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RESEARCH ARTICLE

Treatment of Thoracolumbar Fractures by use of an Index Screw in Short Segment Fixation. Do the Dimensions Matter??

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Abstract

Study design: Single-centre retrospective study

Purpose: We aimed to explore the possibility of better correction of kyphosis and maintenance of gained vertebral height with typical pedicle screw of adequate dimensions in cases of thoracolumbar fractures.

Overview of literature: Literature regarding the management of thoracolumbar fractures describes the need of a pedicle screw in fracture vertebra in short segment instrumentation but seldom describes the dimensions of the screw.

Methods: Forty-five patients with thoracolumbar burst fractures treated by short segment instrumentation and index level vertebra screw fixation were evaluated retrospectively in our study at our institute from 2019 to 2022 and were evaluated for radiological outcome at the end of 2 years.

Results: In the immediate post-operative period, the mean correction of global kyphosis was around 11.76 degrees while that of local kyphosis was around 12.63 degrees. At the final follow-up, 30% of vertebral height gain was achieved but there was a loss of 1.33 and 0.81 degrees of the achieved correction of global and local kyphosis respectively at the final follow-up.

Conclusion: Using a longer and a thicker monoaxial pedicle screw in the fractured vertebra in thoracolumbar burst fractures can yield excellent results in terms of improvement in the global kyphosis, local kyphosis and height of the fractured vertebra.

Keywords: Pedicle screw; Index screw; Thoracolumbar fractures; Kyphosis; Vertebral height.

Introduction

When it comes to managing thoracolumbar burst fractures, opinion is divided, Whether to go anterior or posterior, long segment or short segment fixation is still debated [1,2]. As the anterior column is damaged and deficient due to the injury, there is a chance of biomechanical failure. Indirect or direct reconstruction of the anterior column has thus been proposed. McCormack's load sharing classification predicted the need for additional support or augmentation anteriorly in case of fractures with load sharing classification score of more than seven [3]. Anterior corpectomy and reconstruction can cause significant morbidity especially in the setting of trauma. McCormack's load sharing classification is now viewed with controversy as this was provided in year 1994 when robust pedicle screw fixation was not in vogue, and with the advent of good pedicle screw fixation, there was smooth shift from anterior surgeries to posterior surgeries for burst thoracolumbar fractures. Posterior surgeries typically involved long segment fixation where one spans two levels above and below. In pursuit of saving levels the fixation was further reduced to one level above and below, so called short segment fixation. However, it led to unacceptable implant failures [4]. The short segment fixation further was modified to mitigate the failures with addition of a short index screw in the fractured vertebra with an aim is to support the anterior column which helps in avoiding the anterior surgery [5,6,7]. Biomechanical studies have shown that addition of screw in fracture vertebra protects the anterior column from loading [8]. Most of the time, one of the two pedicles of fractured vertebra remains intact which can be used for pedicle screw fixation. However, the characteristics of this index screw are poorly defined in literature [9]. Our aim is define the characteristics of the index screw that is to be used in the fractured vertebra and achieve desirable results.

Materials and Methods

This is a retrospective study conducted at our institute from year 2019 to year 2022 which included 45 patients with thoracolumbar fractures treated by short segment fixation with screw in the fractured vertebra. Anterior body compression [10] (ABC %) was calculated by dividing the anterior body height of the fractured vertebral body by the mean anterior body height of the intact vertebral bodies above and below the fractured vertebra: (b/[(a+c)/2]x100), shown in figure 1. Local and global kyphosis angles were measured as shown in Figure 2. Outcomes were measured before surgery and immediately after surgery and at the end of 6, 12 and 24 months. Loss of Cobb's angle at 2year follow-up was measured. Screw and rod breakage or screw pull-out were considered as implant failure.

