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Comparing the Efficacy of Short-segment Transpedicular Stabilization with and without Intermediate Screw for Unstable Thoracolumbar Fractures

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Abstract

Objectives: Clinical outcome of thoracolumbar unstable fracture treated by short-segment transpedicular fixation with and without intermediate screw fixation assessed by modified Macnab criteria, visual analog scale (VAS), and Oswestry Disability Index (ODI) and to compare the radiological outcome using Cobb angle, Beck index, and kyphotic deformation.

Methods: A prospective study of 60 patients with unstable thoracolumbar fracture was treated with posterior transpedicular screw fixation at Spine injury Centre, Sanjay Gandhi Institute of Trauma and Orthopaedics, Bengaluru, from December 2016 to July 2019. Clinical assessment was done using Macnab criteria, ODI, and VAS scoring system and radiological assessment was done using Cobb angle, becks index, and segmental kyphotic deformation. The patients were divided into two groups according to the surgical method used. In Group A, 28 patients underwent surgery with a posterior approach through transpedicular screw instrumentation with an additional screw at the fractured vertebrae. In Group B, 32 patients were received a traditional short-segment fixation (1 level above and 1 level below the fractured level). Clinical and radiologic parameters were evaluated before surgery and at 3 and 6 months and 1 year after surgery.

Results: Our study showed predominant male population (80%) of working age group (21–40 years), who had unstable thoracolumbar fractures. The most common mode of injury was fall from height (60%). Majority of the patients had L1 vertebra fracture of about 48% and 28% of T12 vertebra fracture. According to modified Macnab criteria, majority have good results at 3, 6, and 12 months of follow-up, at the end of 12 months, both groups have 50% and 68% good result and 50% and 28% of excellent results, respectively, but non-significant. Mean ODI after 1 year of follow-up shows 6.93 and 8.53 and VAS score at the end of 12th month of follow-up is 1.21 and 1.22, respectively. Both groups have better Cobb angle correction from 18.39° to 10.29° in Group A and 19.25° to 11.38° in Group B. Loss of Cobb angle correction is 2.97 Group A and 2.91 in Group B. Our study shows that there is no statistically significant improvement in Beck index in both groups from 0.64 to 0.78 in Group A and in Group B from 0.62 to 0.78. Both groups have better kyphotic deformation correction from 15.71° to 7.93° in Group A and 15.22° to 8.41° in Group B and it shows that Group A has more correction of kyphotic deformation.

Conclusions: Pedicle screw placement into the fractured vertebra in management of unstable thoracolumbar is safe and feasible. Pre-operative evaluation of pedicle dimension would be useful for the placement into fractured vertebra. Short-term benefits of placing pedicle screw into fractured vertebra are restoration of vertebral body height and kyphotic angle and indirect canal decompression.

Keywords: Thoracolumbar fracture, Short segment, Cobb angle, Transpedicular fixation, Kyphotic deformation, Additional screw, Burst fracture.

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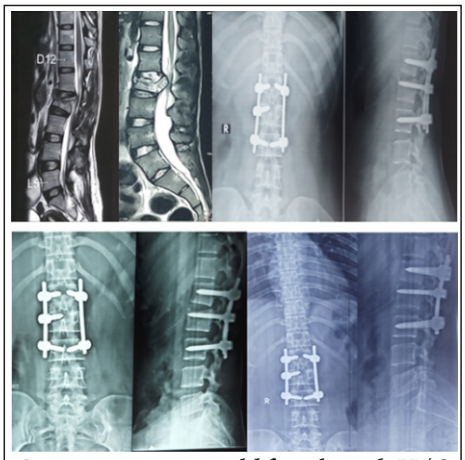
Introduction

Thoracolumbar burst fractures are usually a result of substantial axial loading force that results in compression failure of anterior and middle spinal columns, but in unstable burst fracture, all three spinal columns are involved. Majority of these injuries occur as a result of fall from height and motor vehicle accidents [1].

About 5–10% of polytrauma patients suffer from spinal fractures, with 70–80% of these occurring at the thoracolumbar and lumbar region, with 17% being burst fracture. Neurological injury complicates 19–50% of fractures at the

Case I : A 35-year-old male with H/O fall from tree with L1 burst fracture.



