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ORIGINAL ARTICLE

Predictors of Functional Recovery after Posterior Decompression and Pedicle Screw-Rod Fixation in Unstable Thoracic Spine Pathology

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ABSTRACT

Introduction: *Unstable thoracic spine pathology carries a high neurological risk due to the narrow canal and rigid rib cage, often causing motor, sensory, and autonomic deficits. Posterior decompression with pedicle screw-rod fixation restores stability, but recovery varies. This study aims to identify predictors of functional recovery following this surgical approach.* ***Methods and materials:*** *This study was conducted from January 2021 to December 2023 at the Department of Orthopaedic, Bangladesh Medical University, including 57 consecutive patients with unstable thoracic spine pathology. Patients underwent posterior decompression with pedicle screw-rod fixation. Neurological, functional, and radiological outcomes were assessed pre- and post-operatively at 1, 3, 6, and 12 months using the modified Macnab criteria. Data were analysed using SPSS version 26, including descriptive statistics and logistic regression; $p < 0.05$ was considered significant.* ***Results:*** *Most patients were middle-aged (mean 39.6 years) and 56.1% female. Post-operatively, bowel-bladder dysfunction fell from 77.2% to 3.5%, full motor recovery occurred in 73.7%, and full sensory recovery in 71.9%. Functional mobility improved, with 56.1% walking with support and 43.9% independently. Excellent outcomes increased to 64.9%, and 78.9% achieved satisfactory recovery. Age >40, absent pre-operative motor or sensory function, bowel-bladder involvement, and post-operative complications were independent negative predictors.* ***Conclusion:*** *Posterior decompression with pedicle screw-rod fixation provides significant neurological and functional improvement in patients with unstable thoracic spine pathology.*

Keywords: *Thoracic Spine Instability, Posterior Decompression, Pedicle Screw-Rod Fixation, Functional Recovery Predictors*

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INTRODUCTION

Thoracic spine pathology with instability is a significant clinical problem because the rigid thoracic cage and narrow spinal canal make the thoracic spinal cord particularly susceptible to severe compression. Even a relatively slight compromise of the canal in this region may produce significant neurological deficits. Neurological status at presentation is widely recognised as one of the strongest predictors of postoperative recovery, with several studies confirming its importance in determining functional outcomes after thoracic spinal cord injury [1]. Conditions such as trauma, infection, degeneration, or neoplastic instability commonly result in impairments regarding motor functions, sensations, or even autonomic functions-all factors that underscore the urgency of adequate decompression to prevent irreversible damage. Among the preferred methods of surgical management for unstable thoracic lesions is posterior decompression with pedicle screw-rod fixation. Relatively strict posterior instrumentation provides reliable stabilisation, allows circumferential neural decompression, and enables early mobilisation by restoring a correct biomechanical alignment. These advantages contribute to

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measurable improvements in clinical and radiological outcomes across various thoracic pathologies, including traumatic, infectious, and degenerative conditions [2,3]. Despite the reliability and widespread acceptance of this technique, the degree of postoperative neurological and functional recovery varies substantially among patients. Therefore, an investigation of the determinants associated with favourable surgical outcomes is warranted. Pre-operative neurological condition remains the most consistent and influential factor related to recovery. Patients presenting with incomplete motor deficits generally have a much higher likelihood of recovering functional independence compared with those patients presenting with complete paralysis [4]. The severity of pre-operative sensory impairment reflects the magnitude of spinal cord injury and is strongly correlated with limited postoperative improvement [5]. These relationships demonstrate the prognostic value of detailed neurological assessment before surgery and reinforce the importance of early intervention before deficits progress. Age represents another important determinant of recovery following thoracic spinal cord decompression. The older patient often demonstrates reduced neurological improvement, which is attributed to lessened neural plasticity, slower healing capacity and cumulative burden of degenerative changes [6]. Evidence of autonomic dysfunction, in particular involving bowel or bladder control, further points toward more advanced or severe spinal cord compromise. Such involvement is invariably associated with poorer functional outcomes and lower potential for postoperative recovery [7]. Perioperative and postoperative complications also have a meaningful influence on recovery trajectories. Evidence has accrued to suggest that the timing of decompression is relevant because early decompression limits the progression of secondary injury mechanisms such as oedema, ischemia, and inflammatory damage, leading to improved neurological outcomes [8]. On the other hand, complications like pedicle screw malposition, dural tears, cerebrospinal fluid leakage, or postoperative infections may impede rehabilitation, prolong hospitalisation, and unfavorably affect long-term functional results [9,10]. Pathology further modifies the potential for recovery- for example, traumatic disc injuries might alter alignment and stability and predispose patients to correction loss even after fixation [11]. On the other hand, infectious causes, if decompressed and stabilised early in their course, may demonstrate better neurological progression due to reduced chronic compression [12]. Identifying predictors of functional recovery after posterior decompression and pedicle screw-rod fixation becomes paramount in optimising surgical decision-making with those multidimensional influences, preoperative counselling and postoperative rehabilitation strategies. This study aims to assess the predictors of functional recovery after posterior decompression and pedicle screw-rod fixation in unstable thoracic spine pathology.

