Arthroplasty for cervical spondylotic myelopathy: similar results to patients with only radiculopathy at 3 years’ follow-up

Clinical article

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Object. Cervical arthroplasty has been accepted as a viable option for surgical management of cervical spondylosis or degenerative disc disease (DDD). The best candidates for cervical arthroplasty are young patients who have radiculopathy caused by herniated disc with competent facet joints. However, it remains uncertain whether arthroplasty is equally effective for patients who have cervical myelopathy caused by DDD. The aim of this study was to compare the outcomes of arthroplasty for patients with cervical spondylotic myelopathy (CSM) and patients with radiculopathy without CSM. Methods. A total of 151 consecutive cases involving patients with CSM or radiculopathy caused by DDD and who underwent one- or two-level cervical arthroplasty were included in this study. Clinical outcome evaluations and radiographic studies were reviewed. Clinical outcome measurements included the Visual Analog Scale (VAS) of neck and arm pain, Japanese Orthopaedic Association (JOA) scores, and the Neck Disability Index (NDI) in every patient. For patients with CSM, Nurick scores were recorded for evaluation of cervical myelopathy. Radiographic studies included lateral dynamic radiographs and CT for detection of the formation of heterotopic ossification.

Results. Of the 151 consecutive patients with cervical DDD, 125 (82.8%; 72 patients in the myelopathy group and 53 in the radiculopathy group) had at least 24 months of clinical and radiographic follow-up. The mean duration of follow-up in these patients was 36.4 months (range 24–56 months). There was no difference in sex distribution between the 2 groups. However, the mean age of the patients in the myelopathy group was approximately 6 years greater than that of the radiculopathy group (53.1 vs 47.2 years, p < 0.001). The mean operation time, mean estimated blood loss, and the percentage of patients prescribed perioperative analgesic agents were similar in both groups (p = 0.754, 0.652, and 0.113, respectively). There were significant improvements in VAS neck and arm pain, JOA scores, and NDI in both groups. Nurick scores in the myelopathy group also improved significantly after surgery. In radiographic evaluations, 92.5% of patients in the radiculopathy group and 95.8% of those in the radiculopathy group retained spinal motion (no significant difference). Evaluation of CT scans showed heterotopic ossification in 34 patients (47.2%) in the myelopathy group and 25 patients (47.1%) in the radiculopathy group (p = 0.995). At a mean of over 3 years postoperatively, no secondary surgery was reported in either group.

Conclusions. The severity of myelopathy improves after cervical arthroplasty in patients with CSM caused by DDD. At 3-year follow-up, the clinical and radiographic outcomes of cervical arthroplasty in DDD patients with CSM are similar to those patients who have only cervical radiculopathy. Therefore, cervical arthroplasty is a viable option for patients with CSM caused by DDD who require anterior surgery. However, comparison with the standard surgical treatment of anterior cervical discectomy and fusion is necessary to corroborate the outcomes of arthroplasty for CSM.

Key Words • cervical arthroplasty • degenerative disc disease • radiculopathy • cervical spondylotic myelopathy • heterotopic ossification

Abbreviations used in this paper: ACDF = anterior cervical discectomy and fusion; CSM = cervical spondylotic myelopathy; DDD = degenerative disc disease; FDA = Food and Drug Administration; IDE = investigational device exemption; JOA = Japanese Orthopaedic Association; NDI = Neck Disability Index; OPLL = ossification of the posterior longitudinal ligament; VAS = visual analog scale.

* Drs. Fay and Huang contributed equally to this work.
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vestigations by the United States Food and Drug Ad-
ministration Investigational Device Exemption (FDA-
IDE) trials for comparison of single-level arthroplasty
to ACDF.1,5,14,26,28,30,40 It has been proven that in short- to
tomidterm (2 to 5 years) follow-up, both arthroplasty and
ACDF demonstrate excellent surgical outcomes for the
treatment of single-level cervical disc disease with radic-
ulopathy.1,9,10,26,27,38,44 However, the effect of arthroplasty
for the treatment of cervical myelopathy is less well
documented. Thus it remains uncertain whether cases of
cervical myelopathy caused by DDD can be equally well
managed with arthroplasty.

