Patient-Reported Outcomes and Complications of Simultaneous versus Staged Surgical Decompression for Tandem Spinal Stenosis

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Abstract

Introduction Tandem spinal stenosis (TSS) refers to the narrowing of the spinal canal at two distinct anatomic areas. Symptoms can present due to either cervical myelopathy or lumbar stenosis. Consequently, determining the symptomatic anatomical levels requiring surgery can pose a challenge. We sought to identify the surgical approach associated with better patient-reported outcomes.

Materials and Methods The Information Management System was queried using the International Classification of Diseases Ninth and Tenth Edition codes to identify patients who underwent simultaneous or staged decompression surgery for TSS between 2011 and 2020. Patient records were reviewed to collect data on age, sex, comorbidities, surgical approach, modified Japanese Orthopedic Association (mJOA) score, and complications. The mJOA is a validated composite assessment used to quantify postoperative neurological status. Multivariable regression models were utilized to identify factors associated with better postoperative neurological recovery.

Results Among 42 patients included in the analytical cohort, 33 (78.6%) underwent simultaneous cervical and lumbar decompression, while 9 (21.4%) underwent staged decompression (cervical followed by lumbar). The patient's age, sex, comorbid conditions, and American Society of Anesthesiologists level were similar between the two groups. Furthermore, simultaneous decompression was associated with higher blood loss (676.97 vs. 584.44 mL) and an increased need for transfusion (259.09 vs. 111.11 mL) compared with staged decompression. Moreover, patients who underwent simultaneous decompression experienced a higher number of postoperative complications (10 vs. 1; $p = 0.024$). Notably, postoperative mJOA scores improved in both groups; however, the improvement was more pronounced in the staged group (mJOA score: 15.16% [$\pm$2.18] vs. 16.56% [$\pm$1.59]). On follow-up visits, patients who

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- spinal stenosis
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underwent staged decompression showed better recovery rates (mJOA score: 78.20% [± 24.45] vs. 59.75% [± 25.05]).

Conclusion The patient's clinical history and examination findings should be the main determinants of surgical decision-making. Our study showed a slightly higher postoperative mJOA score and a recovery rate with fewer complications in staged decompression of TSS.

Introduction

Tandem spinal stenosis (TSS) refers to the narrowing of the spinal canal at two distinct anatomic areas.[1] The incidence of TSS increases with age due to age-related degenerative changes and it affects the more mobile areas of the spinal canal such as the cervical and lumbar areas.[2] Clinical identification of symptomatic levels in TSS presents as a diagnostic challenge for the spine surgeon. The patient may present with both upper and lower motor neuron signs and the symptoms of polyradiculopathy, sensorimotor deficits, gait disturbance, and urinary or fecal incontinence could be due to cervical myelopathy or lumbar stenosis-related neurogenic claudication.[3] While both conditions may require surgery, it is at times difficult to decide which anatomic level is symptomatic and should be treated first.[4] It is important to determine the appropriate approach, as at times the decompression of the most stenosed cervical segment can sometimes alleviate the majority of leg symptoms and patient may be spared of subsequent extensive lumbar decompression.[5]

There is no consensus on the best surgical approach and some surgeons suggest that cervical decompression should be treated first.[4] In contrast, others regard that the segment causing predominant symptoms should be addressed first.[4] Generally, myelopathy related to cervical stenosis is decompressed on a priority basis as that might decrease the need for lumbar decompression.[6] Another option is simultaneous surgical decompression of both cervical and lumbar levels in the same setting although that requires a relatively longer operative time and higher risks of possible adverse perioperative events especially since these are elderly patients.[7] There are anecdotal accounts in the literature about different elements that influence surgical decisiveness like the age of patients, presence of comorbidity, contiguity of stenotic levels, degrees of surgical invasiveness, and surgeon's preference.

Currently, there is a lack of high-quality evidence regarding the optimal strategy for managing patients with TSS, due to deficiencies in previous studies, including inadequate sample sizes, lack of comparative analyses of morbidities and complications, and insufficient objective assessment of outcomes.[4,5] Consequently, the current study aims to determine whether staged or simultaneous decompression yields superior clinical outcomes, encompassing recovery rates, and functional enhancement. Moreover, secondary objective included the identification of preoperative factors, comorbidities, and postoperative complications that impact recovery rates.

