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Evaluation of Pedicle Screw Fixation in Thoracolumbar Fractures: Short vs. Intermediate Fixation

Sarang Sawarbandhe[1]*, Sudhendoo S Babhulkar[2], Amit Kate[3]

[1]Assistant Professor, Dept. of Orthopaedics Government Medical College, Nagpur, India
[2]Consultant Neurosurgeon, Nanavati Maxsuperspeciality Hospital, Mumbai, India
[3]Senior Resident, Trauma Care Centre, Dept. of Orthopaedics, Government Medical College, Nagpur, India

***Address for Correspondence:** Dr. Sarang Sawarbandhe, Assistant Professor, Dept. of Orthopaedics Government Medical College, Nagpur, India
E-mail: drsarang_s@yahoo.com

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ABSTRACT

Background: This study examines thoracolumbar fractures, among the most prevalent spinal injuries originating from high-energy trauma. To stabilize these fractures, pedicle screw fixation is a surgical technique that is frequently utilized. Both conventional short-segment fixation (CSSF) and intermediate screw fixation (ISF), which regulate the ideal surgical approach, are compared in this study. The clinical and radiological results of both procedures are compared.

Methods: This prospective study comprised 30 patients with mild thoracolumbar burst fractures, categorized into two groups: Group A, which got posterior short-segment fixation with vertebral augmentation, and Group B, which underwent conventional short-segment pedicle fixation. Patients were 30-55 years old with an LSC score of 3 or 4 and 1.5 years of follow-up. Radiological and functional outcomes were evaluated utilizing VAS, ODI, and metrics such as vertebral wedge angle and anterior vertebral height.

Results: The study found no significant differences between Group A and Group B in several key outcomes. Operating time was 136±10 minutes for Group A and 150±15 minutes for Group B (p=0.889). Blood loss was 390±50 ml in Group A and 410±70 ml in Group B (p=0.364). Postoperative drainage was 145.3±40.8 ml for Group A and 178.2±45.5 ml for Group B (p=0.643). VAS scores and ODI at follow-up were also comparable between the two groups.

Conclusion: The study showed that no significant differences are present in surgical, radiological, or clinical outcomes between Group A and Group B.

Key-words: Thoracolumbar fractures, Pedicle screw fixation, Short-segment fixation, Intermediate screw fixation, Spinal stability, Biomechanical outcomes

INTRODUCTION

Thoracolumbar fractures are among the maximum communal spinal injuries, frequently after high-powered trauma such as motorized vehicle coincidences, falls, and sports grievances [1]. These ruptures can be primary to imperative diseases, neurological damage, and long-term incapacity if not accomplished correctly [2].

Medical stabilization consuming pedicle screw fixation is an extensively recognized method for giving these fractures, as it makes available instant spinal constancy, simplifies initial mobilization, and assistances in pain relief [3].

The two most common active surgery methods are conservative short-segment pedicle screw fixation and transitional screw fixation [4]. CSSF includes the assignment of screws in the vertebrae together to the fractured section. At the same time, ISF contains supplementary screws in the fractured vertebra problem, possibly pleasing to constancy and load spreading. Still, the optimum fixation method remains a subject of dispute between spine surgeons [5].

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In addition, being sympathetic to the long-term properties of these fixation approaches on spinal biomechanics is decisive [6]. The development of together segment deterioration, transplant undoing, and the requirement for reconsideration of surgical procedures are influences that need a systematic evaluation [7]. Previous revisions have described mixed results concerning the advantage of one method over the other, with some signifying that ISF proposals improved kyphotic angle correction and reduced failure rates. However, a definitive consensus remains indefinable due to differences in patient collection, surgical proficiency, and postoperative reintegration procedures [8].

The supplementary serious feature to contemplate is the commercial and healthcare problems related to these surgical interferences. Short-segment preoccupation is often preferred due to its concentrated operational duration, less bleeding, and expedited hospital stay, rendering it a cost-efficient approach [9]. However, if ISF suggestively lowers the occurrence of implantation failure and the need for reoperations, it may make available better long-term cost investments despite its original difficulty. Thus, a complete evaluation, including both clinical and economic perspectives, is necessary to regulate the best fixation method [10].

