively. To determine the stability of the implant–bone interface, they compared the intrinsic motion of DCI and the amount of motion of the adjacent vertebral end plates and found a linear correlation suggesting that the implant–bone interface is stable.

These results differ considerably with our results, with 39.4% DCI fusion in operated segments after 1 year. Wang et al used direct measurements at the implant and the implant-related bony end plates to determine the angles and ROM of the segment. As apparent in Figure 6 of the study by Wang et al,[12] the measurement line in flexion is not aligned with the implant in the same position in comparison with extension. Thus we rejected this method of direct measurement in our study because the resulting values are close to this measurement error. In addition, often following lateral radiographs have not been taken using exactly the same beam course, which complicates the measurement method mentioned earlier. Therefore, we reason that the results of maintained mobility in the DCI segments and the implant–bone interface stability are in doubt. Furthermore, Wang et al reported no resorption on the surface of the bony end plates confirmed by CT scans, whereas we found 90.9% radiolucency in radiographs. Because of the different methods, these results are not directly comparable. We think that CT irradiation artifact could hide the small lucent zones of the implant–bone interface. As visible in Figure 7 of the study by Wang et al,[12] there is a lucent zone at the complete lower implant surface in flexion and a clear lucent zone when lifting up the frontal part of the DCI from the lower end plate in extension. We referred to these signs as radiolucency.

The radiologic disadvantages of DCIs indicated in our study, namely high rates of fusion and radiolucency, may increase still further after longer follow-up periods. This is of particular concern because it contradicts the hypothesis that DCIs preserve motion.

Because the limitations of the study arise from the nonrandomized study design, we cannot rule out bias in patient selection. Furthermore, neither cohort was completely homogeneous, especially regarding the male-to-female ratio, the different numbers of involved C4–C5 and C6–C7 segments, and the inferior clinical baseline parameters of the ACDF group by trend that could add bias.

Conclusion

DCI and ACDF surgery result in similar improvement with regard to clinical outcome in patients with cervical DDD at 3 and 12 months after surgery. Because high rates of radiolucency and fusion associated with DCI treatment occurred in our study, further studies should investigate DCI treatment in larger series with longer follow-up with special regard to these issues.

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