Materials and Methods

We performed a retrospective cohort study at the Aga Khan University Hospital, which is a tertiary care hospital located in Karachi, Pakistan. The hospital Information Management System was searched for patients who underwent simultaneous or staged decompression for cervical and lumbar stenosis using the International Classification of Diseases, Tenth Revision codes. All patients with clinical and radiological assessments consistent with cervical and lumbar stenosis, who underwent either simultaneous or staged decompression surgery for TSS between January 1, 2011, and December 31, 2020, were included in the study. Patients under 18 or over 80 years old, those with neuromuscular diseases, prior spine surgery, isolated nerve root surgery, spinal tumors, infections, fractures, developmental conditions, or any other nondegenerative pathologies were excluded from the study. The contact numbers of patients were retrieved from the hospital database and the informed telephonic verbal consent was obtained from the patients after verification of identity. Two subsequent attempts were made to contact patients who did not respond to the first phone call and nonrespondents were excluded. Of note, a predesigned questionnaire was used to collect patient-level data on basic demographics, type of procedure, modified Japanese Orthopedic Association (mJOA) score, as well as intraoperative and postoperative complications. Follow-up charts were also reviewed for mJOA scores and any possible complications. To maintain patient confidentiality, no patient identifiable information was recorded, and access to the recorded data was restricted to the principal investigator only. The Institutional Review Board at the Aga Khan University approved this study (Number: 2021–6538–19633).

The mJOA score was utilized to evaluate the functional state of patients. mJOA is a validated comprehensive tool consisting of four components addressing motor functions in the upper (5 points) and lower (7 points) extremities, sensation (3 points), and micturition (3 points). A score of 18 reflects no neurological deficits whereas a lower score indicates a greater degree of disability and functional impairment.[8] The preoperative mJOA score and the most recent mJOA score were used to calculate the recovery rate using the Hirabayashi method.[9]

$$\text{Recovery rate (\%)} = \frac{\text{(Postoperative mJOA} - \text{Preoperative mJOA)}}{\text{([Full Score]} - \text{Preoperative mJOA)} \times 100}$$

Statistical Analysis

For continuous variables mean and standard deviation or median and interquartile ranges (IQRs) were calculated, whereas frequencies and proportions were calculated for categorical variables. The data was not normally distributed so nonparametric tests were applied. Linear regression was used to determine the factors associated with a better recovery rate, and unadjusted and adjusted β coefficients, standard error, and 95% confidence interval were calculated. All plausible interactions were considered, and independent variables with a *p*-value of < 0.20 on univariate analysis were included in the multivariable model. A *p*-value of < 0.05 was considered significant. All statistical analysis was done using SPSS version 22.

Results

Among the 42 patients included in the study, 33 (78.6%) underwent simultaneous decompression for cervical and lumbar stenosis, while 9 (21.4%) patients underwent staged decompression (cervical followed by lumbar) for TSS. The analytic cohort had a mean age of 60.26 ± 11.61 years, with the majority being male ($n = 28$, 66.6%). Furthermore, baseline characteristics including age, sex, and comorbid conditions were similar in both groups (►**Table 1**). Notably, the number of stenotic levels was greater in the simultaneous group, and they had more extensive surgery (►**Table 2**). Furthermore, the intraoperative blood loss (676.97 mL [IQR: 500–925] vs. 584.44 mL [IQR: 400–765]) and the amount of blood transfused (259.09 mL [IQR: 0–700] vs. 111.11 mL [IQR: 0–150]) were similar in both groups. However, there was a statistically significant difference in the operative time for both groups, with almost double the time in the staged surgery group (429.11 minutes [IQR: 337–489] vs. 288.42 minutes [IQR: 185–347]; $p = 0.005$) (►**Table 1**). Postoperatively, the rate of complications was significantly higher in the simultaneous surgery group (10 vs. 1; $p = 0.024$). The complications in simultaneous surgery