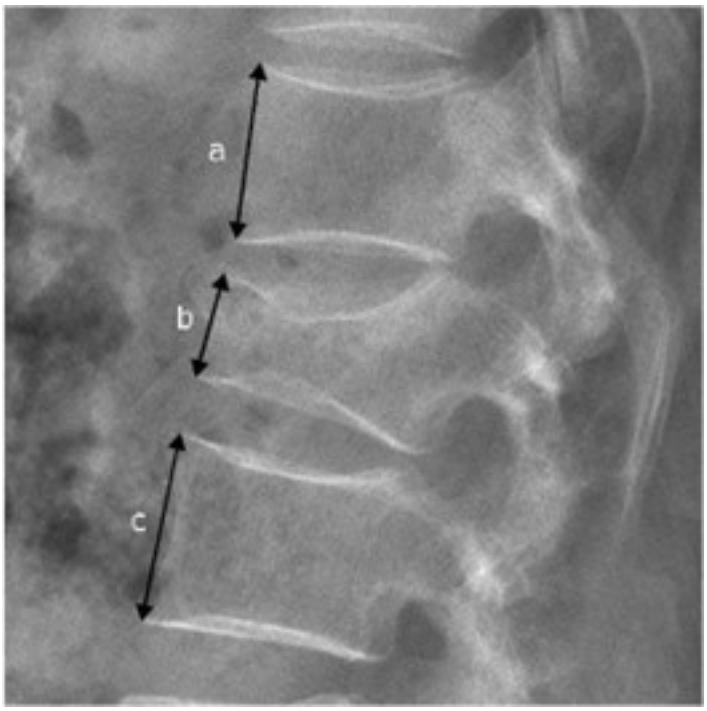

Figure 1: Anterior body compression percentage can be calculated using the formula (b/[(a+c)/2]x100)

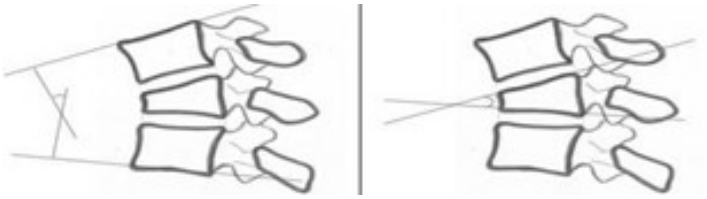

Figure 2: Showing the measurement of global (left) and local (right) kyphosis angle

Surgery

While managing these injuries one has to strike the balance, between the kyphosis created by the injury, and the height restoration created by the strong pedicle screws which have the distracting phenomenon in the vertebral body. A caudally directed screw distracts the vertebral body by cantilever mechanism. The surgeon has to be wary of the iatrogenic over-distraction leading to anterior void. The optimum distraction should be not more than 80% of the cranial vertebral body. It is now known that any void in the metaphysis within physiological limits, secondary to trauma, as in proximal tibia or calcaneus when buttressed adequately, the void fills quickly because of associated osteosynthesis.

The standard of care is same as any other surgery for spinal trauma where the positioning itself will reduce the local kyphosis caused by the trauma in significant amount. The slight modification the senior author performed was to pass a monoaxial screw of appropriate dimension, into the least injured pedicle of the injured vertebra. The screw was passed caudally, as the vertebral body fails in compression, and usually the upper third vertebral body is injured and bursts leaving the lower two third body intact. A caudally directed screw not only gets purchase in the healthy part of the injured vertebral body but also jacks up the vertebral body to restore the vertebral height when tightened to the screw rod construct. This caudally directed screw protects the intravertebral restoration of height by the raft mechanism. A monoaxial screw does this job far better than a poly or bi-axial screw as monoaxial screw acts a single unit in cantilevering process whereas a poly axial screw tilts the tulip without moving the screw in the vertebral

body. Monoaxial screw constructs also proved to be a stiffer construct and reduce von Mises stress on screw [11, 12]. The diameter of screw is important here as a thin screw in the pedicle leads to toggle effect in the pedicle thus defeating the purpose of cantilevering. The screw should be of appropriate length as it should reach all the way to the anterior vertebral border so it can effectively cantilever and buttress the elevated vertebral body as raft screw. A shorter screw, on the contrary stops just short of the compressed depressed fragment and fails to elevate the depressed fragment effectively. In order to have an effective restoration of vertebral body height, the typical index screw should be a monoaxial screw of appropriate dimension with respect to thickness and length.

