

Cervical Disc Arthroplasty in Congenital Cervical Spinal Stenosis: Outcomes Compared to Non-Stenotic Patients

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Disclosures: Hannah Shelby (N), Ram K. Alluri (Orthofix, eCential Robotics, Globus, Medtronic, HIA technologies, NeoOnc, ATEC, Max BioPharma), Joseph Shelby (N), Todd Albert (N)

INTRODUCTION: Cervical spinal stenosis is the narrowing of the spinal canal that can result in cervical nerve root compression and cause significant radicular pain, numbness, and weakness and in more severe cases can progress to cervical spondylitis myelopathy (CSM). Congenital cervical spinal stenosis (CCSS), caused by abnormal development of the pedicle lamina or vertebral column, predisposes patients to symptomatic compression due to the reduced baseline canal diameter. While anterior cervical discectomy and fusion (ACDF) is the most common surgical treatment, it eliminates motion and increases the risk of adjacent-segment degeneration. Cervical disc arthroplasty (CDA) is a motion-preserving alternative with proven safety and effectiveness, but its outcomes in patients with CCSS remain poorly defined. This study examines whether CDA provides comparable clinical results in patients with and without CCSS.

METHODS: IRB approval was obtained for this retrospective review of prospectively collected data. Patients with radiculopathy or myelopathy undergoing one- or two-level cervical disc arthroplasty at a single institution (2017-2020) were included and stratified by the Torg-Pavlov Ratio (TPR), a clinical index of CCSS (<0.82 = CCSS; ≥0.82 = non-CCSS). Patient reported outcome measures (PROMs) included the Neck Disability Index (NDI), Visual Analog Scale for neck and arm pain (VAS-Neck, VAS-Arm), Short Form-12 Physical and Mental Component Scores (SF-12 PCS, SF-12 MCS), and PROMIS Physical Function (PROMIS PF), collected preoperatively, <6 months, and ≥6 months postoperatively. Correlations between radiographic parameters and PROMs were assessed, and between-group and within-group comparisons were performed using standard parametric and non-parametric tests. MCID (Minimal Clinically Important Difference) thresholds were applied, with significance set at p<.05.

RESULTS SECTION: Sixty-two patients were included where the average age was 43 years, and the sex split was 54.8% male. 59 patients were available for TPR analysis, (12 CCSS, 20.3%; 47 non-CCSS, 79.7%). No significant correlations were found between TPR or sagittal canal diameter and PROMs, except for a moderate correlation between TPR and SF-12 PCS improvement at ≥6 months (Table 1). Significant postoperative improvement across most PROMs was seen in both cohorts. CCSS patients did show less consistent gains, with no significant improvement in Arm VAS, SF-12 PCS at <6 months, or SF-12 MCS at ≥6 months. At ≥6 months, non-CCSS patients had greater improvement in Neck VAS (p=0.04) and SF-12 MCS (p=0.02) (Table 2). MCID achievement was similar between groups for most PROMs, except SF-12 MCS at ≥6 months, wherein 18 patients (58.1%) and only 1 patient (10%) in the non-CCSS and CCSS respectively achieved the MCID (P=0.011) (Table 3).

DISCUSSION: This study is the first to directly compare outcomes of CDA in patients with and without CCSS. No consistent association was found between congenital stenosis and most PROMs following CDA. While both cohorts improved postoperatively, CCSS patients showed less reliable gains, with significantly lower improvement in Neck VAS and SF-12 MCS at ≥6 months and lower rates of SF-12 MCS MCID achievement. Our results contrast with prior ACDF literature, where CCSS has been linked to higher adjacent segment degeneration, suggesting CDA may offer a motion-preserving alternative in this population. Limitations include a small CCSS sample size. Longer-term, larger-scale studies are needed to further clarify CDA's role in mitigating the risks associated with CCSS.

SIGNIFICANCE/CLINICAL RELEVANCE: While CCSS is an important risk factor for cervical pathology, its impact on outcomes after CDA remains poorly understood. This study provides evidence that while CDA is safe and effective in both CCSS and non-CCSS patients, certain PROMs and functional gains may be less robust in CCSS patients, highlighting the need for careful preoperative counseling.