Table 1 Comparison of patient demographics and surgical outcomes

Variable	Simultaneous group (33 patients)	Staged group (9 patients)	*p*-Value
Age	61.76 ± 11.03	54.78 ± 12.70	0.181
Sex			0.080
Male	21	7	
Female	12	2	
Comorbid conditions			0.062
DM	15	2	
HTN	20	5	
IHD	6	2	
ASA level			0.072
1	0	1	
2	20	4	
3	12	4	
4	1	0	
Complications			0.024
Wound infection	1	0	
MI	2	0	
UTI	2	1	
AKI	3	0	
Need for ICU	2	0	
Hospital stay (d)	4.22 (IQR: 4–5)	6.09 (IQR: 3.50–8)	0.086
Blood loss (mL)	676.97 (IQR: 500–925)	584.44 (IQR: 400–765)	0.928
Blood transfusion (mL)	259.09 (IQR: 0–700)	111.11 (IQR: 0–150)	0. 249
Operative time (min)	288.42 (IQR: 185–347)	429.11 (IQR: 337–489)	0.005
Preoperative mJOA score	11.39 ± 2.11	12.11 ± 1.83	0.358
Postoperative mJOA score	15.16 ± 2.18	16.56 ± 1.59	0.083
Recovery rate (%)	59.75 ± 25.05	78.20 ± 24.45	0.058

Abbreviations: AKI, acute kidney injury; ASA, American Society of Anesthesiologists; DM, diabetes mellitus; HTN, hypertension; ICU, intensive care unit; IHD, ischemic heart disease; IQR, interquartile range; MI, myocardial infarction; mJOA, modified Japanese Orthopedic Association; UTI, urinary tract infection.

Table 2 Total number of levels operated in simultaneous and staged groups

Total levels operated	Total cervical levels – total lumbar levels	Simultaneous group	Staged group
3	2–1	0	1
4	2–2	6	3
	3–1	1	0
5	1–4	1	1
	2–3	2	1
	3–2	6	0
6	2–4	2	0
	3–3	4	2
	4–2	4	0
7	3–4	1	0
	4–3	2	1
	5–2	2	0
8	5–3	2	0

patients included wound infection ($n = 1$), myocardial infarction (MI) ($n = 2$), urinary tract infection (UTI) ($n = 2$), acute kidney injury (AKI) ($n = 3$), and need for intensive care unit (ICU) ($n = 2$). In the simultaneous group, two patients had non-ST-elevation MI with raised troponin levels and were managed conservatively with antiplatelets and anticoagulants. Two patients in the simultaneous group needed postoperative ICU due to the prolongation of surgery, but both recovered well with no long-term complications, while none in the staged group required postoperative ICU.

The preoperative mJOA scores in both the simultaneous and staged group were similar, for motor functions in the upper extremities (3.06% vs. 3.44%) and lower extremities (4.16% vs. 4.33%), sensation (1.74% vs. 1.67%), and micturition (2.42% vs. 2.67%) (►**Fig. 1** and **2**). Postoperative mJOA scores improved in both groups, but the improvement was more pronounced in the staged group (15.16% ± 2.18 vs. 16.56% ± 1.59); however, this did not reach a significant level. Overall, the hospital stay in the simultaneous group was 4.22 days (IQR: 4–5) with a recovery rate of 59.75% (± 25.05), whereas the staged group had a longer hospital stay (6.09 days [IQR: 3.50–8]) with a better recovery rate 78.20% (± 24.45) (►**Table 1**).

On univariate linear regression with recovery rate as the dependent variable, age (beta coefficient: –0.049), hypertension (beta coefficient: –1.083), and American Society of

