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Original Article

Utilization of L5-S1 interbody cage in adult spinal deformity patients undergoing lumbar spinal osteotomies and spinopelvic fixation: A retrospective comparative study

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ABSTRACT

Background: Adult spinal deformity (ASD) surgeries often face complications, such as pseudoarthrosis and rod fractures (RFs), particularly at the lumbosacral junction. While transforaminal lumbosacral interbody fusion (TLIF) at L5-S1 is thought to improve outcomes, its efficacy in major ASD surgeries remains unclear. This study aims to compare clinical and radiological outcomes and implant complications in patients undergoing spinopelvic fixation with or without L5-S1 TLIF.

Methods: A retrospective cohort study was conducted, including 157 ASD patients who underwent high-grade osteotomies and spinopelvic fixation from 2021 to 2024. Patients were divided into two groups: those with L5-S1 TLIF (C group, n = 71) and those without (NC group, n = 86). Outcomes included rod fracture (RF) rate, sagittal alignment, and patient-reported measures such as the Visual Analog Scale (VAS), Oswestry disability index (ODI), and 36-Item Short Form Survey (SF-36), assessed at baseline, 1, 6, and 12 months postoperatively.

Results: RFs were significantly lower in the C group (4% vs. 13%, P = 0.03). Improved postoperative sagittal vertical axis and pelvic tilt were noted in the C group (P < 0.01). Both VAS and ODI scores were significantly better at 6 and 12 months in the C group (P < 0.01), along with higher SF-36 scores. No significant differences in baseline characteristics, estimated blood loss, or operation time were observed.

Conclusion: The use of L5-S1 TLIF reduces RF rates, improves sagittal alignment, and clinical outcomes in ASD surgery. Incorporating TLIF at L5-S1 may optimize outcomes without increasing perioperative risks.

Keywords: Cage, Interbody fusion, Nonunion, Pseudoarthrosis, Rod fracture, Sagittal

INTRODUCTION

A significant portion of the financial burden of adult spine deformity surgery comes from its complications. Of these complications, the incidence of rod fractures (RFs) in the lower lumbar spine, particularly at the LS junction (L4–S1), is considerable among adult spinal

deformity (ASD) patients.[3,6] Incorporating sacro-pelvic fixation techniques with iliac screws and S2 alar iliac (S2AI) screws has been demonstrated to safeguard the S1 screws and enhance fusion rates in lengthy constructs.[3] Previous studies have shown that anterior approach minimally invasive L5/S1 interbody fusion in ASD patients improves clinical outcomes and reduces the implant failure rate.[7] In this study, we compared patients with ASD who underwent spinopelvic fixation and high-grade lumbar spinal osteotomies, with or without L5/S1 TLIF.

MATERIALS AND METHODS

Study setting and data source

Following Institutional Review Board approval, we retrospectively analyzed ASD patients who underwent high-grade lumbar osteotomy with spinopelvic fusion with or without accompanying L5-S1 transforaminal lumbosacral interbody fusion (TLIF), performed by the senior author (MR) between 2021 and 2024. Demographic, clinical, and surgical data were obtained from the medical records/operative database (i.e., The Yas Spine Center of Excellence Registry Group [YAS-SCORG]).

Study design, grouping, and data extraction method

This retrospective study utilized the YAS-SCORG registry database for analyzing 538 Adult Deformity patients undergoing spinopelvic fusion and lumbar osteotomy in 2021 and 2024 [Figure 1]. Using multiple inclusion and exclusion criteria [Table 1], we identified 157 patients; 86 had bilateral S2AI without a cage (the No Cage [NC] group or NC Group) versus 71 receiving bilateral S2AI plus L5-S1 interbody cages (the Cage group or C group). Patients in both groups averaged 60.5 years of age, and there were no significant differences between groups regarding baseline demographics, radiographic parameters [Table 2 and Figure 1].