METHODS & MATERIALS

This study was conducted from January 2021 to December 2023 at the Department of Orthopaedic, Bangladesh Medical University, including 57 purposively selected consecutive patients regardless of age or sex presenting with unstable thoracic spine pathology. Cases that required a thoracic corpectomy with cord compression or that involved instability brought on by trauma, infection, tumor, or deformity were eligible. Excluded were patients who were medically unfit for surgery, unable to take part in follow-up, or unwilling to cooperate with rehabilitation. Demographics, underlying etiology, neurological status (pain level, motor and sensory function, bowel–bladder involvement, ambulatory capacity), radiological findings, operative details, and postoperative events were all recorded using a structured questionnaire. Bone scans were done selectively, and clinical assessments of instability and cord compression were validated by X-ray, CT, and MRI. Every procedure was carried out using a posterior midline approach while under general anesthesia. Pedicle screw-rod fixation was used for stabilization after posterior decompression, suitable for the lesion. All patients received standardized analgesia, bracing, and early mobilization as tolerated, and perioperative care followed institutional protocols. To evaluate neurological recovery, pain, mobility, and complications, follow-up assessments were carried out at 1, 3, 6, and 12 months. The modified Macnab criteria were used to grade functional status both before and after surgery. The results were categorized as either satisfactory (excellent/good) or unsatisfactory (fair/poor). Baseline and postoperative variables were compiled using descriptive statistics. Paired proportion tests with corresponding absolute risk differences and 95 percent confidence intervals were used to analyze changes in proportions. Multivariable logistic regression and univariate tests were used to find predictors of functional recovery, and adjusted odds ratios were reported. Statistical significance was defined as a p-value <0.05.

RESULTS

Table I summarizes the demographic characteristics of the study population. The mean age of the participants was 39.6 ± 15.8 years. The highest proportion of individuals was in the 21-30 years age group (31.58%), followed by those aged >50 years (26.32%). The remaining participants were distributed across the 31-40 years (19.30%), 41-50 years (17.54%), and 11-20 years (5.26%) categories. Females constituted 56.14% of the study population, while males represented 43.86%, indicating a slight predominance of female participants. [Table I]

Table – I: Demographic Characteristics of the study Population (*n* = 57)

Variable	Category	(n)	(%)
Age (years)	11-20	3	5.26%
	21-30	18	31.58%
	31-40	11	19.30%
	41-50	10	17.54%
	>50	15	26.32%
Mean ± SD		39.6 ± 15.8	
Sex	Male	25	43.86%
	Female	32	56.14%

Table II shows that patients experienced marked neurological improvement after surgery. Preoperatively, bowel and bladder dysfunction were present in 77.19% of patients, but this dropped sharply to 3.51% postoperatively. Motor deficits were also common before surgery, with 75.44% exhibiting diminished function. After surgery, 73.68% achieved full

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recovery, while the remainder showed partial improvement. Sensory impairments were frequent preoperatively, yet postoperative results indicate significant recovery, with 71.93% achieving full sensory restoration.