The FDA-IDE trials for comparison of arthroplasty to
ACDF did not specifically investigate the differences with
respect to the management of cervical myelopathy versus
radiculopathy. The trials included patients with single-level
symptomatic cervical disc herniation or spondylosis who
presented with intractable radiculopathy or myelopathy or
both, but these prospective randomized control trials did
not include patients with multilevel DDD causing cervical
myelopathy requiring surgical management. Therefore, the
effects of the preservation of spinal segment motion by 1-
or 2-level cervical arthroplasty in the treatment of CSM
require further investigation.10,18,26,27,33,41 The present study
was thus designed to evaluate the outcome of arthroplasty
in patients with radiculopathy compared with outcome in
patients with CSM (with or without radiculopathy). Thus
patients were divided into two groups: those who had my-
elopathy and those who had only radiculopathy. Moreover,
unlike most FDA-IDE trials, which only enrolled patients
who had 1-level disease, the present study included patients
with 2-level disease.

Methods

This study was a retrospective review of imaging
studies and clinical data from a prospective data base and
was approved by the institutional ethics committee off
Taipei Veterans General Hospital.

Patient Population

A total of 151 consecutive patients who had 1- or
2-level cervical DDD and underwent cervical arthroplas-
ty between July 2007 and August 2010 were included in
this study.

The indications for cervical arthroplasty included cer-
vical myelopathy and/or radiculopathy caused by cervical
DDD or spondylosis. All patients had received at least 12
weeks of medical treatment that had failed to relieve symp-
toms. Patients were excluded if they had any one of the
following conditions: segmental instability (more than 3.5
mm translation or 20° angular motion) at the index level(s),
segmental arthrosis without mobility, loss of more than
50% of normal disc height, cervical trauma with incompe-
tent facet joints (cervical fusion may be required), adjacent-
segment disease after previous cervical fusion, or kyphotic
deformity. Patients with osteoporosis (T score < −2.5),
confirmed malignancy, metabolic bone diseases, spondy-
loarthropathies (for example, rheumatoid arthritis), active
infection, or severe systemic disease (for example, cerebral
vascular accident) were also excluded.

All patients were grouped into either the myelopathy
group or the radiculopathy group. The myelopathy group
included patients who showed any upper motor neuron
signs or long tract signs, including increased tendon re-
exes below the indexed neurological level, upon neuro-
logical examination. Patients with the chief complaints
of symptoms of cervical myelopathy, such as lower-limb
numbness, weakness, unsteady gait, allodynia, or hypo-
esthesia, were also enrolled in the myelopathy group.
Moreover, patients who had abnormalities demonstrated
by electrophysiological examinations (that is, decreased
motor evoked potentials or somatosensory evoked poten-
tials) or radiological examinations (signal hyperintensity
on T2-weighted MR images) were also included in the
myelopathy group.

The radiculopathy group was composed of patients
who had only radiculopathy. Typically these patients had
radicular pain, specific dermatome sensory deficit corre-
ponding to the level of the herniated disc on imaging
studies or unilateral arm or dermatome weakness.

Surgical Technique

The patient was placed in a supine position under
general anesthesia. A right-side horizontal incision along
a skin crease correlating to the target level of the cervi-
cal disc was made. Intraoperative fluoroscopy was used
to confirm the level(s) and to ensure that the neck was in
a neutral or slightly extended position. Generous decom-
pression of bilateral neural foramina was performed after
discectomy, despite unilateral symptoms in some radicu-
lopathy patients. Drilling of osteophytes over the lips of
vertebral bodies, resection of bilateral uncovertebral joints
and the posterior longitudinal ligament was routinely per-
formed on every patient. Hemostasis around the epidural
venous plexuses was obtained with bipolar coagulation and
Floseal (Baxter Healthcare). Normal saline irrigation was
applied during the whole procedure of milling and drill-
ing of the osteophytes. The endplate was prepared and the
proper size of the artificial disc was then inserted under in-
traoperative fluoroscopy. One of two kinds of arthroplasty
devices, a Bryan (Medtronic) or Prestige LP (Medtronic)
artificial disc, was implanted in the patients in this series.
A closed-system drainage catheter was then placed and the
wound was closed layer by layer.

