

Long segment versus short segment fixation in patients with post-traumatic fractures of the dorsolumbar transitional zone: Single institute experience

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Abstract

Background

Surgery is required to treat unstable thoracolumbar burst fractures. The best operation is still up for debate, though. Decompressing the neural components, reducing the fracture, and stabilizing the spine with fixation until arthrodesis is completed are the objectives of surgery. Our study aims to compare the effectiveness (both radiological and clinical outcomes) of short segment fixation (SSF) compared to long segment fixation (LSF) in dorsolumbar transitional zone post-traumatic fractures. The present study is a retrospective analysis of cases that underwent surgical fixation whether by long segment (more than one level below and one level above) versus short segment fixation (one level above and one level below plus the index level) operated upon in a single institute. The study period spans from January 2024 to January 2025. Patients were monitored through scheduled outpatient visits at 6 months and 1 year post-operatively.

Results

This study included 30 patients (divided into two groups, 15 patients each), with a mean age of 29.37 ± 10.46 years, where the majority of patients were males (73.3%), without previous surgical (76.7%) or medical (90%) history. The most frequently affected vertebra was L1 (53.3%), and the majority of trauma was secondary to road traffic accidents (53.3%), without statistically significant difference between SSF or LSF patients (all $p > 0.05$).

Conclusion

SSF and LSF provided comparable radiological outcomes in managing post-traumatic dorsolumbar transitional zone fractures. However, patients treated with SSF reported lower pain intensity scores at both 6 months and 1 year postoperatively, suggesting a potential clinical advantage of SSF in pain reduction without compromising structural stability.

Background

Trauma most commonly affects the thoracolumbar spine region at T10-L2 due to the particular biomechanics of this portion. This area is commonly referred to as the thoracolumbar junction. (1). Because of their higher levels of flexibility and range of motion, transitional zones of the spine may be more prone to injury. The thoracolumbar region serves as a pivot between the lumbar segment, whose facets are oriented sagittally to permit flexion-extension movement, and the more inflexible thoracic segment, whose facets are directed coronally to inhibit flexion-extension, translation, and rotation (2).

Surgery is required to treat unstable thoracolumbar burst fractures. The best operation is still debatable, though. (3). The convenience of rod placement has greatly increased with the introduction of polyaxial screws, especially in long constructs (4). Pedicle screw constructions enable fracture reduction and deformity reversal in addition to providing solid three-column support. (5). Anterior, posterior, and combination surgery are available as treatments for thoracolumbar fractures. Posterior-only surgery produces good clinical and radiological results (6). Short-segment posterior pedicle screw fixation (SSPF) places pedicle screws one level above and one level below the fracture location in an effort to maintain mobility segments (7). Long-segment posterior pedicle screw fixation (LSPF) structures have been proven to be reliable and effective in treating these injuries, but they may increase fracture stability at the price of mobility segments (8). The goals of surgery are to minimize the fracture, decompress the neural components, and stabilize the spine with fixation until arthrodesis is completed (9).

This theme has been the subject of numerous investigations, which have confirmed the benefit of repairing the fractured vertebra by greatly improving instrumentation stability and lowering the load on screws at nearby levels. In contrast to bridge fixation, it enables the avoidance of fixing more neighboring levels and guarantees stability akin to a longer fixation, hence reducing post-traumatic flattening of the vertebral body. Since then, brief posterior fixation with screws at the fracture level has emerged as the preferred treatment for compression fractures and has gained significant significance. (10).

Our study, then, aims to compare the effectiveness (both radiological and clinical outcomes) of short segment fixation compared to long segment fixation in dorsolumbar transitional zone post-traumatic fractures. Similar studies have undergone the same quest, however, to the best of our knowledge, our study will be the first to be conducted at our institute.

Methods

This study was approved by the local research ethical committee. Written consent was obtained from each patient or a legally authorized representative before procedures were performed. The present study is a retrospective analysis of 30 cases that underwent surgical fixation whether by long segment (more than one level below and one level above) versus short segment fixation (one level above and one level below plus the index level) operated upon in a single institute in the period between January 2024 and January 2025. Patients were divided into two equal groups: **Group I (n = 15)**: patients underwent short segment fixation (SSF) and **group II (n = 15)**: patients underwent long segment fixation (LSF).