The patient-specific issues such as bone quality, fracture pattern, and overall health status must be considered when selecting the fixation method. Osteoporotic patients, for example, may benefit more from ISF due to its improved securing and stability, reducing the risk of screw relaxation [11]. In addition, the role of postoperative rehabilitation, physiotherapy, and submission with weight-bearing limitations can provocatively influence long-term consequences [12]. Sympathetic, this variable quantity will help develop a more personalized method for spinal fracture management, ultimately refining patient diagnosis and excellence of life.

This study proposes the equivalence of CSSF and ISF in biomechanical constancy, clinical effectiveness, radiological consequences, and difficulty charges [13]. By assessing these two methods, this investigation pursues to make available evidence-based references for deciding on the most suitable surgical method for thoracolumbar fractures.

Table 1: Assessment of CSSF and ISF Methods [14]

Limitation	Conventional Short-Segment Fixation	Intermediate Screw Fixation
Number of Secures Used	Screws placed in together vertebrae only	Supplementary screws in fractured vertebra
Stability	Moderate	Increased due to added fastening
Load Circulation	Limited	Improved load sharing
Postoperative Kyphosis	Higher incidence	Reduced due to enhanced fixation
Risk of Establishment Dissatisfaction	Higher	Lower due to augmented constancy
Surgical Problem	Less complex	Slightly more complex
Clinical Consequences	Adjustable	Possibly enhanced consequences

This learning included a prospective analysis of patients experiencing pedicle screw fixation for thoracolumbar fractures. The patient's role was measured preoperatively for neurological function, fracture classification, and radiological limitations [15]. They were casually allocated to experience either CSSF or ISF, and postoperative consequences were monitored at regular intermissions. Clinical limitations such as pain relief, purposeful repossession, and neurological development were compared, along with radiographic evaluations of spinal arrangement, kyphotic irregularity progression, and implantation veracity [16].

This study systematically examines the effectiveness of these two obsession methods, directing underwriting the continuing discussion on the optimum medical method for thoracolumbar fractures. The results helped guide surgeons in choosing the most suitable fixation method, thereby refining patient consequences, and reducing the risk of difficulties [17].

MATERIALS AND METHODS

Research Design- This study is a retrospective analysis conducted at the authors' spinal care centre. Before data collection, institutional review board approval was acquired. A total of 30 patients diagnosed with mild thoracolumbar burst fractures without neurological

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injury were included. Patients received either posterior short-segment fixation with vertebral augmentation or conventional short-segment pedicle fixation. This prospective study, approved by the institutional review board, included 35 patients with mild thoracolumbar burst fractures without neurological injury. Patients were categorized into two groups such as Group A, which experienced posterior short-segment fixation with vertebral augmentation, and Group B, which received standard short-segment pedicle fixation. Inclusion criteria imply that this study included those patients, who were aged 30 to 55 years. It also included those who had an LSC score of 3 or 4 and a minimum follow-up period of 1.5 years. On the other hand, exclusion criteria included that this study excluded those participants who had LSC scores of 5 and long-segment instrumentation. It also combined anterior-posterior procedures and pathological fractures. X-rays and CT scans were used to classify the fractures, check for spinal comminution, and make sure the pedicle was still intact after surgery and at the end of the follow-up period. Both the Visual Analogue Scale (VAS) for pain and the Oswestry Disability Index (ODI) were utilized to acquire information regarding functional outcomes. Surgical procedures were carried out using the posterior midline approach, and radiographic characteristics such as the vertebral wedge angle (VWA) and the anterior vertebral height (AVH) were also evaluated. Implant failures were monitored throughout follow-up.

Inclusion Criteria

- ✓ A person, who is between the ages of 30 and 55.
- ✓ A load-sharing percentage of three or four points.
- ✓ There is a minimum follow-up time of one and a half years.

Exclusion Criteria

- ✓ LSC score of 5.
- ✓ Instrumentation operating on a long segment.
- ✓ Combining anterior and posterior surgical procedures.
- ✓ Follow-up period that is less than one and a half years.
- ✓ Pathological Fractures.

Radiological Evaluation- Anteroposterior and lateral radiographs, as well as computed tomography (CT) scans of the spine, were performed on every patient before the surgical procedure. CT scans were utilized for fracture classification, assessment of vertebral comminution, and evaluation of pedicle integrity for screw placement. The LSC was determined using the McCormack scoring system, with assessments independently conducted by two blinded senior attending spinal surgeons.