Radiographic and Clinical Evaluations

Standard anteroposterior, lateral, and lateral dynamic
(flexion-extension) plain radiographs were obtained in the
preoperative period, the immediate postoperative period
(within 3 days), and at the 3-, 6-, 12-, 24-, and 36-month
follow-up visits. The segmental range of motion at the in-
dex level was measured as the difference in Cobb angle in
the lateral flexion and extension radiographs. The digital
images were reviewed and evaluated by the medical soft-
ware, SmartIris (Taiwan Electronic Data Processing Co.),
compatible with standard picture archiving and commu-
nication systems.

Patients underwent CT scans of the cervical spine
after at least 12 months of follow-up, and CT reconstruc-
tions were assessed for the presence of heterotopic os-
sification. As in our previous studies, the grading of heterotopic ossification was based on McAfee’s classification.24,37,44 Loss of arthroplasty function and immobility at the index level after surgery was defined as a range of motion of 3° or less at the index level on lateral dynamic radiographs. Five radiologists or neurosurgeons reviewed the radiographic images independently.

The assessment of clinical outcomes at follow-up time points was made by two clinical study nurses under the supervision of physicians at the outpatient department. We used the visual analog scale (VAS) to evaluate neck and arm pain. Functional scores such as the Neck Disability Index (NDI) and Japanese Orthopaedic Association (JOA) score were used to evaluate the impairments to daily life activity. The Nurick grading system was specifically used to evaluate the myelopathy group. Any ambiguity was resolved by neurosurgeons at the outpatient department.

Statistical Analysis

Independent t-tests and paired t-tests were used for data analysis using the SPSS software (SPSS Inc.). Statistical significance was defined as p value of 0.05 or less. A physician skilled in statistical analysis performed the calculations and the results were double checked.

Results

Overall Characteristics of the Patient Groups

Of the 151 patients, 125 (82.8%) had at least 24 months of clinical and radiographic follow-up, and their cases were included in the analysis. The mean follow-up time was 36.4 ± 9.5 months (range 24–56 months). Forty-nine (39.2%) of the patients were women, and 76 (60.8%) were men. Their overall mean age at the time of operation was 50.6 ± 10.7 years (range 21–81 years) (Table 1). The other 26 patients (17.2%) were lost to the protocol of follow-up due to incomplete or incorrect timing of postoperative evaluations. Of these 26 patients, 11 patients (42.3%) were in the myelopathy group and 15 (58.7%) were in the radiculopathy group.

The distribution of the levels of cervical DDD of the current study is demonstrated in Table 2. The C5–6 level was the most frequently treated level in both the myelopathy and the radiculopathy groups (treated in 49.1% of the patients in the myelopathy group and 61.8% in the radiculopathy group). The majority of patients in the series had single-level DDD (55.6% in the myelopathy group and 71.7% in the radiculopathy group, p = 0.066).

Myelopathy Versus Radiculopathy

Of the 125 patients with complete follow-up, 72 were in the myelopathy group (Fig. 1) and 53 were in the radiculopathy group (Fig. 2). The mean age of patients in the myelopathy group was significantly greater (53.1 vs 47.2 years, p = 0.001) than that of patients in the radiculopathy group (a difference of approximately 6 years). The female to male ratio in the 2 groups were similar (45.8% women in the myelopathy group vs 30.2% in the radiculopathy group, p = 0.077). The average estimated blood loss (119.0

