Does Disc Distraction after Cervical Total Disc Arthroplasty Impact Range of Motion and Patient-Reported Outcomes?

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INTRODUCTION:

Total disc arthroplasty (TDA) has been established as a safe and effective alternative to anterior cervical discectomy and fusion (ACDF) in the treatment of cervical spine pathology. Recent clinical and biomechanical studies have demonstrated that the degree of disc height distraction after TDA may have an impact on both cervical kinematics and PROMs. However, there remains a paucity of literature regarding the amount of disc height distraction that can be tolerated biomechanically as well as its true impact on clinical outcomes.

METHODS: Consecutive patients who underwent 1- or 2-level cervical TDA with a minimum follow up of 1-year, lateral flexion/extension radiographs at preoperative, 6-weeks postoperative, and final postoperative follow up and patient-reported outcome metrics at preoperative and final follow-up timepoints were included. Radiographic outcomes included operative segment lordosis, segmental and cervical (C2-C7) range of motion (ROM) on flexion/extension, and heterotopic ossification (HO). General health and disease-specific PROMs were compared at the preoperative and final postoperative timepoints. Middle disc space height was measured on preoperative and 6 weeks postoperative lateral radiographs to quantify the magnitude of disc space distraction, and patients were grouped into <2mm distraction and >2mm distraction groups. Independent samples t-test was used to compare outcomes between groups while using multivariate linear regression to adjust for baseline differences.

RESULTS: Overall, 44 patients who received cervical TDA at 50 operative levels were included for analysis. Distraction <2mm was seen at 24 levels, while distraction >2mm was observed at 26 levels. There were no baseline differences except for younger age (42.00 ± 7.29 vs. 46.70 ± 7.52, p = 0.042) and less preoperative segmental lordosis (1.05 ± 3.79º vs. 4.40 ± 4.12º, p = 0.004) among patients with <2mm distraction. There were no differences in TDA device used between cohorts. Radiographically, after adjusting for baseline differences, <2mm distraction resulted in greater C2-C7 ROM at 6 weeks postoperatively (51.18 ± 14.51º vs. 38.32 ± 12.10º, p = 0.022) and final follow up (54.28 ± 13.75º vs. 36.23 ± 12.31º, p = 0.004), as well as a greater increase from preoperative to final postoperative timepoints (11.36 ± 21.19º vs. -6.96 ± 16.86º, p = 0.009). There were no postoperative differences in segmental lordosis, segmental ROM, or HO grades (p=0.450) between groups. When evaluating PROMs, significant improvement was noted for both groups in all PROMs (p<0.05), except for SF12 MCS and VR12 MCS. After controlling for baseline differences, distraction <2mm resulted in better final SF12 PCS (47.30 ± 9.03 vs. 43.55 ± 11.65, p = 0.038), VR12 PCS (49.78 ± 7.57 vs. 46.12 ± 10.80, p = 0.026), VAS Arm (0.68 ± 1.21 vs. 2.38 ± 2.85, p = 0.017), and VAS Neck (1.18 ± 1.79 vs. 3.34 ± 2.83, p = 0.008), as well as in greater improvement in VAS Neck (-4.59 ± 2.75 vs. -1.33 ± 3.70, p = 0.005) and NDI (-30.46 ± 15.08 vs. -9.98 ± -10.71 ± 21.32, p = 0.050).

DISCUSSION AND CONCLUSION: Patients with <2mm disc height difference had increased C2-C7 ROM at both 6 weeks and final follow up and significantly greater improvement in VAS neck and NDI after controlling for baseline differences. Limiting differences in disc space height to <2mm affected C2-C7 ROM, but not segmental ROM, suggesting that less distraction may result in more harmonious kinematics between all cervical levels.

Table 1. Baseline demographics and procedural characteristics between patients and operative levels based on the magnitude of disc space distraction.

	All Patients/Levels	< 2 mm Distraction	> 2 mm Distraction	p-value
Age (years)	44.45 ± 7.70	42.00 ± 7.29	46.70 ± 7.52	**0.042**
BMI	27.73 ± 4.89	26.56 ± 2.78	28.69 ± 6.00	0.175
Sex				0.365
Female	22/44 (50%)	12/21 (57.14%)	10/23 (43.48%)	
Male	22/44 (50%)	9/21 (42.86%)	13/23 (56.52%)	
Number of Levels				0.448
1-Level	38/44 (86.36%)	19/21 (90.48%)	19/23 (82.61%)	
2-Levels	6/44 (13.64%)	2/21 (9.52%)	4/23 (17.39%)	
Operative Level				0.499
C4-C5	2/44 (4.55%)	0/21 (0%)	2/23 (8.70%)	
C5-C6	20/44 (44.45%)	10/21 (47.62%)	10/23 (43.48%)	
C6-C7	16/44 (36.36%)	9/21 (42.86%)	7/23 (30.43%)	
C4-C6	1/44 (2.27%)	0/21 (0%)	1/23 (4.35%)	
C5-C7	5/44 (11.36%)	2/21 (9.52%)	3/23 (13.04%)	
Device				0.136
Mobi-C	29/50 (58%)	11/24 (45.83%)	18/26 (69.23%)	
M6	15/50 (30%)	11/24 (45.83%)	4/26 (15.38%)	
PCM	3/50 (7.69%)	1/24 (4.17%)	2/26 (7.69%)	
ProDisc-C	3/50 (7.69%)	1/24 (4.17%)	2/26 (7.69%)	
Follow Up (months)	33.12 ± 20.74	36.25 ± 21.56	30.27 ± 20.00	0.345

Bold p-value denotes statistical significance; BMI, Body Mass Index

Table 2. Radiographic outcomes between operative levels based on the magnitude of disc space distraction.