We acquired preoperative clinical and radiological data and mechanism of injury. The Visual Analogue Scale (VAS) for postoperative pain evaluation was explained to each patient.. VAS (0 represents “no pain” while 10 represents “the worst pain imaginable”). All procedures were performed under general anesthesia with the aid of intraoperative (C-arm) for guidance throughout the procedure. A posterior midline approach was used in all cases for both short and long segment fixation with insertion of pedicle polyaxial screws and contoured rods in addition to artificial bone. The key difference between the two groups was the number of vertebral levels exposed and instrumented. **Short Segment Fixation:**

Instrumentation included one vertebral level above and below the fracture, with inclusion of the fractured vertebra (index level) (Fig. 1). **Long Segment Fixation:** Instrumentation included two levels above and below the injured vertebra (Fig. 2).

In addition to the routine post-operative follow-up protocol in our institute, patients were closely monitored through scheduled outpatient visits at 6 months and 1 year postoperatively. During each follow-up visit we assessed the implant integrity, need for revision or modification of the fixation construct, radiographic outcomes (including alignment, fusion status, and implant positioning), neurological and functional recovery and the development of any complications such as surgical site infection or hardware failure.

Statistical analysis:

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's t- test. Quantitative non-parametric data was presented as median and interquartile range (IQR) and were analyzed by Mann Whitney-test. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test or Fisher's exact test when appropriate. A two tailed P value < 0.05 was considered statistically significant.

Results

The study included 30 patients, with a mean age of 29.37 ± 10.46 years, where the majority of patients were males (73.3%), without previous surgical (76.7%) or medical (90%) history. The most frequently affected vertebra was L1 (53.3%), and the majority of trauma was secondary to road traffic accidents (53.3%), without statistically significant difference between SSF or LSF patients (all $p > 0.05$) (**Table 1**).

Table (1)

Demographic and clinical characteristics of patients

Gender	All (n = 30)	SSF (n = 15)	LSF (n = 15)	P value
Male	22 (73.3%)	13 (86.7%)	9 (60.0%)	0.215 ^a
Female	8 (26.7%)	2 (13.3%)	6 (40.0%)	
Age (mean ± SD)	29.37 ± 10.46	30.93 ± 10.8	27.8 ± 10.2	0.422 ^b
Fractured Vertebra				
D11	3 (10.0%)	2 (13.3%)	1 (6.7%)	0.241 ^c
D12	5 (16.7%)	2 (13.3%)	3 (20.0%)	
L1	16 (53.3%)	10 (66.7%)	6 (40.0%)	
L2	6 (20.0%)	1 (6.7%)	5 (33.3%)	
Surgical history				
Present	7 (23.3%)	4 (26.7%)	3 (20.0%)	1.00 ^a
Free	23 (76.7%)	11 (73.3%)	12 (80.0%)	
Medical history				
DM	1 (3.3%)	1 (6.7%)	0 (0.0%)	0.386 ^c
HTN	1 (3.3%)	0 (0.0%)	1 (6.7%)	
IHD	1 (3.3%)	1 (6.7%)	0 (0.0%)	
Free	27 (90.0%)	13 (86.7%)	14 (93.3%)	
Mode of trauma				
Fall from truck	1 (3.3%)	1 (6.7%)	0 (0.0%)	0.515 ^c
Fall from height	13 (43.3%)	7 (46.7%)	6 (40.0%)	
Road traffic accidents	16 (53.3%)	7 (46.7%)	9 (60.0%)	

a: Fisher's exact test. b: Independent samples T test. c: Chi square test. p < 0.05 is significant.

After 6 months of follow up, two patients (6.7%) had developed kyphosis, without statistically significant difference between SSF or LSF patients (6.7% vs. 6.7%, p = 1.000), however, patients who underwent SSF showed significantly lower VAS score (4.33 ± 0.488 vs. 5.73 ± 0.457 , p = 0.001) than LSF patients (Table 2).

Table (2)

Kyphosis and pain score after 6 months

Developed Kyphosis	All (n = 30)	SSF (n = 15)	LSF (n = 15)	P value
Kyphosis	2 (6.7%)	1 (6.7%)	1 (6.7%)	1.000 ^a
Successful	28 (93.3%)	14 (93.3%)	14 (93.3%)	
VAS score (mean ± SD)	5.03 ± 0.85	4.33 ± 0.488	5.73 ± 0.457	0.001^b

a: Chi square test. b: Independent samples T test. $p < 0.05$ is significant.