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### Table 1: Clinical and demographic characteristics of 125 patients*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>sex</td>
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</tr>
<tr>
<td>male</td>
<td>76 (60.8%)</td>
</tr>
<tr>
<td>female</td>
<td>49 (39.2%)</td>
</tr>
<tr>
<td>age (yrs)</td>
<td></td>
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<tr>
<td>range</td>
<td>21–81</td>
</tr>
<tr>
<td>mean</td>
<td>50.6 ± 10.7</td>
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<tr>
<td>clinical follow-up (mos)</td>
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<tr>
<td>range</td>
<td>24–56</td>
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<tr>
<td>mean</td>
<td>36.4 ± 9.5</td>
</tr>
<tr>
<td>EBL (ml)</td>
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<tr>
<td>range</td>
<td>30–800</td>
</tr>
<tr>
<td>mean</td>
<td>123.7 ± 117.5</td>
</tr>
<tr>
<td>operation time (mins)</td>
<td></td>
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<tr>
<td>range</td>
<td>100–530</td>
</tr>
<tr>
<td>mean</td>
<td>213.2 ± 76.8</td>
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<td>NSAID prescription</td>
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<td>yes</td>
<td>87 (69.6%)</td>
</tr>
<tr>
<td>no</td>
<td>38 (30.4%)</td>
</tr>
<tr>
<td>surgery level</td>
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</tr>
<tr>
<td>1-level</td>
<td>76 (62.4%)</td>
</tr>
<tr>
<td>2-level</td>
<td>47 (37.6%)</td>
</tr>
<tr>
<td>HO rate levels</td>
<td></td>
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<tr>
<td>patients</td>
<td>72 (41.9%)</td>
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<tr>
<td>yes</td>
<td>118 (94.4%)</td>
</tr>
<tr>
<td>no</td>
<td>7 (5.6%)</td>
</tr>
</tbody>
</table>

* Values represent numbers of patients unless otherwise indicated. Means are presented with standard deviations. EBL = estimated blood loss; HO = heterotopic ossification; NSAID = nonsteroidal antiinflammatory drug.

### Table 2: Distribution of 172 treated levels in 125 patients

<table>
<thead>
<tr>
<th>Group &amp; Level</th>
<th>No. of Levels Treated (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>myelopathy (72 patients)</td>
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<tr>
<td>C3–4</td>
<td>13 (12.5%)</td>
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<tr>
<td>C4–5</td>
<td>30 (28.8%)</td>
</tr>
<tr>
<td>C5–6</td>
<td>51 (49.1%)</td>
</tr>
<tr>
<td>C6–7</td>
<td>10 (9.6%)</td>
</tr>
<tr>
<td>radiculopathy (53 patients)</td>
<td></td>
</tr>
<tr>
<td>C3–4</td>
<td>4 (5.8%)</td>
</tr>
<tr>
<td>C4–5</td>
<td>10 (14.7%)</td>
</tr>
<tr>
<td>C5–6</td>
<td>42 (61.8%)</td>
</tr>
<tr>
<td>C6–7</td>
<td>11 (16.2%)</td>
</tr>
<tr>
<td>C7–T1</td>
<td>1 (1.5%)</td>
</tr>
</tbody>
</table>
Arthroplasty for cervical spondylotic myelopathy

ml in the myelopathy group vs 129.2 ml in the radiculopathy group, \( p = 0.652 \) and mean operation time (211.3 minutes in the myelopathy group vs 215.8 minutes in the radiculopathy group, \( p = 0.754 \)) were also similar in the 2 groups. The rates of perioperative use of analgesic agents (prescribed in 63.9% of cases in the myelopathy group vs 77.4% in the radiculopathy group, \( p = 0.113 \)) were not significantly different.