Case II : A 32-year-old female with H/O fall from height with L2 burst fracture.

thoracolumbar and lumbar region [2]. The most frequent site of spinal injuries is reportedly the thoracolumbar junction as it is the transition zone between the relatively rigid thoracic and the more flexible lumbar spine [3, 4]. The goals of treatment of these fractures include restoring vertebral column stability and preventing deformity, spinal canal decompression, and early mobilization.

Unstable burst fractures frequently require surgical correction. Progressive neurological deterioration is generally considered an absolute indication for early surgery. Other strong indications for surgical intervention include incomplete neurological deficit, more than 25–30% angle of kyphotic deformity, more than 50% loss of vertebral body height, and more than 40–50% of canal narrowing.

Approach for surgery can be anterior, posterior, or combined and the selection of treatment approach is controversial. Anterior surgery has the advantage of thorough decompression, which effectively corrects the kyphosis and receives good bone graft fusion, to establish the fused segment. However, this surgery may cause large traumas that easily damage the large blood vessels and other organs, as well as complications caused by thoracotomy and laparotomy, including intestinal adhesion and pneumothorax. It is recommended that compressed fractures and mild violence fractures receive posterior surgeries. Posterior approach is most frequently used by surgeons because the posterior fixation fusion through the use of pedicle screws is a simple surgery, resulting in little injury and has a rapid recovery [5].

The introduction of transpedicular instrumentation systems was considered highly beneficial because of its distinct advantages such as rigid segmental fixation, stabilization of the three columns, least failure at bone metal interface, early post-operative mobilization with efficient nursing care, and least complication. Long-segment instrumentation has advantage of rigid fixation and better canal recovery, but it also results in a motionless spine [2]. In recent years, short-segment instrumentation with pedicle screws introduced one level down and one level up from the fractured vertebra has become the preferable surgical method because of its ease of application, use of less surgical fixation material, reduction of blood loss, and smaller incision field [6,7,8,9,10,11]. However, disadvantages of this method, such as inadequate long-term reduction, instrumentation insufficiency, and increase in kyphosis, have been reported.

Pedicle screw insertion at the level of fractured vertebra, known as intermediate screw, has shown to improve clinical and radiological outcomes by achieving greater stability of the segmental fixation without interfering with the biological healing process [12, 13, 14, 15]. However, there is lack of powerful evidence to support it. The aim of the study is to study the effect of pedicle screw placement into the fractured vertebra in the management of unstable thoracolumbar fractures.

Tables 1: Clinical assessment with VAS and ODI score

		Group	N	Mean (SD)	Median (Q1-Q3)	Mann Whitney U Test	
						U Statistic	p-value
ODI score	3Mon	Group 1	28	9.21 (4.74)	8 (6 - 10.75)	393	0.41(NS)
		Group 2	32	10.50 (6.21)	9 (6 - 12.75)		
	6 Mon	Group 1	28	7.46 (4.13)	6 (5 - 8)	322	0.06(NS)
		Group 2	32	9.31 (5.41)	7 (6 - 11.75)		
	1Year	Group 1	28	6.93 (4.69)	5 (4 - 8.75)	309.5	0.04*
		Group 2	32	8.53 (4.68)	8 (5 - 10)		
VAS score	3Mon	Group 1	28	1.89 (0.69)	2 (1 - 2)	421	0.66(NS)
		Group 2	32	1.81 (0.64)	2 (1 - 2)		
	6 Mon	Group 1	28	1.43 (0.57)	1 (1 - 2)	402.5	0.44(NS)
		Group 2	32	1.53 (0.57)	1.5 (1 - 2)		
	1Year	Group 1	28	1.21 (0.50)	1 (1 - 1)	444.5	0.94(NS)
		Group 2	32	1.22 (0.49)	1 (1 - 1)		

Materials and Methods

A prospective study of 60 patients more than 18 years of age with a history of trauma and fall from height presented with unstable thoracolumbar fracture at Spine injury Centre, Sanjay Gandhi Institute of Trauma and Orthopaedics, Bengaluru, between December 2016 and July 2019. AO classification was used for categorization and Thoracolumbar