Surgical procedures

All surgeries were performed by the same surgeon and involved Grade 3 or 4 osteotomies in the lumbar spine. The four-rod technique (satellite rod) was used at the osteotomy level.[4] Two 6.2 mm diameter chromium-cobalt rods were attached to the upper instrumented vertebra and bilateral S2AI screws, spanning the vertebrae except those directly adjacent to the osteotomy. No interbody cage was used in the NC group of patients treated from 2021 to 2023 [Figure 2]. In contrast, the cage (C) group from 2023 to 2024 underwent an L5-S1 discectomy, during which an autologous bone-filled polyether ether ketone (PEEK) interbody cage was placed through open TLIF [Figure 2]. The cage size was determined intraoperatively after clearing the disc space, and the largest fitting cage was positioned with intraoperative imaging confirmation. If the surgery lasted over 6–8 h or blood loss exceeded 2000 cc, a temporary rod was placed on both sides, and the procedure was paused after consulting the anesthesiologist. The second stage, involving osteotomy completion and final rod fixation, was delayed by 4–6 days.

Table 1: Inclusion and exclusion criteria for the study.

Inclusion criteria	Exclusion criteria
1. Should have radiographic criteria of ASD (one or more of the following criteria) • SVA ≥50 mm • Lumbar lordosis <30° • Thoracic kyphosis >60° • Pelvic tilt >25° • Pelvic incidence minus lumbar lordosis >10° 2. Underwent high-grade three-column osteotomy (Grade 3 or 4 Schwab) 3. Spinopelvic fixation with bilateral single S2AI screw 4. At least 12-month postoperative follow-up	1. Incomplete clinical follow-up 2. Inadequate radiographic evaluation <12 months of follow-up 3. Infectious, traumatic, or neoplastic etiologies of spinal deformity 4. Patients on high-dose corticosteroid therapy

SVA: Sagittal vertical axis, ASD: Adult spinal deformity, S2AI: S2 Alar iliac

Table 2: Baseline characteristics of patients included in the study.

Variables	No cage (*n*=86)	Cage group (*n*=71)	*P*-value*
Age (years)	61.0±7.0	58.6±12.9	0.17
Sex (male/female)	(38/48)	(25/46)	0.25
BMI (kg/m^2)	28.9±6.0	29.9±5.4	0.28
Follow-up duration (months)	17.5±4.5	16.3±3.8	0.08
Smoking, *n* (%)	21 (24%)	15 (21%)	0.62
DM, *n* (%)	18 (20%)	14 (19%)	0.85
T-score	−1.61±0.38	−1.73±0.53	0.10
History of spine surgery, *n* (%)	80 (93%)	70 (98%)	0.09