Table – II: Neurological Status Before and After Surgery (*n* = 57)

Parameter	Category	Frequency	%age
Bowel & bladder (Pre-op)	Present	44	77.19%
	Absent	13	22.81%
Bowel & bladder (post-op)	Present	2	3.51%
	Absent	55	96.49%
Motor function (Pre-op)	Diminished	43	75.44%
	Absent	14	24.56%
Motor function (Post-op)	Full recovery	42	73.68%
	Partial recovery	15	26.32%
Sensory status (Pre-op)	Diminished	39	68.42%
	Absent	13	22.81%
	Intact	5	8.77%
Sensory status (Post-op)	Full recovery	41	71.93%
	Partial recovery	13	22.81%
	Intact	3	5.26%

Table III demonstrates that perioperative complications were low, with 41 cases (71.93%) showing none, while dural tears occurred in 7 (12.28%) and haemorrhage in 9 (15.79%). Post-operatively, 46 patients (80.70%) had no complications, with donor-site pain in 6 (10.53%) and residual pain in 5 (8.77%). [Table III]

Table – III: Complications During and After Surgery (*n* = 57)

Complication	Category	Frequency	%age
Per-operative	No complication	41	71.93%
	Dural tear	7	12.28%
	Per-operative hemorrhage	9	15.79%
Post-operative	No complication	46	80.70%
	Donor site pain	6	10.53%
	Residual pain	5	8.77%

Table IV shows marked improvement in functional and pain outcomes after surgery. Before the operation, 77.19% of patients could not stand or walk, and 94.74% experienced pain. Postoperatively, all patients regained mobility, with 56.14% walking with support and 43.86% walking independently. Pain was substantially reduced, with 84.21% reporting complete relief. [Table IV]

Table – IV: Functional and Pain Outcomes (*n* = 57)

Parameter	Category	Before Operation (n, %)	After Operation (n, %)
Ability to stand/walk	Can't stand/walk	44 (77.19%)	-
	Can stand/walk	13 (22.81%)	-
	Walk with support	-	32 (56.14%)
	Walk without support	-	25 (43.86%)
Pain	Present	54 (94.74%)	9 (15.79%)
	Absent	3 (5.26%)	48 (84.21%)

Table V shows that overall functional status improved markedly after surgery. Before the operation, none of the patients had excellent or good function, while the majority were classified as poor (64.9%) or fair (35%). After surgery, 64.91% achieved an excellent outcome and 14% a good outcome, with only 7% remaining in the poor category. The final overall result reflects this improvement, with 78.9% of patients achieving a satisfactory outcome and only 21% classified as unsatisfactory. [Table V]

Table – V: Overall Functional Outcome and Study Result (*n* = 57)

Outcome	Category	Before Operation (n, %)	After Operation (n, %)
Functional outcome	Excellent	0 (0%)	37 (64.91%)
	Good	0 (0%)	8 (14%)
	Fair	20 (35%)	8 (14%)
	Poor	37 (64.9%)	4 (7%)
Final Outcome	Satisfactory	-	45 (78.9%)
	Unsatisfactory	-	12 (21%)

Table VI indicates that satisfactory functional recovery was higher in patients ≤40 years old. Specifically, 93.8% in this group recovered satisfactorily compared with 60% in those >40 years (p = 0.003). The other variables similarly showed

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distinct trends, with males (72.0%) and females (84.4%) demonstrating comparable outcomes (p = 0.41). Pre-operative motor status favoured those with diminished function (88.4%) over absent function (50%; p = 0.001). Sensory status also influenced recovery, with intact sensation (100%) and diminished sensation (84.6%) showing better outcomes than absent sensation (53.8%; p = 0.012). Patients without bowel–bladder dysfunction had superior recovery (100%) compared to those with dysfunction (72.7%; p = 0.004). Absence of peri-operative complications improved outcomes (87.8% vs 56.3%; p = 0.028), as did absence of post-operative complications (87.0% vs 45.5%; p = 0.016). [Table VI]

Table – VI: Association between baseline variables and satisfactory functional recovery (*n* = 57)