The mean VAS neck, VAS arm, and NDI scores all showed significant improvement after surgery when compared with the preoperative scores in both the myelopathy and the radiculopathy groups (Figs. 3 and 4). There were also no significant differences between the 2 groups at each time point of follow-up. The clinical outcomes measured by JOA scores also showed significant improvement in the 2 groups. However, the mean JOA score was better in the
radiculopathy group than in the myelopathy group at each time point of evaluation (Fig. 4). The mean Nurick score, specifically recorded for the patients in the myelopathy group, improved from 2.5 ± 0.9 preoperatively to 1.0 ± 1.0 after cervical arthroplasty (p < 0.001) (Fig. 5).

Radiographically, most of the implanted artificial discs remained mobile. Sixty-nine patients (95.8%) in the myelopathy group and 49 patients (92.5%) in the radiculopathy group had mobile artificial discs in the last follow-up (no significant difference, p = 0.417) (Table 3). Regarding heterotopic ossification, 34 patients (47.2%) in the myelopathy group and 25 (47.1%) in the radiculopa-
thy group were found to have heterotopic ossification on careful evaluation of CT scans (47.2% vs 47.1%, p = 0.995). Although heterotopic ossification was detected by CT in almost half the patients in each group, most of the artificial discs in the current study remained mobile at the last follow-up (95.8% vs 92.5% for the myelopathy and radiculopathy groups, respectively, p = 0.417) (Figs. 1 and 2). In the present study, there were no patients who required secondary surgery (revision, removal of the arthroplasty, or conversion to fusion). Two patients (1.6%) had postoperative temporary hoarseness that resolved at 3 months after surgery in one case and 6 months after

**Fig. 4.** Clinical outcomes measured by mean NDI and JOA scores in the myelopathy and radiculopathy groups. The mean JOA scores for the radiculopathy group were better than those for the myelopathy group at each follow-up point, although the difference was not statistically significant. Error bars indicate standard deviations. *Significant improvement compared with preoperative scores.
surgery in the other. One patient (0.8%) had mild dysphagia that resolved 10 days after the operation, and a temporary nasogastric tube was inserted for intake of enteric nutrition. One patient (0.8%) had intraoperative leakage of CSF. The leak was repaired and the patient had no new postoperative neurological deficit or wound issues upon discharge or at follow-up. No other complications (such as permanent dysphagia or hoarseness, wound infection, new-onset neurological deficits, or instrument failure) were identified as of the most recent follow-up. As of this writing, no patient has required a second operation for symptomatic adjacent-segment disease, with the longest duration of follow-up being 56 months.

Discussion

This is the first study to specifically compare the results of cervical arthroplasty in patients who have cervical myelopathy with the results in patients who have radiculopathy without myelopathy. We analyzed a total of 151 consecutive cases involving patients with symptomatic 1- or 2-level cervical DDD who underwent cervical arthroplasty. At least 24 months of clinical and radiographic follow-up was completed in 125 cases (82.8%). These patients were grouped into the myelopathy group (n = 72) and the radiculopathy group (n = 53) according to the preoperative evaluations. The patients who presented with any symptoms or signs of myelopathy upon neurological, electrophysiological or radiological evaluations were grouped into the myelopathy group, while patients in the other group had radiculopathy only. The mean follow-up time was 36.4 ± 9.5 months (range 24–56 months). The mean age for the myelopathy group was approximately 6 years older than that for the radiculopathy group (53.1 vs 47.2 years, p < 0.001). There were no significant differences between the 2 groups in terms of sex, mean operation time, estimated blood loss, or the use of perioperative analgesics (p = 0.077, 0.754, 0.652, and 0.113, respectively). There were significant improvements in VAS neck and arm pain, JOA scores, and NDI in both groups. Moreover, the Nurick scores in the myelopathy group also improved significantly after surgery. In radiographic evaluations, more than 92.5% of the patients in this series retained spinal motion upon follow-up, and there were no significant differences between the 2 groups (p = 0.417). Scrutiny of follow-up CT scans revealed heterotopic ossification in 34 patients (47.2%) in the myelopathy group and 25 patients (47.1%) in the radiculopathy group (p = 0.995). There was no correlation between myelopathy and the development of heterotopic ossification in the current series. No secondary surgery was reported in either group. Therefore, cervical arthroplasty appears to be equally effective for patients with myelopathy or radiculopathy caused by cervical DDD and requiring surgery. Not only did the patients with myelopathy experience improvement in their symptoms after surgery, but the complication rate, motion at the index level, and relief of pain for these patients were similar to those with radiculopathy only.