	All Levels	< 2 mm Distraction	> 2 mm Distraction	p-value
Preoperative				
Segmental Lordosis	2.79 ± 4.27	1.05 ± 3.79	4.40 ± 4.12	**0.004**
Segmental ROM	6.28 ± 3.81	6.70 ± 4.76	5.87 ± 2.61	0.519
C2-C7 ROM	40.41 ± 18.56	40.96 ± 24.04	39.85 ± 11.41	0.860
6 Weeks Postoperative				
Segmental Lordosis	5.55 ± 6.68	3.85 ± 6.77	7.12 ± 6.33	0.517
Segmental ROM	8.55 ± 3.88	8.05 ± 4.15	10.26 ± 2.39	0.404
C2-C7 ROM	47.97 ± 14.79	51.18 ± 14.51	38.32 ± 12.10	**0.022**
Final Postoperative				
Segmental Lordosis	6.30 ± 6.59	5.00 ± 6.68	7.50 ± 6.40	0.894
Segmental ROM	8.54 ± 4.47	9.21 ± 5.50	7.92 ± 3.25	0.915
C2-C7 ROM	45.25 ± 15.80	54.28 ± 13.75	36.23 ± 12.31	**0.004**
Δ				
Segmental Angle	3.50 ± 6.83	3.08 ± 7.18	3.86 ± 6.64	0.538
Segmental ROM	2.20 ± 5.54	2.39 ± 6.00	2.03 ± 5.26	0.277
C2-C7 ROM	2.20 ± 21.02	11.36 ± 21.19	-6.96 ± 16.86	**0.009**

Bold p-value denotes statistical significance; ROM, Range of Motion; HO, Heterotopic Ossification

Table 3. Patient-reported outcomes between operative levels based on the magnitude of disc space distraction.

	All Levels	< 2 mm Distraction	> 2 mm Distraction	p-value
Preoperative				
SF12 PCS	35.43 ± 9.45	33.58 ± 8.46	37.14 ± 10.14	0.641
SF12 MCS	51.76 ± 9.10	52.23 ± 7.36	51.33 ± 10.59	0.478
VR12 PCS	37.59 ± 10.44	35.88 ± 9.79	39.17 ± 10.95	0.890
VR12 MCS	54.15 ± 8.79	54.34 ± 7.24	53.97 ± 10.15	0.400
VAS Arm	5.23 ± 2.80	5.76 ± 2.73	4.77 ± 2.84	0.476
VAS Neck	5.25 ± 2.52	5.80 ± 2.45	4.76 ± 2.53	0.163
NDI	36.09 ± 15.83	41.81 ± 14.10	31.08 ± 15.84	0.381
Final Postoperative				
SF12 PCS	45.47 ± 10.45	47.30 ± 9.03	43.55 ± 11.65	**0.038**
SF12 MCS	55.11 ± 6.98	55.30 ± 6.57	54.91 ± 7.53	0.618
VR12 PCS	47.99 ± 9.37	49.78 ± 7.57	46.12 ± 10.80	**0.026**
VR12 MCS	59.12 ± 7.09	59.65 ± 6.41	58.57 ± 7.84	0.257
VAS Arm	1.55 ± 2.35	0.68 ± 1.21	2.38 ± 2.85	**0.017**
VAS Neck	2.28 ± 2.59	1.18 ± 1.79	3.34 ± 2.83	**0.008**
NDI	14.99 ± 14.75	10.77 ± 11.55	19.22 ± 16.55	0.058
Δ				
SF12 PCS	9.88 ± 11.91	13.37 ± 9.70	6.23 ± 13.09	0.071
SF12 MCS	2.95 ± 8.18	2.86 ± 8.71	3.05 ± 7.80	0.829
VR12 PCS	9.98 ± 11.57	13.29 ± 9.93	6.52 ± 12.35	0.118
VR12 MCS	4.80 ± 8.47	5.36 ± 9.39	4.22 ± 7.57	0.769
VAS Arm	-3.63 ± 3.85	-4.98 ± 3.22	-2.39 ± 4.03	0.063
VAS Neck	-2.89 ± 3.64	-4.59 ± 2.75	-1.33 ± 3.70	**0.005**
NDI	-20.36 ± 20.86	-30.46 ± 15.08	-10.71 ± 21.32	**0.050**

Bold p-value denotes statistical significance; SF12, Short Form 12-Item Health Survey; VR12 Veteran RAND 12-Item Health Survey; PCS, Physical Component Score; MCS, Mental Component Score; VAS, Visual Analog Scale; NDI, Neck Disability Index