BMI: Body mass index, DM: Diabetes mellitus, *P<0.05: Significant

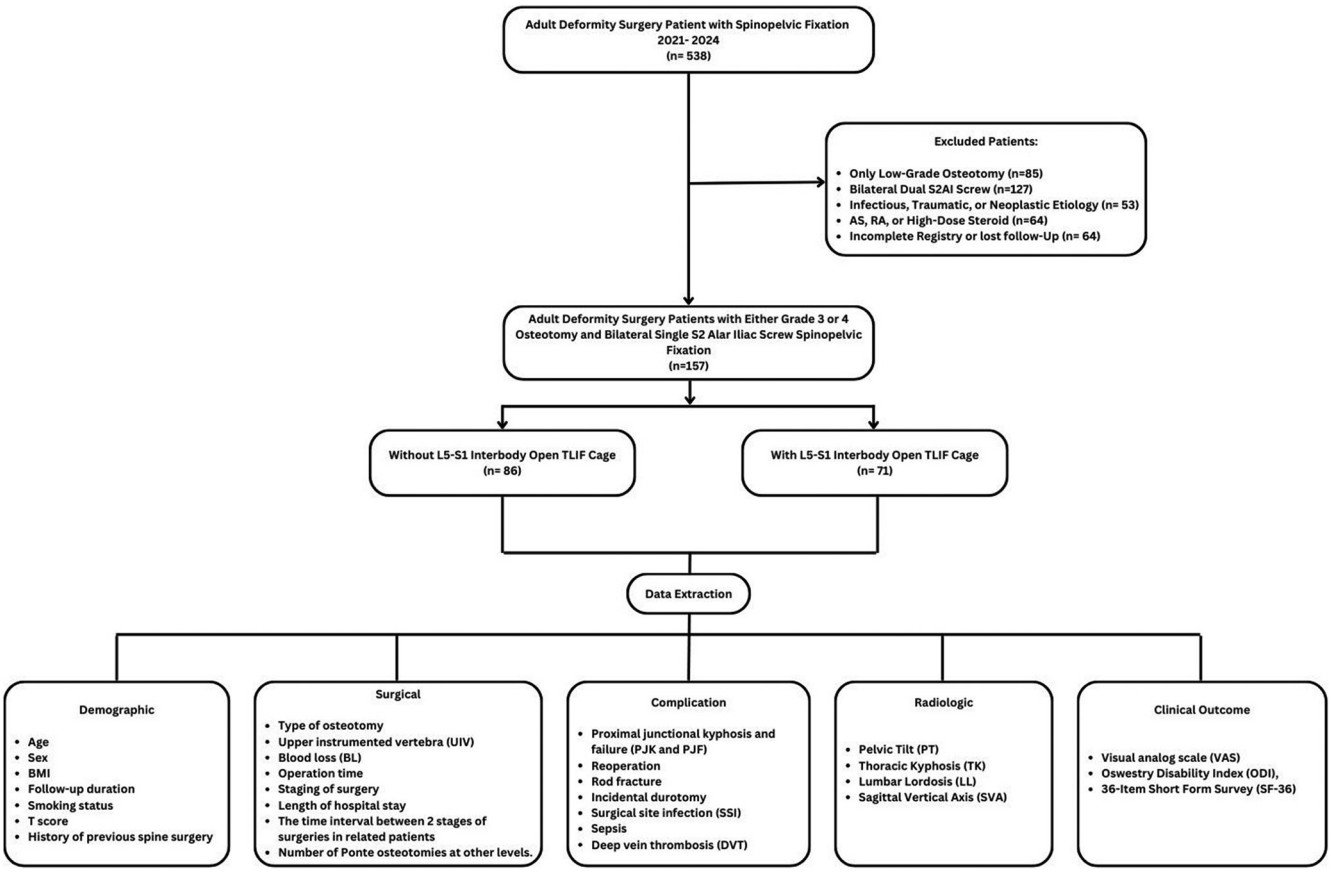

Figure 1: Study design and data collection of the study.

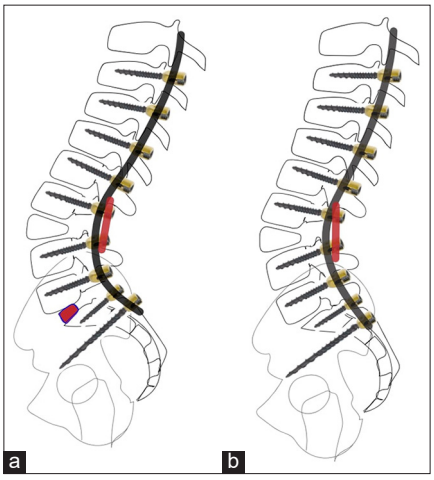

Figure 2: Schematic illustration shows the surgical procedure. (a) Demonstrates the Cage Group (there is a rectangular L5-S1 cage and satellite rod between the L3 and L5), (b) Demonstrates the no-cage group (there is no cage in L5-S1 space, there is a satellite rod between L3 and L5).

Statistical analyses

Statistical analyses were conducted using IBM Statistical Package for the Social Sciences version 26.0. The Kolmogorov–Smirnov test assessed normal distribution, and continuous variables were reported as means (standard deviation). Parametric tests, including Chi-square and independent sample *t*-tests, compared outcomes between groups. A two-sided $P < 0.05$ was deemed significant, with results visually represented using GraphPad Prism.

RESULTS

Surgical data assessment

Table 3 shows that a greater percentage of patients in the C group underwent single-stage surgeries compared to the NC group (C: 73% vs. NC: 47%; $P = 0.03$). In addition, the interval between stages for two-stage surgeries was longer in the C group (C: 5.5 ± 1.1 days vs. NC: 4.1 ± 1.6 days; $P < 0.01$).