TABLES AND FIGURES:

| Torg Ratio - Average of Discerned Levels | Pearson Correlation Coefficient R | | p-value | N | NDI Canal Diameter - Average of Non-operated Levels | Pearson Correlation Coefficient R | | p-value | N |
|---|-----------------------------------|-------|---------|----|---|-----------------------------------|------|---------|---|
| | pre | post | | | | pre | post | | |
| Pre-operative Neck Disability Index | 0.151 | 0.253 | .12 | 59 | 0.114 | 0.102 | .102 | 47 | |
| NDI (6 weeks - 3months) - Change > MCID | -0.134 | 0.375 | .16 | 47 | 0.037 | 0.212 | .407 | 47 | |
| NDI (<=6 months) - Change from pre-op | -0.229 | 0.156 | .40 | 47 | 0.002 | 0.4 | .91 | 37 | |
| NDI (>6 months) - Change from pre-op | -0.167 | 0.274 | .17 | 47 | -0.134 | 0.201 | .11 | 37 | |
| VAS Neck (6 weeks - 3months) - Change > MCID | -0.303 | 0.112 | .17 | 47 | 0.029 | 0.104 | .41 | 47 | |
| VAS Neck (<=6 months) - Change from pre-op | -0.22 | 0.161 | .42 | 47 | 0.111 | 0.104 | .37 | 37 | |
| VAS Neck (>6 months) - Change from pre-op | -0.184 | 0.11 | .17 | 47 | -0.047 | 0.164 | .11 | 37 | |
| VAS Arm (6 weeks - 3months) - Change > MCID | -0.151 | 0.219 | .17 | 47 | 0.002 | 0.104 | .41 | 47 | |
| VAS Arm (<=6 months) - Change from pre-op | -0.124 | 0.209 | .42 | 47 | 0.118 | 0.10 | .37 | 37 | |
| VAS Arm (>6 months) - Change from pre-op | -0.268 | 0.167 | .17 | 47 | 0.206 | 0.148 | .11 | 37 | |
| SF-12 PCS (6 weeks - 3months) - Change > MCID | 0.084 | 0.156 | .46 | 47 | 0.103 | 0.103 | .407 | 47 | |
| SF-12 PCS (<=6 months) - Change from pre-op | -0.268 | 0.177 | .41 | 47 | 0.044 | 0.171 | .36 | 37 | |
| SF-12 PCS (>6 months) - Change from pre-op | -0.139 | 0.164 | .17 | 47 | -0.044 | 0.103 | .11 | 37 | |
| SF-12 MCS (6 weeks - 3months) - Change > MCID | 0.033 | 0.17 | .46 | 47 | -0.016 | 0.103 | .407 | 47 | |
| SF-12 MCS (<=6 months) - Change from pre-op | 0.151 | 0.167 | .41 | 47 | -0.016 | 0.103 | .11 | 37 | |
| SF-12 MCS (>6 months) - Change from pre-op | -0.111 | 0.169 | .17 | 47 | 0.007 | 0.103 | .11 | 37 | |
| PROMIS PF (6 weeks - 3months) - Change > MCID | 0.089 | 0.168 | .41 | 47 | 0.119 | 0.104 | .37 | 37 | |
| PROMIS PF (<=6 months) - Change from pre-op | 0.045 | 0.165 | .16 | 47 | 0.075 | 0.103 | .11 | 37 | |
| PROMIS PF (>6 months) - Change from pre-op | | | | | | | | | |

Table 1. Correlation between the radiographic measurements of Torg Ratio and sagittal canal diameter and PROMs at three different time points.