Table 2: Modified Macnab criteria

	MCNAB criteria	Group			Fisher's Exact Test
		Group 1	Group 2		p-value
3 Mon	Excellent	8	9	17	1.00(NS)
		28.60%	28.10%	28.30%	
	Fair	3	4	7	
		10.70%	12.50%	11.70%	
	Good	17	19	36	
		60.70%	59.40%	60.00%	
6 Mon	Excellent	14	13	27	0.20(NS)
		50.00%	40.60%	45.00%	
	Fair	0	4	4	
		0.00%	12.50%	6.70%	
	Good	14	15	29	
		50.00%	46.90%	48.30%	
1Year	Excellent	14	9	23	0.11(NS)
		50.00%	28.10%	38.30%	
	Fair	0	1	1	
		0.00%	3.10%	1.70%	
	Good	14	22	36	
		50.00%	68.80%	60.00%	

Table 3: Radiological Assessment

		Group	N	Mean (SD)	Median (Q1-Q3)	Mann Whitney U Test	
						U Statistic	p-value
COBB angle	Pre	Group 1	28	18.39 (7.08)	18 (12.5 - 20.75)	410	0.57(NS)
		Group 2	32	19.25 (7.16)	18 (15.25 - 23.5)		
	3 Mon	Group 1	28	7.32 (4.66)	6.5 (3 - 11.75)	388.5	0.38(NS)
		Group 2	32	8.47 (5.30)	6.5 (4.25 - 12)		
	6 Mon	Group 1	28	8.93 (5.20)	7 (5 - 12.75)	425.5	0.74(NS)
		Group 2	32	9.25 (5.83)	8 (5.25 - 10)		
	1 Year	Group 1	28	10.29 (6.37)	8.5 (5.25 - 14)	406	0.53(NS)
		Group 2	32	11.38 (8.26)	9 (8 - 12)		
Kyphotic Deformation	Pre	Group 1	28	15.71 (6.30)	15 (11.25 - 18.75)	445	0.96(NS)
		Group 2	32	15.22 (4.80)	15 (12 - 17)		
	3 Mon	Group 1	28	7.36 (5.24)	5.5(3.25- 10.75)	405	0.52(NS)
		Group 2	32	7.62 (4.16)	7 (4 - 9.75)		
	6 Mon	Group 1	28	7.57 (5.25)	5.5 (4 - 12.25)	369.5	0.24(NS)
		Group 2	32	8.25 (4.63)	7 (5 - 11.5)		
	1Year	Group 1	28	7.93 (5.36)	6.5 (3 - 12.75)	400	0.48(NS)
		Group 2	32	8.41 (4.74)	8 (5 - 10.75)		

Table 4: Beck Index

Beck Index	Group	N	Mean	SD	Mean Difference	95% Confidence Interval of the Difference		p-value
						Lower	Upper	
Pre	Group 1	28	0.64	0.14	0.019	-0.06	0.099	0.63(NS)
	Group 2	32	0.62	0.16				
3 Mon	Group 1	28	0.81	0.15	0.006	-0.063	0.076	0.86(NS)
	Group 2	32	0.8	0.12				
6 Mon	Group 1	28	0.8	0.16	0.016	-0.057	0.089	0.66(NS)
	Group 2	32	0.78	0.13				
1 Year	Group 1	28	0.78	0.15	-0.001	-0.071	0.069	0.98(NS)
	Group 2	32	0.78	0.12				

Injury Classification and Severity (TLICS) score for management purpose. In our study, patients having AO classification of A-4 and above and TLICS score more than 5 were included in the study.

Patients having complete paraplegia with bowel and bladder involvement, pathological fracture, and multiple vertebral fractures >3 were excluded from the study.