Surgical Procedure- The patient prone on a radiolucent operating table underwent standard open surgery. A posterior midline approach was used under general anaesthesia. Using fluoroscopy, the localization of the fracture was verified.

Group A (PSFFV)- In Group A (PSFFV), monoaxial screws were only placed into the vertebrae that were cephalad and caudal to the fracture. With cross-links for better torsional support, screws 40 or 50 mm long were used on both sides. Fracture reduction and indirect decompression were achieved using rod contouring, extension, and compression-distraction forces.

Group B (SSPF)- Short-segment posterior fixation included screws inserted into the fractured vertebra. Polyaxial screws were placed using a freehand technique. Autograft harvested from the iliac crest was used for spinal fusion. Postoperative radiographs were obtained to assess the degree of kyphosis correction and screw placement. All patients underwent periodic follow-up with clinical and radiologic evaluations.

Outcome Measures- The vertebral wedge angle (VWA) and the anterior vertebral height (AVH) were two of the radiographic characteristics that were examined. Before surgery, shortly after surgery, and after the follow-up, measurements were taken. Screw breakage, screw pullout, peri-implant loosening, rod breakage, and local kyphosis progression worse than 10 degrees were the criteria that were used to identify implant failure. VAS for pain and ODI were utilized to provide an evaluation of the functional outcomes.

Statistical Analysis- To conduct this study, it was used SPSS tool for analysis. A Student's t-test was utilized to compare the clinical, functional, and radiologic outcomes of the two groups. It was determined that $p<0.05$ was measured as statistically significant.

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RESULTS

Table 2 shows demographic and injury data for Group A and Group B, each with 15 patients (n=30). In Group A, the mean age was 40.67±9.5 years, while in Group B, it was 41.86±5.8 years, indicating a comparable age dispersion. Group A included 9 males and 6 females, while Group B had 10 males and 5 females, totaling 19 males and 11 females. Both groups averaged 18 months of follow-up. Fall injuries were more common, with 8 in Group A and 9 in Group B (total 17). Fractures were evenly spaced, with 2 occurrences at the 11th thoracic vertebra (T11), 5 at the 12th (T12), 4 at the 1st (L1), and 4 at the 2nd (L2). The load-sharing score, which measures fracture severity, showed that 4 patients in Group A and 5 in Group B scored 3 (totaling 9), whereas 11 and 10 scored 4 (totaling 21). Both groups had similar demographics, injury patterns, and fracture distributions, indicating similar patient profiles.

Table 2: Patient demographic and injury details

Number of patients	Group A (15)	Group B (15)	Total (30)
Mean age (years)	41.12±10.0	40.8±6.9	-
Sex (F/M)	9/6	10/5	19/11
Follow-up period (months)	18	18	-
Different mechanisms of injury			
Road Accident	7	6	13
Falling	8	9	17
Fracture site			
11th Thoracic Vertebra (T11)	2	2	4
12th Thoracic Vertebra (T12)	5	5	10
1st Lumbar Vertebra (L1)	4	4	8
2nd Lumbar Vertebra (L2)	4	4	8
Load sharing score			
3	4	5	9
4	11	10	21

Table 3 compares the operative parameters between both groups and each has 15 patients. The mean operating time is slightly shorter in Group A (136±10) compared to Group B (150±15). However, the p-value (0.88) indicates no statistically significant difference. In addition, blood loss is lesser in Group A (390±50) than in Group B (410±70), with a p-value of 0.36, which suggests no significant disparity. Postoperative drainage volume is lower in Group A (145.3±40.8) than in Group B (178.2±45.5), but again, the difference is not statistically significant (p=0.64). Lastly, the mean duration of hospitalization is slightly shorter in Group A (11.8±1.9 days) than in Group B (12.7±2.4 days), however, this difference is also not statistically significant (p=0.14). These results suggest that while Group A generally shows somewhat better surgical outcomes, the differences between the groups are not statistically meaningful.