Predictor Variable	Category	Satisfactory (n = 45) (n, %)	Unsatisfactory (n = 12) (n, %)	p-value
Age group (years)	≤40 (n=32)	30 (93.8%)	2 (6.2 %)	0.003
	>40 (n=25)	15 (60.0 %)	10 (40.0 %)	
Sex	Male (n=25)	18 (72.0 %)	7 (28.0 %)	0.41
	Female (n=32)	27 (84.4 %)	5 (15.6 %)	
Pre-operative motor function	Diminished (n=43)	38 (88.4 %)	5 (11.6 %)	0.001
	Absent (n=14)	7 (50.0 %)	7 (50.0 %)	
Pre-operative sensory status	Intact (n=5)	5 (100 %)	0 (0 %)	0.012
	Diminished (n=39)	33 (84.6 %)	6 (15.4 %)	
	Absent (n=13)	7 (53.8 %)	6 (46.2 %)	
Pre-operative bowel & bladder dysfunction	Absent (n=13)	13 (100 %)	0 (0 %)	0.004
	Present (n=44)	32 (72.7 %)	12 (27.3 %)	
Per-operative complications	No (n=41)	36 (87.8 %)	5 (12.2 %)	0.028
	Yes (n=16)	9 (56.3 %)	7 (43.7 %)	
Post-operative complications	No (n=46)	40 (87.0 %)	6 (13.0 %)	0.016
	Yes (n=11)	5 (45.5 %)	6 (54.5 %)	

Table VII demonstrates the independent predictors of reduced satisfactory functional recovery. These included age >40 years (AOR 0.22, p = 0.024), absent pre-operative motor (AOR 0.18, p = 0.008) or sensory function (AOR 0.31, p = 0.042), bowel-bladder involvement (AOR 0.29, p = 0.039), and post-operative complications (AOR 0.27, p = 0.037). [Table VII]

Table – VII: Multivariable Logistic Regression Identifying Independent Predictors of Satisfactory Functional Recovery (*n* = 57)

Predictor Variable	Adjusted Odds Ratio (AOR)	95 % CI	p-value
Age > 40 years	0.22	0.05-0.81	0.024
Pre-operative motor absent	0.18	0.04-0.62	0.008
Pre-operative sensory absent	0.31	0.09-0.96	0.042
Bowel & bladder involvement	0.29	0.07-0.94	0.039
Per-operative complications	0.41	0.11-1.38	0.14
Post-operative complications	0.27	0.08-0.93	0.037

Table VIII shows that several factors predict reduced functional recovery. Older age (>40 years) and absent pre-operative motor or sensory function were associated with poorer outcomes. Bowel-bladder involvement and post-operative complications also significantly lowered the odds of satisfactory recovery, reflecting severe spinal cord injury and limited neurological reserve. Early intervention and prevention of complications are essential to maximize recovery. [Table VIII]

Table – VIII: Determinants of functional recovery (*n* = 57)

Significant Predictor	Direction of Effect	Clinical Interpretation
Age > 40 years	Lower recovery (AOR 0.22)	Older patients recover more slowly due to degeneration and poor neurological reserve
Pre-op motor absent	Strong negative predictor (AOR 0.18)	Complete paralysis predicts poorer outcomes
Pre-op sensory absent	Moderate negative predictor (AOR 0.31)	Severe cord disruption leads to limited post-op gain
Bowel & bladder involvement	Significant negative predictor (AOR 0.29)	Indicates high-grade cord injury
Post-op complications	Reduces odds of good recovery (AOR 0.27)	Infection or donor site pain delays rehabilitation

DISCUSSION

The study population was predominantly female (56.1%) with a mean age of 39.6 years. Participants were mostly between 21 and 30 years of age, at 31.6%, and over 50 years of age, at 26.3%. Fehlings et al. described thoracic spine injury patients as mainly middle-aged with slight male predominance, while Joaquim et al. showed a similar pattern of age distribution in cohorts with thoracic spine trauma treated surgically [13, 14]. This is a reflection of the inclusion of degenerative in addition to traumatic pathologies. Bowel-bladder dysfunction declined from 77.2% pre-operatively to 3.5% post-operatively. Full motor recovery occurred in 73.7% of cases, and partial recovery in 26.3%. Full sensory recovery was observed in 71.9% of cases, and partial recovery in 22.8%. Aarabi et al. reported motor improvement in 68% of the patients with thoracic spinal cord injury after decompression, and Rajasekaran et al. reported neurological improvement in 70-75% of the patients following posterior stabilization [15,16]. Our study demonstrated slightly higher motor and sensory recovery, likely due to early surgical intervention and structured rehabilitation. The perioperative complications were minimal; no complications were noted in 71.9%, dural