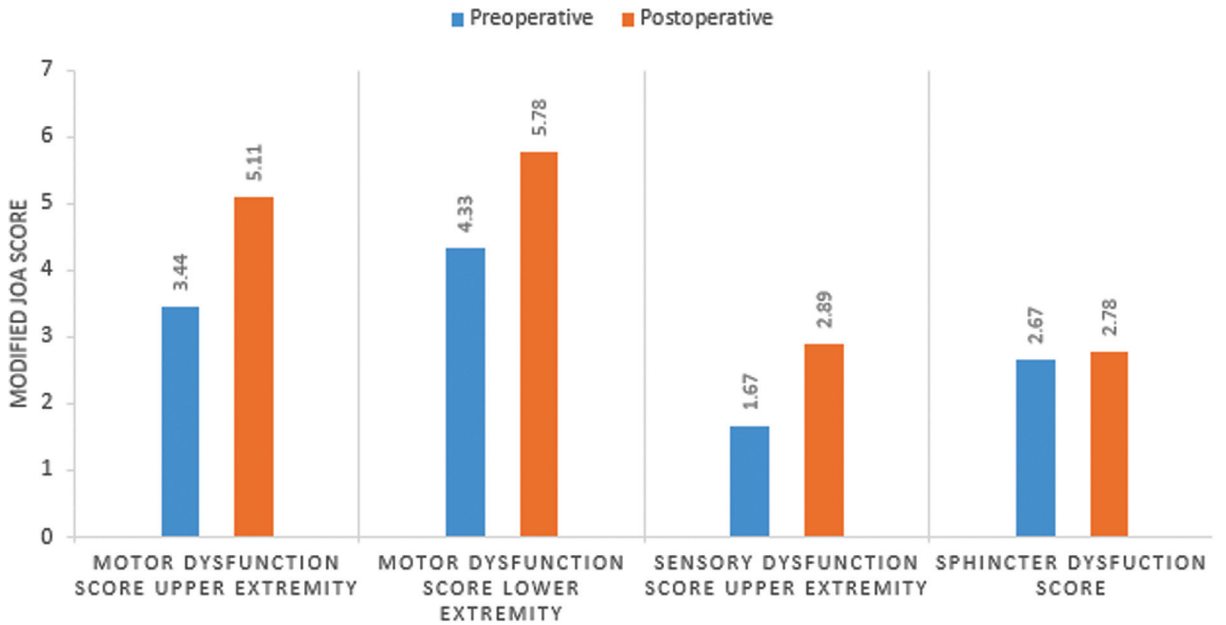

Fig. 1 Preoperative and postoperative modified Japanese Orthopedics Association score in patients who underwent simultaneous repair of tandem spinal stenosis (TSS).