After one year of follow up, three patients (10%) had developed kyphosis, one patient had slipped rod (3.3%), and three patients (10%) had failed screw, without statistically significant difference between SSF or LSF patients ($p = 1.00$), however, patients who underwent SSF showed significantly lower VAS score (5.13 ± 0.64 vs. 6.2 ± 0.56 , $p = 0.001$) than LSF patients (**Table 3**).

Table (3): Kyphosis and pain score after one year

Developed Kyphosis	All (n = 30)	SSF (n = 15)	LSF (n = 15)	P value
Kyphosis	3 (10%)	2 (13.3%)	1 (6.7%)	1.00 ^a
Successful	27 (90%)	13 (86.7%)	14 (93.3%)	
Slipped rod	1 (3.3%)	0 (0.0%)	1 (6.7%)	1.00 ^a
Failed screw	3 (10%)	2 (13.3%)	1 (6.7%)	1.00 ^a
VAS score (mean± SD)	5.67 ± 0.80	5.13 ± 0.64	6.2 ± 0.56	0.001^b

a: Fisher's exact test. b: Independent samples T test. $p < 0.05$ is significant.

There was no statistically significant difference between SSF or LSF patients in terms of absolute or percent of change of VAS score (all $p > 0.05$) (**Table 4**).

Table (4): Degree of change of VAS from 6 months to one year among patients

Median, IQR	All (n = 30)	SSF (n = 15)	LSF (n = 15)	P value*
VAS score				
Absolute change	0.64 ± 0.05	0.8 ± 0.15	0.47 ± 0.10	0.174
Percent of change	12.7 ± 5.8	18.4 ± 30.1	8.2 ± 21.5	0.056

*: Mann Whitney test.

Discussion

Due to biomechanical stresses associated with its position in a transitional zone between the more mobile and dynamic lumbar spine and the relatively rigid thoracic spine that is connected to the rib cage, the thoracolumbar (TL) junction (T11-L2) is the most frequently injured segment of the vertebral column (11).

When treating thoracolumbar burst fractures, most spine surgeons favor surgical surgery (12). The goal of surgical intervention is to rectify local kyphosis at the broken level, accomplish rigid spinal fixation, and decompress the spinal canal to aid in neurological rehabilitation. Neurological impairment was present in 23% of instances of lumbar and thoracic fractures (13). Compression fractures, burst fractures, flexion-distraction injuries, and translational injuries are the four most common spinal injuries (14).

Kyphosis can be effectively corrected using long segment fixation (LSF), which lengthens the lever arm. Nevertheless, this method necessitates more extensive dissection of the paraspinal muscles, more intraoperative blood loss, a longer operating time, and the loss of several spinal motion segments for fixation (15).

The most likely causes of failures include insufficient fixation because of osteoporosis, insufficient anterior column support, and insufficient fixation level (16). More level integration was achieved by using long-segment constructions that connect two or three levels up and down from the affected vertebra. This lessens the strain on each pedicle screw. This approach has a lower failure rate, but it is more difficult and requires more equipment (17).

One level up and one level down from the broken vertebra, short-segment stabilization with pedicle screws (SPF) has recently acquired popularity due to its simpler administration, less implant utilization, reduced blood loss, and smaller incision (18). SSPF requires fewer motion segments than long-segment pedicle fixation (LSF), which is its primary advantage. However, over time, SSPF may cause implant failure and re-kyphosis (9–54%) (19).

The purpose of the current study was to evaluate the effectiveness of long-segment fixation versus short-segment fixation in the treatment of dorsolumbar transitional zone post-traumatic fractures. This retrospective comparative study was carried out on 30 patients with post-traumatic dorsolumbar

transitional zone fractures who underwent fixation at Cairo University Hospitals. All patients were followed up at 6 months and 1 year post-operatively using plain radiographs and the Numeric Pain Intensity Score for assessment. The cohort was equally divided into two groups: Group I comprised patients who received short-segment fixation, while Group II included those who underwent long-segment fixation.