| Patient Reported Outcome | Time Point (months) | Torg Factor <0.82 (n=CCSS) | Torg Factor ≥0.82 (n=non-CCSS) | P-value (CCSS vs non-CCSS) | P-value (within group for non-CCSS) |
|--|---------------------|----------------------------|--------------------------------|----------------------------|-------------------------------------|
| NDI | | | | | |
| Pre-operative Neck Disability Index | 20/00/21/18 | 40/76/14/41 | 0.04 | | |
| Early Postoperative Improvement (0-6 months) | -27/13/34 | -14/76/14/44 | 0.70 | 0.002 | <0.0001 |
| Mid Postoperative Improvement (6-12 months) | -33/10/48 | -21/55/16/37 | 0.11 | 0.01 | <0.0001 |
| Late Postoperative Improvement (12+ months) | | | | | |
| Neck VAS | | | | | |
| Pre-operative Neck Pain | 3/7/0/42 | 4/46/2/41 | 0.02 | | |
| Early Postoperative Improvement (0-6 months) | -2/7/2/38 | -3/36/2/43 | 0.06 | 0.006 | <0.0001 |
| Mid Postoperative Improvement (6-12 months) | -2/10/37 | -3/39/2/41 | 0.04 | 0.007 | <0.0001 |
| Late Postoperative Improvement (12+ months) | | | | | |
| Arm VAS | | | | | |
| Pre-operative Arm Pain | 1/10/1/20 | 4/10/1/47 | 0.23 | | |
| Early Postoperative Improvement (0-6 months) | -2/10/24 | -3/15/1/31 | 0.24 | 0.09 | <0.0001 |
| Mid Postoperative Improvement (6-12 months) | -2/10/17 | -3/14/1/34 | 0.36 | 0.08 | <0.0001 |
| Late Postoperative Improvement (12+ months) | | | | | |
| SF-12 PCS | | | | | |
| Pre-operative SF-12 Physical Component Score | 42/38/2/17 | 38/31/4/36 | 0.17 | | |
| Early Postoperative Improvement (0-6 months) | 3/40/4/41 | 7/14/1/31 | 0.29 | 0.26 | <0.0001 |
| Mid Postoperative Improvement (6-12 months) | 7/32/7/29 | 4/11/1/44 | 0.79 | 0.02 | <0.0001 |
| Late Postoperative Improvement (12+ months) | | | | | |
| SF-12 MCS | | | | | |
| Pre-operative SF-12 Mental Component Score | 48/39/1/31 | 44/32/1/37 | 0.28 | | |
| Early Postoperative Improvement (0-6 months) | 10/10/10/40 | 4/10/1/4 | 0.09 | 0.007 | 0.001 |
| Mid Postoperative Improvement (6-12 months) | 4/10/10/40 | 4/10/1/4 | 0.09 | 0.007 | 0.001 |
| Late Postoperative Improvement (12+ months) | | | | | |
| PROMIS PF | | | | | |
| Pre-operative PROMIS Physical Function | 40/34/1/34 | 40/31/4/31 | 0.088 | | |
| Early Postoperative Improvement (0-6 months) | 9/10/1/9 | 9/11/1/14 | 0.09 | 0.006 | <0.0001 |
| Mid Postoperative Improvement (6-12 months) | 11/10/1/10 | 11/10/1/11 | 0.06 | 0.009 | <0.0001 |
| Late Postoperative Improvement (12+ months) | | | | | |

Table 2. Patient-Reported Outcomes Based on Torg-Pavlov Ratio

| | MCIID? | Torg Ratio | | p-value |
|---|--------|------------|-----------|---------|
| | | <0.82 | ≥0.82 | |
| NDI (6 weeks - 3months) - Change > MCID | No | 3 (10) | 15 (46.9) | 0.473 |
| | Yes | 7 (20) | 17 (46.9) | |
| NDI (<=6 months) - Change > MCID | No | 5 (55.6) | 9 (33.3) | 0.267 |
| | Yes | 4 (44.4) | 18 (66.7) | |
| VAS Neck (6 weeks - 3months) - Change > MCID | No | 2 (20) | 23 (28.1) | 1.000 |
| | Yes | 4 (40) | 17 (21.9) | |
| VAS Neck (<=6 months) - Change > MCID | No | 2 (40) | 4 (14.6) | 0.228 |
| | Yes | 3 (60) | 23 (85.2) | |
| VAS Arm (6 weeks - 3months) - Change > MCID | No | 1 (20) | 3 (12) | 0.538 |
| | Yes | 4 (80) | 22 (88) | |
| VAS Arm (<=6 months) - Change > MCID | No | 1 (20) | 13 (13) | 1.000 |
| | Yes | 4 (40) | 20 (20) | |
| SF-12 PCS (6 weeks - 3months) - Change > MCID | No | 8 (72.7) | 20 (57.1) | 0.486 |
| | Yes | 1 (7.3) | 15 (42.9) | |
| SF-12 PCS (<=6 months) - Change > MCID | No | 6 (60) | 16 (51.6) | 0.727 |
| | Yes | 4 (40) | 15 (48.4) | |
| SF-12 MCS (6 weeks - 3months) - Change > MCID | No | 4 (36.4) | 19 (54.3) | 0.491 |
| | Yes | 7 (63.6) | 16 (45.7) | |
| SF-12 MCS (<=6 months) - Change > MCID | No | 9 (90) | 13 (41.9) | 0.011 |
| | Yes | 1 (10) | 18 (58.1) | |

Table 3. Comparison of patients in each group who either did or didn't reach MCID.