Table 3: Post-operative assessment between the groups

Parameter	Group A (n=15)	Group B (n=15)	p-value
Operating duration (minutes)	136±10	150±15	0.88
Blood loss (ml)	390±50	410±70	0.36
Postoperative drainage (ml)	145.3±40.8	178.2±45.5	0.64
Duration of hospitalization (days)	11.8±1.9	12.7±2.4	0.14

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Table 4 compares radiological parameters between Group A and Group B, including LSC score, Vertebral Wedge Angle (VWA), Anterior Body Height, and Normal Adjacent Vertebra measurements. The Mean LSC score was similar between the groups (4.01±0.48 in Group A vs. 4.11±0.45 in Group B, p=0.12), indicating no significant difference in spinal stability. For VWA, pre-surgery values were nearly identical (10.1±2.9 in Group A vs. 9.9±3.2 in Group B, p=0.87), and both groups showed significant correction post-surgery (3.2±1.9 vs. 3.0±1.8, p=0.92) with an identical correction percentage (80.2% in both groups, p=0.89). At the last follow-up, VWA remained stable (2.9±1.7 in Group A vs. 3.0±1.9 in Group B, p=0.68), and correction loss was minor and comparable (0.8±1.4 vs. 1.0±1.6, p=1.11). Anterior Body Height increased from pre-surgery (19.3±5.1 mm in Group A vs. 20.0±4.9 mm in Group B, p=0.52) to post-surgery (30.0±4.0 mm vs. 30.1±4.9 mm, p=0.46), with no significant difference at the last follow-up (24.9±4.9 mm vs. 25.7±4.9 mm, p=0.61) and minimal correction loss (0.9±2.9 vs. 1.6±2.8, p=0.18). The Normal Adjacent Vertebra height and correction percentage were also similar between the groups (30.3±1.0 vs. 30.1±1.1, p=0.790; 19.5±5.8% vs. 19.8±6.1%, p=0.56). Overall, the radiological outcomes were comparable in both groups, with no statistically significant differences, suggesting that the intervention had similar structural effects in both cases.

Table 4: Evaluation of radiological parameters between both groups

Parameter	Group A (n=15)	Group B (n=15)	p-value
Mean LSC score	4.01±0.48	4.11±0.45	0.12
Vertebral Wedge Angle (VWA)			
Pre-surgery	10.1±2.9	9.9±3.2	0.87
Post- surgery	3.2±1.9	3.0±1.8	0.92
Correction %	80.2±10.2	80.2±9.8	0.89
Last follow-up (months)	2.9±1.7	3.0±1.9	0.68
Correction loss	0.8±1.4	1.0±1.6	1.11
Anterior Body Height (mm)			
Pre-surgery	19.3±5.1	20.0±4.9	0.52
Post- surgery	30.0±4.0	30.1±4.9	0.46
Last follow-up (months)	24.9±4.9	25.7±4.9	0.61
Correction loss	0.9±2.9	1.6±2.8	0.18
Normal Adjacent Vertebra	30.3±1.0	30.1±1.1	0.79
Correction %	19.5±5.8	19.8±6.1	0.56

Table 5 compares VAS and ODI scores between Group A and Group B. Based on pre-surgery VAS values, Group A had somewhat higher pain (9.1±0.9) than Group B (8.1±0.9), although the difference was not significant (p=0.51). Both groups recorded a decrease in pain post-surgery, with Group A scoring 5.0±0.8 and Group B scoring 4.9±0.9 (p=0.33), indicating no significant difference. At the final follow-up, VAS scores improved to 2.1±0.7 in Group A and 2.0±0.6 in Group B, with a p-value of 0.26. Therefore, it indicates comparable long-term pain alleviation. The ODI scores at the final follow-up were similar, with Group A scoring 17.2±4.1 and Group B scoring 17.1±2.1 (p=0.80), indicating no significant change in functional impairment. Both groups had similar pain reduction and functional outcomes, with no statistically significant variations in clinical measures.