Spondylosis and DDD are frequently occurring aging processes and may cause CSM or cervical radiculopathy. In the present study, the mean age of the patients with myelopathy was approximately 6 years greater than that of those with radiculopathy.
of the patients who had only radiculopathy (53.1 vs 47.2 years). The older mean age may imply that the myelopathy was caused by more advanced degeneration of the cervical spine. This inference can be corroborated in this series by the observation that patients in the myelopathy group had worse JOA scores than those in the radiculopathy group at each of the time points of evaluation. Thus the patients with CSM were in a more advanced stage of degenerative disease with a worse quality of life than those who had DDD causing radiculopathy. After cervical arthroplasty, both groups showed significant improvement in JOA scores. There were no significant differences in sex, operation time, perioperative prescription of nonsteroidal anti-inflammatory agents, segmental motion, or complications between the 2 groups. Therefore, the results indicate that arthroplasty is equally safe and effective for both cervical myelopathy and radiculopathy at a mean of over 3 years’ follow-up. Furthermore, CSM should be managed early and cervical arthroplasty is a potential option in carefully selected patients.

The long-term effect of preservation of spinal motion in the management of CSM remains uncertain. Currently, the best available data about cervical arthroplasty in the management of cervical spondylosis and DDD are the prospective clinical trials by the FDA. These large-scale, randomized, and controlled clinical trials have included patients with single-level symptomatic cervical spondylosis between the C-3 and C-7 levels who presented with intractable radiculopathy or myelopathy or both. The 2- to 5-year results of these trials suggest that cervical arthroplasty is a safe and effective alternative to ACDF to treat patients with single-level cervical DDD who meet the FDA inclusion criteria, which include cervical myelopathy. The safety and efficacy for the management of multiple-level cervical DDD causing CSM requires further validation. In the present study, we compared 1- and 2-level cervical DDD managed with arthroplasty and demonstrated that in the myelopathy group the average Nurick score improved significantly from 2.5 to 1.0 after cervical arthroplasty (p < 0.001). Patients in the myelopathy group who underwent 1- or 2-level arthroplasty had a level of improvement in their symptoms similar to those patients who had only radiculopathy. Thus, it is reasonable to infer that 2-level arthroplasty might be an alternative option to ACDF in the treatment of CSM.

A few nonrandomized studies have demonstrated superior results for arthroplasty in comparison with ACDF. For example, Cheng et al. conducted a study of 83 patients with cervical myeloradiculopathy who were divided into an arthroplasty group (n = 41) and a fusion group (n = 42). At 3 years’ follow-up, the patients who had undergone arthroplasty had better clinical outcomes than the fusion group on JOA score, SF-36, and NDI, and mobility was retained. The authors concluded that the arthroplasty group had fewer complications and that the results were superior to those obtained with fusion at follow-up. Due to the small sample size and retrospective study design, one must be very cautious in interpreting these results, however, and it is well accepted that ACDF is an effective surgical management of multilevel cervical DDD causing CSM.

In the present study, the authors have demonstrated that the use of arthroplasty for the management of cervical DDD involving more than one vertebral level and causing myelopathy is equally effective as for radiculopathy. Furthermore, previous studies have demonstrated very similar clinical outcomes for 1- and 2-level arthroplasty. Therefore, in combination, the results of these studies provide some indirect evidence for the safety and efficacy of cervical arthroplasty in patients with cervical DDD at more than one level causing CSM. More data are required to compare multiple-level arthroplasty to ACDF in the management of CSM.