Our findings showed that there were no appreciable differences between the SSF and LSF patients in terms of age, gender, fractured vertebra, surgical history, medical history, or type of trauma. In agreement with our study, Choudhury and colleagues (19) conducted a study on 80 patients with incomplete spinal cord injuries. SSF or LSF were administered to two groups of forty patients each. Regarding age, sex, trauma mode, level of pathology, and fracture type, they found no significant differences between the groups.

El-Khadarway and colleagues (20) conducted a study on sixty patients who underwent posterior pedicle screw treatment for burst thoracolumbar spine fractures at the Neurosurgery Department of El-Ahrar General Hospital and Al-Azhar University Hospitals in Zagazig. The patients were divided into two groups at random. The thirty patients in the short segment group were treated with short segment fixation, which involves placing one level above and one level below the fractured vertebra. They noted that there were no appreciable differences between the two groups' demographic data, including age and gender.

Additionally, 50 consecutive patients with thoracolumbar burst fractures were randomly assigned to one of two groups in a prospective randomized controlled trial research conducted by El-Sharkawi and colleagues (21). Long segment pedicle screw fixation, or fixing of two levels above and below the broken vertebra, was used to treat Group A (25 patients). Short segment fixation, or one level above and one level below the fractured vertebra, with one or two intermediate screws in the fractured vertebra itself, was used to treat Group B (25 patients). They illustrated that the age, gender, mechanism of injury and associated injuries were insignificantly different between SSF and LSF patients.

Our findings showed that after 6 months of follow up, no significant difference between SSF or LSF patients were observed regarding developed kyphosis. Patients who underwent SSF showed significantly lower VAS score than LSF patients. While after one year of follow up, no significant difference between SSF or LSF patients were observed regarding developed kyphosis, slipped rod and failed screw. Patients who underwent SSF showed significantly lower VAS score than LSF patients. There was no statistically significant difference between SSF or LSF patients in terms of absolute or percent of change of VAS score.

Similarly, Choudhury and colleagues (19) showed that radiological indicators like degree of kyphosis, kyphotic deformity, and Beck index did not appear to change significantly at the end of follow-up; however, there was no statistically significant difference in ODI and VAS. The variations in the results might be attributed to the differences in the population characteristics as well as geographical disparities in surgical practices and postoperative care standards, could all contribute to the observed divergence in results across studies.

Similarly, El-Khadarway and colleagues (20) highlighted that the change in VAS was insignificantly different between both groups. Additionally, the follow up imaging evaluation including developed kyphosis, slipped rod and implant system failure were insignificant between SSF and LSF groups. However, the VAS score at 12-weeks follow-up was insignificant between the SSF and LSF groups. This discrepancy in outcomes could be explained by the variations in pain intensity preoperatively as most patients in their study had mild pain.

In agreement with our findings, Ahsan and colleagues (22) carried out a study on 56 patients with thoracolumbar fracture. There were 25 patients in the short segment group (open = 11, minimal invasive surgery (MIS) = 14) and 31 patients in the long segment group. They stated that the SSF group showed significantly superior outcomes regarding the VAS at 6 months compared to LSF group.

This was in line with the meta-analysis conducted by Aly and colleagues (23) to compare the efficacy of long and short segment pedicle screw fixation in the treatment of thoracolumbar burst fractures. They came to the conclusion that there was no discernible difference between the two groups in terms of neurologic improvement, radiological outcome, functional outcome, and implant failure rate. However, there was no statistically significant improvement in the VAS status for pain between the preoperative and final follow-up ($p = 0.161$).

Further supporting our study, Biakto and colleagues (24) performed a g cross-sectional study on 21 patients with neglected single level thoracolumbar burst fracture underwent SSF or LSF. They revealed that the kyphotic angle correction was insignificant between both groups.

Additionally, El-Sharkawi and colleagues (21) found no significant difference between the two groups in terms of the degree of correction of the local kyphosis angle, the restoration of anterior vertebral body height, or the corrective loss seen throughout the follow-up. Furthermore, there was no significant difference in the clinical result between SSF and LSF patients at the 6-month follow-up.

Additionally, Ökten and colleagues (25) found that the preoperative mean angle of kyphosis was $20.96^\circ \pm 4.74^\circ$ in SSF and $22.59^\circ \pm 5.890$ in LSF ($p = 0.234$). At the most recent follow-up, the mean angle for the SSF and LSF groups was $15.97 \pm 5.62^\circ$ and $17.76 \pm 11.22^\circ$, respectively. This difference was not statistically significant ($p = 0.579$).