Patients were divided into two groups, where Group A includes 28 patients who had been managed with short-segment transpedicular instrumentation constructs, spanning fractured vertebrae with additional screw, and one cephalad and one caudal to the fracture and Group B included 32 patients who had been managed with a traditional short-segment fixation (1 level above and 1 level below the fractured level). Procedure was conducted in prone position with bolster in placed, posterior midline approach was used after confirming the level of fractured vertebra under fluoroscopy. Exposed spinous process and facet joints subperiosteally and entry point for pedicular screw were carried out by Roy-Camille method and screws of size 30–50 mm long and 5.5–6.5 mm size depending on the level and size of the vertebra. The instrumentation was applied bilaterally and cross-linked were placed cephalad and caudal to the fracture to augment the torsional rigidity. Laminectomy performed in cases with severe neurological deficit, in order either to excise the retropulsed bone fragments or disc remnants from the spinal canal. All patients were managed postoperatively with immobilization with thoracolumbar brace for 2–3 weeks.

Patients were followed postoperatively for functional and radiological assessment at 3 months, 6 months, and 1 year. Results were evaluated and assessment done by clinically using modified Macnab criteria, visual analog scale (VAS), and Oswestry Disability Index (ODI) score and radiologically by measuring Cobb angle, Becks index, and segmental kyphotic deformation.

Results

Most patients are in the age group of 21–30 years and mean age is 42.46 and 35.12 for Group A and Group B,

Table 5: Summary of Radiographic Data

Index	Checkpoint	Mean	
		Group A	Group B
Cobb angle	Pre-op	18.39	19.25
	Post-op	7.32	8.47
	Follow-up	10.29	11.38
Kyphotic deformation	Pre-op	15.71	15.22
	Post-op	7.36	7.62
	Follow-up	7.93	8.41
Beck Index (Vertebral height)	Pre-op	0.64	0.62
	Post-op	0.81	0.8
	Follow-up	0.78	0.78

respectively. Out of 60 patients, 47 were male which constitute of 78% and 13 females. Fifty-one patients were presented with AO-A4 which constitutes around 85%, AO-B constitutes to 10%, and AO-C type constitutes 5%. Majority of the patients had L1 vertebra fracture of about 48% and 28% of T12 vertebra fractures. Majority of patients were presented with a history of fall from height which constitutes about 60% and rest with road traffic accidents.

According to modified Macnab criteria, majority have good results at 3, 6, and 12 months of follow-up, at the end of 12 months, both groups have 50% and 68% good result and 50% and 28% of excellent results, respectively, but non-significant. Mean ODI after 1 year of follow- up shows 6.93 and 8.53 with no statistically significant and both groups fall under minimal disability score. Both groups have nearly same mean value of VAS at 3, 6, and 12 post-operative months and VAS score at the end of 12th month of follow-up is 1.21 and 1.22, respectively, with no statistically significant P-value.

Radiological assessment

Both groups have better Cobb angle correction from 18.39° to 10.29° in Group A and 19.25° to 11.38° in Group B with both no statistically significant P-value. Loss of Cobb angle correction is 2.97 Group A and 2.91 in Group B. Our study shows that there is no statistically significant improvement in Beck index in both groups from 0.64 to 0.78 in Group A and in Group B from 0.62 to 0.78. Both groups have better kyphotic deformation correction from 15.71° to 7.93° in Group A and 15.22° to 8.41° in Group B and it shows that Group A has more correction of kyphotic deformation but no statistically significant P-value. Loss of correction of kyphotic deformation angle at 12 months of follow is 0.57° and 0.79°.

Discussion

In our study, 60% of the injuries were around L1 vertebra and thus L1 is the most common site of injury as this area represents the transition from normal thoracic kyphosis to flexible lumbar lordosis. Loading force on spine concentrates and creates maximum stress over this transition zone. AO classification was used to assess the severity and AO-A4 constitutes around 85% and AO-B constitutes to 10%, AO-C type constitutes 5%. TLICS scoring system was used to select the cases, scoring of more than 5 was considered for surgery.

Unstable thoracolumbar fractures, in our study, were defined which meet the following criteria:

1. TLICS – 5 or more than 5
2. Kyphotic angle >15
3. Anterior vertebral height loss >30%
4. Progressive neurological deterioration
5. Involvement of 2 or 3 columns of spine
6. Canal narrowing >40%.