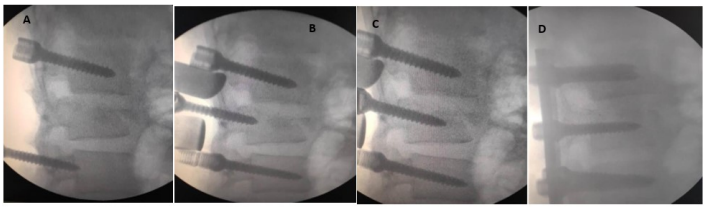

Figure 3: A) showing the instrumentation of the cephalad and caudal vertebrae. B)showing pedicle insertion into the fracture vertebra in caudal direction C) showing that the pedicle screw passing beyond the middle column D) showing the achieved height of the fractured vertebra after the completion of the construct

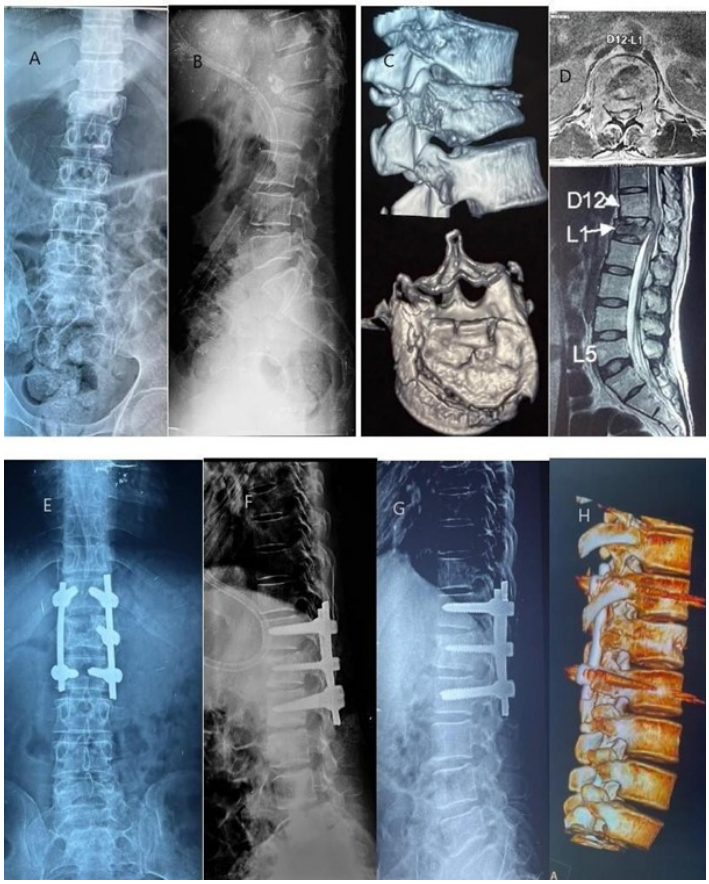

Figure 4: 31 year old male with L1 burst fracture. (A-D) Pre-operative images show burst fracture in lateral radiographs, CT scan and retropulsion of fragments in MR images. (E, F) Immediate post-operative radiographs. Pre-operative global kyphosis angle of 34.1°, local kyphosis angle of 48.2° improved to 2.8° and 4.4° respectively in the immediate follow-up. (G, H) Final follow-up radiographs showing gain of vertebral height by 80% compared to pre- operative radiographs

Results

Patient demographics and injury information

Forty-five patients with a mean follow-up of 28 months (24-32 months) were analysed. Table 1 depicts the demographic data in terms of age, gender and details of fracture, American spinal cord injury association [ASIA] and associated complaints. The mean age was 29.3 (±10.5) years. Male-female ratio was 35:10. Among the fractures, L1 was the most commonly fractured vertebra (n=21), followed by T12 (n=7), L2 (n=6), L3 (n=6), T11 (n=3) and L4 (n=2). Seventeen patients had normal neurology (ASIA E), twenty patients had incomplete deficits (ASIA B, C, D) and 8 had complete deficits (ASIA A). All the cases had TLICS score of more than 5.

Surgery details

Short segment instrumentation which included fracture vertebra as a point of fixation was done for all the patients. Out of 45 cases, all but two cases were instrumented on one side of the pedicle of fractured vertebra and for the remaining two cases bilateral pedicle instrumentation was done for the fractured vertebra. The mean operating time was 90 minutes and the mean blood loss was 200ml. The most common screw that was used for the fractured vertebra was 6.5mm in diameter, 40mm in length. Length of the screw was usually taken 0.5mm lesser than that of the cephalad vertebra. Only posterior instrumentation was performed for all the patients.