Conclusion

SSF and LSF provided comparable radiological outcomes in managing post-traumatic dorsolumbar transitional zone fractures. However, patients treated with SSF reported lower pain intensity scores at both 6 months and 1 year postoperatively, suggesting a potential clinical advantage of SSF in pain reduction without compromising structural stability. The primary limitations of our study are the relatively small sample size, being a single center study, relying primarily on radiographs and pain scores, without incorporating more comprehensive functional or quality-of-life assessments and the relatively short follow-up period (1 year).

Abbreviations

LSF: long segment fixation, LSPF: long-segment posterior pedicle screw fixation, ODI: Oswestry disability index, SSF: short segment fixation, SSPF: short-segment posterior pedicle screw fixation, TL: thoracolumbar, VAS: visual analogue scale.

Declarations

Author Contribution

Conception and design: M.M., A.A. drafted the manuscript, Y.A. and M.F.: Critical evaluation of the manuscript. All authors approved the final version to be published.

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Figures

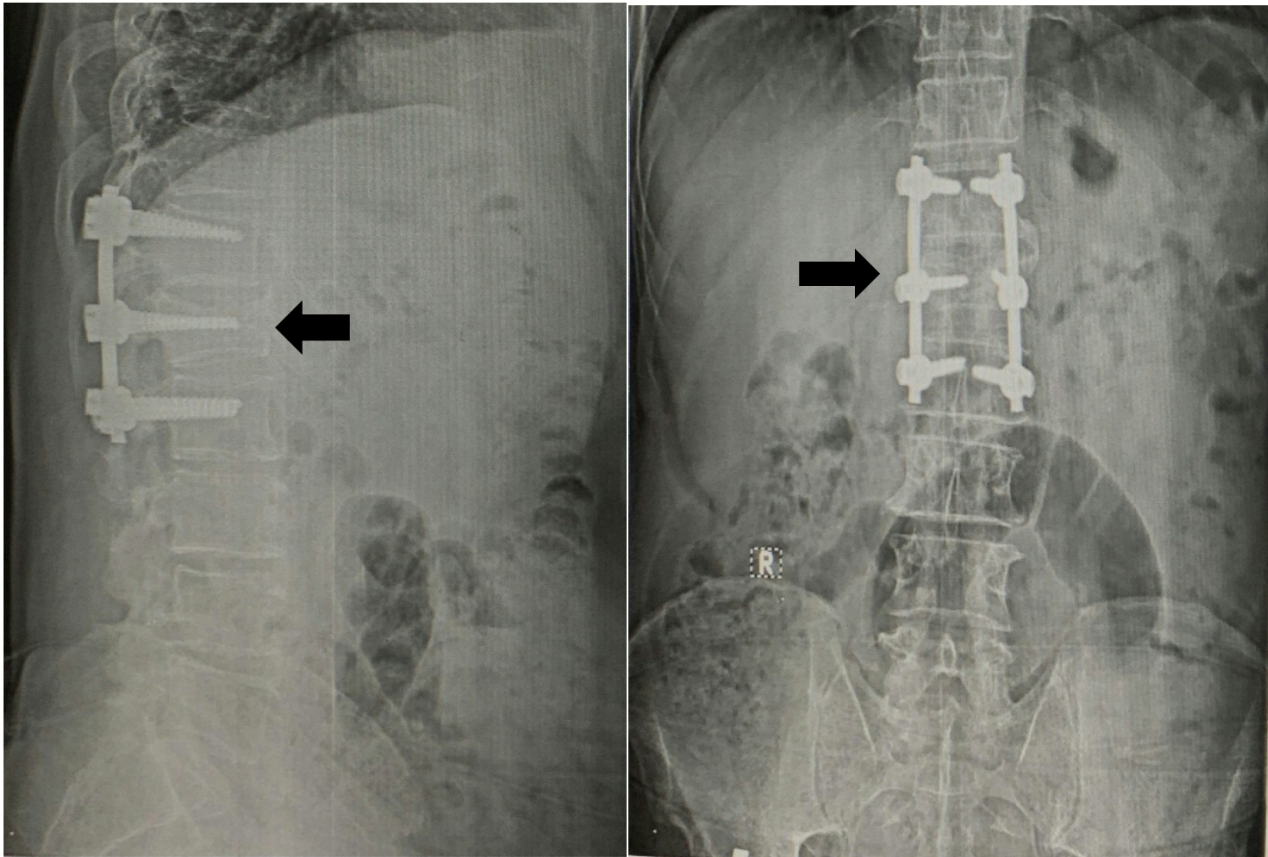


Figure 1

Short Segment Fixation: Instrumentation included one vertebral level above and below the fracture, with inclusion of the fractured L1 vertebra (index level) represented by the black arrow