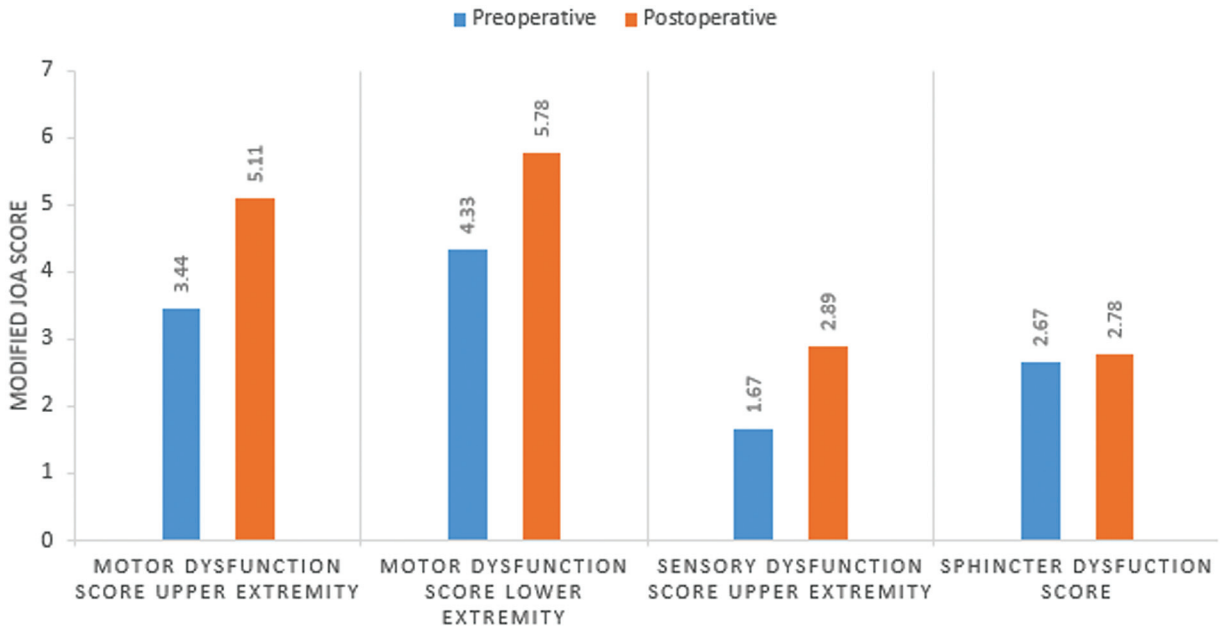

Fig. 2 Preoperative and postoperative modified Japanese Orthopedics Association score in patients who underwent staged repair of tandem spinal stenosis (TSS).

Anesthesiologists level (beta coefficient: –0.804) were negatively associated with recovery rate. Type of procedure (beta coefficient: 1.394) and preoperative mJOA (beta coefficient: 0.705) were positively associated with recovery rate. Whereas on multivariable linear regression, a higher preoperative mJOA was significantly associated with a better recovery rate (►**Table 3**).

Discussion

While deciding on the surgical approach in TSS, a few key considerations include the patient's functional status and comorbidities. Elderly patients with multiple comorbidities have been shown to suffer from more postoperative complications when undergoing simultaneous surgery, probably due to prolonged anesthesia time. Sun et al, in their study, selected those with good physical health, no contraindications to surgery, age less than 60 years old, and severe neck and waist symptoms for single-staged operation, and those patients with TSS whose symptoms were mainly located to a single site for two-staged operation. The study suggested that imaging manifestations, clinical symptoms, patient preferences, and financial circumstances should also be taken into account when devising a surgical plan.[10] However, good, encouraging, and comparable results with simultaneous surgery have also been found in the literature. Abbas et al showed significant improvement in clinical parameters postoperatively after single-staged surgery in young as well as elderly without any significant difference between them. At the final follow-up, none of the patients had any neurological deficits.[5] A randomized control trial done in 2016 also concluded that single-stage surgery had comparable clinical outcomes compared with two-stage operations without exposing the patients to unnecessary risks.[11]

At our center, the patients were selected for either of the surgeries mainly based on the surgeon's preference, the patient's choice, and symptom localization. However, we believe that another factor that might have been considered at our setup would be the financial status of the patient as that can be of significant value in low- and middle-income countries. Although the authors could not find any evidence of the cost-effectiveness of both surgeries in the reported literature, it only seemed obvious that additional hospital admission, surgery, and anesthesia charges would increase the cost in phased operations. In our study, the authors found that there was no significant difference in the age and comorbidities of patients in both groups. The combined operative time for both stages in the staged group was longer than the simultaneous surgery group (429.11 vs. 288.42 minutes, respectively, $p = 0.005$); however, the difference in hospital stay was relatively narrow (4.22 day in simultaneous vs. 6.09 days in the staged group, respectively, $p = 0.086$). More levels were operated on in the simultaneous group (►**Table 2**), likely resulting in more blood loss and complications than in the staged surgery group (259.09 vs. 111.11 mL). Eskander et al, in their study, suggested that patients who were operated on for less than 150 minutes and had an estimated blood loss of less than 400 mL were less likely to have major complications regardless of the choice of surgery.[12] In this study, the patients in the simultaneous group suffered from complications like wound infection ($n = 1$; 3.03%), MI ($n = 2$; 6%), UTI ($n = 2$; 6%), AKI ($n = 3$; 9.09%), and need for intubation ($n = 2$; 3.03%) postoperatively, while the complications in staged surgery included UTI in one patient (11%) postoperatively.