Radiographic evaluation

The mean preoperative angles of global kyphosis and local kyphosis were 20.92 degrees and 20.91 degrees respectively. This improved significantly to 9.16 degrees and 8.28 degrees respectively at the final follow-up (P value <0.001). There was a loss of mean global kyphosis of 1.33° and local kyphosis of 0.81° at the final follow-up. The mean vertebral height was 54.44% and it improved to 85.07% in the immediate post-operative period and at the final follow-up it was maintained at 82.40% (P value <0.001), indicating that there was no significant loss of the vertebral height that was achieved.

Table 2 depicts the descriptive statistics of the variables that were studied. Table 3 shows the preoperative and postoperative comparison data for local and global kyphosis angle. Table 4 depicts the preoperative and postoperative comparison data for achieved vertebral height gain.

No post-operative MRI was obtained as the parameters we discussed could be compared on the radiographs.

Table 1: Distribution of general characteristics of the patients enrolled in the study. (n=45)

Characteristics	Number	Percentage
Age groups (in years)		
<20	9	20
20-30	21	46.7
30-40	7	15.5
>40	8	17.8
Gender		
Male	35	77.8
Female	10	22.2
Fracture level		
L1	21	46.7
L2	6	13.3
L3	6	13.3
L4	2	4.4
T11	3	6.7
T12	7	15.6
Associated fractures		
Calcaneum fracture	10	22.2
Femur fracture	5	11.1
Others	9	20
Nil	21	46.7
Bowel and bladder involvement		
Yes	16	35.6
No	29	64.4
ASIA score		
Pre-operative		
A	8	17.8
B	4	8.9
C	5	11.1
D	11	24.4
E	17	37.8
Post-operative		
A	4	8.9
B	0	-
C	2	4.4
D	11	24.4
E	28	62.2

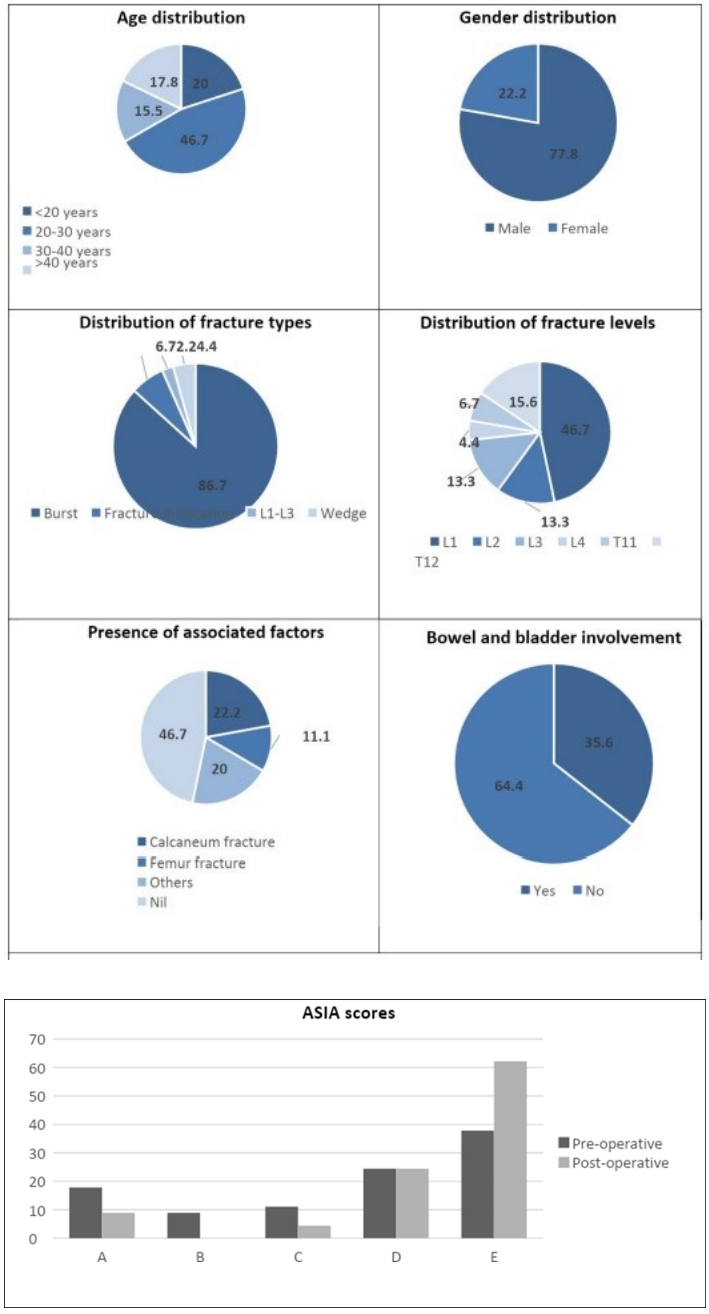

Figure 5: Demographics of the data demographic data in terms of age, gender and details of fracture, American spinal cord injury association [ASIA] and associated complaints