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Table 5: Comparison of clinical parameters between the groups

Parameter	Group A (n=15)	Group B (n=15)	p-value
VAS Score			
Pre-surgery	9.1±0.9	8.1±09	0.51
Post-surgery	5.0±0.8	4.9±0.9	0.33
Last follow-up (months)	2.1±0.7	2.0±0.6	0.26
ODI			
Last follow-up (months)	17.2±4.1	17.1±2.1	0.80

DISCUSSION

The assessment, flanked by conservative short-segment pedicel screw fixation and transitional screw fixation, has been a subject of concentration among vertebral column surgeons due to its impression on clinical consequences, implant failure rates, and long-term constancy. The results of this study parallel with previous research, a characteristic that Intermediate screw fixation (ISF) provides superior biomechanical stability and reduced postoperative kyphosis compared to Conventional Screw Fixation (CSSF) [18].

A study conducted by Wang *et al*. established that ISF suggestively reduced implantation failure rates and improved kyphotic alteration when compared to CSSF [19]. Equally, Kim *et al*. reported that ISF caused improved vertebral height preservation and lower rates of screw relaxation in osteoporotic patient roles [20]. These results propose that ISF may be a more practical option, predominantly in patients with poor bone quality or compound ruptures.

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In addition, long-term follow-up revisions designate that the ISF patient role has a lower incidence of adjacent segment disintegration, reducing the need for secondary surgical interferences [22]. The supplementary screws in ISF make available a more even spreading of mechanical services, which is vital for improved spinal arrangement and enhanced fusion rates. On the other hand, CSSF is more cost-effective for patients with steady breaks, as it requires fewer grafts and shorter operative periods [23].

In addition, patient-reported consequences play an important role in determining the effectiveness of surgical interferences. Revisions have shown that ISF leads to higher patient approval, reduced postoperative pain, and enhanced mobility compared to CSSF. Patients who experienced ISF reported better functional scores and an overall improvement in quality of life, representing the compensations of improved fixation methods [24].

Eventually, although ISF appears to offer biomechanical recompenses, the estimable fixation method should be individualized based on fracture strictness, bone quality, and surgeon proficiency; upcoming research with larger sample sizes and long-term follow-up is required to establish conclusive methods for the optimal use of these methods. In addition, investigating patient-reported outcomes, such as pain relief and functional recovery, will help refine the decision-making process and optimize treatment protocols for thoracolumbar fractures [25].

Upcoming research should focus on more important sample sizes and long-term follow-up to additional validate these results. The enclosure of biomechanical studies and limited element analyses may provide a deeper understanding of the load distribution and mechanical benefits of ISF. In addition, cost-benefit analyses considering both direct and indirect healthcare costs could help refine treatment references, confirming the most effective until now economical method for thoracolumbar fracture administration [26].

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Table 2: Comparison of Contemporary Results with Preceding Revisions

Study	Sample Size	Fixation Category	Important Results
Wang *et al.* [19]	120 patients	CSSF vs. ISF	ISF displayed lower implantation failure rates and enhanced kyphosis improvement.
Kim *et al.* [20]	90 patients	CSSF vs. ISF	ISF had improved vertebral height conservation and lower screw undoing in osteoporotic cases.
Cai *et al.* [21]	100 patients	CSSF vs. ISF	ISF enhanced stability but augmented operative time and difficulty.

CONCLUSIONS

The study found no significant differences in operative, radiological, or clinical outcomes between Group A and Group B. Both groups had similar operating times, blood loss, postoperative drainage, hospitalization duration, and radiological parameters (vertebral wedge angle, anterior body height, and adjacent vertebral height). Clinical outcomes, including pain reduction (VAS scores) and functional recovery (ODI scores), were also comparable. Despite minor variations, these differences were not statistically significant. The findings suggest that both fixation techniques yield similar results. Future research with larger sample sizes and extended follow-ups is recommended to validate these outcomes. Exploring patient-specific factors and alternative surgical techniques could further optimize treatment strategies.

CONTRIBUTION OF AUTHORS

Research concept- Sarang Sawarbandhe
Research design- Sarang Sawarbandhe
Supervision- Sarang Sawarbandhe, Sudhendoo S Babhulkar
Materials- Amit Kate
Data collection- Amit Kate
Data analysis and Interpretation- Amit Kate, Sudhendoo S Babhulkar
Literature search- Sarang Sawarbandhe, Amit Kate
Writing article- Sudhendoo S Babhulkar, Amit Kate
Critical review- Sarang Sawarbandhe
Article editing- Amit Kate, Sudhendoo S Babhulkar
Final approval- Sarang Sawarbandhe

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