The optimal surgical strategy and timing for management of CSM remains controversial. Evidence for the utilization of the new technology for the preservation of spinal motion in the management of CSM is largely anecdotal, although a few case series have been published in recent years. These reports demonstrated that arthroplasty could be effective in 1- or 2-level disease causing myelopathy. However, the weaknesses of the above-mentioned studies included small case numbers, lack of a control group, or relatively short follow-up. Riew et al. analyzed data from a cohort of patients with myelopathy who were enrolled in the US FDA-IDE trials of the

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**TABLE 3: Comparison between patients with myelopathy and radiculopathy**

<table>
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<th>Variable</th>
<th>Myelopathy</th>
<th>Radiculopathy</th>
<th>p Value</th>
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<tbody>
<tr>
<td>no. of patients</td>
<td>72</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>age (yrs)</td>
<td>53.1 ± 11.6</td>
<td>47.2 ± 8.4</td>
<td>0.001†</td>
</tr>
<tr>
<td>sex</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>male</td>
<td>39 (54.2%)</td>
<td>37 (69.8%)</td>
<td>0.077</td>
</tr>
<tr>
<td>female</td>
<td>33 (45.8%)</td>
<td>16 (30.2%)</td>
<td></td>
</tr>
<tr>
<td>operation time (mins)</td>
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<td>0.754</td>
</tr>
<tr>
<td>mean</td>
<td>211.3 ± 76.9</td>
<td>215.8 ± 77.3</td>
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</tr>
<tr>
<td>range</td>
<td>110.0–530.0</td>
<td>100.0–480.0</td>
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<td>EBL (ml)</td>
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<td></td>
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</tr>
<tr>
<td>mean</td>
<td>119.0 ± 105.9</td>
<td>129.2 ± 131.0</td>
<td>0.652</td>
</tr>
<tr>
<td>range</td>
<td>30.0–500.0</td>
<td>30.0–800.0</td>
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</tr>
<tr>
<td>NSAID</td>
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<td></td>
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<tr>
<td>yes</td>
<td>46 (63.9%)</td>
<td>41 (77.4%)</td>
<td>0.113</td>
</tr>
<tr>
<td>no</td>
<td>26 (36.1%)</td>
<td>12 (22.6%)</td>
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</tr>
<tr>
<td>surgery level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-level</td>
<td>40 (55.6%)</td>
<td>38 (71.7%)</td>
<td>0.066</td>
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<tr>
<td>2-level</td>
<td>32 (44.4%)</td>
<td>15 (28.3%)</td>
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<td>HO</td>
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<tr>
<td>yes</td>
<td>34 (47.2%)</td>
<td>25 (47.1%)</td>
<td>0.995</td>
</tr>
<tr>
<td>no</td>
<td>38 (52.8%)</td>
<td>28 (52.9%)</td>
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<tr>
<td>yes</td>
<td>69 (95.8%)</td>
<td>49 (92.5%)</td>
<td>0.417</td>
</tr>
<tr>
<td>no</td>
<td>3 (4.2%)</td>
<td>4 (7.5%)</td>
<td></td>
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</table>

* Values represent numbers of patients unless otherwise indicated. Means are presented with standard deviations. † Statistically significant (p < 0.05).
Prestige ST and Bryan discs (Medtronic). They found that arthroplasty was as good as anterior arthrodesis for myelopathy caused by single level disc disease or spondylolisthesis at two-year follow up.

There are a few common conditions other than DDD that cause CSM (ossification of posterior longitudinal ligament [OPLL]), hypertrophy of the ligamentum flavum, or kyphotic deformity). However, similar to the FDA IDE trials, the present study did not include pathologies other than spondylolisthesis and DDD. It must be noted that the results of arthroplasty and arthrodesis for 1- or 2-level DDD and/or spondylolisthesis should never be generalized to the treatment of other causes of CSM. Strict selection of appropriate candidates for arthroplasty remains a cornerstone for the success of surgery. There were sparse data in the literature to support utilization of arthroplasty in OPLL or kyphosis, which are also common causes of CSM. Furthermore, it is not uncommon to find DDD involving 3 or more levels in patients with CSM. The current data do not indicate whether these cases can be managed with arthroplasty. Unlike the arthrodesis procedures conventionally used to treat CSM, arthroplasty aims to maintain segment motion. Thus, the dynamic construct may face more challenges as time passes, and the long-term effects on the neural tissue remains uncertain. Further studies are needed to validate the results of durability in arthroplasty for CSM.