tears in 12.3%, and haemorrhage in 15.8%. Post-operatively, no complications were seen in 80.7%, donor-site pain in 10.5%, and residual pain in 8.8%. La Maida et al. quoted the incidence of dural tear during thoracic instrumentation as ranging from 5 to 15% and Rajasekaran et al. stated the post-operative complication rate following surgery as ranging from 10 to 12% [16,17]. Our study represents the complication profile that portends posterior fixation to be safe even in unstable thoracic pathology. There was a significant improvement in the functional outcomes. Pre-operatively, 77.2% of patients were unable to walk, while in the post-operative period, 56.1% walked with support and 43.9% independently. Pain prevalence decreased from 94.7% to 15.8%. Aarabi et al. reported 66-68% ambulatory recovery after decompression in thoracic injury patients, while Furlan et al. recorded a reduction of 60-70% in pain scores [15,18]. Our cohort achieved slightly higher ambulatory recovery and greater pain reduction, likely due to combined decompression and pedicle fixation, allowing early mobilisation. Overall functional outcomes improved, excellent outcomes increased from 0% pre-operatively to 64.9%, good outcomes increased to 14%, fair outcomes remained at 14%, and poor outcomes decreased from 64.9% to 7%. Rajasekaran et al. reported 70-80% good-to-excellent outcomes following posterior stabilization [16]. Our study had a higher proportion in the excellent category, probably reflecting early surgery and effective post-operative rehabilitation. Analysis of baseline variables showed that patients aged ≤40 years had 93.8% satisfactory recovery, while patients >40 years had 60%. Divi et al. showed that with increasing age, there is a significant reduction in recovery potential because of diminishing neurological reserve [19]. Pre-operative motor function strongly influenced the outcomes; 88.4% of patients with diminished motor function had satisfactory recovery, compared with 50% with absent motor function. Scivoletto et al. also reported that complete motor deficits result in a substantial reduction of functional gains [20]. Sensory status and bowel-bladder dysfunction also accurately predicted recovery; 100% of patients with intact sensory function recovered, versus 53.8% with absent function, and 100% with no bowel-bladder involvement achieved recovery, versus 72.7% with involvement. McKinley et al. reported that autonomic dysfunction reflects severe cord injury and diminishes recovery potential [21]. It also reported that absent sensory function predicts limited neurological restoration after spinal cord trauma [18]. Multivariable analysis confirmed that factors including age >40 years, absence of pre-operative motor or sensory function, bowel-bladder involvement, and post-operative complications independently predicted poorer recovery. Kwon et al. identified the baseline neurological severity and autonomic dysfunction as key determinants of functional outcome [22]. Post-operative complications reduced the likelihood of recovery, in line with the previous finding of Wilson et al. that infections or dural problems delay rehabilitation and limit neurological improvement [23]. Overall, older age, severe baseline deficits, autonomic involvement, and surgical complications were critical determinants of functional recovery. The overall pattern of findings aligns strongly with Ghobrial et al., whose meta-analysis highlighted older age, more severe neurological deficits, and complications as principal predictors of poorer outcomes following thoracic and thoracolumbar surgery [24]. This study reinforces the importance of early decompression, careful surgical technique, and the prognostic role of baseline neurological function in determining recovery following fixation for unstable thoracic spine pathology.

Limitations of the Study

This study is limited by its small sample size, single-centre design, and purposive sampling, which may restrict generalisability. Short follow-up duration and reliance on clinical rather than electrophysiological assessments may underestimate long-term neurological recovery and functional progression.

CONCLUSION

Posterior decompression with pedicle screw-rod fixation is effective for unstable thoracic spine pathology, producing notable neurological and functional recovery. Younger age, preserved pre-operative motor and sensory function, absence of bowel-bladder involvement, and an uncomplicated postoperative course were strong predictors of good outcomes. Conversely, older age, complete deficits, autonomic dysfunction, and complications reduced recovery potential. Overall, early intervention and careful perioperative management are essential to achieving optimal functional recovery.

RECOMMENDATIONS

Future studies would include larger multicentre cohorts, longer follow-up durations, and comparisons of surgical approaches. Incorporating advanced imaging, biomarkers, and rehabilitation variables might help refine predictive models and improve understanding of factors influencing functional recovery in unstable thoracic spine pathology.

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