Table 2: Descriptive statistics of the outcome variables – Kyphosis and vertebral height

Parameter	Mean	SD	Median (IQR)
TLICS score	6.38	1.47	7 (5-8)
Correction of kyphosis			
Global	10.39	8.6	8 (4-16)
Local	11.56	9.12	8 (6-15)
Achieved vertebral height			
Follow-up	82.4	10.35	84 (78-90)
Correction percentage	31.64	18.75	27 (20-41)
Loss of correction of kyphosis			
Global	1.67	2.02	1.5 (0-3)
Local	0.84	2.95	1 (0-2)

Table 3: Difference in correction of kyphosis pre-operatively and post-operatively (N=45)

	Pre-operative		**Immediate post-operative**		
End correction of kyphosis					**P value**
	Mean	**SD**	**Mean**	**SD**	
Global	20.92	9.49	9.16	5.66	**<0.001**
Local	20.91	9.19	8.28	5.38	**<0.001**

	Pre-operative		**After follow-up**		
End correction of kyphosis					**P value**
	Mean	**SD**	**Mean**	**SD**	
Global	20.92	9.49	10.49	6.38	**<0.001**
Local	20.91	9.19	9.09	5.18	**<0.001**

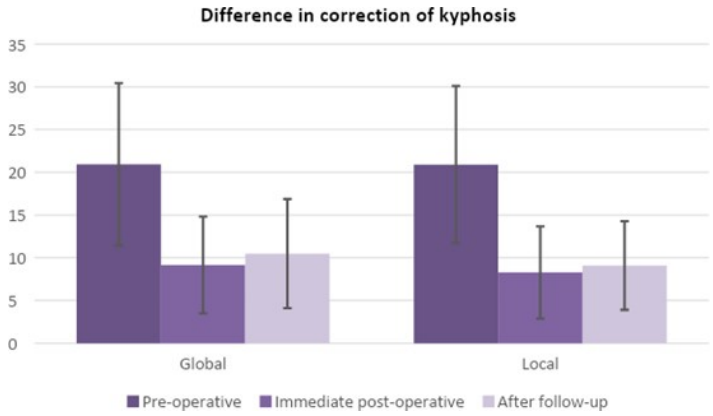

Figure 6: Comparision of Pre-operative kyphosis with immediate post-op period and follow-up period

Table 4: Difference in pre-operative and post-operative achieved vertebral height (N=45)

Achieved vertebral height	Pre-operative		Immediate post-operative		
	Mean	**SD**	**Mean**	**SD**	**P value**
	54.44	18.63	85.07	11.21	**<0.001**

Achieved vertebral height	Pre-operative		Post-operative after follow-up		
	Mean	**SD**	**Mean**	**SD**	**P value**
	54.44	18.63	82.40	10.35	**<0.001**

Discussion

In pursuit of saving levels, short segment instrumentation became the standard of care for thoracolumbar fractures. Though it restrains less number of motion segments when compared to the long segment fixation, mono segmental short segment instrumentation had significant failure rate in terms of loss of kyphosis and implant breakage [13,14]. Many studies showed that this short segment fixation has led to early implant failure and loss of achieved correction in the follow-up period. The kyphosis causes stress on the anterior part of the vertebra and because of this stress, the construct may become loose and implant fails. To mitigate the implant related failures, adding a short pedicle screw in the fractured vertebra was initiated [5]. This modality of instrumentation of the fracture vertebra increased the number of anchor points and hence the strength of the construct increased without involving more motion segments. By adding an index short screw in the fractured vertebra increased the strength of the construct and the failure rates substantially reduced. However, the progression of local kyphosis, and late implant failures were still there.