Table 3: Surgical data of patients who underwent grade 3 or 4 osteotomy.

Variables	No cage (*n*=86)	Cage (*n*=71)	*P*-Value*
Upper instrumented vertebrae			
T10	44 (51%)	36 (50%)	0.93
T9	12 (13%)	10 (14%)	
T8	3 (3%)	4 (5%)	
T4 or upper	27 (31%)	21 (29%)	
Stage (s) of operation			
Single stage	41 (47%)	46 (71%)	0.03*
Two stages	45 (52%)	25 (35%)	
Operation time (Min)	560±150	593±151	0.18
Blood loss	1258±364	1276±391	0.76
Type of osteotomy			
Pedicle subtraction osteotomy, *n* (%)	77 (89%)	62 (87%)	0.66
Corner osteotomy, *n* (%)	9 (10%)	9 (12%)	
Level of osteotomy, *n* (%)			
L2	15 (17%)	16 (22%)	0.68
L3	15 (17%)	13 (18%)	
L4	56 (65%)	42 (59%)	
Number of Ponte osteotomies at other levels	2.3±1.5	2.6±1.6	0.24
The time interval between 2 stages of surgeries in related patients	4.1±1.6	5.5±1.1	<0.01*
Length of hospital stay postoperative	7.6±2.8	7.7±2.4	0.76

(**P*<0.05=significant).

Postoperative complication profile

The complication profiles of both groups showed no significant differences in reoperation, proximal junctional kyphosis, incidental durotomy, surgical site infection, sepsis, or deep vein thrombosis. However, the C group had a significantly lower RF rate of 4% compared to the NC group's 13%, with an odds ratio of 0.27 [Table 4].

Table 4: Complication profile of patients who underwent grade 3 or 4 lumbar osteotomies with or without L5-S1 cage.

Variables	No cage (*n*=86) (%)	Cage (*n*=71) (%)	*P*-value*
Need to reoperation	11 (12)	8 (11)	0.77
PJK	22 (25)	19 (26)	0.86
PJF	8 (9)	7 (9)	0.90
Rod fracture	12 (13)	3 (4)	0.03*
Incidental durotomy	5 (5)	8 (11)	0.21
Surgical site infection	10 (11)	7 (9)	0.72
Sepsis	4 (4)	3 (4)	0.89
DVT	8 (9)	9 (12)	0.49

PJK: Proximal junctional kyphosis, PJF: Proximal junctional failure, SAI: S2 alar Iliac, DVT: Deep vein thrombosis, **P*<0.05: Significant

Radiological outcome

Table 5 shows no significant differences in baseline preoperative radiological parameters between the two groups. Postoperatively, lumbar lordosis and thoracic kyphosis were similar, but the pelvic tilt was significantly lower in the C group (C: 12.9 ± 5.6 vs. NC: 17.7 ± 5.0). The final sagittal vertical axis was also lower in the C group (C: 44.1 ± 18.4 vs. NC: 59.3 ± 13.3).

Clinical outcomes

Table 6 and Figure 3 show the patient-reported outcomes of the study. The Visual Analog Scale (VAS) scores were similar at baseline and 1 month postsurgery but significantly lower in the C group at the 6-month and 12-month follow-ups. The Oswestry Disability Index (ODI) and SF-36 demonstrated similar trends, with no significant differences initially but improved scores in the C group at later follow-ups.

Table 5: Radiological outcomes of patients who underwent grade 3 or 4 osteotomies with or without L5-S1 cage insertion.

Variables	No cage (*n*=86)	Cage (*n*=71)	*P*-value
LL			
Preoperative	−13.9±7.9	−15.6±5.7	0.12
Postoperative	−47.1±9.7	−48.1±6.8	0.45
Changes	−33.1±12.7	−32.4±9.2	0.68
PT			
Preoperative	28.0±7.7	29.9±7.7	0.12
Postoperative	17.7±5.0	12.9±5.6	<0.01*
Changes	−10.2±9.3	−17.0±9.1	<0.01*
TK			
Preoperative	25.7±12.8	23.8±12.3	0.35
Postoperative	47.4±10.0	45.0±10.8	0.14
Changes	21.7±16.0	21.1±16.4	0.81
SVA			
Preoperative	219.8±71.1	205.0±68.1	0.18
Postoperative	59.3±13.3	44.1±18.4	<0.01*
Changes	−160.4±74.2	−160.8±72.9	0.97

LL: Lumbar lordosis, PT: Pelvic tilt, TK: Thoracic kyphosis, SVA: Sacral vertical axis, *P<0.05: Significant

Table 6: Comparison of outcome measurements between the groups.