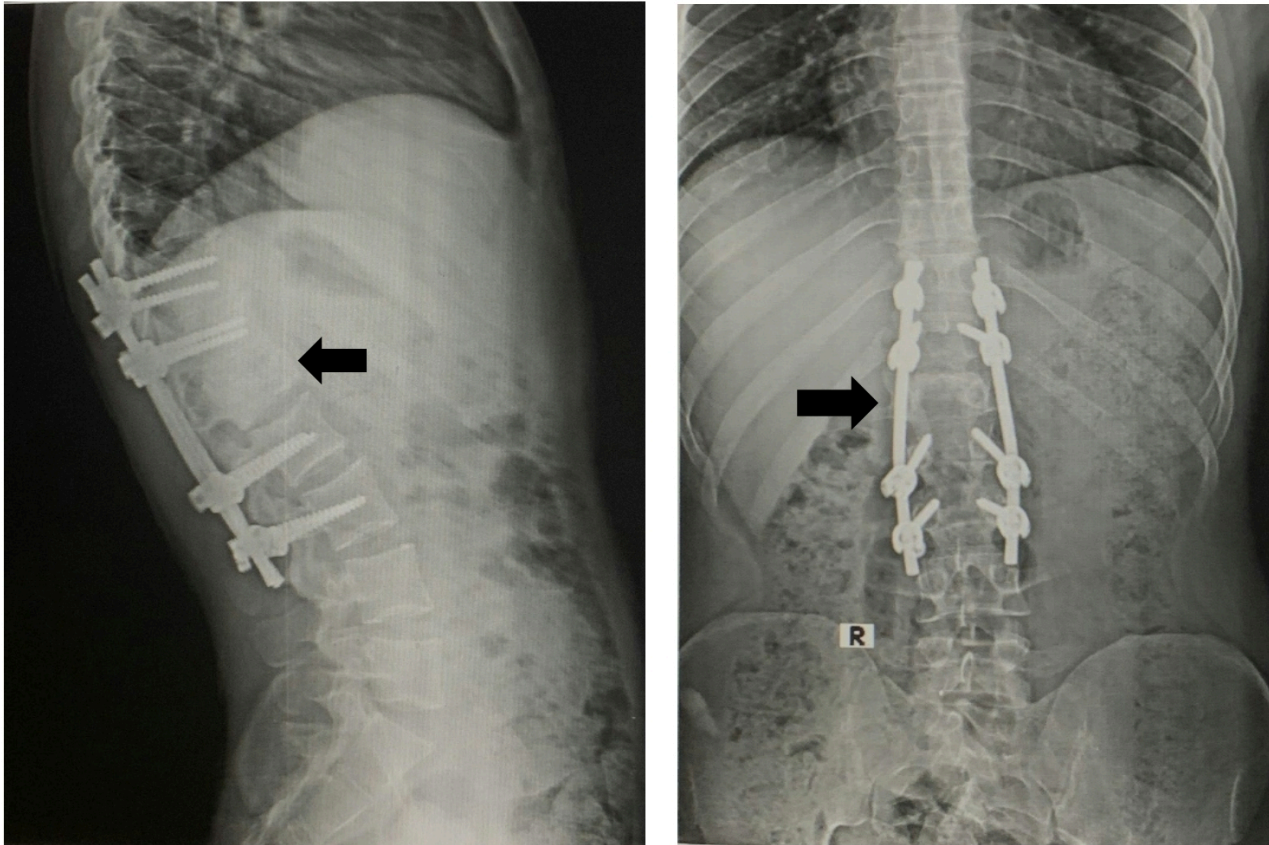


Figure 2

Long Segment Fixation: Instrumentation included two levels above and below the injured L1 vertebra represented by the black arrow