Two great surgeons Boucher in 1959 and in 1963 Roy Camille et al. used pedicle screws for the 1st time. Since then, posterior pedicle screw fixation was invented, rigid three-column fixation emerged where pedicle screws hold posterior column, cortical bone of pedicle in the middle column, and cancellous bone of anterior column.

The pedicle internal fixation of fractured vertebrae is technically feasible and effective in restoring vertebral body height and correcting dislocation [8, 16]. The screw implantation through fractured vertebrae significantly improves the stress distribution of screws, reduces screw load, and provides a fulcrum for the reduction to make it coincide with the mechanical mechanism, so as to significantly improve its anti-stress ability and significantly enhance the stability of the fixation [17]. In the stress screw fixation through fractured vertebrae, an appropriate amount of ventral pressure overcomes the kyphosis stress caused by fractures, which is helpful for maintaining the physiological curvature of fixed parts postoperatively to prevent the screws from loosening. This may also benefit and reduce dislocation for patients with fracture dislocation. The stress added between the screw and pedicle is a ventral pressure stress but not a pullout force. Complete pedicle fixation is enough to guarantee the stability of the vertical stress screw.

The advantages of using pedicle screws to treat fractured vertebrae include the following:

1. It provides a good three-point fixation to reduce the suspension effect of the internal fixation system
2. It reduces the parallelogram effect to increase the stability
3. It avoids stretching the normal intervertebral disc, which is beneficial to the recovery of the vertebral fracture form
4. It dispenses the stress of the pedicle screw connection.

Therefore, conditional application of vertical stress screw fixation of fractured vertebrae
enhances the stability of the posterior short-segment internal fixation system for thoracolumbar fractures and facilitates the correction of kyphosis and maintenance of the corrective effect [15, 18].

Ye et al., [19] in their study, found no significant difference in the demographic characteristics between the two groups and no significant difference was

observed with respect to operative time, intraoperative blood loss, VAS, and ODI scores. The Cobb angle, anterior vertebral body height of the fractured level, and anterior vertebral height compression ratio were also similar between groups before surgery and 1 week after surgery but found significant difference in radiological findings at 6 months and 1 year after surgery. In our study, we also found no significant difference in demographic characteristics and VAS and modified Macnab criteria; however, we found no significant difference in Cobb angle, kyphotic deformation, and vertebral height ratio between two groups.

Huang and Luo, [20] in their study, observed satisfactory post-operative recovery of vertebral body height in the triplane fixation group and dual-plane fixation group, with 92.9 and 90.9% recovery, respectively. There was also relatively good post-operative correction of spinal kyphosis, with a post-operative Cobb's angle of 2.51 and 3.26°, respectively. There were no significant differences between the two groups. One year after surgery, the vertebral body height in the two groups was 91.4 and 89.1%, respectively, without a significant difference and we found with a post-operative Cobb's angle of 7.32 and 8.47, respectively, which is non-statistically significant difference and vertebral height ratio after 1 year was both 0.78% with no significant difference.

In our study, we found two cases of screw breakage, one case of screw pullout, few cases with loss of correction and high risk of failure in Group A, even though material failure did not always influence the clinical outcome [21]. Under the circumstances, the use of two additional screws for the fractured vertebrae has been introduced and is thought to result in stronger biomechanical stability of the anterior column by forming a more segmental structure, thereby improving efficacy in some studies.

The present study had some limitations, we did only decompression and stabilization without fusion with cage or bone graft and no anterior fixation along with posterior transpedicular fixation. Our study is focused on relatively short-term follow-up outcomes and further studies with larger population and longer follow-up period are needed to assess the efficacy of this technique more accurately.

Conclusions

Pedicle screw placement into the fractured vertebra in the management of unstable thoracolumbar is safe and feasible. Pre-operative evaluation of pedicle dimension would be useful for the placement into fractured vertebra. Short-term benefits of placing pedicle screw into fractured vertebra are restoration of vertebral body height and kyphotic angle and indirect canal decompression. We conclude that short-segment pedicle screw instrumentation with intermediate screws has a better effect on maintaining the reduction of unstable thoracolumbar fractures than the traditional short-segment pedicle screw fixation.

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