Variables*	No cage (*n*=86)	Cage (*n*=71)	*P*-value
Pain intensity (VAS)			
At baseline	67.1±15.8	62.6±16.7	0.85
1st-month postop	67.5±12.7	68.6±13.4	0.61
6th-month postop	46.1±10.8	38.0±11.3	<0.01*
12th-month postop	42.8±10.6	34.3±8.8	<0.01*
ODI			
At baseline	66.8±17.1	69.1±14.0	0.36
1st-month postop	67.9±14.4	72.1±14.9	0.07
6th-month postop	31.3±15.6	23.8±11.7	<0.01*
12th-month postoperative	35.6±11.1	25.1±10.7	<0.01*
Quality of life (SF-36)			
At baseline	21.8±7.2	23.5±9.3	0.19
1st-month postop	18.2±12.1	19.0±13.9	0.71
6th-month postop	50.4±13.4	57.9±12.9	<0.01*
12th-month postop	52.6±12.2	65.3±12.1	<0.01*

VAS: Visual Analog Scale, Y: Yes; N: No, *values are represented as mean±standard deviation, ODI: Oswestry disability index

DISCUSSION

Table 7 summarizes the characteristics and results of the study and we will discuss our findings in the following part. Table 8 summarizes the studies included in discussion with results and design.

Table 7: Comprehensive summary of clinical and radiological outcomes, highlighting the effects of L5-S1 TLIF on rod fracture rates, sagittal alignment, and patient-reported measures.

Section	Summary
Title	Utilization of L5-S1 Interbody Cage in Adult Spinal Deformity Patients Undergoing Lumbar Spinal Osteotomies and Spinopelvic Fixation
Background	Challenges in ASD surgeries include pseudoarthrosis and rod fractures, especially at the lumbosacral junction.
Objective	To assess the clinical and radiological outcomes of L5-S1 TLIF in ASD surgeries.
Methods	Retrospective study (2021–2024) with 157 ASD patients divided into Cage (C, *n*=71) and No Cage (NC, *n*=86) groups. Clinical, surgical, and radiological outcomes were analyzed.
Key Results	- Rod Fractures: Significantly lower in the C group (4% vs. 13%, *P*=0.03). - Sagittal Alignment: The c group demonstrated a superior improvement in PT and SVA (*P*<0.01). - Patient Outcomes: At 6 and 12 months, the C group had lower VAS and ODI scores and higher SF-36 scores (*P*<0.01).
Conclusion	Incorporating L5-S1 TLIF enhances alignment, reduces rod fractures, and improves patient-reported outcomes without increasing complications.
Limitations	Retrospective design; lack of detailed data on cage complications and specific rod fracture patterns.
Keywords	Cage, interbody fusion, pseudoarthrosis, rod fracture, sagittal alignment

ASD: Adult spinal deformity, SVA: Sagittal vertical axis, PT: Pelvic tilt, VAS: Visual Analog Scale, ODI: Oswestry disability index, TLIF: Transforaminal lumbosacral interbody fusion

RF is reduced by L5-S1 interbody fusion

The rate of RF after ASD, based on the surgical approach and constructs used in different studies, varies widely in reports, ranging from 15% to 40%.[2,6,9] We found a reduced RF rate of 9.5% in our study. This may be attributed to (1) using cobalt-chromium rods that exhibit superior strength/fatigue resistance and reduced susceptibility to fracture versus Ti rods, (2) using satellite rods around the osteotomy level [Figure 4],[10], (3) improved anterior column supports and better load sharing,[5] (4) decreased L5-S1 pseudoarthrosis by providing a circumferential fusion,[8] and (5) better spinopelvic alignment: Sardi *et al*.[9] have demonstrated a correlation between postoperative PT and the risk of RF.