The authors used a mJOA score to compare neurological outcomes in both groups. The most recent meta-analysis of tandem spine stenosis, published in February 2023 by Lu

Table 3 Univariate and multivariate regression analysis with recovery rate as the dependent variable

Factors	Univariate				Multivariate regression model			
	Unstandardized coefficient (β)	Significance	95% CI for β		Unstandardized coefficient (β)	Significance	95% CI for β	
			Lower bound	Upper bound			Lower bound	Upper bound
(Constant)					5.560	0.044	0.149	10.971
Age	−0.049	0.098	−0.107	0.009		NS		
Hypertension	−1.083	0.115	−2.444	0.277		NS		
Procedure (single/staged)	1.394	0.083	−0.190	2.979		NS		
ASA level	−0.804	0.163	−1.948	0.340		NS		
Preoperative mJOA score	0.705	0.00	0.456	0.954	0.706	0.00	0.440	0.971

Abbreviations: ASA, American Society of Anesthesiologists; CI, confidence interval; mJOA, modified Japanese Orthopedic Association; NS, not significant.

et al, analyzed the data from inception to September 22, 2022, and suggested that outcomes in terms of postoperative JOA score were better after the two-staged procedure in most of the studies for cervical-lumbar stenosis; however, the sample size had fewer patients treated via simultaneous decompression than two-staged procedure. Other operative variables like surgical time, total blood loss, and complications revealed similar results in both groups. The analysis declared that the elderly and those with multiple comorbidities and in a poorer health state had more chances to be selected for staged operation by surgeons.[13] Our results did not show any significant difference in JOA outcomes in patients treated simultaneously or via staged surgery ($p = 0.083$). All the other parameters, including blood loss, blood transfusion, and hospital stay showed no significant difference in either group. We also found that the preoperative JOA score had a significant effect on outcomes, and the better the preoperative score, the better are the outcomes. We have reviewed and tabulated the results of the major and most recent meta-analysis and systematic reviews for cervical-lumbar tandem spine stenosis published by Lu et al and Ahorukomeye et al, and have compared our result with the studies previously conducted for staged or simultaneous surgery outcomes for cervical-lumbar TSS.[13,14]

The limitations of our study are that it is a single institutional retrospective study with a limited sample size. Moreover, only the JOA score was used to evaluate the surgical outcomes; other scales, such as the Oswestry Disability Index, Nurick's grade, and Cooper scale, were not used to verify the similarity in results.[15] The patients in the staged group were younger than the simultaneous group and this may underestimate some of the complications. In our study, the time interval between staged operations was extensive. The fact that patients were selected for both groups based on surgeons' preferences may have introduced bias.

The current data indicates that while simultaneous decompression may offer certain advantages such as reduced operative time, staged decompression appears to result in fewer postoperative complications and potentially better functional outcomes. However, for surgical decision making, it is imperative to note that these conclusions should be validated on a case-by-case basis, particularly considering the presence of cervical spondylotic myelopathy and preoperative functional status of patients on surgical outcomes. Furthermore, preoperative assessment, particularly of mJOA scores, plays a crucial role in predicting recovery rates and guiding treatment decisions for patients with tandem stenosis. To corroborate our findings and abate bias, future prospective studies employing randomization and a larger patient cohort with extended follow-up periods are warranted. Moreover, future studies should incorporate recent advancements in surgical techniques, including minimally invasive approaches, for a comprehensive assessment of outcomes.

Conclusion

The patients' clinical symptomatology and pertinent imaging findings should be the main determinants of surgical

decision-making. Our study showed a slightly higher postoperative mJOA score and a better recovery rate with fewer complications in staged decompression of TSS. Surgeons should approach TSS with careful deliberation, emphasizing symptomatic presentation to dictate therapeutic decisions and prioritizing the treatment of cervical spondylotic myelopathy, while taking into account the patient-related comorbidities and anticipated functional outcomes.

Note

Institutional Review Board Approval No. 2021-6538-19633.

Authors' Contributions

M.M.H. contributed to the conception and design of the manuscript, drafted and revised the manuscript critically for important intellectual content, and agreed to be accountable for the article. M.K. was involved in drafting the manuscript, data analysis, critical review of the manuscript draft, and agreed to be accountable for the article. F.S. participated in drafting the manuscript, critical review of the manuscript draft, and agreed to be accountable for the article. I.F.M.A. focused on data collection, obtaining consent, and agreed to be accountable for the article. M.M. contributed to drafting the manuscript, collecting data, and agreed to be accountable for the article. M.S.S. was responsible for the conception and design of the manuscript, revising the manuscript critically for important intellectual content, and agreed to be accountable for the article.

Conflict of Interest

None declared.

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