There are limitations to the current study, including a relatively small sample size, the retrospective design, and heterogeneity in the degree of myelopathy. The study included no patients treated with multilevel ACDF, which is considered one of the standard surgical management procedures for CSM. The myelopathy group included patients with myelopathy and myeloradiculopathy. Moreover, the group included patients with varying degrees of myelopathy, ranging from patients with some neurological (long tract) signs and minimal disability to patients with significant clumsiness of both hands and bilateral lower limb weakness. Patients representing the two extremes of this spectrum could have had markedly different pathologies: one patient might have had a small lateral disc protrusion causing mainly radiculopathy with slight dural sac compression unilaterally, while another might have had a large central disc protrusion causing severe dural sac compression and myelomalacia. Outcomes after arthroplasty in patients with mainly radiculopathy and very mild myelopathy are assumed to be similar to those in patients with radiculopathy only. Pooling these patients with different degrees of myelopathy together could affect the analysis. The actual effect of arthroplasty in CSM is uncertain, and further studies are warranted to address the heterogeneity in the myelopathy group.

Second, 2 kinds of arthroplasty devices, the Bryan disc and the Prestige LP disc, were used in this study. The change in device type was caused by the lack of supply of Bryan discs in our institution and may have increased implant-related variation. However, all patients were treated and followed up by the same surgeons under the same protocol for more than 2 years. The study demonstrated that 1- or 2-level arthroplasty is equally effective in the management of cervical myelopathy and radiculopathy. A larger-scale, prospective, randomized, and controlled trial will be needed to determine the difference between arthroplasty and ACDF in the management of CSM.

To date, the best available evidence for cervical arthroplasty is the FDA-IDE trials. These randomized controlled trials specifically compared cervical arthroplasty to ACDF.8,11,13,22,27,33 In the experimental group (that is, the arthroplasty group) of each of these trials, patients were enrolled for treatment of myelopathy or radiculopathy or both. The results demonstrated equivalent outcomes for cervical arthroplasty and ACDF as the surgical treatment for cervical DDD and spondylolysis. However, it is not clear whether there was any difference in outcome between the patients with myelopathy and radiculopathy in either the experimental (arthroplasty) or the control (ACDF) groups. In our study of patients who underwent 1- and 2-level cervical arthroplasty, we found little difference in outcome between patients with myelopathy and radiculopathy. This subgroup analysis can be regarded as a proxy for a direct comparison of cervical arthroplasty and ACDF for myelopathy, but there is no doubt that the true efficacy of cervical arthroplasty for CSM can only be corroborated by a head-to-head comparison of arthroplasty to ACDF in patients with CSM. This issue is an important caveat for interpreting the results of the present study.

Conclusions

The severity of myelopathy improves after cervical arthroplasty in patients with CSM caused by DDD. With a mean of 3 years' follow-up, the clinical and radiographic outcomes of cervical arthroplasty patients with CSM were similar to those patients who had only cervical radiculopathy. The results of this study suggest that cervical arthroplasty is a viable option for patients who have CSM caused by DDD and require anterior surgery. However, comparison with the standard surgical treatment of ACDF is necessary to corroborate the outcomes of arthroplasty for CSM.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: JC Wu, Huang, Cheng. Acquisition of data: Fay, Tsai, Tu, CL Wu. Analysis and interpretation of data: Tsai, Ko, Tu. Drafting the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: JC Wu. Study supervision: Huang, Cheng.

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Arthroplasty for cervical spondylotic myelopathy


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