Table 8: Summary of references with study design and results.

Ref. No.	Authors and year	Study design	Key findings/focus	Results	Conclusion	Journal
1	Cho *et al*., 2023	Retrospective cohort study of posterior lumbar interbody fusion (PLIF) cases using lordotic cages.	Using lordotic cages at the L5-S1 level does not guarantee improved sagittal alignment in posterior lumbar interbody fusion.	No significant difference in sagittal alignment correction between cage and noncage groups.	Lordotic cages alone may not significantly enhance sagittal alignment; surgical technique and patient-specific factors are critical.	Asian Spine J
2	El Dafrawy *et al*., 2021	Retrospective analysis comparing long fusion constructs with and without distal interbody fusion in ASD patients.	Long fusion to the sacrum with interbody fusion reduces rod fracture and nonunion rates compared to constructs without interbody fusion in ASD patients.	Rod fracture rates and nonunion significantly reduced with distal interbody fusion.	Interbody fusion at distal levels provides stability, reduces complications, and improves fusion rates in long constructs.	Spine Deformity
3	Kankam *et al*., 2023	Retrospective comparison of single vs. dual S2 alar-iliac screws in high-grade lumbar osteotomies.	Compared complication profiles of dual versus single S2 alar-iliac screws in high-grade lumbar osteotomies, showing better stability with dual screws.	Dual screws exhibited reduced mechanical failure and improved construct stability.	Dual S2 alar-iliac screws offer superior mechanical stability and reduced risk of complications compared to single screws.	World Neurosurgery
4	Kankam *et al*., 2024	A multicenter retrospective study comparing four-rod and two-rod constructs in pedicle subtraction osteotomy cases.	Demonstrated the advantages of four-rod constructs over two-rod techniques in ASD patients undergoing pedicle subtraction osteotomy.	4-rod constructs significantly reduced mechanical failure rates.	Four-rod constructs significantly enhance construct stability, reducing the risk of mechanical failure after pedicle subtraction osteotomy.	World Neurosurgery
5	La Barbera *et al*., 2021	Biomechanical analysis of lumbar fixation constructs with interbody fusion in complex constructs.	Analyzed load-sharing biomechanics in lumbar fixation, highlighting improved outcomes with interbody fusion in complex constructs.	Load-sharing improved, reducing stress on rods and enhancing biomechanical stability.	Interbody fusion improves load sharing and biomechanical stability in lumbar fixation, reducing stress on hardware.	Scientific Reports
6	Lertudomphonwanit *et al*., 2018	A prospective cohort study of 526 ASD patients assessing rod fractures and alignment parameters.	Explored prevalence and risk factors for rod fractures in ASD surgery, linking spinopelvic alignment to reduced rod fractures and improved outcomes.	Improved spinopelvic alignment correlated with lower rod fracture rates.	Proper spinopelvic alignment is critical in minimizing rod fractures and optimizing long-term outcomes in ASD surgery.	Spine J

(*Contd*...)

Table 8: (*Continued*).

