



## Neck range of motion following cervical spinal fusion: A comparison of patient-centered and objective assessments



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### ABSTRACT

**Objectives:** A common question posed by patients undergoing cervical fusion pertains to the likelihood of perceiving a postoperative limitation in neck mobility. The aim of this study was to assess the change in neck mobility after subaxial cervical fusion using an objective range of motion (ROM) measure and patient reported assessment.

**Patients and methods:** Patients older than 18 years of age, undergoing first-time anterior or posterior subaxial cervical arthrodesis for a symptomatic spondylotic process (radiculopathy, cervical spondylotic myelopathy or primary neck pain) at a single center were eligible. Assessment included: 1) neck pain on a numeric rating scale; 2) four-directional objective neck mobility using the validated cervical ROM goniometer; and 3) a novel Mobility Assessment Scale (MAS) for patient perceived neck mobility. Subjects were dichotomized by number of levels fused (1–2 levels and  $\geq 3$  levels).

**Results:** There were 25 patients with a mean of  $2.7 \pm 1.5$  levels fused. Neck pain was improved in both groups with mean change of  $-3.4$  [95% CI  $-4.7, -2.1$ ],  $p = 0.004$  for 1–2 levels and  $-3.5$  [95% CI  $-5.4, -1.5$ ],  $p = 0.009$  for  $\geq 3$  levels. MAS score improved significantly in group undergoing 1–2 level fusion ( $-1.8$  [95% CI:  $-3.1, -0.4$ ],  $p = 0.016$ ) but not in those with  $\geq 3$  levels fused. There was a significant positive correlation between MAS and neck pain in the 1–2 level fusion group ( $r_s = 0.667$ ,  $p = 0.012$ ) but not in the  $\geq 3$  level group. Objective neck mobility did not change significantly in either group.

**Conclusions:** Patient reported neck mobility was significantly improved following 1–2 level cervical fusion. This change correlated significantly with patient reported improvement in neck pain. No significant difference in reported neck mobility was found in those undergoing fusion of  $\geq 3$  levels.

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## 1. Introduction

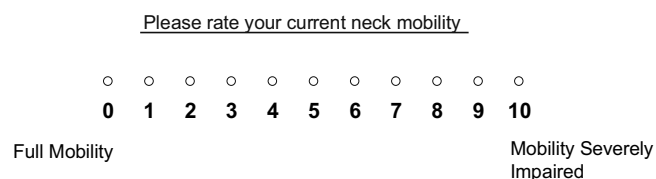
Traditionally, success following surgical intervention has been defined by objective outcome measures, frequently assessed by clinicians. The current era of patient centered care has ushered in new, and often more appropriate, definitions of success. These patient-reported outcome (PRO) instruments rely upon patients' own subjective perceptions of their outcome are now prominent in the field of spinal surgery. Herein, many surgical interventions are undertaken on an elective basis, largely with a goal of enhancing

quality of life and there has been greater emphasis on measurement on success following surgery as perceived by the individual patient.

Neck mobility represents a domain with a potential to impact quality of life following cervical spinal arthrodesis. Fusion is synonymous with lost mobility, and individuals undergoing cervical arthrodesis commonly ask "How much motion will I lose?" Generally, cervical range of motion (ROM) is graded with objective, radiographic measures of movement [1,2]. There has yet to be an accepted transition to patient centered measures for this important domain. The objective of this study was to better understand patients' perspective on cervical mobility following arthrodesis by using the novel, patient reported Mobility Assessment Scale (MAS) and compare the reported outcomes with objective assessment of cervical ROM using a validated instrument to measure cervical spine ROM.

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**Fig. 1.** Mobility Assessment Score (MAS). An 11-point numeric rating scale for self-perceived neck mobility.

## 2. Methods

A consecutive cohort of patients undergoing subaxial cervical arthrodesis at a single tertiary care institution were enrolled. Institutional review board approval was obtained prior to initiation of the study. Patients older than 18 years of age, undergoing first time cervical arthrodesis for a symptomatic spondylotic process (radiculopathy, cervical spondylotic myelopathy or primary neck pain) were eligible for inclusion. Those with active infection, neoplastic disease, rheumatoid arthritis or ankylosing spondylitis were excluded.

### 2.1. Clinical assessment

All patients had baseline clinical assessment that included demographics and comorbidities. Neck and arm pain were recorded using a standard 11-point numeric rating scale (NRS) and cervical spine specific disability was recorded using the Neck Disability Index (NDI) [3]. Patients were also asked to rate their self-perceived neck mobility using the novel MAS; an 11-point NRS (Fig. 1). During the same assessment, patients also had an objective neck mobility assessment with the previously validated and reliable cervical range of motion (ROM) goniometer (Performance Attainment Associates, Lindstrom, MN, USA) by a study research coordinator not involved in the clinical care of patients [4–7]. The following standardized protocol was implemented for the assessment: 1) the frame was set on the patients head, 2) a baseline recording on the appropriate inclinometer was established in the neutral position, 3) the patient was then asked to perform an active movement in the appropriate plane and a second recording was taken at the point of maximum movement, 4) the initial neutral value was subtracted from second value to obtain the maximal ROM [4]. This process was repeated until a value of maximal active ROM was obtained for each of flexion and extension in the sagittal plane and rightward and leftward lateral bending in the coronal plane. The final score for lateral bend ROM was taken as the average of the maximal active ROM for rightward and leftward movement. Neck rotation was not tested as all fusions were of the subaxial cervical vertebrae and minimal change in rotational ROM was anticipated. The surgical approach, number of operated levels and length of stay were recorded. Patients were then reassessed at 6-month clinical follow-up. Neck and arm pain, subjective neck mobility and objective neck ROM was recorded for each subject by an independent research assistant, blinded to the initial measurements and number of vertebral levels fused.