Short segment fixation is the norm for treating unstable burst fractures. Instability is determined by the involvement of posterior ligamentous complex, loss of 50% of anterior vertebral height, local kyphosis greater than 20 degrees or canal encroachment of more than 50%, presence of neurological injury. Contraindications for using short segment fixation would be wedge fractures, osteoporosis, highly unstable type C injuries, ankylosing spondylosis. In the type C fractures or ankylosed spines long segment constructs are required to reduce the risk of implant failure.

Previous studies have used a shorter and a lesser diameter screw in the fractured vertebra as it would act as a push point and helps in correction of kyphosis. No studies have described the characteristics of the index screw that are to be used and hence we conducted a study in which we used a pedicle screw which is 6.5 mm in diameter and 5mm shorter than the one in cephalad vertebra.

Dick et al first proposed the concept of an intermediate screw and Anekstein et al had proved the efficacy of the same in his animal studies [5, 15]. Guven et al found that there is less loss of achieved correction with the use of monoaxial intermediate screws [7]. Mahar et al in their study had concluded that the intermediate screw offers two times more stability especially in flexion and extension [13]. Torio et al compared 24 cases treated by segmental fixation including the fractured vertebra with non-segmental group and found significant difference in maintenance of achieved correction in the segmental group[16]. Kanna et al found that use of screw in the fracture vertebra helps in achieving good results even in cases where LCS score is >7 obviating the need of anterior reconstruction [17].

Guven et al had used a monoaxial screw in group 4 in his study and achieved correction of 160 and the loss of correction in the follow-up was 2.80 and in our study the loss of correction was 1.30 . Hassan et al [19] in 2020 in their study had used a monoaxial screw which is left prouder and loss of correction was 2.5 degrees of global kyphosis and 1.2 degrees of local kyphosis. But the achieved vertebral height gain is 28% which is lower than what we have achieved in our study (58%) which can be attributed to the

use of longer and thicker screw. Kanna et al had used a polyaxial shorter screw in their study and achieved 13.70 of kyphosis angle and had a loss of 2.40 at final follow-up. They achieved 13.30 of correction in the wedge angle and had loss of 1.20 at final follow-up.

The results were better in our study which can be attributed to the use of a longer monoaxial screw which is caudally directed in the anterior part of the vertebra.

In our study we used a monoaxial screw, directed caudally which is longer, thicker screw which goes beyond the middle column, unlike in other studies where the screw was left proud as it would act as a push point [12]. The screw creates mass effect thus bearing the anterior load on the vertebra and helps in better vertebral height gain and also helps in reducing von Mises stress on the screw [10, 11]. A shorter straight screw lands up in the fractured part of vertebral body and hence has lesser torque strength.

As, fracture occurs in the upper third of vertebral body and a short straight screw grabs purchase in the fractured part of vertebral body, and this may be the cause of implant failure in short segment fixations. This progression of local kyphosis can further be allayed by using a typical monoaxial longer pedicle screw of appropriate diameter in the fractured vertebra which is caudally directed. By caudally directing the screw, the screw gets purchase in the relatively non fractured part of vertebral body, as in unstable burst fractures the upper third part of vertebral body gets fractured, and the monoaxial screw by the phenomenon of cantilevering elevates the depressed fragment and acts as a raft screw. Caudally directed screw also increases the length of the screw and the torque strength of the screw automatically increases as it gets its purchase in the non-fractured part of the vertebral body. The void created in the vertebra is taken care of by the screw in the fracture vertebra as it creates a mass effect directly which helps in maintaining the construct. The void created anteriorly is partly filled by the screw and it ossifies rapidly as these fractures occur in non-osteoporotic young individuals where the anterior longitudinal ligament is usually intact.

Monoaxial screws were used as the tulip and the shaft act as a single unit and provide more stiffness to the construct. The screw is initially directed caudally, beyond the middle column to get good bone purchase in the lower one-third of the vertebral body and later cantilevered, resulting in achieving vertebral height restoration. These factors may have contributed to the lesser loss of correction, maintenance of the vertebral height in the follow-up period.

Our study is not without limitations. The mean age of the cohort in our study was 29.3 years; the results may not be reciprocable in case of older induviduals where there may be assosciated osteoporosis. Our study did not have a comparision group where there is no usage of pedicle screw in the fractured vertebra. We compared our results with previous studies that were done in the same context. We gave a short period of 3 weeks immobilisation for all patients which might have contributed to the results. Our study is not a multi-centric study and studies with a bigger sample size are needed for validation of our results.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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