Ref. No.	Authors and year	Study design	Key findings/focus	Results	Conclusion	Journal
7	Lovecchio and Qureshi, 2019	Comprehensive review of MIS in ASD correction.	Reviewed minimally invasive approaches to ASD, emphasizing the potential for improved outcomes and reduced complications.	MIS techniques demonstrated effective deformity correction with fewer complications.	Minimally invasive techniques can provide effective deformity correction with lower complication rates compared to traditional approaches.	Current Reviews in Musculoskeletal Medicine
8	O'Shaughnessy *et al*., 2012	Comparative analysis of T3-sacrum versus T10-sacrum constructs in primary adult scoliosis surgeries.	Compared long fusion outcomes for T3-sacrum versus T10-sacrum in primary surgery for adult scoliosis, identifying no major difference in overall outcomes.	Outcomes were comparable; shorter constructs reduced surgical morbidity.	Both constructs provide comparable long-term outcomes, but shorter fusions may reduce surgical morbidity.	Spine
9	Sardi *et al*., 2023	A multicenter prospective cohort study of thoracolumbar fusions assessing hardware failure rates.	Examined rod fractures in thoracolumbar fusions, showing correlations between proximal junctional kyphosis and long-term hardware failure.	Proximal junctional kyphosis increased hardware failure risk.	Proximal junctional kyphosis is a significant risk factor for rod fractures and hardware failure in long thoracolumbar constructs.	Journal of Neurosurgery: Spine
10	Shega *et al*., 2020	Systematic review and meta-analysis comparing CoCr and Ti rods in spinal deformity.	A systematic review comparing cobalt-chromium versus titanium rods, showing superior strength and fatigue resistance with cobalt-chromium rods in ASD surgery.	CoCr rods had better strength, durability, and fatigue resistance than Ti rods.	Cobalt-chromium rods outperform titanium in strength and durability, making them preferable for long-segment deformity surgeries.	Advances in Orthopedics

MIS: Minimally invasive techniques, ASD: Adult spinal deformity, VAS: Visual Analog Scale, CoCr: Cobalt-chromium, Ti: Titanium,

Impact of the L5-S1 interbody cage on sagittal alignment parameters

We demonstrated that L5-S1 IF led to improved spinopelvic alignment in our study, in which we showed more significant improvement in PT and a more corrected postoperative SVA. However, Cho *et al*.[1] found no such significant difference in sagittal alignment correction when using different lordotic cages at L5-S1.

Clinical and patient-reported outcome measures

In Figure 3, the results show no significant difference in patient-reported outcomes (PROs) between the baseline and the 1st month of follow-up. However, at the 6 and 12-month follow-ups, patients with L5-S1 cage had significantly better outcomes (lower ODI, lower VAS, higher SF-36). This is likely due to L5S1 TLIF restoration of intervertebral space providing indirect decompression and decreased RF rate.[6]

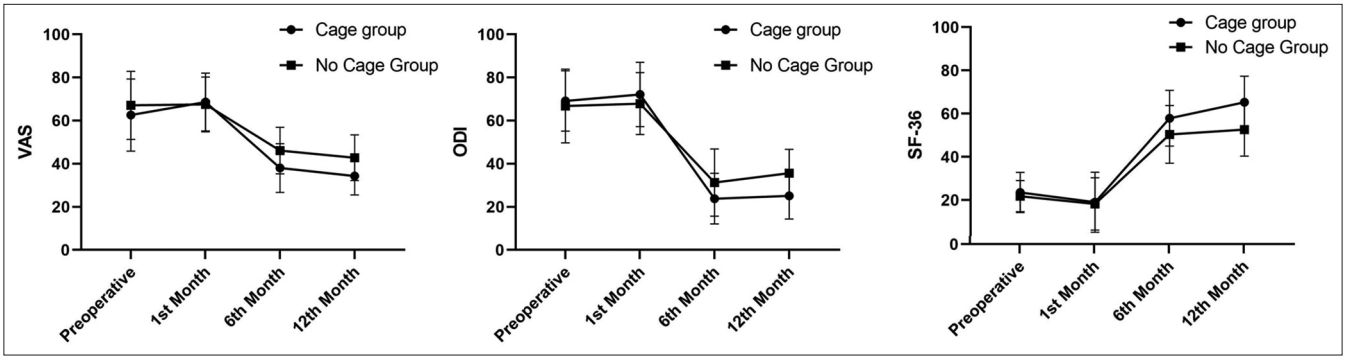

Figure 3: Diagram illustrating the patient-reported outcome measures of cage and no-cage groups. (VAS: Visual Analog Scale, ODI: Oswestry disability index, Quality of life [SF-36]).

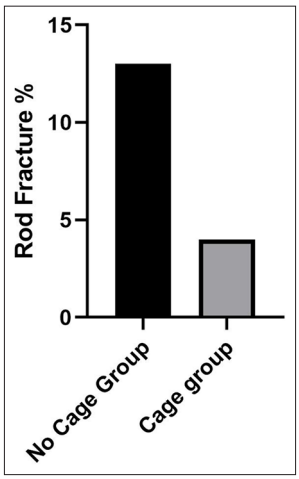

Figure 4: The rod fracture rate in the cage group is significantly lower than in the no-cage group.