### 2.2. Statistical analysis

Raw data is presented using descriptive statistics. Continuous variables are presented as means with standard deviations and categorical data as frequencies with percentages. Patients were divided into dichotomous categories by number of vertebral levels fused (1–2 or  $\geq 3$ ) to provide sufficient numbers for statistical analyses. Within patient comparisons were made between baseline and follow-up assessments using the Wilcoxon matched-pairs signed-ranks test. Correlations were assessed using Spearman's

**Table 1**  
Patient Demographics and Surgical Characteristics.

Characteristic	Study Group (n = 25)
Age $\pm$ SD (years)	54.8 $\pm$ 14.7
Female (%)	15 (60)
Smoker (%)	6 (24)
Body Mass Index $\pm$ SD (kg/m <sup>2</sup> )	30.1 $\pm$ 5.2
Mean Number of Levels $\pm$ SD	2.7 $\pm$ 1.5
Length of Stay $\pm$ SD (days)	3.2 $\pm$ 3.0

Standard Deviation (SD).

rank correlation test. The level for accepting statistical significance was set at 0.05. Statistical analyses were performed using Stata 14 (Stata Corp, College Station, TX) (Table 2).

## 3. Results

Twenty-five patients were included in the study. Baseline demographics and surgical details are presented in Table 1. The majority of patients underwent an anterior cervical discectomy and fusion (ACDF) procedure (80%), while a smaller proportion underwent posterior (12%) or circumferential (8%) procedures. The distribution by number of vertebral levels fused was nearly equivalent within each group, with 13 (52%) subjects undergoing 1–2 level fusion and 12 (48%) having 3 or more levels fused. The full distribution by levels fused and surgical approach is detailed in Fig. 2.

Neck pain was significantly improved between preoperative baseline scores and postoperative assessment in both groups. Those undergoing 1–2 level fusions, had an average change in self-rated pain of  $-3.4$  [95% CI  $-4.7, -2.1$ ],  $p=0.004$  and those undergoing  $\geq 3$  level fusion had an average change of  $-3.5$  [95% CI  $-5.4, -1.5$ ],  $p=0.009$  (Fig. 3A). Self-reported neck mobility, using the MAS score, was significantly improved in the group undergoing 1–2 level of fusions with a mean change in score of  $-1.8$  [95% CI:  $-3.1, -0.4$ ],  $p=0.016$ , but there was no significant change for those with  $\geq 3$  levels fused (Fig. 3B). A significant correlation was found between the change in neck pain and the change in the MAS score for those in the 1–2 level group and also between increased neck extension for both groups. There was no significant correlation between change in neck pain and change in mobility for those in the group undergoing fusion of  $\geq 3$  levels (Table 3).

Objective neck mobility was not significantly changed in either group (Fig. 4). In the 1–2 level group, there was an increase neck

**Table 2**  
Preoperative to Postoperative Comparison of Outcome Metrics.

Outcome Metric	Preoperative	Follow-up	Mean Diff. (95% CI)	p value <sup>a</sup>
Neck Pain (11-Point NRS)				
1–2 Levels	7 $\pm$ 2.0	3.5 $\pm$ 2.2	$-3.4$ ( $-4.7, -2.1$ )	<b>0.004</b>
$\geq 3$ Levels	7.4 $\pm$ 2.7	4.2 $\pm$ 2.2	$-3.5$ ( $-5.4, -1.5$ )	<b>0.009</b>
Neck Disability Index				
1–2 Levels	22 $\pm$ 10.3	17.9 $\pm$ 10.7	$-2.0$ ( $-6.6, 2.6$ )	0.624
$\geq 3$ Levels	25.0 $\pm$ 10.7	17.1 $\pm$ 8.3	$-9.1$ ( $-15.0, -3.1$ )	<b>0.013</b>
Flexion (Degrees)				
1–2 Levels	39.1 $\pm$ 15.2	36.6 $\pm$ 15.4	$-3.1$ ( $-11.9, 5.7$ )	0.724
$\geq 3$ Levels	38.9 $\pm$ 16.0	34.7 $\pm$ 10.4	$-4.3$ ( $-13.8, 5.3$ )	0.170
Extension (Degrees)				
1–2 Levels	29.6 $\pm$ 14.9	39.0 $\pm$ 13.6	8.2 ( $-4.4, 20.7$ )	0.169
$\geq 3$ Levels	28.8 $\pm$ 8.0	27.1 $\pm$ 12.6	$-1.8$ ( $-8.5, 5.0$ )	0.409
Lateral Bend (Degrees)				
1–2 Levels	28.0 $\pm$ 9.3	30.2 $\pm$ 10.8	1.1 ( $-2.1, 4.3$ )	0.169
$\geq 3$ Levels	25.8 $\pm$ 9.5	24.6 $\pm$ 7.8	$-1.2$ ( $-6.7, 4.3$ )	0.409

Numeric Rating Scale (NRS); Mobility Assessment Scale (MAS); Confidence Interval (CI).

The p values that were statistically significant were mentioned in bold.

<sup>a</sup> Wilcoxon matched-pairs signed-ranks test.

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