Limitations

Our study's retrospective design poses limitations. Open TLIF complications include nonunion, cage subsidence, and exiting nerve root injury, but we did not record this data. We also did not collect information on RFs' unilateral or bilateral nature, their locations, or the need for reoperation due to these fractures.

CONCLUSION

In adult deformity surgery patients with high-grade lumbar osteotomy and long segment constructs with spinopelvic fusion, using interbody fusion in L5-S1 by open TLIF with rectangular PEEK cage reduces the RF rate, improves sagittal alignment results, and enhances PROs in terms of VAS, ODI, and SF-36.

Data and material availability

The article includes all the data regarding the presented case.

Ethical approval: The research/study was approved by the Institutional Review Board at Imam Khomeini Hospital Complex, number IR.TUMS.IKHC.REC.1403.046, dated 2024.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent.

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REFERENCES

1. Cho JH, Hwang CJ, Lee DH, Lee CS. Using lordotic cages at the L5-S1 level does not guarantee the improvement of sagittal alignment in patients who underwent posterior lumbar interbody fusion. Asian Spine J 2023;17:477-84.
2. El Dafrawy M, Bridwell K, Adogwa O, Shlykov M, Koscso J, Lenke LG, *et al*. Rod fractures and nonunions after long fusion to the sacrum for primary presentation adult spinal deformity: A comparison with and without interbody fusion in the distal lumbar spine. Spine Deform 2021;9:231-7.
3. Kankam SB, Zarei M, Moghadam N, Jouibari MF, Bazzazi AM, Yaseen Khan FM, *et al*. Clinicoradiological outcomes and complication profiles of bilateral dual sacral-alar-iliac screws versus bilateral single sacral-alar-iliac screws in patients with spinal deformity who underwent grade 3 or 4 spinal osteotomies: A retrospective comparative study. World Neurosurg 2023;178:e646-56.
4. Kankam SB, Zarei M, Moghadam N, Roohollahi F, Moosavi M, Yaseen Khan FM, *et al*. The advantages of 4-rod construct over the 2-rod techniques in adult spinal deformity patients who underwent pedicle subtraction osteotomy: A multicenter retrospective comparative study. World Neurosurg 2024;183:e530-9.
5. La Barbera L, Wilke HJ, Ruspi ML, Palanca M, Liebsch C, Luca A, *et al*. Load-sharing biomechanics of lumbar fixation and fusion with pedicle subtraction osteotomy. Sci Rep 2021;11:3595.
6. Lertudomphonwanit T, Kelly MP, Bridwell KH, Lenke LG,

McAnany SJ, Punyarat P, *et al.* Rod fracture in adult spinal deformity surgery fused to the sacrum: Prevalence, risk factors, and impact on health-related quality of life in 526 patients. Spine J 2018;18:1612-24.
7. Lovecchio F, Qureshi SA. The current state of minimally invasive approaches to adult spinal deformity. Curr Rev Musculoskelet Med 2019;12:318-27.
8. O'Shaughnessy BA, Bridwell KH, Lenke LG, Cho W, Baldus C, Chang MS, *et al*. Does a long-fusion "T3-sacrum" portend a worse outcome than a short-fusion "T10-sacrum" in primary surgery for adult scoliosis? Spine 2012;37:884-90.
9. Sardi JP, Lazaro B, Smith JS, Kelly MP, Dial B, Hills J, *et al*. Rod fractures in thoracolumbar fusions to the sacrum/pelvis for adult symptomatic lumbar scoliosis: Long-term follow-up of a prospective, multicenter cohort of 160 patients. J Neurosurg Spine 2023;38:217-29.
10. Shega FD, Zhang H, Manini DR, Tang M, Liu S. Comparison of effectiveness between cobalt chromium rods versus titanium rods for treatment of patients with spinal deformity: A systematic review and meta-analysis. Adv Orthop 2020;2020:8475910.

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